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MANAGING GIGA PROJECTS

Advice from Those Who've Been There, Done That

Managing Gigaprojects

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This book is dedicated to the late Henry Michel, Chairman Emeritus of Parsons Brinkerhoff, who was a mentor and a dear friend to us and sat as an outside board member on our company's board of directors. Hank was a pioneer in megaproject management and took Parsons Brinkerhoff to international recognition in this field. The concepts of Pegasus Global Holdings and the vision that megaprojects and gigaprojects can be executed successfully to meet stakeholder expectations were inspired by Hank's own visions and leadership. Writing *Managing Gigaprojects: Advice from Those Who've Been There, Done That* was an idea that Hank thought we should pursue and that has now come to fruition. This one's for you, Hank!

Pat, Kris, and Jack

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Foreword

John J. Reilly

This timely book presents the views of a group of highly qualified professionals involved in the effective planning, design, construction, and delivery of megaprojects. It outlines processes that are applicable to the very biggest projects, which we are now beginning to call "gigaprojects." Two key characteristics of megaprojects are that their complexity increases exponentially with size and that they can span long time frames—both of which lead to many challenges that we must overcome to be successful.

Therefore, in this context, I would like to reflect on two themes:

1. The evolution of our personal interaction with complexity and how our ability to understand new ways of thinking (new paradigms) relates to the successful management and delivery of megaprojects.
2. Rational approaches to changing the public's perception that megaprojects are always delivered late and over budget—with examples from a city where this is not the case.

Complexity, Understanding, and Paradigms

In our careers as developing professionals, we generally encounter significant increases in the size and complexity of the technical and nontechnical demands of our projects (Barker 1993). For example, in the first eight years after graduation I progressed from designing individual building structures to the design of a complex elevated freeway (in Sydney, Australia, the Western Distributor) and then a large urban underground Metro system (in Washington, D.C.). My understanding of many new technical areas, some involving cutting-edge techniques, had to be gained quickly. Additionally, there were demands for more strategic and comprehensive understandings of how all these factors should be integrated and aligned for the effective delivery of large-scale programs. This situation required moving from my comfort zone of technical specialization to a more

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integrated understanding of the management requirements necessary for successful delivery of complex infrastructure programs.

A few years later, I was responsible for management of design and delivery of another urban transportation megaproject. The complexity of this project now required me to develop an understanding of local politics and stakeholder needs—with their associated problems—which generated many potential roadblocks and risks. I was forced to confront a series of difficult issues, some critical, none technical, which were successfully overcome. The project was delivered under budget and close to schedule and was subsequently named the ASCE Outstanding Civil Engineering Achievement of 1988.

As demonstrated in this book, the increase in complexity of projects caused by size, specific circumstances, and long time frames, plus new and evolving technical applications, requires us to quickly, sometimes urgently, change our perceptions and understanding of issues or circumstances—that is, to change the paradigm we hold regarding that situation. We must then communicate that new paradigm to, and align it with, other project participants and stakeholders, who may have diverse, sometimes conflicting, goals and priorities.

Paradigms represent how we understand and interpret our environment and guide how we operate and make decisions. Changing our paradigms when we encounter new circumstances can help us to realize new possibilities and resolve new issues and can enable us, for example, to more effectively manage and deliver megaprojects.

As you read this book, please reflect on how you interpret and understand the textual material with its concepts, recommendations, and considerations. What are your paradigms, your experience, your context, your filters? You might reflect on the way in which your understanding develops and changes in response to new environments, challenges, complexities, and understandings. Some time ago, my then co-authors and I (Reilly et al. 1999) listed three phases in our understanding as we encounter new and complex subjects:

1. Initially simple—when everything seems clear and obvious;
2. Then complex—as we get more information and as the implications and interrelationships are better understood;
3. Finally simple again—when new insights tame and frame the complications. At this point, we have adopted a new paradigm.

Successful Management and Delivery of Megaprojects

The chapters in this book illustrate specific requirements, considerations, and techniques that are necessary for all projects. For megaprojects, the requirements for excellence in execution are significantly, if not dramatically, higher than for a normal project—complex though that project might be.

There is a perception among the public that large, complex programs are always delivered late, over budget, and with deficiencies. This description has been true for some projects, but not for all, perhaps not even the majority. I would like to emphasize that there have been, and continue to be, many large, complex projects that have been delivered successfully. This notion means that they meet stakeholder expectations, function efficiently, and have been delivered under, at, or close to the initial budget and schedule. What are the characteristics of these successful projects? Many responses and considerations are given in the following chapters, but two factors are clearly important: (1) competent management consistent with stakeholder expectations, particularly with regard to anticipated cost and schedule and (2) competent and sufficient staff capability, supporting processes, and available resources.

We should be careful about many things—but primarily we should only commit to delivering a project on a specific schedule and budget when we understand the project sufficiently and have the necessary management and technical resources in place or reliably available (Reilly et al. 2011). As documented in Flyvbjerg et al. (2002), there is a temptation to publish a cost and a schedule early in a project's life cycle, and many stakeholder groups demand this publication. This demand should be resisted because it takes a strong, wise, informed, and credible manager to effectively understand and commit to a specific cost and schedule. When early (usually optimistic) cost estimates are given—resulting in projects that may then be delivered significantly over those cost estimates—the negative results to that project and the damage to our profession are significant. At the appropriate time, developing and communicating a "range of probable cost" is necessary and desirable (Reilly et al. 2004).

There are many cases where project costs have been well managed and the projects have been delivered within budget and schedule. Examples follow.

Examples: Boston Area Megaprojects

By now, almost everyone has heard about the significant cost overruns and delays in the delivery of the Boston Central Artery/Tunnel Project (CA/T). What many have not heard about are four other megaprojects in Boston—with similar politics and environmental requirements—that were successfully delivered under, at, or close to budget and schedule. These other projects were

- *Boston Southwest Corridor*—a grade-separated high-speed rail, commuter rail, transit, and urban development project cutting through an urban section of Boston. Delivered in early 1987 within six months of the date projected at the close of the environmental process in 1978 (the reference budget number given should correspond to the number given to the public at the time of the decision to proceed, generally at the end of the environmental process; this timing is consistent with Flyvbjerg's methods) and with a construction cost of US$743 million—$7 million under the 1978 budget of US$750 million. This project qualifies as a megaproject (cost greater than $1 billion) since in today's dollars it would be approximately $2.6 billion using the average construction cost index from 1982 to today (approximately 4.5% per year).
- *Logan Airport Modernization Program*—a long-term modernization and reconfiguration of Logan Airport with new and renovated terminals, road systems, parking

facilities, cross-harbor regional transportation, and an urban development program. Some of the individual projects were over and some were under their budgets, but Massport completed the US$4 billion program within a "couple of percent" of the published estimates.

- *MBTA Red Line North Extension*—a rapid transit rock tunnel Metro project, delivered at a cost of US$570 million—91% of the number referenced at the time of the environmental process (US$625 million).
- *Boston Harbor Project (BHP)*—a court-mandated harbor cleanup with new sewage treatment facilities and conveyance systems, including a five-mile interharbor tunnel and a nine-mile outfall tunnel. The initial range number given to the public was US$4 to US$4.9 billion, reduced to US$3.65 billion at the start of construction. The project was delivered, on schedule, at US$3.8 billion.

What does this mean? It means we, as a profession, have the ability to successfully deliver complex megaprojects within tight cost and schedule constraints, in dense urban environments, while working with diverse political and community stakeholder groups.

Communication, Policy, and Public Perceptions

Managing public perceptions and expectations and communicating well are some of the keys to success. It may be illustrative to compare the Boston Central Artery/Tunnel (CA/T) and Boston Harbor Project (BHP) in this regard.

From the public's point of view, the CA/T and the BHP signify opposite extremes of project performance and communication with the public. With respect to the cost estimates:

- The CA/T project was initially presented in 1986 with a cost under US$3 billion, a number that followed the Federal Highway Administration (FHWA) cost guidelines at that time. However, this number did not have a solid relationship to the actual project, as constructed, with respect to scope, complexity, and time. By 1990, as construction was about to begin, the estimate had risen to US$6 billion (Salvucci 2003). The project was ultimately delivered at a cost of more than US$15 billion (National Research Council 2003).
- A study on the cost growth of the CA/T states that the low original estimate developed in 1982 was presented in the 1985 environmental impact statement before detailed technical studies were undertaken. (Of course, an initial low estimate is not a direct cause of cost growth.) Other major cost increases have been associated with scope additions, major delays, environmental and other mitigation, and significant changes before and during construction.
- The 1987 facilities plan for the BHP presented a range of costs from US$4 to US$4.9 billion. (The media drew another number, $6.1 billion, from early BHP plans, which included additional project elements and a generous inflation factor. This number created its own set of public credibility issues that, in large

part, drove the cost refinements made in 1992.) In 1992, in the early stages of construction, a thorough review of the project cost was performed, and the estimate was fine-tuned to US$3.65 billion. When the project was completed a decade later, the final cost was US$3.8 billion.

Among the many substantial differences between these two projects, one key differentiator is the way in which the original estimates were prepared and presented. This difference dramatically affected the initial cost estimate (the "number" that the public remembers):

- The CA/T costs were the estimated costs of a very much more basic project in 1986 dollars, with no escalation or contingency built into the number. This method was consistent with FHWA requirements at the time but did not reflect the true potential cost.
- The BHP estimate under which the project was managed—and that was used for public reporting and in disclosure to potential bond investors—was based on estimated costs for the total final program and included contingencies and escalation to the projected midpoint of construction. It also included the costs of planning, design, and construction management, as well as soft costs that were required for delivering the program.

Each project cost estimate was different—in scope, context, and time frame—and was being used, and understood, differently by each agency. However, neither the public nor the media understood these major differences. The majority of the public had—and still has, in the case of the CA/T—no understanding that the numbers represented two completely different scopes, contexts, and time frames. For the CA/T, the media has continued to use the 1986 number as the basis of comparison in every discussion of cost on that program over the years. Therefore, for the CA/T, public opinion has been shaped by these poorly understood numbers and circumstances.

Final Thoughts

Keys to success in the delivery of megaprojects and gigaprojects include the competent use of many classic management and technical capabilities. However, because of the extraordinary demands caused by the great size, long time frames, diverse stakeholders, and political and other transitions associated with these projects, megaprojects require visionary and technically capable leaders (perhaps several such leaders over the course of the project) who have the ability to think strategically, communicate effectively, motivate people, and deal with adversity and setbacks. These leaders must manage internal stakeholders, communicate with and understand external stakeholders, and deal strategically with the specific circumstances and environment in which the megaproject is located.

It's not an easy task.

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Preface

This book is the brainchild of Patricia Galloway, Kris Nielsen, and Jack Dignum. In their 35 years in the construction industry working on some of the world's largest projects, they have truly seen the bold and beautiful as well as the good, the bad, and the ugly. All three had a vision to write a book that would share with senior executives and government leaders the lessons learned and best practices used on the megaprojects and gigaprojects in which they were fortunate to take part. Both Galloway and Nielsen have worked in more than 80 countries. Dignum isn't far behind, having worked in some of the far corners of the earth on major infrastructure and energy projects. As team members, they have seen what can go wrong and right with every phase of megaprojects and gigaprojects.

Expanding on their vision and dream, Galloway, Nielsen, and Dignum reached out to those around the world "who have been there and done that" on some of the world's largest projects, including those who have served in the roles of financier, owner, program manager, consultant, designer, contractor, and legal counsel, to ascertain what they too feel were lessons learned and best practices.

Having served in various roles as consultants, dispute review board members, independent experts, and arbitrators, their broad knowledge of global practices and expertise complements well the experiences of their 22 coauthors. Every one of the contributors has "been there, done that," and every author brings his or her unique voice to a book that should serve as one source of information for those who are embarking on the world's next megaproject or gigaproject.

Galloway, Nielsen, and Dignum over their careers have worked on some of the world's largest projects, two of which are included in ASCE's listing of the Wonders of the Modern World. Although the list is too long to include here, some of the recent and more well-known mega- or gigaprojects on which they have been involved include the following:

- Vogtle Nuclear Power Plant, Units 3 & 4, Georgia, United States;
- Edwardsport Integrated Gasification Combined Cycle (IGCC) Project, Indiana, United States;
- London Crossrail Project, United Kingdom;

- Venice Lagoon Floodgate Project, Venice, Italy;
- Sakhalin Island Pipeline Project, Russia;
- Panama Canal, Panama;
- Xiaolangdi Dam, China;
- Guri Dam and Hydroelectric Complex, Venezuela;
- California Courthouse Construction Program, California, United States;
- Murrin-Murrin Nickel Cobalt Refinery, Australia;
- Toronto Transit Commission Subway Line Expansion, Toronto, Canada;
- Tsing Ma Bridge, Hong Kong;
- Kuala Lumpur International Airport, Malaysia;
- Minerva Gas Project, Australia;
- Casecnan Multi-Purpose Tunnel, Irrigation and Power Project, Philippines;
- Melbourne City Link and City to Airport toll road, Australia;
- Oman LNG Project, Oman;
- HBJ Gas Pipeline, India;
- Combisa Cantarell EPC 22, off-shore oil platform, Mexico; and
- Milwaukee Water Pollution Abatement Program, Wisconsin, United States.

If the individual projects of the chapter contributors were included, the list would be exhausting.

Galloway, Nielsen, and Dignum, as well as their coauthors, have written extensively on the subjects of governance, project and program management, risk management, prudence and performance audits, project delivery, project controls, and dispute resolution, and their papers have been published in numerous journals, magazines, and conference proceedings throughout the world. They have either analyzed or sat through countless cases where in retrospect it seemed that issues should have been obvious but were virtually undetected in real time. To paraphrase Dignum, "Today's megaprojects live on the edge of risk. They also live on the edge of innovation and creativity."

There have been only a handful of books written on megaprojects over the past decade, and only recently have gigaprojects been recognized as yet another complexity of megaproject construction. However, the subject has heretofore been approached from either an academic viewpoint or has been written from a perspective of a how-to guide. And some have been blatantly critical, ignoring the technological and social benefits that megaprojects bring to our lives while offering no solutions. The three authors decided that it was time for a new approach to the analysis of megaprojects and gigaprojects, an approach that would combine the expertise and experience from others around the world who have been active in the development of many of the solutions to problems encountered on both megaprojects and gigaprojects.

Galloway, Nielsen, and Dignum sought those individuals, all of whom they have worked with intimately, who could tell the personal stories of what makes megaprojects and gigaprojects successful and could present examples of how success was achieved in their own voices and in their own ways. Unlike the other books published on this topic of megaprojects and gigaprojects, this book is not written as a textbook, a how-to guide, or even as a critical piece, but rather it is written in the voices of those who wanted to share their experiences with others. This book will be a success if the lessons learned from megaprojects herein can provide a platform from which to launch into the future world of gigaprojects. Over the years and through all the projects, the authors have learned much from each other and they hope you will be able to learn from them, too.

Acknowledgments

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Acronyms and Abbreviations

AAA	American Arbitration Association
AACE	American Association of Cost Engineers International
AC	Alliance contractor
ACEC	American Consulting Engineers Council
ACECC	Asian Civil Engineering Coordinating Council
ACET	Anti-Corruption Education and Training
ADA	Americans with Disabilities Act
ADR	Alternative dispute resolution
A/E	Architect/engineer
AGC	Associated General Contractors
AIA	American Institute of Architects
ALARP	As low as reasonably practical
ALG	Alliance leader group
ANSI	American National Standards Institute
AOC	Actual outturn cost
APMT	Alliance project management team
AQCS	Air quality control system
ASAP	As soon as possible
ASCE	American Society of Civil Engineers
ASEAN	Association of Southeast Asian Nations
ASEAN+6	ASEAN plus China, India, Japan, South Korea, Australia, and New Zealand
ASIC	Australian Securities and Investments Commission
ASX	Australian Securities Exchange

BART	San Francisco Bay Area Rapid Transit
BATC	Bay Area Transit Consultants
Bbl/d	Barrels per day
BBO	Buy–build–operate
B/C	Benefit/cost
BHP	Boston Harbor Cleanup Project
BIM	Building information modeling
BIMS	Business integrity management system
BOO	Build–own–operate
BOOT (BOT)	Build–own–operate–transfer
BOP	Balance-of-plant
BOQ	Bill of quantities
BP	British Petroleum
BPC	Bipartisan Policy Center
CA/T	Boston Central Artery/Tunnel Project
CAF	Corporacion Andina de Fomento
CAPEX	Capital expenditure
CCPPP	Canadian Council for Public–Private Partnerships
CDB	Combined dispute board
CEDR	Centre for Effective Dispute Resolution
CEO	Chief executive officer
CEVP	Cost estimate validation process
CFO	Chief financial officer
CGL	Comprehensive general liability
CM	Construction manager
CM@R	Construction manager at risk
CM/GC	Construction manager/general contractor
CPCN	Certification of public convenience and necessity
CPM	Critical path method
CREATE	Chicago Region Environmental and Transportation Efficiency
CWIP	Construction work-in-progress
DAB	Dispute adjudication board
DB	Design–build
DBB	Design–bid–build
DBFO	Design–build–finance–operate

DBFOM	Design–build–finance–operate–maintain
DBIA	Design Build Institute of America
DBO	Design–build–operate
DBOO	Design–build–operate–own
DBOOM	Design–build–operate–own–maintain
DBOOT	Design–build–operate–own–transfer
DC	Design certification
DHS	Department of Human Services
DIA	Denver International Airport
DOT	Department of transportation
DPX	Dublin/Pleasanton Extension
DRA	Dispute resolution advisor
E&C	Engineer and construct
EA	Engineers Australia
ECI	Early contractor involvement
EEC	European Economic Community
EEI	Edison Electric Institute
EIA/RIMA	Environmental impact assessment/Relatório de Impacto Ambiental (environmental impact report)
EIB	European Investment Bank
EJCDC	Engineers Joint Construction Documents Committee
EPA	Environmental Protection Authority
EPC	Engineering, procurement, and construction
EPIC	Engineering, procurement, installation, and construction
EU	European Union
FAR	Federal acquisition regulations
FDC	Field design changes
FERC	Federal Energy Regulatory Commission
FERMA	Federation of European Risk Management Associations
FHWA	Federal Highway Administration
FIDIC	Fédération Internationale des Ingénieurs-Conseils (International Federation of Consulting Engineers)
FOIA	Freedom of Information Act
GARVEE	Grant anticipation revenue vehicle
GCC	Gulf Cooperation Council

GCCM	General contractor–construction manager
GIACC	Global Infrastructure Anti-Corruption Centre
GMP	Guaranteed maximum price
GPIMS	Government procurement integrity management system
HGCRA	Housing Grants, Construction and Regeneration Act
HMT	Her Majesty's Treasury
HR	Human resources
HSE	Health, safety, and environmental
IAEA	International Atomic Energy Agency
ICC	International Chamber of Commerce
ICDR	International Centre for Dispute Resolution
ICE	Institution of Civil Engineers
ICE5	Institution of Civil Engineers *Conditions of Contract*, 5th Edition
ICMFA	International Construction Management Forum in Asia
IDB	Inter-American Development Bank
IFC	Issued for construction
IGBT	Insulated gate bipolar transistor
IGCC	Integrated gasification combined cycle
INPO	Institute of Nuclear Power Operations
IOC	International oil companies
IPA	Independent project analysis
IPPs	Independent power producers
IRP	Integrated resource planning
ISC	International Sponsor Council
ISOs	Isometric drawings
ITA	International Tunneling Association
ITAAC	Inspections, tests, analyses, and acceptance criteria
ITIG	International Tunnel Insurance Group
JAMS	Judicial arbitration and mediation
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JSCE	Japanese Society of Civil Engineers
KPI	Key performance indicators
kW·h	Kilowatts per hour
LCIA	London Court of International Arbitration

LILCO	Long Island Lighting Company
LP&VHPP	Lake Pontchartrain and Vicinity Hurricane Protection Project
LRT	Light rail transportation
LRV	Light rail vehicle
MBE	Minority business enterprise
Med-Arb	Mediation-then-arbitration
MENA	Middle East and North Africa
Million ft^3/d	Million cubic feet per day
Million t/yr	Million tons per year
MMR&R	Major maintenance, repairs, and replacements
NAFTA	North American Free Trade Agreement
NCR	Non-conformance report
NDC	Notice of design change
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act
NOC	National oil companies
NPV	Net present value
NRC	Nuclear Regulatory Commission
NSPE	National Society of Professional Engineers
NWS	North West Shelf
NWSV	North West Shelf Venture
O	Owner
O&M	Operations and maintenance
OCI	Optimized contractor involvement
OCM	Organizational change management
ODA	Official development assistance
OEM	Original equipment manufacturer
OFS	Oil field services
OGC	Office of Government Commerce
OSHA	Occupational Safety and Health Administration
OSR	Over-the-shoulder review
PACI	Partnering Against Corruption Institute
PACS	Project Anticorruption System
PAX	Pittsburg/Antioch Extension
PCA	Panama Canal Authority

PEI	Prince Edward Island
PEP	Project Execution Plan
PFI	Private Finance Initiative
PMBOK	Project management body of knowledge
PMC	Program management contractor
PMC+	Program management contractor+
PMI	Project Management Institute
PMO	Program management oversight
PPA	Power purchase agreement
PPP	Public–private partnership
PSP	Planning and scheduling professional
PUC	Public utility commission
QIC	Queensland Investment Corporation
QSP	Quality service payments
RCH	Royal Children's Hospital
RCHF	Royal Children's Hospital Foundation
RFI	Request for information
RFP	Request for proposal
RFQ	Request for qualifications
ROE	Return on equity
ROI	Return on investment
S&WB	New Orleans Sewerage and Water Board
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SBO	Strategic business objectives
SEIU	Service Employees International Union
SFO	San Francisco Airport
SII	Structural Impediments Initiative
SPC	Special purpose company
SPE	Special purpose entity
SPV	Special-purpose vehicle
TBL	Triple bottom line
TBM	Tunnel boring machine
TEA-21	Transportation Equity Act of the 21st Century
TGV	Train à Grande Vitesse (high-speed train)

THSR	Taiwan High Speed Rail
THSRC	Taiwan High Speed Rail Consortium
TI	Transparency International
TIFIA	Transportation Infrastructure Finance and Innovation Act
TIS	Tampa Interstate System
TJ/d	Terajoules per day
TOC	Total outturn cost
T-REX	I-25/I-225 Southeast Corridor (Denver, CO)
Trillion ft^3	Trillion cubic feet
TTA	Transportation Ticketing Authority
UAE	United Arab Emirates
USACE	U.S. Army Corps of Engineers
VFM	Value for money
VPD	Vehicles per day
WA	Western Australia
WFEO	World Federation of Engineering Organizations
WSDOT	Washington State Department of Transportation
WSX	Warm Springs Extension
WWF	World Wildlife Fund

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Part 1

Megaprojects to Gigaprojects

The Way of the 21st Century

The definition of a megaproject has evolved over the years. It is fair to say that the concept of the modern megaproject began with the post–World War II expansions of nuclear power plants. It is also fair to say that huge projects from the Colossus of Rhodes and the Cathedral at Chartres to the Vietnam War Memorial contain many of the technological and societal issues and problems that a modern project manager of a megaproject would recognize instantly.

Dr. Galloway describes megaprojects as any undertakings that are

> generally defined within the industry as very large capital investment projects (costing more than US$1 billion) that attract a high level of public attention or political interest because of substantial direct and indirect impacts on the community, environment, and companies that undertake such projects.

Other attributes of a megaproject include the following:

- attracts a high level of public attention;
- is the execution of an engineered facility or structure that is complex or unusual;
- has an extended execution schedule (more than four years measured from initial concept development to final completion);
- involves multiple equipment and material suppliers;
- involves multiple specialty trade contractors;
- involves multiple project stakeholders and investors; and
- may have multinational party stakeholder involvement.

Although many people have their own definitions of what a megaproject may be, it is typically defined as a project that is designed and constructed over a period of at least four or more years and at a cost of more than US$1 billion. Gigaprojects represent the natural step beyond a megaproject; as we continue into the 21st century, the term is taking a more definitive state. Generally, a gigaproject is a project with a cost of at least US$10 billion. In 2012, we have already seen projects near the US$40 billion mark. These gigaprojects take a minimum of 10 years to complete and frequently include multinational stakeholders. The projects are typically so large that no one company can provide the sufficient personnel for all aspects of the project. Nor can it afford to finance or absorb all the risks associated with the physical project magnitude or extended time periods over which most megaprojects and gigaprojects operate. Throughout this book, the authors describe their experiences with megaprojects. However, in most instances the word "megaprojects" could be used interchangeably with "gigaprojects" because the same management concepts discussed throughout the book can be applied to both megaprojects and gigaprojects. Indeed, many of the original project team members in today's megaprojects and gigaprojects may not even be around to see the ribbon-cutting ceremonies celebrating their final completion.

Today's large projects evolve around some common themes. Perhaps a further definition of a megaproject might be that it is almost a certainty that many of the technological and physical systems, operating systems, management systems, and even the major stakeholders, as described in Chapter 1, change through the lifetime of the project. That fact means that those controls and systems must be dynamic, not static, and that everything from regulatory environments to financing and risk assessment change over time.

It is also apparent that the financial models are changing—in the past the majority of public infrastructure megaprojects were publicly financed. Now many of the largest projects are privately financed through multiple financial partnerships under various delivery methods and various investment structures, with many of the financial participants foreign to the country in which the project is being built.

Additionally, the list of stakeholders in a large project has climbed from a few immediately affected parties to intervenors that may never see the final project or be directly affected by its presence and operation. It is not abnormal to see advocacy groups from foreign countries becoming involved with the preliminary planning and execution of many of these projects.

Considering the financial constraints, inherent risks, and extended performance period involved with executing these projects, why are megaprojects evolving into gigaprojects and becoming larger and more prevalent as we move into the 21st century? Is it the result of the increasing supply of the world's aging infrastructure and the need to replace that infrastructure on larger scales? Are they implemented by some governments seeking to demonstrate their ability to be top players in the world's markets? Some observe that to satisfy demand, whether demand for increased power availability or quicker, more available mobility, a modern project has to serve so many people on such a vast scale that it becomes a megaproject or gigaproject because of circumstances rather than specific merit.

One thing is clear: There will be more and more large projects as an emerging middle class in Africa, India, and China begin to demand modern transportation and the basic necessities of a civilized middle class life.

In Part 1, our authors, from a wide array of disciplines, bring us their knowledge of execution strategies. They offer a firsthand look at some of the problems they have solved and give us their on-the-ground experiences with those problems.

- **Kris R. Nielsen** writes about governance and what senior management, directors, and government overseers should do to meet stakeholder expectations.
- **Kris R. Nielsen, Jack L. Dignum, and John J. Reilly** address risk and the need for dynamic risk modeling systems.
- **Christyan F. Malek** offers some thoughts on international investment and transparency.
- **Peter Hughes** discusses project delivery methodologies and talks about the change in relationships in international financing and construction consortia.
- **Richard G. Little** covers public–private partnerships and their possible solution to megaproject delivery problems.
- **Robert Prieto** gives us some background on the program manager's role and importance in megaproject management systems.
- **Gerald Tucker** talks about public–private financing in transportation projects.
- **Patricia D. Galloway and John J. Reilly** address project control systems and six challenges to controlling megaprojects.
- **Thomas R. Warne** gives us his thoughts on design management and its importance to the bottom line.
- **James Crumm** offers his unique outlook on megaprojects and their associated procurement and construction issues.
- **William P. Henry** addresses the different concerns of culture and ethics in a multinational megaproject.
- **John Hinchey** gives us an exhaustive overview of dispute resolution from his unique legal perspective.

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CHAPTER 1

Governance of the Megaproject

Kris R. Nielsen

Governance addresses the need of all stakeholders to the megaproject because all stakeholders have a common interest in completing the megaproject within the goals of time, quality, and cost. For the context of governance of megaprojects, the author defines governance as follows:

> Governance of megaprojects is the establishment of proper program management systems, processes, and management structure to achieve the goals and objectives of the various stakeholders, while at the same time making sure the system, processes, and management structure function to maintain uniformity, transparency, and accountability across every aspect of the megaproject.

Stakeholders share a common interest regarding the overall objective of time, quality, and cost, but stakeholder needs and requirements vary greatly depending on the extent of their involvement and on how they influence the project. Typically, stakeholder needs take the form of the "information needs and requirements," and this information needs to be managed.

As defined by the Project Management Institute (PMI), stakeholders to a megaproject fall into one of the following category groups (2008a):

1. Direct stakeholders: those stakeholders involved in the execution of the megaproject, including, but not limited to the following:
    - Owners,
    - Engineers,
    - Consultants,
    - Contractors,
    - Subcontractors,
    - Suppliers, and
    - Vendors.

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LESSONS LEARNED

1. The governance environment has changed around the world, making senior management and directors personally liable for actions taken and decisions made relative to megaproject execution.
2. Senior management and directors must, when called upon, demonstrate that the decisions made and actions taken over the course of a megaproject were both reasonable and prudent.
3. Reactions by stakeholders are based on their own expectations for the megaproject.
4. Corporations fuel stakeholder expectations through general statements posted to websites, newsletters, blogs, and reports.
5. Stakeholders tend to judge the reasonableness and prudence of decisions and actions against the results those stakeholders expected to flow from the megaproject early in the project or program.
6. The reasonableness of a management decision or action is judged against whether or not the critical information that was available at the time the decision or action was taken was adequate.
7. The prudence of a decision or action is judged against whether or not senior management, the directors, or the overseers weighed the specific decision or action taken against other possible options available.
8. Senior management or director ignorance of the facts concerning the execution and condition of a megaproject is no defense against personal liability that may flow from that megaproject.
9. The filtering of critical information at various points in the organizational structure is a barrier to senior management, directors, and overseers receiving information critical for taking reasonable and prudent decisions or actions.
10. Using the risk profile as a guide, senior management, boards, and oversight bodies should identify gaps in their corporate reporting structure that are preventing potential critical information on risks to successful completion from reaching them in a timely manner.

The needs and requirements of the direct stakeholders are often detailed in the contract(s), specifications, and work standards used.

2. Industry stakeholders: those not directly involved in the execution of the project, but sometimes having an influence on the execution of the megaproject, including, but not limited to, the following:
    - Outside investors,
    - Regulatory agencies or authorities,
    - Special interest groups,
    - The general public,
    - Labor unions,

- Local government departments, and
- The media.

How the megaproject is governed is determined by senior corporate management and the board of directors in private construction and government entities in public infrastructure construction. Governance requires that senior management, directors, or government overseers have ensured that the necessary systems, processes, and management structure are in place for the megaproject so that timely information can flow up and down the organization while reasonable and prudent decisions can be made at the appropriate level within the megaproject.

Literally, a day does not pass that an article is not written somewhere in the United States (or the world at large) questioning the reasonableness of the actions of senior corporate management, boards of directors, and government overseers on the prudence of the decisions made—or not made—by those entities. Over the past 10 years, the business environment in the United States has grown particularly dark and foreboding (Greenburg and Martin 2002):

> In May 2002, *Business Week*'s special report entitled "The Crisis in Corporate Governance" questioned corrupt analysts, complacent boards, and questionable accounting. At the time, it seemed like media hype. It may have been, but Federal Marshals parading hand-cuffed, business-suited Adelphia executives in front of television cameras was a serious, visible sign that the crisis was real. Since then, a blur of headlines, arrests, and financial reporting revisions etched an impression of malfeasance and financial panic not experienced in this country in decades.

Suddenly, chief executive officers (CEOs), chief financial officers (CFOs), and boards of directors found their every decision and every action placed under intense scrutiny from government regulators, shareholders, and even the public at large. Each of those actions and decisions was examined in depth, and questions were raised as to the prudence of those actions and decisions. Although the brightest lights have been focused on the largest corporations and governments in the most headline-grabbing cases, the fallout of the trust crisis has left no corporation or government building agency untouched, including those subsidiary corporations and government agencies that are involved in a megaproject as financiers, owners, consultants, contractors, and subcontractors. The manner in which corporations are managed and governed has become the focus of legislative bodies, regulatory agencies, licensing authorities, the shareholders of those corporations, and ultimately the public at large as at no other time in history.

The most publicized example of this increased oversight is the Sarbanes–Oxley Act passed by the U.S. Congress in 2002. According to Greenburg and Martin (2002), that act made

> a number of significant changes to federal regulation of public company corporate governance and reporting obligations and also meaningfully alters

> the *standards for accountability of directors and officers* of those companies [emphasis added].

Accountability is not a new concept: Senior management and directors have always been accountable for their actions and decisions. However, today the operational definition of *accountable* has shifted from simply owing a shareholder or stakeholder an obligation to report conditions truthfully to having to explain and justify why those conditions exist. In other words, in today's business climate it is not enough to report the quarterly and annual condition of the corporation or government entity. Now senior management, directors, and oversight agencies are required to explain the reasons why the corporation or entity is where it is and, more critically, they must justify any actions and decisions they took that either created those conditions or responded to those conditions.

Senior management, directors, and oversight agencies must be able to demonstrate that their actions were reasonable and that their decisions were prudent in light of the conditions faced by the organization. For the first time, senior management, directors, and oversight agencies must be able to defend their actions and decisions to regulators, financial institutions, shareholders, and the stakeholders at large. To an unprecedented degree, they are being held legally accountable for the results of their actions and decisions. This worldwide focus on governance of corporations and government entities and the legal implications that now accompany the position of senior manager, director, or overseer have led to an interesting response from those who would normally agree to serve in these positions. One potential corporate director said (Ryan and Shand 2002),

> I would rather stick pins in my eyes than take on another board seat.

Although that sentiment may appear rather extreme, the knowledge that an individual director may be held legally responsible for the actions taken and decisions made by a board of directors of a corporation has resulted in numerous instances where highly qualified and sought-after individuals have either resigned their seats on boards or have refused invitations to serve on the boards of corporations.

Behind the headlines, the legislation, the regulations, and the changing standards of care by which governance is judged lies a fundamental question:

> Have the senior managers, directors, or overseers acted *reasonably* and were their decisions *prudent* and in the best interests of the corporation and its shareholders?

Prudence looks at decisions made and whether those decisions were made in a reasonable manner in light of conditions and circumstances that were known or reasonably should have been known at the time the decisions were made. For too many organizations, the response of the media, government regulators, shareholders, and the public at large to that question has been "No." For instance, the specifics of the Sarbanes–Oxley Act and its resulting regulations in the United States, as well as similar legislation enacted by other countries, are not the focal point of this chapter. Rather this chapter examines the *underlying question,* which is centered on the concepts of *reasonable actions and prudent decisions* by management, boards, and overseers, particularly in relation to an organization's decisions and actions pertaining to the construction of a megaproject or gigaproject.

Subsidiary financial institutions, design consultants, contractors, and subcontractors involved in the funding, planning, design, and construction of megaprojects and gigaprojects are, in many instances, organized as corporations. As such, they fall under the same rules and regulations as larger corporations; they should understand that they are subject to the same public scrutiny from government regulators, financial institutions, and shareholders as the largest corporations in the world. Specifically this chapter is directed at those organizations engaged in the financing, design, and construction of megaprojects and gigaprojects around the world.

The Expectation Is the Problem

Every reaction by regulators, financial institutions, shareholders, and the public taxpayer is based on and flows from their *expectations* of an organization's senior management, directors, or government overseers. Those expectations may or may not be based upon the reality of the conditions within which the organization is operating; in fact, expectations may be based on little or no information. Too often, expectations arise out of information that has little direct bearing on the issue under examination. For example,

> A newspaper reports that the investment in new power facilities worldwide is expected to exceed US$100 billion over the next five years. The financial institutions and shareholders of a large international engineering, procurement, and construction (EPC) contractor expect that as the third largest design builder of power facilities in the world that their corporation will capture at least 25% of that US$100 billion over that period.

Obviously, there is absolutely no factual basis for that expectation; however, if that corporation fails to gain control over a significant percentage of that new power work (i.e., fails to meet the expectations of the financial institutions or shareholders), then it should not be surprised to find itself subjected to intense questioning relative to why that expectation was not realized. The bulk of those questions will focus on the actions and decisions of the senior management and directors.

Unfortunately, it is not unusual for the senior management of a corporation or government overseers to actually fuel expectations to unrealistic levels in their own public announcements and reports. For example, a typical annual report might say,

> The XYZ Corporation is well placed to capture a dominant share of the expanding global power production market. Over the past year, the Corporation has expanded its design and construction capabilities in traditional

> fossil fuel plants, alternative fuel plants, and nuclear power generation. Our breadth of experience and long history in the industry make XYZ a clearly superior choice for full-service EPC power plant construction throughout the world.

Even though that same document may include extensive qualifying statements in an effort to ensure that no "guarantees or promises" are made relative to market conditions or share of the market, the expectation that XYZ will "dominate" the world power market exists. A scenario where investors are expected to invest more than US$100 billion over five years has been set in the mind of the financial institutions, shareholders, and the public. The engineering and construction market is intensely competitive, particularly for megaprojects, such as new power generation stations, but it is impossible to predict with any level of certainty exactly what will happen, when it will happen, and what form it will take when it does happen.

In the 1970s, nuclear energy was predicted to be the "power plant of the future," and billions of dollars were invested in the design and construction of nuclear power facilities in the United States. Utility shareholders were told that nuclear power was the answer to producing clean, relatively inexpensive, and practically inexhaustible power. Design firms, construction contractors, and nuclear equipment manufacturers told their financiers and shareholders that the market for nuclear power plants was immense and global. Everyone in the 1970s believed that nuclear power would one day be the dominant if not the only power production technology in place throughout the world.

By the 1990s, less than 20 years later, however, no nuclear generation facilities were being designed or constructed within the United States. Throughout some parts of the world, nuclear-fueled power facilities were still being constructed, though the market was a mere fraction of what had been anticipated in the 1970s. The markets that did exist were highly competitive in light of the high number of firms chasing the greatly diminished megaproject opportunities. What led to the collapse of the nuclear power market is the subject of thousands of studies and articles and is not the topic of this chapter. However, the fallout from that collapse is illustrative of the current business atmosphere. As the nuclear power market collapsed, literally hundreds of legal actions involving billions of dollars were filed by shareholders, utilities, designers, constructors, and nuclear equipment manufacturers. Hundreds of millions of dollars were spent in legal fees and costs as each party in the nuclear industry was simultaneously attempting to pursue recovery of its *expectation losses* while at the same time defending itself from those who sought to recover their own *expectation losses* from them. Now that governance concepts have become commonplace, the resurgence of the nuclear power industry worldwide requires again billions of dollars of investment under an increasing microscope.

During the legal holocaust that followed in the 1990s, the fundamental question brought before judges, juries, and arbitrators was,

> Did the (utility, owner, designer, constructor, or nuclear equipment manufacturer) officers and directors act reasonably, and were their decisions prudent

and in the best interests of the corporation and its shareholders in the pursuit and execution of the power generation plant megaproject?

The most critical aspect of that question is in establishing how to judge whether or not an action was reasonable or a decision prudent. How does one judge whether or not an action was reasonable; and against what outcome is a decision determined to have been prudent? Certainly measured against the original expectations of the financial institutions, shareholders, the utility ratepayers, the utilities, the owners, the designers, the contractors, and the nuclear equipment manufacturers, the actual outcome experienced during the execution of nuclear power projects came nowhere near the expectations first established in the 1970s. Attempting to establish the reasonableness of actions or the prudence of decisions by comparing the ultimate results achieved solely against the *original expectations* is at the least dangerous, and may ultimately be extremely damaging. Nevertheless, the question had to be answered: Those pursuing recovery attempted to define reasonable actions and prudent decisions in terms of actual outcome compared to expected outcome, whereas those defending themselves against recovery attempted to define reasonable actions and prudent decisions as being equal to those that produced the actual result achieved.

The situation was further complicated by the fact that a party to the nuclear generation megaproject often found itself the plaintiff in one case and the defendant in another, both being tried at the same time. For example, the senior management and directors of utilities were often named defendants in actions filed by shareholders, ratepayers, and financial institutions at the same time they were acting as plaintiffs in actions filed against designers, construction contractors, and nuclear equipment suppliers. Simultaneously, the senior management and directors of the utility were attempting to prove that they took reasonable actions and made prudent decisions while at the same time attempting to prove that the senior management and directors of the other parties to the nuclear generation megaproject failed to act reasonably or decide prudently. Utilities had to defend themselves against expectation-based demands for recovery while at the same time attempting to recover their own damages based upon their own expectations. The same question remained at the heart of those cases.

Ultimately, to answer that question, the "nuclear project prudence audit" was used. A nuclear project prudence audit was a process under which the actions taken and the decisions made by corporate senior management and directors were judged against the conditions of the megaproject at the time at which the actions were taken (or should have been taken) and the decisions were made (or should have been made). The goal of the nuclear project prudence audit was to establish an independent expert opinion relative to the reasonableness of the actions taken and prudence of the decisions made without having to judge reasonableness or prudence against the original expectations of any of the parties to the project.

In summary, every action or decision that is subjected to questions relative to the reasonableness of that action and prudence of that decision must be judged against some measure other than the expectations of the parties that were established at the time the megaproject was originally planned. Just as the previous statement became one of the most critical issues in the aftermath of the first two generations of nuclear generation megaprojects, so it is again under the current business environment within the United States and around the world as megaprojects and gigaprojects increase in size and complexity.

What Is Reasonable and Prudent

The purpose of governance is to ensure that decisions made over the course of the megaproject are reasonable and prudent in meeting stakeholder expectations. As with the nuclear generation megaproject prudence audits in the past, the first step in auditing prudence in today's business environment is to define reasonable actions and prudent decisions. Briefly,

> The *reasonableness* of the actions taken by senior management, directors, or overseers relative to an issue facing an organization is always founded on seeking and understanding that information that is critical to formulating all the possible responses to that issue—in other words, what was known or what should have been known relative to the conditions surrounding the issue at the time the issue arose. The important concept is to have sufficient relevant information from which to identify the full complement of various courses of action available to the organization in response to the issue.
>
> The *prudence* of the decisions made in response to an issue facing an organization is always founded on senior management, directors, or overseers having examined all the reasonable alternative responses, weighing the risk-to-reward balance of each alternative, and selecting the alternative that is judged to be in the best interest of the organization and its stakeholders.

Ultimately, every action taken and decision made is an exercise in balancing risk with reward. In every construction megaproject, it is possible to have been both reasonable and prudent and yet fail to achieve the expectations of all of the stakeholders in the megaproject. Simply failing to attain an expectation or reward (i.e., a certain profit margin) does not mean that the senior management, board, or oversight entity was irresponsible or imprudent. In a construction project, as in all of life, risk can be identified, anticipated, planned around, and actively addressed, but *risk can never be totally eliminated*. Even so, owners, designers, and construction contractors face attempts by financial institutions and shareholders (and each other) seeking to recover the "losses" they sustained when the final results of the megaproject do not meet their original expectations. More and more frequently, those losses are sought on the assertion that in some way the senior management and directors failed to act reasonably or make prudent decisions in response to the issues that arose during the planning and execution of the megaproject.

To judge prudence or reasonableness in decision making, boards and management should be asking some of these questions as they solve problems. How does one judge whether or not we took reasonable action to investigate, understand, and examine the facts and conditions relevant to the issue at question? How does one judge whether we examined every reasonable action in response to the issues? By what measure does one confirm that we weighed the various response actions to establish the risk-to-reward ratios of each of those actions and then prudently selected the response action that was judged in the best interest of all the stakeholders?

The results attained at the end of a construction mega- or gigaproject cannot be used as the sole measure against which actions taken and the decisions made were reasonable or prudent. Indeed, sometimes even reaping a reward as a result of the actions taken and decisions made is not sufficient to demonstrate that the senior management, board, or overseers acted reasonably and prudently. In today's environment, one must be able to demonstrate that one's actions were reasonable and one's decisions were prudent. And that demonstration begins with what one knows.

What Every Senior Manager, Director, or Government Overseer Needs to Know

According to an article in *International Business Lawyer* (Robinson 2002),

> Given the increasing responsibilities and liabilities which can result from serving as a director of a public or even private company, one wonders why any responsible person would be willing any longer to seek or remain in such a position.

That same question can be asked relative to chief executive officers and chief financial officers of corporations and government entities. Given the increased responsibility and liability, why would anyone seek either of those positions within an organization? The article (Robinson 2002) goes on to say,

> It is also clearer than ever before that a director needs to know all that he possibly can about the business and financial operations of the corporation on whose board he serves.

Again, the same point can be made relative to the senior management or oversight entity. Senior managers, directors, and government overseers cannot be passive participants in construction megaproject execution. Yet, under the traditional project management structures used in most construction megaprojects, these parties tend to be passive receptors of information passed to them by the management of the individual megaproject. Often senior management, directors, and government overseers do not even know that a particular megaproject is in trouble until they read about it in the media or hear about it directly from a disgruntled client, designer, or contractor.

In today's business environment, the surest way to establish that one acted neither reasonably nor prudently is to assert that one didn't know there was a problem until it was too late to respond. If nothing else, the governance standards today are focused on the proposition that senior management, directors, or government overseers owe an organization and its stakeholders a fundamental duty to both know what was happening within the organization and to act on the basis of that knowledge.

That does not mean that senior managers, directors, or government overseers must be technically proficient in every aspect of a corporation's or government organization's mega- or gigaproject work. However, it does mean that they must be in a position to ask the right questions at the right time of the right people to obtain the information necessary to understand the issue, identify the options, weigh the risks and rewards of each option, and finally make a prudent decision.

To summarize, the following are just a few of the more critical topics for senior managers, directors, and government overseers to understand in making reasonable and prudent decisions to meet stakeholder expectations:

- The legal obligations of being a senior manager, director, or government overseer;
- In general, the legal structure within which the construction megaproject industry works (regulations, codes, permits, licenses, etc.);
- The nature of the construction megaproject industry (i.e., how megaprojects are planned, financed, and executed);
- In general, the risks and rewards inherent within the construction megaproject industry for all direct stakeholders, including financial institutions, owners, designers, and construction contractors;
- Specifically, the risks and rewards inherent within the construction megaproject industry for the corporation or government that one serves (such as power generation, major infrastructure, etc.);
- The structure and viability of the organization;
- The procedures and processes by which the organization decides to move ahead with construction of megaprojects or gigaprojects;
- The procedures and processes by which the organization finances, plans, and executes construction megaprojects;
- The procedures and processes by which the organization collects, analyzes, and reports data critical to achieving the cost, schedule, and quality requirements of the megaprojects and gigaprojects; and
- The current status of construction megaprojects and gigaprojects: how they are financed, planned, designed, executed, and completed.

Obviously, the list is not inclusive of everything that a senior manager, director, or government overseer must know to execute his or her function. However, the leader must first know and understand the laws, the construction megaproject industry, and the corporate structure within which megaprojects are executed if one is to truly demonstrate that one's actions were reasonable and one's decisions were prudent. Demonstrating that one was reasonable and prudent begins with having the necessary information.

The Barriers to Information

Information and how information is obtained, recorded, and transmitted for making decisions is a critical aspect to reasonable and prudent decision making and good governance. The evaluation of the prudence of the decision-making process and the decision implementation includes the following steps:

1. Data development,
2. Information flow,
3. Analysis, and
4. Decisions.

The steps are described below:

- Data development addresses what information was available and determines if the megaproject system and processes were organized and implemented in a way that produces available information in a reliable manner to management for analysis.
- Information flow addresses to whom and when the available data were transmitted and communicated and in what format the information was available to management. The evaluation of the information flow determines if management received the information in an understandable, timely manner to make the decision.
- The analysis step addresses how the information was evaluated, what alternatives, if any, were evaluated based on the available information, and what benefits and effects were projected by management based on that information.
- Finally, the decision step addresses what decision was made, when the decision was made, how the decision was made, how the decision met stakeholder needs, and whether the decision was reviewed as assumptions and circumstances changed.

Proper megaproject and gigaproject governance must ensure that the systems, processes, and management structure are in place to ensure that information is gathered, fully disseminated, and properly analyzed to manage the megaproject in such a way that stakeholder expectations are met. The system and processes for managing megaprojects and gigaprojects are discussed in Chapter 8, and the management structure is discussed in Chapters 4–6 of this book. Ultimately, any barriers to receipt and analysis of information from the system and processes in place caused by an incomplete management structure may seriously affect meeting the ultimate goals of time, quality, and cost. As noted in one article (Ryan and Shand 2002),

> Directors interviewed shared common concerns. They pointed to inadequate channels of information. The former chairman of several major companies ... told the Australian Financial Review: "Everybody covers up all down the line. There is a rationing of information at every level" ... Boards

> are inherently in a vulnerable position because the information they get is filtered.

Although the article quoted above was not examining the construction industry in particular, the observations are still applicable. In fact, the observations may be even more applicable in a construction setting and in particular in construction megaproject settings, where the megaprojects are themselves complex and often difficult to understand. Within the typical organization involved in the construction industry, a similar statement might be made about senior management, directors, or government overseers. Filtering of information is a fact of life in every construction megaproject; part of the reason for that filtering is simply a result of the technical complexity of a construction project and the way projects are generally executed within the industry.

Although a megaproject may consist of a number of independent projects, thus comprising a program, construction of any megaproject facility or structure is a discrete project. A project is defined (Project Management Institute 2000) as

> a temporary endeavor undertaken to create a unique product or service. Temporary means that every project has a definite beginning and a definite end. Unique means that the product or service is different in some way from all other products or services.

A construction megaproject does not produce unique products or services. Rather, construction megaprojects are temporary endeavors formed to create a specific structure or facility, the purpose of which is defined by the ultimate owner of the structure or facility. Because construction megaprojects must take into account such issues as geographical location, natural conditions and events, physical constraints and limitations, physics and material applications, political ramifications, cultural perspectives, and multinational stakeholders, they may be considered some of the more complex projects undertaken by human beings. Information is filtered naturally as it travels up the structure of an organization involved in a construction megaproject for three primary reasons:

- The information is too technical to be of value to those levels of the corporation. It is not necessary to understand the details of the structural steel design to manage the business of the EPC contractor.
- The megaproject management structure has evolved in an environment in which the individual megaproject management team acts autonomously and where the megaproject management has almost total control over all aspects of the megaproject. One example of exercising control over a megaproject involves exercising the level of the control of information flow relative to that megaproject. A subordinate megaproject management team may simply decide that it is not necessary to report a problem because they believe that they can correct the problem before it becomes a critical organization issue and choose not to pass the information upward.

- The fact that every construction megaproject involves several stakeholders has led to a natural tendency to generate abstract information, to summarize it into a single reporting structure that is not conducive to recognizing or reporting critical problems or issues.

The process is fairly standard; take, for example, the typical information flow within an EPC contractor executing a power generation megaproject:

1. The subcontractors and suppliers submit summarized progress reports to the project management team.
2. The project management team abstracts those reports, summarizing the information from those already summarized sources and adding summaries of its own information to a general monthly progress report, which is distributed both internally within the EPC company and externally to the owner of the megaproject.
3. The internally circulated reports from several different component projects, including the condition of the overall megaproject, are abstracted and summarized into a status report, which is then passed on to senior management.
4. Finally, senior management abstracts what it believes to be relevant from each project summary, including the megaproject summary, and prepares what is, in effect, a summary of the summaries for the board directors.

At each stage, information is filtered, abstracted, and summarized. It is not unusual in large EPC firms with numerous construction projects, which may include one or more megaprojects under execution, to hear senior managers demand that all project summary progress reports—including megaproject summary reports—be limited to a single page of financial data and a single page of "critical issues."

As might be expected, it would be extremely difficult for any senior manager, director, or government overseer to demonstrate that they had taken reasonable action to inform themselves about the issues in any particular construction megaproject if they relied on a two-page summary submitted monthly on a project costing more than a billion U.S. dollars. It would be equally difficult to prove that they had made prudent decisions in response to those issues on the basis of two pages of information that had been through at least three filtering points before being delivered. As noted earlier, an assertion of ignorance is not an acceptable excuse for failing to meet the duties owed to the organization and its stakeholders.

Opening the Information Flow without Flooding the Recipients

Knowledge contains the power to make necessary changes. The construction industry is a mature industry; its basic structure and composition are well known and well understood. It is not the physical act of constructing a megaproject facility or structure that is the issue; rather it is the *business* of construction that is at the heart of the problem faced by senior management, directors, and government overseers.

What is the line between the information needed by senior management to run the business of the corporation constructing a megaproject and the information needed by the megaproject execution team to actually design and construct the facility or structure? Most organizations involved in construction of megaprojects and gigaprojects, including owners, designers, construction contractors, and subcontractors, struggle with that question.

Simplistically, it seems that those who design and construct the facilities and structures should focus their attention on the technical job of executing the megaproject, while those who manage and control the organization should focus their attention on the job of running the business. However, it is not that simple. Construction megaprojects are conducted under contracts among various parties, and the terms and conditions of those contracts cover both the technical components of the megaproject and the business components of the megaproject. One simply cannot draw a line through a contract document set and say that the project execution team manages the technical scope of work while the senior management, directors, or government overseers manage the business scope of the work. Those two scopes are, in fact, totally and completely intertwined and interdependent. Failure in a technical sense automatically leads to failure of the business conditions.

> What does a senior manager, director, or overseer need to know about every construction megaproject to take reasonable actions and make prudent decisions?

That question rests at the heart of a significant problem that has plagued construction organizations for a long time. The proof of that statement is simple to defend: One need only look at the fact that few construction megaprojects in the world are executed to completion without disputes arising among the parties to that megaproject. As a megaproject nears completion, issues that may have existed since the earliest days of the megaproject are too often brought to the fore as the parties make an attempt to reach the expectations set for the megaproject by each of those parties before the project was even formally awarded.

Is it reasonable for a senior manager, director, or government overseer to first hear of a problem with a particular megaproject in the last quarter of the megaproject when the issue was first evident by the end of the first quarter of the megaproject? Is it prudent for a senior manager or board director to be forced into a single available alternative—arbitration or litigation—simply because all other possible alternative decisions were lost over time during the execution of the megaproject?

What should the senior management, directors, or government overseers have known, and when should they have reasonably known it? What actions should they have taken to ensure that they were provided the information necessary from which to formulate possible responses, weigh the risks to rewards of those choices, and finally make a prudent decision?

Demonstrating that one took reasonable action and made prudent decisions begins with establishing and controlling the flow of information within the organization in a manner that leads to the defensibility of a decision. In a construction organization, it is a given that megaproject execution teams hate to "waste time" preparing reports that do not contribute to the actual design or physical execution of the structure or facility. However, the information that those reports *should* carry is literally the life's blood of senior management, directors, or government overseers attempting to manage and control the organization's business.

Where does improving the current situation start? How does a senior manager, director, or government overseer obtain the information needed to act reasonably and make prudent decisions without being inundated with technical information that has no bearing on the business of controlling and managing the business? It starts with a question:

> What do I need to know to fulfill my responsibility for taking reasonable actions and making prudent decisions relative to the business of my organization?

The knee-jerk reaction would be to develop a standardized report that forces megaproject execution teams to report literally everything that happens on the megaproject every day. Naturally such a reporting requirement would be extremely expensive and would divert attention from the actual tasks of designing and constructing the structure or facility. Such a course of action is not reasonable, nor would the decision to take that course of action be thought of as prudent.

A different response would be to examine critical reporting from two perspectives:

1. The basis of reporting upward should be founded in the risk profile of the megaproject.
2. The process of reporting should begin with an examination of the gaps that exist in the corporation's current reporting processes and practices.

Relationship between Governance at the Program and Project Management Levels

The earlier sections of this chapter addressed governance at the senior management level. Senior management governance of the megaproject includes ensuring that the necessary policies, procedures, and processes are in place to provide the necessary governance at the program and project level. As noted earlier, megaprojects typically consist of multiple projects and thus are referred to as a "program." The governance at the program and individual project level within the program is focused on how the necessary policies, procedures, and processes are implemented to enable the data development and flow of information as previously discussed for decision making at a program and project level. This section of this chapter looks at the governance at the program and project levels and their interrelationships.

Four objectives are common to every capital construction program:

1. **Scope**—completing the full scope of work necessary to meet the intended purpose of the facilities that, in total, make up the program;
2. **Cost**—completing the entire program within the budget established for that program;

3. **Schedule**—completing the entire program within the time set for execution of that program; and
4. **Quality**—completing the program that meets the functional standards established for the program.

The individual projects that make up the program must meet or exceed those same objectives for the program to successfully attain those four objectives. Every project that does not meet any or all of its four objectives may directly affect the program's successful achievement of those same four objectives at the program level. In fact, the relationship between the program-level objectives and project-level objectives is reciprocal. Every decision made or action taken at the program level has the possibility of affecting the achievement of goals and objectives set at the individual project level. Likewise, every decision made or action taken on an individual project level has the possibility of affecting the achievement of goals and objectives set at the total program level.

Regardless of this reciprocal objective relationship, when any of those four objectives are not met, either at the program or project level, that lapse may be attributed to program management's perceived (or actual) inability to manage and control the execution of the individual projects. Even though program management may have delegated the authority to manage and control a specific program task or the entire execution of a specific project to a staff position, and even though program management may hold a staff position responsible and accountable for achieving the program or project objectives, the owner and investors in the program may hold program management directly responsible for the inability to achieve program or project objectives.

There are any number of management concerns and issues that need to be addressed by program management relative to the planning and execution of a program consisting of multiple discrete projects. In addition to developing and disseminating those policies, procedures, and processes necessary to govern the execution of the program and its constituent projects, there are three primary functions that program management must fulfill to improve the chances of successfully meeting the program objectives:

Establishing a reasonable span of control within the program and projects;

Testing the implementation of policies, procedures, and processes at the project level; and

Instituting a continuous improvement loop that strengthens the program as lessons are learned on every project executed.

Those three elements are discussed briefly below to establish the context of the relationship between program and project management and control. That relationship is, in part, a critical element of any program, but especially of a megaproject, where the expectations at both the program level and the project level are directly tied to the ultimate success of the program.

Span of Control within the Program and Projects

Because program management is ultimately held responsible by senior management and the stakeholders for the inability to achieve program or project objectives, the issue becomes what the industry refers to as program and project management's actual span of control over the program and the individual projects. As defined by Tim Hindle (2009),

> A manager's span of control is the number of employees that he or she can effectively be in control of at any one time.

Before the growth in the number, size, and complexity of construction megaproject, management theory held that (Kerzner 1998)

> an effective span of control is five to seven people [or functional positions].

That traditional limit on span of control results in a vertical organizational structure composed of multiple layers of management, within which each manager manages and controls a specifically limited number of responsibilities and staff positions. According to Tim Hindle (2009),

> Over the years ... there have been so many differing views about the optimum span of control that the unavoidable conclusion is that it is a matter of horses for courses. The ideal span is partly determined by the nature of the work involved.

A vertical organization relies on multilayered tiers of management with each descending layer of management having authority, control, and responsibility limited to less and less of the total program or project management responsibility required to successfully achieve program objectives. At each layer down through the vertical organization, management's function and control sphere is confined to an ever-shrinking set of authorities and responsibilities.

The traditional theories relative to span of control and a vertical, multitiered management structure simply do not work effectively or efficiently in a megaproject setting. In a megaproject context, each added layer of (vertical) management significantly adds to the cost and complexity of managing and executing the megaproject, which by its definition is larger and more complex than any traditional construction project. For example, one of the most critical elements in every megaproject consisting of multiple projects is the effective, efficient, and timely collection and dissemination of program and project status information. There are several impediments to effective, efficient, and timely communication of critical program and project information in a vertical management structure, among them the following:

- Information is filtered as it travels through the management layers, as discussed earlier in this chapter. At each management level, the information being communicated is filtered by that management layer to align with that management layer's interpretation of the information. With each interpretation, the information becomes more and more diluted, to the point where the urgency and import of the original communications may be lost.

- Vertical management structures inevitably delay the movement of communications up through the organization, with a similar delay imposed as the response to those communications pass back down through the organization. The delay is based partly on the process because each management level imposes its own communications processes to move communications through the organization, and part of the delay comes from the fact that at each management level, management must formulate and implement a response to the communication (i.e., pass the communication upward or sideways through the management structure or develop a proposed response to the communication before moving the communication forward for final action).

Time is the enemy of every construction project, but losing time in a megaproject can have a devastating effect on the ability of the program or project management to identify and take actions that may enable the project to avoid or mitigate failure to attain project objectives. The reliance on the traditional, vertical management structure in construction megaprojects and gigaprojects began to change in the early 1960s as the industry began to adopt horizontal management structures, which were more efficient and cost effective than traditional vertical organizational structures. However, the adoption of a horizontal management structure was not immediately or completely successful (Kerzner 1998):

> The span of control has expanded [and] the results have ranged from mass confusion in some companies to complete success in others.

One of the reasons for the "mass confusion" that was evident in the early years of the switch to a horizontal organization was that (Kerzner 1998):

> Flatter organizations mandate better communications, more cooperation, and an atmosphere of trust. In other words, mature project management organizations advocate flatter structures mainly because of the presence of multidirectional, cooperative work flow.

Successfully achieving that cooperative workflow requires that program and project management is given (Kerzner 1998)

> authority and power ... in written form; formal project management policies and procedures ... and [the] documentation [that] is necessary even for simple tasks.

The successful adoption of the horizontal organizational structure became more widely achievable with (Hindle 2009)

> the coming of the virtual organization.... In a virtual organization people work as independent self-contained units, either individually or in small teams. They have access to (electronic) information that lays down the boundaries within which they can be autonomous. But at the same time they

are allowed to be completely free within those boundaries. In such an environment, the ideal span of control can be very large. Indeed, it can scarcely be called a span of control any longer; it is more a span of loose links and alliances.

Virtual management is organized in a horizontal structure within which there are far fewer management levels, but each level has management and control responsibility and authority over a wider set of functions. The horizontal organization essentially depends on fewer people controlling and managing the same amount of work required of any megaproject. There are two keys to a successful horizontal structure in a megaproject, as summarized from the sources quoted above:

- Access to electronic information in order to install and maintain the effective, efficient, and timely communication of critical program and project information; and
- The establishment of boundaries within which each manager acts autonomously to execute their delegated authorities.

Electronic information is not confined to such tasks as scheduling or cost control systems, but as discussed in Chapter 8, requires careful development and implementation of a document control system that provides a program or project manager with the sophisticated tools necessary to fulfill a number of retention and communication functions that in the past would have required much more management attention and higher levels of support staff.

Boundaries in a megaproject are established in the development, distribution, and enforcement of policies, procedures, and processes and the formal delegation of authority by program management. Enabling a manager to act autonomously does not mean program management cedes total control and authority over any element of the megaproject or its various management elements, including total control or authority over any individual project within that megaproject. Program management may ultimately be held responsible for the success or the inability to meet goals or objectives of the program and each of its constituent projects. For that reason, program management must clearly and formally (in writing) define both the *expectations* for the program and each individual project and the *boundaries* within which those program and project managers have the authority and responsibility to make decisions and take actions in executing their specifically assigned functions, including the execution of the individual project levels.

Testing and Implementing Policies, Procedures, and Processes

Autonomy in a megaproject setting works in the following situations:

1. Program management must clearly define and formally delegate authority to the project management to make decisions and take actions during their execution of a project, which includes formally setting the limits on those delegated authorities. Program management cannot simply tell a project manager that he or

she is solely responsible for the successful execution of a particular project; program management must specifically list those decisions and actions delegated to the project manager within which the project manager may act with autonomy.

2. The formal delegation of authority must clearly cite any limitations to the autonomy for making decisions and taking actions. Those limitations should be based on program management's need to protect the entire program from any effects at the project level that could have a reciprocal effect on the entire program. If program management does not formally delegate to the project manager authority to act and/or does not establish the limitations within which the project manager has the authority to act with autonomy on a given project, then program management cannot expect the project manager to be accountable for any decision made or action taken on a project that ultimately affects the program as a whole.

Project managers acting autonomously without limitations on their autonomy naturally base their decisions and actions on the needs of their project(s) without regard for the broader needs of the program; and that is how it should be. Conversely, program managers must put the needs of the program above the needs of any one project; and that also is how it should be. To achieve both project and program objectives, those two layers of management must have a clear understanding of how they need to work in concert to achieve both project and program goals. In short, both levels of management must understand and accept the delegation of authority and the boundaries set on those delegated authorities.

Industry practice agrees on the importance of investing a significant amount of time to establishing the foundation upon which a megaproject and the individual projects will be managed and controlled before initiating any execution of the individual projects. The period during which the foundation of the megaproject is laid is referred to as program "ramp-up," which includes planning, staffing, and setting the policies, procedures, and practices within which the program and its projects will be managed and controlled.

The depth and length of the ramp-up phase of a megaproject is determined by the intricacy and complexity of the management and control functions required by the megaproject. Within the industry, the generally accepted sequence of management actions during program ramp-up for a megaproject is as follows:

- Set the program objectives from all perspectives and with a maximum of stakeholder input.
- Perform a formal risk review to identify and quantify the risk elements that have the potential to affect the successful attainment of the program objectives.
- Identify and establish the functional management roles and responsibilities necessary to fulfill management and operational control tasks and successfully overcome risks and impediments to the successful execution of those functional requirements.
- Prepare preliminary program management and execution plans.
- Establish formal policies, procedures, and processes under which the program and project management will function to successfully meet the program obligations

and objectives. This step includes setting and formalizing delegations of authority and boundaries on autonomy for each functional management position at both the program and project management levels.
- Recruit and hire staff that has the background and qualifications necessary to fill the functional positions at both the program and project management levels, given the objectives of the program and the risk profile of the program. Staff will work under the delegations of authority and boundaries on autonomy set for the functional program and project management positions.

To be effective, the policies, procedures, and processes that are established at the program level must be *uniform* and *transparent* and must reflect a *single point of accountability*. Part of the reason for building uniformity into every policy, procedure, and process is to give the project manager a clear path though the various policies, procedures, and processes that, taken as a whole, establish the boundaries of the project manager's autonomy relative to management and control of their specific project(s). Uniformity also reflects the boundary within which each project manager is free to exercise autonomy in their decisions and actions in managing and controlling the project(s) for which they are accountable and responsible.

Part of the reason for building transparency into each policy, procedure, or process is to establish

- How and why those policies, procedures, and processes were developed;
- How and when they are to be applied; and
- How the functional manager is to execute his or her functional assignments within the boundaries set by those formal policies, procedures, and processes.

Transparency also enables program management to review and evaluate the execution of all projects against a standard set of governance documents, which enables program management not only to maintain ultimate control over the projects but also to adjust those policies, procedures, and processes if and when necessary to increase the effectiveness and efficiency of the program and the project management and control.

Part of the reason for building a single point of accountability is that it provides direction for decision making and for implementation of the actions taken in response to that information. Accountability identifies those elements of a project for which project management will be held responsible as delineated within the authorities and boundaries established at the program level. Given the current level of autonomy granted to each project manager under a horizontal organizational structure, it can be difficult for program management to demonstrate accountability if there are no formal, clear authorities delegated and boundaries set within the policies, procedures, and processes that have been implemented. Remembering that policies, procedures, and processes are in place to establish the boundaries on the autonomy exercised by a project manager, program management must judge a project or functional manager against those delegated authorities and boundaries established within the governance documents and not simply based on a personal opinion as to whether or not the program manager believes the project manager has done a good job or poor job during the execution of a project.

Ultimately, unless expectations relative to performance are set and the project manager is formally delegated authority (with boundaries) within which that performance is to be accomplished, it is difficult to hold a functional or project manager accountable for the results actually achieved. Just as important to program management is the ability to judge whether or not the authorities delegated and boundaries established within the policies, procedures, and processes are working as intended or need to be modified to be effective in enabling project management to meet both the project and the program objectives.

In the case of program-level functional management positions, program management has direct supervisory control over the decisions made and actions taken by the staff assigned specific program management and control tasks. As a result, program management should have intimate and almost immediate knowledge of any violation of, or weakness in, those policies, procedures, or processes.

At the project level, however, the project manager has much more autonomy because most of the decisions made and actions taken on a project are allocated (formally or by default) to the project manager. However, that autonomy is not (or should not be) limitless, and program management cannot simply grant autonomy to the project manager without evaluating the results of the level of autonomy granted to a project manager.

Effective and efficient management of a megaproject requires that there be some level of autonomy. However, it is up to program management to ensure that the level of autonomy is reasonable and that the project management staff is operating within the level of autonomy granted by program management. The author suggests that the best way for program management to ensure that the boundaries established on that autonomy are reasonable (via the governance documents established) and are being followed at the project level is to audit performance on each project at certain critical points during the planning and execution of that project.

Typical audit programs are focused on determining if the actual practices being implemented and followed at the project management level conform to the formal policies, procedures, and processes established at the program management level. Project management audits are generally conducted at crucial points during project execution. For example,

- An audit of the completed project plan to ensure that the project scope, cost, schedule, and quality were developed following the applicable policies, procedures, and processes and met the objectives of the program overall.
- An audit of the project procurement plan and actions to ensure that they meet the conditions set within the policies, procedures, and processes set by program management; meet the objectives set for the project; and meet the program objectives overall.
- At least two audits, depending upon the size and scope of the project, of the project execution (based upon the approved project plan):

  - One conducted at the completion of design; and
  - One conducted at approximately one third of the way through the planned construction phase.
- Finally, an audit of the project at final completion, whether or not the project met its objectives, to ascertain the effect of the project final results on the program plan (positive or negative) and to identify specific lessons learned, which should be integrated into the program and disseminated to every project (though a formal process).

Such audits can be conducted in a reasonably short time span following specific templates developed for each of the various elements of the project to be audited and using the documents resident in the project's formal document control files. That document review need not be done at the project site, thereby minimizing the amount of disruption to the execution of the project. Once the document review is complete, a one-day site visit to the project is generally all that is necessary to address any questions or concerns program management may have relative to the document review findings. After the audit is complete, the project manager should receive a written report of results, which should be based on the template used on each audit, identifying any gaps in the management of the project and containing specific actions to be taken by the project manager to overcome any deficiencies.

The Performance Improvement Loop

Program and project management walks a fine line between science and art. There are hundreds (if not thousands) of books and articles that advocate the use of prescriptive methods for making every decision or taking any action during the execution of a capital construction project. For those authors, project and program management is more science than art. There are fewer authors who have addressed project and program management as more an art than a science. The reality is somewhere in the middle and involves both science and art. According to PMI (2008b),

> Project Management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements.

Knowledge and skills are based on personal experience, which involves less scientific rigor than it does personal (artistic) application of a learned pattern of successful behavior. Tools and techniques involve a higher degree of scientific rigor in that a formal, organized methodology is used to develop and test a tool or technique and then apply that tool or technique in a regimented progression.

The science of project or program management is generally *adoptive* in that program management adopts a specific tool or technique to address a specific program or project need. A computerized critical path method (CPM) schedule is a tool and technique adopted by a program to meet the need to deconstruct a project or program into manageable activities (a work breakdown structure) that can be placed in sequence to achieve the schedule objectives at both the program and project levels.

A formal document control system is a tool to meet the collection, retention, and communication demands within a megaproject and its constituent projects.

The art of project or program management is generally *adaptive* in that the individual program or project manager uses knowledge and skills gained primarily through direct experience to modify a policy, procedure, process, or practice to address a specific effect to the program or project or to improve the chances of meeting or exceeding the objectives set for the program or project.

Both science and art are required to execute a successful project or program. It is important to recognize and focus on the need for program and project management to be able to identify potential effects or opportunities by *adopting* the tools and techniques that can be used to identify and manage those potential effects or opportunities. But tools and techniques do not make decisions or take actions that are focused on overcoming potential effects or taking advantage of opportunities. In addition to adopting the right tools and techniques for the program, management must continuously *adapt* its policies, procedures, processes, and practices based on actual contemporaneous experience, thereby altering the basis of decisions and actions in response to those potential effects or opportunities.

Adopting and adapting are both key elements in what is sometimes referred to as a performance improvement loop. In the simplest terms, managers learn by experiencing successes and inabilities to meet planned goals and objectives as they execute programs and projects and then by sharing those successes and inabilities to meet planned goals and objectives continuously in a repeating, sustained loop focused on improvements in the execution of the program and the projects.

A continuous improvement loop is dependent on developing, installing, and using a formal, updated "lessons-learned" program. PMI (2008b) describes lessons learned as a "process asset," which contributes to or influences a project's—or program's—ultimate success (e.g., the achievement of program and project objectives). Lessons-learned systems involve the formal transfer of knowledge learned during one project (or one phase of a project) to subsequent projects (or phases of a project).

Lessons-learned systems depend on capture, consolidation, and communication of actions by program and project managers:

1. The manager must capture the lessons learned during the execution of the program or project. Capture requires both thought and action—thinking through events and issues that arose during the execution of a project or portion of the program and capturing those lessons formally to share them across the projects and the program. This step is more difficult than one would think because it requires the identification of the situation, the response action taken, the subsequent result of the decisions and actions, and the presentation of the lesson learned (positive or negative) as a consequence of the decision or action. Too often, program and project managers are too busy managing the project or program to devote time to lessons learned and put that task off to the end of the project or program (or never undertake the effort involved), at which point the issue, the action, and the result are no longer fresh in the manager's mind.

2. Management must *consolidate* the lessons learned across the program and projects into a formal repository in an organized fashion, which enables other managers to easily identify and access those lessons. It is when a similar situation arises on another project or in some other portion of the program that a program or project manager is most likely to search the lessons-learned repository in an effort to identify those responses to similar issues that worked and those responses that did not work. To do that, the lessons learned must be consolidated into a central repository with open access to the entire program and project management structure.
3. Management at all levels must proactively *communicate* the existence of and contents of the lessons-learned repository. This communication does not mean that program management simply sends out a notice that there is a database of lessons learned available in an electronic file folder. It involves the development of a specific process of informing project and program managers of the content of a lessons-learned repository and categorizing the lessons learned into situations and applications, thereby making it easier for the user to quickly identify and locate those lessons learned that might be applied (or avoided) in that manager's specific situation.

Capturing, consolidating, and communicating lessons learned is a process that must cross the boundary between program management and project management. At both management levels, lessons are learned; at both levels, those lessons must be captured; but it is at the program level that the lessons-learned system must be managed and the central repository of the lessons must be housed.

It is especially critical to capture, consolidate, and communicate lessons that are learned involving formal policies, procedures, and processes so that those governance documents can be modified to meet the actual conditions that exist across the projects. Simply setting a set of policies, procedures, and processes in place without constantly checking to determine how those policies, procedures, or processes may be helping or hindering the execution of the program or project exacerbates the difficulty that already exists in bringing a megaproject or its constituent projects to a successful conclusion. The art of program and project management is reflected in the ability of those program and project managers to adapt to actual conditions encountered during the execution of the program as a whole, or the individual projects that make up the program.

Summary

The construction industry is a unique mixture of the theoretical, the artistic, the physical, and the ultimate function of the facility or structure. Organizations exist to fill a need for a specific cost and at a specific profit (or benefit) for all of those concerned. However, the unique breadth of stakeholders it takes to bring a construction megaproject from idea, to concept, to design, to construction, to completion makes it an industry within which the senior management, directors, and government overseer need to fully understand what is necessary from a governance standpoint to ensure uniformity, transparency, and accountability in meeting stakeholder expectations.

The four objectives common to every capital construction program (scope, cost, schedule, and quality) can be successfully managed by establishing a reasonable span of control, testing the implementation of policies, procedures, and processes at the project level, and instituting a continuous improvement loop using lessons learned. To do so requires the system processes and management structure to obtain information and to have that information delivered throughout the megaproject in a manner that ensures reasonable and prudent decision making. Methods, such as adopting a horizontal management structure, must be used to improve that information flow, or those charged with managing and controlling the business of construction will find it difficult to demonstrate that they acted reasonably or made prudent decisions during the execution of the world's megaprojects and gigaprojects. By capturing, consolidating, and communicating lessons learned on a project and program level, the appropriate changes can be made to the governance documents to reflect the actual conditions on the project level. The use of audit programs, specifically during crucial points in a project's execution, can further identify weaknesses in the execution of a project, all of which in turn assist in meeting the stakeholders' common goals of time, quality, and cost.

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CHAPTER 2

Risk Management

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Ask anyone involved in megaprojects from any perspective to name the most challenging element in executing a megaproject and they will usually say, "the enormous risks involved." And there is no doubt that megaprojects inherently contain a level of risk that can be both daunting and, seemingly, difficult to overcome. Take any risk element of any large construction project, then adjust each element to take into account such things as the extended duration of the megaproject; the global nature of procurement for a megaproject; political changes during this period; the complexity of managing multiple contractors with thousands of trade laborers; and the expanded stakeholder base, each with a different perspective of, and definition of, "success," and it quickly becomes apparent why a heightened attention to risk management is a key priority and prime focus for most megaproject and gigaproject investors, owners, contractors, suppliers, and geopolitical entities. Some have expressed the thought that risk management is now, or should be, a higher level activity than traditional program management.

This chapter examines risk from two perspectives. The first, written by Kris R. Nielsen and Jack Dignum, deals with risk from a macro level, focusing on the broader view of megaproject risk from the perspective of stakeholders who are not directly involved in the execution of the megaproject, including governments, boards of directors, and senior corporate executives. The second, written by John J. Reilly, deals with risk from the perspective of those who must identify, manage, and control risk during the planning and execution of the megaprojects.

These two perspectives demonstrate the fact that, even in discussing the risk inherent in a megaproject, where you sit in relation to the megaproject often determines how you view and respond to the risk that was accepted once the megaproject was approved for execution.

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The Importance of Risk Management

Kris R. Nielsen and Jack L. Dignum

LESSONS LEARNED

1. Risk management is no longer simply a corporate operational issue. The management of risk during a megaproject is now considered a corporate governance issue.
2. There is no "one-size-fits-all" risk management system or program that fits all organizations or every project.
3. The definition of what constitutes a risk continues to evolve and expand.
4. The definition of a project stakeholder continues to evolve and expand.
5. Project risk involves risk elements both internal and external to the organization and megaproject.
6. It is critical to pull as many potential stakeholders into the risk identification process as possible; even if those stakeholders have no direct financial stake in the ultimate outcome of the megaproject, they can significantly influence outcomes.
7. A reasonable, sound, and prudent risk profile does not always result in the optimum tool for managing risk during execution of the megaproject.
8. Effective risk management requires that the total risk profile be broken into manageable subcategory risk profiles, each with a "risk owner" who is responsible for that subcategory.
9. Risk modeling of the subcategory risk profiles provides the overall risk manager and risk owners with a set of related risk elements, which can be effectively monitored and managed.
10. Risk management across these subcategory risk profiles is essential.
11. Risk is inherent in a megaproject; ultimately, because any risk may affect every stakeholder, it must be managed by a process that involves all stakeholders working together.

Elevation of Risk Management to the Boardroom

The management of risk has been elevated from being primarily an operations-level concern to a matter of corporate governance because it is defined by a multitude of regulatory bodies across the globe. That elevation means that a corporate board of directors, whether for the owner or the contractor, is now responsible for ensuring that the risks inherent in the individual construction megaprojects or gigaprojects undertaken by the owner or the contractor are properly identified, managed, and controlled.

Before the last five to seven years, those risk elements that accompanied a megaproject were seen as a project management and control issue, and only peripherally an issue of concern to a governing corporate board of directors. The old routine was to report to a board of directors quarterly on the financial risks, if any, that had affected, or might affect, a megaproject. Simply, risk management was an operational issue and as such was beyond the purview of the board of directors of an owner or contractor firm. However, new governance laws and regulations have changed risk assessment from a passive board function to make boards of directors liable for decisions by an owner or a contractor in assuming risk that is beyond the capability of the owner or the contractor to manage and control. Boards may also be held liable for failing to ensure that the corporate operations are adequately managing and controlling any risk they have assumed through a decision to execute a megaproject.

Once risk management was elevated to the boardroom, management of risk during the planning and execution of any construction project (and most especially megaprojects) became more than just another function that a project management team was expected to address. For that reason, it is worth taking a few minutes to address the governance context within which risk management on megaprojects must function in today's political and regulatory environments.

Profits, for many ventures, and in particular megaprojects, live on the edge of risk. As noted by the London Stock Exchange and RSM Robson Rhodes LLP (2004),

> Profits are the reward for successful risk-taking in a modern competitive economy. Companies that are overly cautious will miss opportunities and are unlikely to succeed in the longer run. Even more certain failure awaits those who take risks recklessly. The board's challenge, therefore, is to ensure risk is managed effectively in the business, not to eliminate it altogether. The board has to be proactive in its oversight role and to recognize that the risks confronting a business are constantly changing.

In short, for megaprojects, an organization must often dance on the edge of risking more than the organization can afford to lose if it is to realize a margin higher than the organization needs simply to survive, or in many cases, just successfully deliver the project. The Malaysian Code on Corporate Governance agrees that "business decisions require the incurrence of risk" (Malaysian Securities Commission 2000) but also tempers that understanding by noting that "the target is to achieve a proper balance between risks incurred and potential returns to shareholders."

At a fundamental level, organizations exist to take risks and turn them into rewards. And thus the dilemma faced by organizations around the world: Meeting or exceeding goals means that the organization must willingly take risks; and every risk carries with it a potential for reward and a concomitant potential for loss.

Since the mid-1990s, immense attention has been focused on improving the governance of both public and private organizations, a level of attention that has not been limited to the United States but has become a global issue. A quick search of the Internet identifies "governance" issues being examined in every part of the globe. More often than not in recent years, the concept of "risk management" has been included as a major component of good governance. Originally, risk management as a topical issue was focused on aspects of an organization's financial risk and reporting, for example, does the organization manage and accurately report on the financial risks faced by the organization during its operations? Risk evaluations were generally limited to issues such as the cost of materials and equipment, capital costs, and economic conditions. More recently, risk management has started to evolve beyond the purely financial to encompass the more esoteric and harder-to-define elements of corporate risk, as noted by the Australian Securities Exchange (ASX Corporate Governance Council 2006):

> There [have] been a number of recent developments in the understanding of risk particularly post-Basel II.... "Risk" is not just financial risk. It includes operational, compliance and strategic external risks. It also clearly recognized that these other risks can have a significant impact on the financial position and reputation of a company and investor sentiment in relation to the company.

Australia and the United States are not the only countries that have experienced a redefinition of risk insofar as it pertains to good governance practices. In Russia, for example (FERMA 2003),

> Risk identification sets out to identify an organisation's exposure to uncertainty. This requires an intimate knowledge of the organisation, the market in which it operates, the legal, social, political and cultural environment in which it exists, as well as the development of a sound understanding of its strategic and operational objectives, including factors critical to its success and the threats and opportunities related to the achievement of these objectives.

The logical question for an organization's governing board and senior management is: If risk as an element of good governance is evolving to include risk factors beyond simple financial risk, from whence do those risks flow? The short answer is everywhere. There is no single source globally that provides a "standard risk register," and every country appears to have defined nonfinancial risk slightly differently. However, those international sources generally agree that nonfinancial risk flows from any source that has the potential to affect an organization's attainment of strategic goals and objectives. A review of international best practices reveals that nonfinancial risks can be grouped into two general risk factors, each composed of four elements, as follows:

Internal Project Risk Factors:
- Delivery/operational risks,
- Technological risks,
- Financial risks, and
- Procurement/contractual risks.

External Project Risk Factors:
- Political risks,
- Environmental risks,

- Social/cultural risks, and
- Economic risks.

These risk factors are discussed in greater detail throughout this chapter; however, at a basic level, risk elements that arise during the life cycle of a megaproject from any one or all of those sources can affect an organization's ability to reach its strategic goals and objectives, which in turn can affect an organization's financial condition. The ASX refers to such nonfinancial risks as sustainability/corporate responsibility risks (ASX Corporate Governance Council 2006).

The next logical question is who within the organization is responsible for ensuring that the organization's risk management program has correctly identified, quantified, and managed risk, including nonfinancial risk? The answer is predictable (British Standards 2007):

> Risk is a Board matter: the Board (or equivalent) view themselves as ultimately accountable for risk management.

ASX also made it clear who bears the responsibility for risk management within an organization (ASX Corporate Governance Council 2006):

> The company board has ultimate responsibility for risk oversight and for determining the company's risk profile. As part of its oversight, each board will need to determine what risks are "material" for a company of its type and size and how they should be taken into account in the process of sign-off.

In summary, the definition of what constitutes a risk to an organization has evolved and continues to evolve internationally. As that evolution progresses, boards of directors and senior management find their roles and responsibilities relative to the identification, quantification, and management of risk growing faster than the staff and programs available within the organization can evolve to support that role and those responsibilities. Consequently, boards of directors and senior management find themselves in a position of having to act quickly to build the internal capability to enable the total risk environment that may threaten the attainment of the organization's goals and objectives to be identified, quantified, and managed. However, in that drive to install that capability, boards of directors and senior management need to heed a warning issued by British Standards (2007):

> There can be no "one size fits all" approach to the application of risk management. Risk management should be tailored to suit the organization's unique circumstances and reflect as a minimum the organization's structure, its legal and regulatory context, the decision making process, reporting requirements, insurers' and funders' requirements, shareholder expectations, and the markets within which the organization operates.

Because of this expansion of the definition of risk and the elevation of risk to a corporate governance level, owners and contractors undertaking a megaproject must treat risk management with a much higher degree of attention than might be acceptable in a more moderate, standard construction project. Indeed, if an owner's board of directors finds itself liable for ensuring that the megaproject risk profile is adequate, accurate, and defensible, then one should expect risk management to become an issue of intense focus from the moment that the idea of executing such a megaproject first surfaces within the organization until the megaproject goes into full service. Because of that effect, any organization intent on executing a megaproject, whether as an owner, engineer, construction contractor, or supplier, must alter its perception of risk from the relatively simple execution risks that are normal to every construction project to encompass a vastly expanded definition of what constitutes an element of risk, and, as a result, what constitutes a sound risk management process. What follows is an examination of risk and risk management in megaprojects.

Risk Management in General

By now it would be difficult to find any major organization in the world that has not heard of, has not been trained on, or has not installed some type of risk management program. In fact, the mantra of risk management has become accepted and ingrained across international borders, reaching into countries that have little experience with any aspect of private organization governance practices. For example, in adopting guidelines to govern the formation and operation of two "pilot banks" in China, risk management through governance was a significant enough concern to lead to the promulgation of 26 articles intended to direct the operations of those banks. One of the 26 articles (China Banking Regulatory Commission 2006) was devoted to risk management:

> Each pilot bank shall adopt a system of risk management, which covers the credit risk, market risk and operational risk, and is effective in identifying, measuring, monitoring and controlling risks.

Globally, any document dealing with risk management in any form has at its core that same definition of a risk management program:

- Identification,
- Quantification,
- Treating (risk response plans), and
- Monitoring and controlling.

There is a fifth element of risk management in the context of governance: reporting.

In practically every book or article on risk management published in the past decade, those four (or five) elements are presented in that order, and in truth, every effective risk management effort undertaken by an organization passes through those elements in the order they are presented. It is axiomatic that the risk evaluation process contains the following steps:

- First, you identify the risk elements, those risk events that could occur;
- Second, you quantify (characterize) each of the risk elements identified in a matrix that establishes both probability of occurrence and level of impact (i.e., time and/or money or other attribute, such as safety) should that risk element occur;
- Third, you take those treatment actions necessary (avoid, mitigate, transfer, or accept) to manage the effect of the risk element on the megaproject;
- Fourth, you monitor the megaproject to anticipate if and when a particular risk element has occurred and apply the planned control actions; and
- Fifth, you report how effectively your organization was at minimizing, mitigating, or controlling risks you have encountered over a defined period of time.

Of course, it is not as simple to successfully undertake and execute each of these steps as it sounds; risk management is in the end an involved and continuously evolving process because each day, every decision made by management eliminates some risk elements while at the same time introducing new risk elements into the megaproject's environment. However, it can generally be said that managing risk involves repeatedly implementing and completing a series of steps taken in a sequential order over the entire life of the megaproject.

Those sequential steps have become so formulaic and ingrained in the global lexicon of risk management that it seems as though there should be a single, accepted risk management program that could be purchased off the shelf and installed in a megaproject, much the same way that various other productivity software systems are purchased by organizations today. Indeed, there are companies that market "risk management programs or systems" that assert that their program is easy to install, simple to use, and practically self-perpetuating. Many of these packaged risk management systems have at their core a computer-generated probability evaluation program that can generate sophisticated models of risk from both risk element probability-of-occurrence and risk effect perspectives. These software systems are extremely powerful and can, if properly used, organize and generate valuable data that will aid an organization in maximizing the effectiveness of their risk management program. However, those software systems do not in and of themselves either manage or control risk during the execution of a megaproject. They are simply powerful computer-driven tools that can improve and enhance the ultimate efficiency and effectiveness of an organization's risk management and control, if properly used. Simply having a sophisticated computerized risk modeling program does not mean that risk on a megaproject has been adequately identified or is actually being managed and controlled.

The Association of Insurance and Risk Managers and The National Forum for Risk Management in the Public Sector (Association of Insurance and Risk Managers and ALARM 2002), jointly concluded that

> Risk management should be a continuous and developing process which runs throughout the organization's strategy and implementation of that

> strategy. It should address methodically all the risks surrounding the organization's activities past, present and in particular, future.
>
> It must be integrated into the culture of the organization with an effective policy and programme led by the most senior management. It must translate the strategy into tactical and operational objectives, assigning responsibility throughout the organization with each manager and employee responsible for the management of risk as part of their job description. It supports accountability, performance measurement and reward, thus promoting operational efficiency at all levels.

There is almost global acceptance of the fact that managing risk is good for an organization and its stakeholders and ignoring risk is bad for an organization and its stakeholders. There is almost global acceptance that risk management is a systematic method by which an organization identifies, quantifies, treats, and reports risk. And there is growing global acceptance of the fact that the definition of risk has grown significantly beyond simple financial risk. However, even with the (almost) global acceptance and unanimity concerning risk management definitions and methodology, experience over many years has led us to complete agreement with the British Standards (2007) that there is no one-size-fits-all risk management program that works across every megaproject globally.

The first dynamic that prevents the concept of a uniform or standard risk management program is that every megaproject is to some extent unique. Megaprojects, even though they may ultimately involve the same end product (e.g., an 800 MW coal-fired power plant), do not have identical goals, objectives, standards, organizational structures, operating systems, staffing profiles, execution, and operating locations. It is the uniqueness of each megaproject that prevents the construction industry from adopting a uniform risk profile that could be applied across every megaproject that is authorized to proceed.

The process of managing risk on a discrete megaproject depends on the development of a risk profile unique to the conditions within which that megaproject is executed. That risk profile first identifies each risk specific to the achievement of the project goals and objectives. Then the profile delineates the probability of the risk occurring during the execution of the project and the effect to the project should the risk occur. Next the risk profile establishes proactive management risk response plans for avoidance and mitigation of the risk element. And finally, the risk profile contains the project management structure by which the risks identified in the profile will be monitored, managed, and controlled during the execution of the megaproject.

There are two elements of a full contextual definition for a megaproject risk profile, each of which is built by asking, and answering, some basic questions:

- Internal elements are questions that refer to the internal operations of the organizations executing the megaproject.
- External elements are questions that refer to the external demands on those organizations.

Internal elements are the ones about which most organizations are most knowledgeable because they involve those elements that are critical to the actual operations and management of the organization. Internal element questions involve such issues as the following:

- What core organizational values must be reflected within the risk management program (e.g., profit, social, economic, and citizenship values)?
- What is the organization's "appetite for risk" (e.g., can the organization accept the high degree of risk that accompanies every megaproject)?
- What is the organization's management philosophy (e.g., centralized control vs. distributed decision making)?
- What is the organization's market focus (e.g., who is the ultimate end-user from the organization's perspective)?
- Where does the organization operate (e.g., locally, nationally, and/or internationally)?
- What data and information must flow from the risk management program to meet each organizational level's need for data and information (e.g., what the board needs to meet its governance responsibilities vs. what the accounting department needs to meet its fiscal responsibilities)?

The responses to the internal element questions assist in establishing the contextual definition within which the risk management program must perform for the organization involved in the execution of a megaproject. Ultimately, a risk management program is only effective if it meets the needs of both the megaproject and the owner (corporation or agency).

Until recently, there was little or no attention paid to developing a contextual definition of risk management that acknowledged or included many external elements. Only within the past three to five years have international governance bodies begun to apply risk management practices to external, nonfinancial risks faced by organizations. For example, there is growing global recognition that an organization cannot limit its definition of a stakeholder to just those with a vested financial interest in the megaproject. Stakeholders now include anybody or anything that may be affected by the execution (or even existence) of a megaproject. Examples of such nonfinancially invested stakeholders include the people who live in the area where the megaproject will be constructed; the environment that might be affected by the execution or existence of the megaproject; and the political bodies that must review and respond to the public concerning the effect (or potential effect) of the megaproject's construction or existence.

In short, the definition of a megaproject stakeholder has changed. The new, evolving definition recognizes that even those with no direct financial stake in the megaproject have a vested interest in where and how that megaproject is constructed and how it will operate. Part of that recognition has arisen in no small part because of the fact that those nonfinancial stakeholders can (and do) have a significant effect on an organization's ability to meet its goals and objectives while at the same time having no direct financial stake in the megaproject's success or failure. Given this evolution of both the definition of who constitutes a stakeholder and the breadth of risks that a risk management program should encompass, an organization must expand its contextual risk management definition to include an external element. As with the internal element, external elements that go into a full contextual definition of external risks are developed by asking questions, such as the following:

- How will the organization respond to environmental effects the megaproject poses to those locations where it operates (e.g., generation of greenhouse gases or generation of solid and water waste during construction)?
- How will the organization respond to macroeconomic effects the megaproject poses to those locations where it operates (e.g., what effect will the execution of the megaproject have on the cost of basic goods and services in the geopolitical location)?
- How will the organization respond to social effects the megaproject poses to those locations where it operates (e.g., overstressing of local infrastructure systems or disruption of basic human services)?
- How will the organization respond to political effects the megaproject poses to those locations where it operates (e.g., creation of political opposition to the organization)?

Creating the external elements of the contextual risk definition is considerably more difficult and complex than identifying and managing the internal risk elements. Nevertheless, the current trend globally is to include the external elements as critical to a definition of "good governance" and thus a measure of how well an organization manages and controls risk during the execution of megaprojects. It is referred to differently depending upon where one looks: It is the operational "environment" in Britain, "sustainability" or "corporate responsibility" in Australia, and "corporate citizenship" in the United States, but essentially the concept (British Standards 2007) is the same:

> The environment comprises the external factors which influence the management of risks for all organizations that are engaged in similar activities and over which an individual organization has no direct control.

For many in the industry, the process of managing risk has almost become routine: Identify, quantify, respond, monitor, and control. However, the definition of what constitutes a risk to an organization continues to evolve, along with the definition of an organization's stakeholders. It is a major mistake to assume that the risk profile of a megaproject is similar to the risk profile of any other construction project. In fact, the risk profile of a megaproject raises the level of importance of corporate governance issues if for no other reason than the amount of money invested (and risked) in undertaking any megaproject. Failing to meet the megaproject's primary cost, schedule, or quality goals can mean the destruction of the corporate owner or any of the other direct stakeholder organizations, including engineering firms, construction firms, and equipment vendors. Attempting to manage risk by using the traditional construction risk management processes and programs may not be sufficient to enable any organization to successfully manage the risks inherent in a megaproject.

Megaproject Risk Management

All megaprojects start as an idea, that is, a concept that will fill a specific need, within a specific time, and at a specific location. Thus, the primary party involvements are those of the owner-operators (public and private), financing sources (public and private), and users. There are essentially no limits or boundaries on concepts; if it can be imagined, someone can turn the concept into a potential megaproject. But there are enormous risks and resources involved in moving a megaproject from concept through feasibility to financing to execution. It is no longer enough to have a good idea upon which to seek funding or financing. In today's global economic structure, the good idea must be backed by analysis and examination of the multitude of risks involved in executing a megaproject and ensuring its useful life. As megaprojects become increasingly complex and as competition for a share of the finite pool of global capital resources to undertake megaprojects increases, stakeholders must make decisions based on which megaproject investments have the best chance of a significant economic and social return, and these decisions must in part be tied to identifying potential risks inherent in each megaproject. As a result, development of a megaproject risk profile begins at the earliest stage of the megaproject life cycle, the conceptual phase.

During the conceptual phase, the owner identifies the need for the megaproject and establishes the initial outer limit parameters of the megaproject in terms of function, location, and preliminary funding and timing targets. Other possible stakeholders during this phase may include regulatory bodies, governmental entities, engineering firms, and financial advisors. The majority of proposed megaprojects may never advance beyond this stage, or they may take generations to advance beyond this stage. The concept of a subsea tunnel to cross the English Channel (the Channel Tunnel, or Chunnel) was not a concept born in the late twentieth century. The first attempt to tunnel under the channel was begun in 1881 by England and France but was aborted because of an external risk element identified by the British: "fear that it could serve the French as an invasion route" (Lienhard 1997–1998).

From the concept, the megaproject moves into the feasibility phase, during which the owner establishes the fundamental design and construction attributes of the megaproject and prepares an order-of-magnitude cost estimate and schedule for completion of the megaproject based on those fundamental design and construction attributes. Other possible stakeholders during this phase may include regulatory bodies, governmental entities, engineering firms, financial advisors, and contractor firms. The feasibility phase involves more than simply looking at whether or not the project is technologically possible; risk managers also have to determine if the megaproject is also financially, politically, and socially feasible. For example, building a nuclear power plant is technologically feasible within the United States; however, beginning in the 1980s, building a nuclear power plant in the United States was not financially, socially, or politically feasible. In the 1980s, nuclear power megaprojects experienced billions of dollars in claims, disputes, and litigations over the extraordinary cost increases in nuclear power plant construction, disputes that pitted stakeholders against one another as to who should bear those cost overruns. At the same time, protests against the building of nuclear power plants by nonfinancial stakeholders grew as worries arose over the issue of long-term disposal of nuclear waste generated by those nuclear power plants. Finally, in the face of the huge cost overruns and the social protests, the political and regulatory bodies essentially abandoned supporting nuclear power projects for 20 years.

If the concept is proven to be feasible, the megaproject moves into the financing phase. During this phase, the owner secures financing or dedicates funding for the megaproject based upon the order of magnitude cost and schedule estimates, the comparative need for the megaproject (for example, evaluation and ranking of all capital projects identified to attain a priority ranking), the total capital funds available, the feasibility of completing the megaproject as planned, and the cost-to-benefit ratio expected as a result of placing the completed structure or facility into its intended service. This phase certainly includes financial institutions and/or investor groups and shareholders (if any), and it may include regulatory bodies and other governmental entities. Engineer and contractor involvement may be limited to initial project cost estimating and representation of feasibility. Going back to the Channel Tunnel, 15 years before the start of construction of the now completed and operational Chunnel, the British had initiated plans of their own to construct the tunnel, only to abandon that first twentieth-century effort "for lack of money" (Lienhard 1997–1998).

The last phase before actual execution of the megaproject involves the development of the strategy to be followed during the execution of the megaproject. During this phase, the owner finalizes the primary cost, schedule, and quality goals for the megaproject; selects the project delivery system; identifies the contractual and payment methods; drafts the contract document set; sets the basic design or performance specifications for the structure or facility; and establishes its own megaproject management and control processes, procedures, and organization. Other stakeholders will include investors, financers, and shareholders; regulatory bodies; other governmental entities; engineers and contractors; and possibly social institutions (i.e., environmental groups, industrial groups, and trade unions). Perhaps the biggest and undoubtedly costliest (in money, materials, and lives) gigaproject in modern history was World War II. The concept was not really argued; the Allies had a unified goal of defeating the Axis forces. The feasibility, while in doubt for a host of reasons, did not deter the stakeholders' commitment to the gigaproject. The financing was a struggle, but stakeholders found ways to pay for the war (though retiring the debt incurred took many years). The most significant internal risk element faced by the Allies arose from setting, agreeing on, and executing the strategy under which the war would be fought.

By the end of the strategy phase of a megaproject, all of the primary project stakeholders should be identified and all of those stakeholders should have initiated their "participation" in the megaproject. Throughout these early phases of the megaproject, the stakeholders are all advancing their own perspectives as to the appropriate goals and objectives for the megaproject. Through this process, the stakeholders will attempt to influence the owner (and other stakeholders) to adopt their definition of risk (or at least include that definition within the overall project risk definition) as well as their measure of what will constitute a "successful project." During this project formation stage, work on the risk profile must begin, both as a sound management practice and as a requirement of any attempt to secure reasonable investment and financing for the megaproject. The best risk profiles are representative of the goals, objectives, and concerns of the megaproject, regardless of whether or not the stakeholder is an investor in the megaproject. However, it is also at this point that there is the greatest risk that the profile that flows from this formation stage will be unmanageable by any stakeholder, including the owner and its board of directors.

For example, another British transportation gigaproject, the London Crossrail Project (approximately US$30 billion in 2007 dollars), in the late formation and early execution stage in early 2007, had progressed to the point where essential elements of the megaproject had been defined, governmental and private funding had been secured, initial engineering was underway, and construction planning was just in progress. The total count of stakeholders was unknown, but it exceeded several hundred and ranged from individual property owners to several environmental groups, from public and private investors, up to the head of the national government. Every stakeholder one might imagine, from the sovereign head of the government of the nation to a local shop owner who might be affected, was actively involved in the development of the risk profile developed during the project formation stage.

That risk profile took more than three years to assemble (and was still being added to at the end of the project formation stage) and contained literally thousands of separate risk elements. It took more than 24 hours to run the computerized probability and effect range prediction for the entire risk profile. Quite simply, the sheer size of the risk profile assembled made the document almost useless as a functional management tool. With every predictive run of the profile, the risk element factors changed to the extent that depending on the run and the probability matrix used, the critical project risk elements were never the same two runs in a row.

The process used to develop the risk profile in the example above was internationally accepted as the standard for the industry. The risk profile was implemented following standard industry practices, and the system used to develop and model that risk profile was recognized as one of the most advanced available to the industry at that time. An examination of the entire risk management program determined that the owner had been both reasonable and prudent in its risk management actions throughout the project formation period. However, that does not mean that the ultimate result of the risk management program was useful to the project during the execution phase of that gigaproject.

It is during the early phases of a megaproject that a prudent owner will want to have the widest range of risk elements identified from the broadest possible range of potential and actual project stakeholders. It is much better to learn of a potential social effect risk during the project formation stage than it is to first learn of it when the lawsuit hits at the midpoint of the megaproject. It is also better to have a risk profile that must be reorganized to be of practical use to management than it is to overlook a vital risk element simply because the stakeholder that identified the risk was precluded from voicing that risk issue at a time when avoidance and mitigation planning for such risks can be the most effective.

As a result, risk management during the project formation stage is the point when the risk profile is first set, but it must also be the beginning of evolving the risk profile into a meaningful and useful project management and control tool. At the later stages of project formation, decisions are made relative to execution and contracting strategies; in short, how is the owner going to actually execute the megaproject?

Organizing a Risk Management Profile

How does one organize a risk profile containing thousands of risk elements so that the risk profile can be useful instead of useless during actual execution of the megaproject? As in the old joke,

> How does one eat an entire elephant?
> One bite at a time.

The same answer applies to managing risk on any megaproject. One can find oneself virtually paralyzed if one focuses on the entirety of a risk profile. The answer is to reduce the risk profile into ever smaller bites, which can be effectively managed. This process is done by first carefully and logically arranging those disparate risk elements into two focus-oriented categories:

1. Those risks that are specific to project execution; and
2. Those risks that are specific to project context.

Simplistically, a risk element that is specific to project execution arises from the actual execution of the megaproject. A risk element that is specific to project context arises from the environment within which the megaproject will be executed. The next step in reducing the risk profile into useful bites is to organize each of those two primary risk categories into factors.

In general, there are four primary project execution–specific factors and four primary project context–specific factors from which the majority of risks arise.

Project Execution (Internal)–Specific Factors:

- **Delivery and Operational Risk.** The ability to overcome the risk of not delivering and operating the project as conceived. These risk factors involve those issues or concerns associated with actual engineering, procurement, construction execution, and operation of the project, including nontraditional approaches, such as a public owner's use of design–build (DB), collaborative, or allianced contracts.
- **Technological Risk.** The ability to overcome the technological risks of the project. These risk factors involve those issues or concerns associated with the technologies involved in the execution methods and operational technology of the project.

- **Financial Risk.** The ability to overcome the financial risk of the project through to final completion and operation. These risk factors involve those issues or concerns associated with the financing of the project, including the execution period and operations or equity financing.
- **Procurement or Contractual Risk.** The ability to overcome the risks associated with the procurement of, or contracting for, the execution and operation of the project. These risk factors involve those issues or concerns associated with the contractual and procurement approaches—systems—used for both project execution and operation.

Project Contextual (External)–Specific Factors:

- **Political Risk.** The ability to overcome the political risks of the project, including local, state, and national political opposition and code and regulatory impediments. These risk factors involve those issues or concerns associated with the local, regional, and national political and regulatory situation confronting the project.
- **Environmental Risk.** The ability to overcome the environmental risks of the project. These risk factors involve those issues or concerns associated with the environmental problems, concerns, and activities confronting the project during both project execution and project operation.
- **Social or Cultural Risk.** The ability to overcome the social risks of the project. These risk factors involve those issues or concerns associated with the social and cultural effects of the project to the community and region within which it is to be located and potential objections from specific stakeholder groups.
- **Economic Risk.** The ability to overcome the economic effect risks of the project. These risk factors involve those issues or concerns associated with the macroeconomic effect of the project to the community and region within which it is to be located.

Risk management tools used include risk models and data that allow for the rating of potential risks and provide the input to shape project management processes by which those risk elements will be managed as the megaproject moves into its execution phase. Those risk management tools focus on providing project stakeholders with the means for determining risks associated with the project execution–specific and project context–specific conditions noted above. Additionally, if the competition for financing is from limited capital, this modeling can compare the projected costs to those of other potential megaprojects relative to their benefit-return-to-capital use demand. For example, the kinds of risk typical of power generation megaprojects may include the following:

- **Power reserve risk** (an operations risk factor) addresses the extent of the need for power, which is based on long-term forecasts of consumer need.
- **Engineering risk** (a technology risk factor) addresses the fact that technology in power generation is constantly changing, and construction of a power megaproject may take between five and eight years to complete from the point of conception.

Regulatory requirements at completion may be based on a new technology that was not commercially viable at the time the power megaproject was designed and constructed.

- **Credit risk** (a financial risk factor) addresses the fact that public utility rate bases for power facilities are set only after the completion of the power plant. These rate base proceedings set the total amount of project execution cost that can be recovered within the rate base and the time over which that recovery can be spread.
- **Materials risk** (a procurement risk factor) comes from the huge costs of power projects, which are driving the search for the cheapest material that meets specification that is to be fabricated in a location that has the least cost, often in different countries.
- **Regulatory project risk** (a political risk factor) addresses the fact that power generation facilities are heavily regulated and controlled by governmental entities, which in turn are directed by elected officials. Significant changes in the political environment can occur over the execution life cycle, which in turn can greatly affect the financial viability of that project.
- **Weather risk** (an environmental risk factor) addresses that issue that power projects are exposed construction sites within which the majority of the facility is directly exposed to weather conditions. Given the extended duration over which major power generation facilities are executed, weather can pose a major source of risk to project goals.
- **Local population response risk** (a social risk factor) deals with changing social relationships and forced cultural effects caused by power generation megaprojects, which may destabilize local support and long-term operability conditions (e.g., with not-in-my-backyard (NIMBY) attitudes).
- **Insurance risk** (an economic risk factor) is caused by the global reinsurance market, which currently has severe capital restrictions that limit access to project insurance. This problem is particularly true with megaprojects, given their size, complexity, and cost.

Ultimately, an owner cannot simply decide to cut risk elements from the total megaproject risk profile in an attempt to reduce the size of the megaproject's risk profile. As far as the owner's position in managing risk on any megaproject is concerned, it is important to remember that what an owner does not know can hurt the owner. But with each pass through the risk profile, an owner can cut the megaproject risk profile "elephant" into more manageable bites, creating multiple subcategory risk profiles for the megaproject. Within each subcategory of risk profile, models can be run to identify those risk elements with the greatest potential to occur and to affect the successful execution of the megaproject, which ultimately allows the party responsible for that risk to focus attention on the most critical threats to the successful execution of the megaproject.

Megaproject Risk Ownership

One of the most often debated issues among stakeholders on a megaproject is "Who owns the risk?" In the past, it was believed that the owner of a megaproject "owned the risk" on the project until the point at which a particular risk element (or set of risk elements) was allocated to another stakeholder on the megaproject. It was assumed that if an owner contractually allocated a risk element to another party to the megaproject that that risk element somehow disappeared from the owner's risk profile because it had become someone else's responsibility. One need only look at the claims, disputes, and litigation histories of megaprojects to discover the fallacy of this assumption. The real answer to the question of who owns the risk is that risk elements are inherent in the megaproject itself, regardless of the stakeholder to whom management and control of a specific risk element may have been allocated. What this situation means is that every stakeholder directly or indirectly involved in the megaproject to some extent "owns the risk" inherent in that megaproject.

What a contract actually allocates is some level of responsibility to manage and control a particular risk element (or set of risk elements) and some amount of liability should an allocated risk affect the megaproject. The fallacy is in believing that an owner can simply "allocate then forget" a risk via a contract with another stakeholder. More and more often, neither responsibility to manage nor liability for a risk element is decided until after the megaproject is completed, at which time the courts, arbitrators, or mediators decide the extent to which each of the stakeholders shares responsibility to manage a risk and shares the liability for the effect of a risk element.

Putting contractual arrangements aside, because of the complexity of a megaproject risk profile, it is almost impossible to isolate a single risk element to allocate total responsibility or total liability to a single stakeholder. An effect from any one risk element may ricochet into other risk elements, which in turn are likely to have a successive ricochet effect (which is described in detail in Chapter 8), creating other risk effect events. Because of the complexity, interrelationship, and ricochet effect of risk elements on a megaproject, there can be no soloists on a megaproject; risk management must be an orchestrated team effort. It is this senior corporate and senior project level risk management team, composed of representation from the primary executing stakeholders, that must monitor and coordinate risk management plans and actions of the individual stakeholders in the megaproject.

The senior risk management team "owns" the responsibility for the entire risk profile of the megaproject, and they are essentially focused entirely on managing from that profile, adjusting the profile as necessary to reflect actual conditions on the megaproject by discarding risk elements that no longer pose a threat to the megaproject, while adding other risk elements that arise with each decision made and action taken during the execution of the megaproject. The senior risk management team monitors and coordinates the risk management efforts of each of the individual executing stakeholders to avoid or mitigate the ricochet effects of any given risk element on the megaproject as a whole.

Typically, risk management plans can be identified as either avoidance or mitigation based. Avoidance action plans are applied when the best way to control the risk element in question is to preclude the conditions that would result in the occurrence of the risk during execution of the megaproject. For example, failure to obtain the required environmental permits by a certain date within the project schedule is a risk element that is best addressed through an avoidance-based risk management plan. Obtaining the permits as scheduled—or earlier than scheduled—will eliminate any ripple effect delay to the megaproject's schedule that would flow from those permits being obtained later than planned. Conversely, it would be much more difficult to mitigate the effect of failing to obtain the required environmental permits as required by the megaproject schedule.

Mitigation action plans are predicated on the assumption that a particular risk element will, at some time during the execution of the megaproject, occur and rather than attempting to avoid the risk, the best response is to initiate actions that are directed toward reducing (or mitigating) the effects of that risk element on the megaproject. For example, owners make changes in megaproject structures and facilities as they are designed and constructed. Rather than try to ban changes (many of which are beneficial), an owner would be better served by managing a strict change control process that limits the number of changes, streamlines the processing of changes, and closely monitors the cost and schedule effect of each change on the megaproject as a whole.

Managing risk on a megaproject is not simple, and the law of unintended consequences often seems to work overtime on megaprojects, as the ricochet effect caused by a risk element that has occurred spreads in unexpected patterns throughout the megaproject. As a result, there must be a functional group focused on risk management at a senior level to ensure that adequate plans are in place, being followed and updated as a matter of routine by all stakeholders.

Measuring Success

Simply measuring whether a risk has been successfully managed on a megaproject is not a matter of determining whether a risk element may or may not have had an effect on the successful attainment of every goal or objective set for that megaproject. Project management research has addressed metrics in many forums that generally focus on measurable functionality, scope, cost, and timeliness (Pinto and Slevin 1988; Freeman and Beale 1992; Shenar et al. 1997). However, in the practical reality of megaprojects, the success is more likely perceived than measured by most stakeholders involved in a megaproject. Recent research (Diallo and Thuillier 2004) suggests that

> each stakeholder assesses project success on the basis of evaluation dimensions that fit within his own agenda or within the interests of the group he represents.... Perceptions may sometimes be incorrect representations of reality, but perceptions are the [stakeholder's] sole possession and are the very basis upon which he makes his decisions.

As a consequence, the individual stakeholder defines and develops metrics and measures success in terms that satisfy that stakeholder's project goals and objectives. So then the issue becomes twofold: How does one define successful risk management, and how does one measure successful risk management within the context of a megaproject? This second question is especially troubling to, and critical for, boards of directors and senior corporate management.

Defining and measuring effective project risk management on megaprojects have evolved dramatically over the past decade. Early techniques were heavily focused primarily on statistical measures involving such things as cost, schedule, quality, and return on investment. More and more, however, the current focus has shifted to include practicality in application of the risk management programs and techniques being applied on megaproject construction globally. In short, instead of being based almost completely on ultimate results achieved, definition and measurement of successful risk management are founded in the soundness of the risk management procedures, processes, and practices used during the execution of the megaproject.

Risk Management in a Public Context

John J. Reilly

LESSONS LEARNED

1. Risk definition and management are fundamental project management requirements.
2. The owner must take prime responsibility for risk planning and risk management.
3. Risk strategies and management plans should be considered early in project planning and design.
4. Risk management should be continuous from planning through design and construction.
5. The objective should be to reduce the effects of risk events to as low as reasonably practical (ALARP).
6. Specific risk objectives and minimum risk requirements should be identified.
7. Ownership of risk should be clear and explicit in the risk management plan and bid documents.
8. Risk registers should be comprehensively used, updated, and communicated.
9. Risks that affect multiple areas of a project (i.e., involve multiple owners) need to be addressed and managed.
10. Risk analysis should be as detailed as required by the conditions of the specific project.
11. Risk mitigation should be comprehensive, logical, and practical.
12. Implications and effects of the form of the contract on the risk environment should be considered.
13. All risks identified in design should be communicated to bidders with specific allocations so that the bid environment is clear and risks allocated to the contractor can be priced in a competitive environment.

Risk Management Specifics—Process and Examples

This section of Chapter 2 describes risk management procedures and examples to illustrate risk management from project planning through design and construction. For the purposes of this document, "risk" or "risk management" includes the processes of developing and implementing a risk management strategy, including risk identification, risk analysis (i.e., characterization, including quantification of probabilities and consequences), and the implementation of risk response and risk monitoring and control.

Objectives of Risk Management

The general objective of risk management is to reduce to as low as reasonably practicable (ALARP) the effects of risk events on the project, using an appropriate risk management policy and process.

Specific risk objectives may be defined in addition to general risk objectives. For example, as a principle, the general public should be exposed to a small additional risk from the construction of a project (minimum requirement) compared to the risk they are normally exposed to as users of buildings and transportation systems and when walking on adjacent streets. A specific and absolute risk objective of the contractor might be to eliminate risk of catastrophic collapse, and a general objective might be to successfully complete the work on time, under budget, and maximizing profit.

Risk management includes the following steps:

- **Risk management planning**—deciding how to structure, implement, and execute a risk management process, as defined in a risk management plan.
- **Risk identification**—identifying potential risk events and their characteristics.
- **Qualitative risk analysis**—rating identified risks for further action by assessing initial probability and consequence (relative scales).
- **Quantitative risk analysis**—more detailed numerical analysis of the probabilities and consequences of the identified risks on overall project objectives.
- **Risk response**—developing, quantifying, and implementing options and/or actions that will reduce either the probabilities or the consequences of identified risks. These actions can include, as appropriate, mitigation, avoidance, transfer, or acceptance.
- **Risk monitoring and control**—implementing risk mitigation, tracking the identified risks and actions taken to mitigate those risks, monitoring residual risks, identifying new risks, requantifying existing risks, and evaluating the effectiveness of actions taken.

Basic Definitions:

1. Uncertainty is a state where it is impossible to exactly predict a future outcome.
2. Risk is defined as the result of an uncertain event or condition that, if it occurs, has a consequence. (The consequence can be negative or positive. Positive outcomes are usually called "opportunities.")

3. Risk is quantified as the combination of the probability of an event and the resulting consequence.
4. Probability is the chance or likelihood of the event occurring.
5. Consequence may be measured in terms of safety, cost, schedule delay, quality of construction, or other quantifiable project outcome.
6. Risk management includes risk identification, risk characterization, and risk mitigation.
7. Risk characterization and analysis includes identification of the type of risk, the probability of its occurrence, and the consequences of the risk event should it occur. Dependencies and correlations between risks are also considered.
8. Risk mitigation includes identification, evaluation, and adoption of actions that can be taken to eliminate, reduce, or avoid the risk and its consequences. If no action is taken, the risk is "accepted."
9. Residual risk is that risk remaining after all mitigation actions have been implemented; it is generally impossible to completely eliminate risk. Owners and the public should be aware of this fact.

Risk Policy and Risk Management Plan

Risk policies should be identified by the owner and communicated in a formal risk management plan as early as possible, consistent with the characteristics of the particular project. The development of this risk management plan may be delegated to consultants in the planning and design phases (although the owner remains responsible for overall project risk at this time). Subsequently, the requirements for risk management during construction will be incorporated in the contractual documents for implementation by the contractor, who is then responsible for those specific construction-related risks defined in the contract documents. The owner retains or otherwise mitigates all other risks.

Risk Acceptance Criteria

The risk objectives expressed in the owner's risk policy should be "translated" into risk acceptance criteria suitable for use in the risk management process. These criteria may include

1. A limit or threshold above which the risk is considered unacceptable and thus must be reduced regardless of the costs.
2. A limit below which it is not required to consider further risk reduction.
3. An area between these two limits where risk mitigation is considered and mitigation measures are implemented according to the circumstances (e.g., using the ALARP principle and considering benefit–cost analyses).

These risk acceptance criteria are used to guide risk management planning and risk mitigation.

Who "Owns" the Risk?

The "ownership" of risks varies with circumstances and the phase of the project. For example (these are representative statements; many other conditions and possibilities exist):

1. At the beginning (project planning and conceptualization), all risks belong to the project owner.
2. In the design phase, the risk of not exceeding the project budget may be shared by owner and designer.
3. In the construction phase, some risks are assigned to the contractor, and some are retained by the owner (this allocation must be clear). For example, the responsibility for damage to adjacent properties is normally the contractor's responsibility, although mitigation may be shared.
4. For a long-term public–private partnership (PPP), funding and revenue risks may be shared between owner and contractor, but the contractor may own all design and construction risks.

Who Should Own the Risk?

The generally accepted principle is that the risk should be owned by that party who is in the best position to effectively manage that risk. This determination is not always clear, especially where complex risk elements involve multiple parties to an agreement or contract. This principle is often compromised in practice, which can lead to problems, particularly in a contractual "low-bid" environment.

Characteristics of Risk

Where Do Risks Come From?

Risk events do not "just occur"; their seeds are sown by many directly and indirectly associated events, perhaps early in the planning and design phases. For example, when we choose and approve construction means and methods—especially for complex equipment such as tunnel-boring machines—we introduce the potential for future risk events. There are different categories of risk, as outlined in Table 2-1, related to complex conditions in a tunneling construction project (Isaksson et al. 1999).

Examples of types of risks to be considered:

1. Risk to the health and safety of workers, including personal injury and, in the extreme, loss of life.
2. Risk to the health and safety of third parties.
3. Risk to the owner for schedule delay, cost overruns, financial losses, and additional unplanned costs.
4. Risk to the contractor for accidents, delays, loss of profit, bonding capability, and reputation.
5. Risk to third-party property, specifically existing buildings and structures and infrastructure.
6. Risk to the environment, including land, water, and air pollution and damage to flora and fauna.
7. Political and public issue risks.
8. Difficulties for the project to be funded and to proceed.

Table 2-1. Categories of Risk Regarding Tunneling Construction

Category	Description	Example
Stable and known processes	"If this, then that"	If there is a loss of slurry pressure in an unstable zone, then there is a chance of face collapse.
Chaotic systems, highly variable but within certain boundaries	"If this, maybe that, and also that is possible"	If we raise the profile into the sands, then settlements are reduced, but more ground conditioning is necessary, which is unproven under these circumstances.
Chain-of-events, linkage	"Because of this, associated with that, then that"	If the bearing seals leak and the monitoring system fails, the main bearing will be compromised.
Events caused by intent	"Directed threats"	Sabotage, terrorist threats

The Process of Risk Management

Because several contractual parties (e.g., planners, designers, and contractors) are engaged by the owner at different project phases, allocation of responsibility for identified and foreseeable risks should be as clear as possible in each phase. This step requires that risk policy, risk management, and risk characterization be defined early and updated as a continuous process. This identification is the owner's responsibility.

Risk management includes the following steps:

1. Risk Identification and Analysis or Characterization (qualitative or quantitative):
   - 1.1 Compile a list of credible or possible risk events, and initiate the risk register.
   - 1.2 Estimate the probability of occurrence of each event.
   - 1.3 Estimate the consequence (cost, time, or other) of each event, should it occur.
   - 1.4 Review the product of consequence and probability, i.e., the risk level.
   - 1.5 Enter the product in the risk register.
2. Risk Response and Management:
   - 2.1 Rank risks for appropriate action (mitigate, transfer, avoid, or accept).
   - 2.2 Develop risk mitigation options for the top-ranked risks according to the risk level.
   - 2.3 For these options, determine a benefit–cost ratio.
   - 2.4 Decide which risks require action (mitigate, transfer, avoid, or accept).
   - 2.5 Confirm these decisions in the risk management plan, as agreed to by key parties or contractually required.
   - 2.6 Monitor and manage the risk mitigation plan and risk register, updating as necessary.

Risk Register

A risk register is used to list and track the identified risks, their characteristics and quantification, risk mitigation actions, and status. The content of a typical risk register includes the following (this list is taken from the Washington State Department of Transportation's risk management guidelines [WSDOT 2010, 2011]):

Risk identification
- 1.1 Risk event number or ID
- 1.2 Summary description of risk event
- 1.3 Detailed description of risk event
- 1.4 Risk "trigger"

Area affected
- 2.1 Area or functional element affected
- 2.2 Phase of project affected

Qualitative analysis results
- 3.1 Relative probability (1 to 5)
- 3.2 Relative impact or consequence (1 to 5)
- 3.2 Risk matrix (graphical representation, 5 × 5 matrix) score of 1–25

Quantitative analysis results
- 4.1 Probability—usually a percentage (can have a distribution or be conditional)
- 4.2 Impact or consequence—cost, schedule, other (can have a distribution or be conditional)

Risk Response Plan (action to be taken may include mitigate, transfer, avoid, or accept)
- 5.1 Owner of the risk or action
- 5.2 Strategy (e.g., mitigate, transfer, avoid, or accept)
- 5.3 Specific action to be taken
- 5.4 Related project activities affected or involved

Risk Response benefit–cost
- 6.1 Estimated cost of action
- 6.2 Estimated value of risk that is mitigated

Current status (updated and reported regularly)

Types of Risk to Be Considered—Risk Checklists

Generic risk checklists are available and should be used to inform the risk identification process. Molenaar et al. (2006) contains checklists from several sources. Also see ITA (1992), ITA (2004), PMI (2004), and ITIG (2006). Specific risks related to the project and its circumstances would be added to these generic checklists. Examples of top-level categories and more detailed elements follow—these are just a few of the checklist elements; for details, see references.

Types of Risk Areas—Examples

- Project Feasibility
  - Technical feasibility
  - Long-term viability
  - Political circumstances
- Funding
  - Sources of funding

  - Inflation and growth rates
  - Accuracy of cost and contingency analysis
  - Cash flow
  - Exchange rates
- Planning
  - Scope
  - Complexity of the project
  - Technical constraints
  - Constructability
  - Milestones (schedule)
  - Time to complete (schedule)
  - Synchronization of work and payment schedules
- Engineering
  - Design and performance standards
  - Unreliable data (especially geotechnical)
  - Complexity and completeness of design
  - Accountability for design
  - Implicit means and methods
- Type of Contract
  - Lump sum
  - Unit price
  - Cost plus
  - Guaranteed maximum
  - Collaborative
  - Allianced
  - PPP
- Contracting Arrangement
  - Owner managed
  - Design–bid–build (DBB)
  - Design–build (DB)
  - Joint venture design–build–own–operate–maintain (DBOOM)
  - Construction manager at risk (CM@R)
  - General contract—construction manager (GCCM)
  - Innovative procurement methods, e.g., early contractor involvement, cost + incentives, alliancing
- Unfavorable Contract Clauses
  - Differing site conditions requirements
  - Hold harmless
  - No damage for delay
  - No relief for force majeure losses
  - Undefined process for quantity variations
- Construction
  - New, untried methods or requirements
  - Delays in mobilization
  - No geotechnical baseline defined

Unanticipated groundwater or geology
Delay in delivery of tunnel-boring machine (TBM)
High wear rates in cutters or other equipment
Failure of TBM main bearing
Community objections to methods or effects

Risk Characterization

Risk characterization is the process of determining the probability of occurrence (P) of a defined risk event and the consequence of the event (C) should it occur. The combination of probability and consequence (P and C) indicates the relative severity of the risk (risk level). Note that C can be positive, which represents an opportunity.

Qualitative Risk Analysis

Qualitative analysis rates the probability and consequence in relative terms for ranking and comparison. Quantitative analysis (see the section called "Quantitative Risk Analysis") is more numerically specific and can consider multiple distributions, correlations, and interdependence of risk events.

Qualitative Classification: Probability of Occurrence and Relative Consequence

Table 2-2 presents a scale of the relative probability of risk occurrence. Table 2-3 shows the relative consequences that are representative of a megaproject. However, different values for cost and time should be used on a project-specific basis (the levels depend on the specific circumstances, e.g., complexity and size of the project).

Qualitative Risk Ranking

Relative severity can be used as a determinant of action. The potential relative severity of each risk event (risk level) can be obtained by multiplying P and C. The result is a risk action matrix (Table 2-4), where higher numbers indicate more severity. This matrix is used to classify and rank each risk for appropriate action. These ranges are taken from a representative project, but they are reasonably representative of many projects. They should be adjusted for project-specific circumstances.

It must be noted that there are some risks with very low probability but very high consequence. They might have low risk levels (e.g., 1–4), but these risks should be given special consideration, and generally, specific risk management strategies should be adopted for these risks. An example would be a low probability (P = 1) of a TBM being stuck in squeezing ground that is located under an area from which the machine could not be accessed (C = 5). The probability is low, but the consequence may be intolerable, and special mitigation measures may be required.

Qualitative analysis deals with general levels of probability and consequence. In practice, most risk events are not simple. They have specific and sometimes complicated probability distributions and consequences that need to be considered in the

Table 2-2. Relative Probability of Occurrence (P)

Level	Description	Probability
1 =	Very Unlikely	P < 5%
2 =	Unlikely	P = 5–20%
3 =	Possible	P = 21–50%
4 =	Likely	P = 51–75%
5 =	Very Likely	P = 76–100%

Table 2-3. Relative Consequences (C)

Level	Description	Cost	Time
1 =	Insignificant	C < $10 million	< 1 week
2 =	Minor	C = $11–25 million	1 week–1 month
3 =	Moderate	C = $26–50 million	1–2 months
4 =	Significant	C = $51–100 million	3–6 months
5 =	Severe	C > $100 million	> 6 months

Table 2-4. Relative Risk Action Matrix

Rating	P × C	Risk response
Intolerable	17–25	Unacceptable—mitigate
Very significant	13–16	Unacceptable—mitigate
Substantial	9–12	Evaluate mitigation
Tolerable	5–8	Consider options
Insignificant	1–4	Accept and monitor

evaluation of the risk and determination of action. In these cases, quantitative risk analysis needs to be used.

Quantitative Risk Analysis

The identification and quantification of risk during the different phases of a megaproject require appropriate tools. The actions required are to identify risk, quantify risk, understand risk, and categorize causes and effects, considering such factors as “chain of events.” There are existing risk analysis tools and processes that can be used reliably for problems encountered in the design and construction of megaprojects without major adjustments—with a caution that the size and complexity of megaprojects may require specific systems that can manage the interrelationships between discrete risk areas and track interdependent and interrelated effects that may affect the responsibilities of specific “risk owners.”

The goal is to recognize the interdependencies and avoid a “silo mentality,” which is found in vertical organizational reporting with no cross fertilization across the boundaries typically identified as departments or divisions and does not recognize or deal with potential risks that may cross such “silo” boundaries.

Some of these tools and/or methods are listed briefly as follows. For details of these processes, see literature and references herein, particularly Godfrey (1996), Barnes and Norman (1986), Isaksson (2002), and ITA (2004).

1. Fault tree analysis,
2. Event tree analysis,
3. Decision tree analysis,
4. Multirisk, and
5. Monte Carlo simulation.

Use of Probabilistic Methods in Dealing with Uncertainty

Probabilistic methods, such as Monte Carlo simulations, are now widely used to evaluate the effects of potential, multiple risks and to produce a "range of probable results," e.g., cost, schedule, or other project values. Software for these methods is readily available and because of the increasing use of this tool in quantifying risk and risk management decisions, it is worthwhile to outline its use and application relative to risk identification and risk management. Use of probabilistic methods to more accurately estimate the range of probable cost and schedule effect has increased over the past decade and is required for megaprojects, for reasons clearly described in other chapters of this publication. An accepted method is the one developed by the Washington State DOT in 2002, called "Cost Estimate Validation Process" (Reilly et al. 2004).

Fig. 2-1 shows that the probable future cost of a project, produced by a Monte Carlo simulation, consists of a range, not a single number, and that the range is dependent on factors that can be modeled in the simulation.

Explicit Risk Identification

The probabilistic process and the associated simulation models have a benefit in that risk events are explicitly identified and quantified, with their estimated probability and effect (consequence) to the project. This benefit permits more informed management decisions because the quantified risk events allow specific, quantified risk management plans to be developed and implemented. The focus of these plans is to first mitigate the high-cost risk events, as indicated in Fig. 2-2.

Risk Response—Actions That Can Be Taken

The following risk response actions can be taken depending on the character of the risk event, the severity of the risk rating, and the benefit–cost ratio:

1. Mitigate: Implement an action to reduce either the probability and/or the severity (or both) of a risk event. Generally, the benefit–cost ratio for the action is greater than 1.0.
2. Transfer: Transfer the consequence of risk by allocating the risk contractually either to the contractor or, by agreement, to another party, such as an insurance carrier.
3. Avoid: Make changes to the project plan to eliminate risk or to protect project objectives from its consequence. This avoidance may be achieved by changing scope or location or by adding resources.

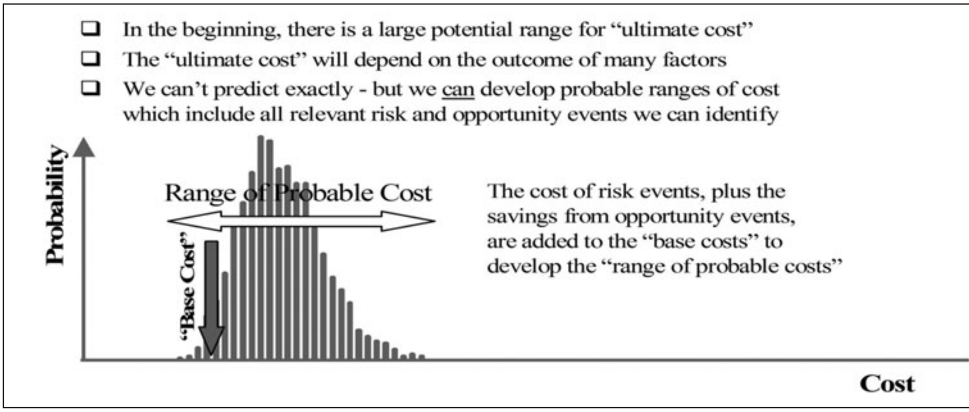

Fig. 2-1. Range of probable cost considering the effects of risk events

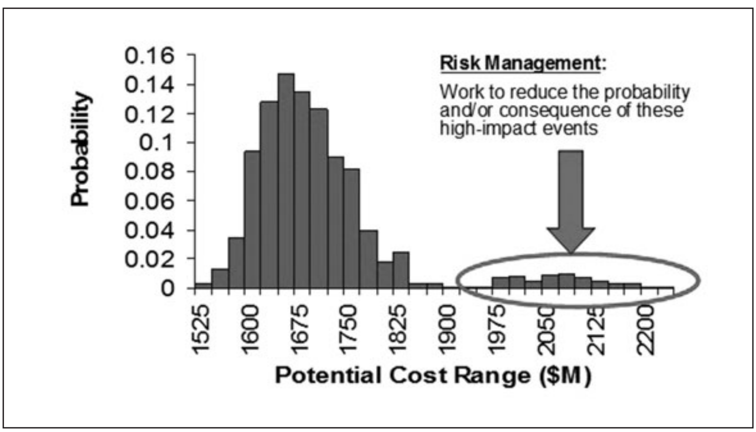

Fig. 2-2. Risk mitigation after explicit risk quantification

4. Accept: No changes are adopted to respond to or deal with the risk. The risk is retained.

A hypothetical example of risk identification, characterization, mitigation, and benefit is given here to illustrate the process and logic.

Risk event:	A tunnel project has a large, complicated TBM, and the alignment passes close to a sensitive laboratory and then under a lake. The TBM has a special main bearing to reduce vibration, but that makes it less robust. Replacing the bearing near the laboratory is restricted, and the TBM cutter head is not accessible under the lake.
Probability:	There is an estimated 15% chance that the main bearing will fail under the lake.

Consequence:	Disastrous—major cost and schedule delay—more than US$12 million in 8 months.
Quantified risk:	15% of US$12 million; expected value is US$1.8 million (schedule delay may also be quantified).
Mitigation:	Engineer the main bearing to be replaceable from within the tunnel drive, adding a cost of approximately US$1.2 million. No project delay.
Benefit–cost:	US$1.8 million/US$1.2 million = +1.5 (plus schedule benefits)—therefore, adopt this mitigation.

Although this is a simplified example, the specific circumstances always involve many considerations, for example, including the effect on communities, adjacent facilities, and the lack of job continuity. The mitigation action needs to be determined considering all the relevant factors.

Risk Allocation

The specifics of a contract determine, explicitly and implicitly, the associated risk allocation. It should also define responsibilities for dealing with specific risks to allow the contractor to price his or her risks in a competitive bidding environment. This allocation therefore influences the final cost, schedule, quality, and the relative potential for claims, disputes, and litigation.

An acceptable policy for construction risks is typically to allocate the risks between parties on the principle that a risk should be allocated to the party that has the best means for controlling that risk. The appropriate allocation is dependent on the project and also the contractual approach, e.g., DBB, DB, DBOOM,

Table 2-5. Example of a Risk Allocation Matrix

Risk	Party normally assuming risk	How risk is assigned or managed
Site access	Owner	Advanced planning and site acquisition
Site conditions	Owner	Adequate geotechnical investigations and contract clauses, geotechnical data report, geotechnical baseline report
Means and methods of construction	Contractor	Specific contractual clauses
Settlement of adjacent structures	Contractor	Contract clauses specify limit of settlement or maximum movements in adjacent structures
Weather	Shared	Contractor assumes risk of normal weather events. Owner assumes risk of above normal events
Force majeure	Owner and/or contractor	Contingency reserve, insurance

CM@R, GCCM, collaborative, or alliancing processes. The determination of risks and their allocation need to be made objectively and sufficiently, and this allocation must be clear in the contract documents since misallocation of risk is a leading cause of construction disputes. Table 2-5 gives a simplified example of risk allocation.

Because of the sensitivity of results after allocation of risk, each project should be assessed individually to determine for each risk what allocation is of greatest overall benefit to the project. Those risks then must be covered by the appropriate party. This allocation needs to be clear in the risk management plans and in the bid documents. It should be noted that the common practice of allocating all, or nearly all, risk to the contractor is counterproductive, frequently leading to increased cost and delay to the owner through disputes, claims, and litigation.

Implementation of Risk Management

Risk management should be used throughout the project from the early planning through to the end of construction and start of operations. The level of detail increases from initial planning through design and into construction. The content of the risk management plan normally includes the following:

1. Definition of the risk management responsibilities of the various parties involved (e.g., different departments within the owner's organization, consultants, designers, contractors, insurance agents, and sureties).
2. A description of the activities to be carried out at different stages of the project to achieve the project's risk objectives (related to the risk acceptance criteria).
3. A process to be used for documentation and follow-up of results obtained through risk management activities by which information about identified risks (including their nature and significance) is freely available in a format that can be communicated to all parties. This documentation is generally accomplished by a comprehensive risk register.
4. A process to follow up regarding initial assumptions and the current results of risk management.
5. Monitoring, audit, and review of results for compliance with the risk management requirements.

Responsibility for Risk Management

Table 2-6 presents a summary of risk management responsibilities. Before bidding (or negotiation) certain risks may be transferred either contractually or through insurance. Other risks may be retained, and some risks may be eliminated or mitigated. In the construction phase, possibilities of risk transfer are minimal, and the best course for both owner and contractor is to continue to reduce the potential consequence of as many risks as possible.

Table 2-7 lists elements of risk management by project phase. This table represents a basic listing; more detail can be found in the references, particularly ITIG (2006).

Table 2-6. Summary of Risk Management Responsibilities by Project Phase

Phase	Responsibility
Planning and Design (including Feasibility and Conceptual Design)	In this phase the responsibility of establishing a risk policy and carrying out risk assessment is the owner's, assisted by the design consultants.
Bidding and/or Contract Negotiation	In this phase the owner is the primary responsible party, assisted by the design and/or construction management consultants.
Construction Phase	In this phase the primary responsibility for risk management belongs to the contractor using an approved risk management plan. The owner, with a construction manager if engaged, should supervise, inspect, and review compliance with the approved contractor's risk management plan and should continue to assess, manage, and mitigate risks which are not the responsibility of the contractor. Interface risks between contracts are the owner's or construction manager's responsibility.

Table 2-7. More Detailed Risk Management Responsibilities by Project Phase

Phase	Owner (+ consultants)	Contractor
Planning and early design	• Establish risk policies and procedures applicable to the project. • Establish risk acceptance criteria. • Establish applicable codes of practice. • Initiate risk identification workshops to identify and quantify risks (qualitative and quantitative analyses). • Develop initial project risk register. • Rank and review risks for initial action. • Identify initial risk mitigation strategies. • Initiate risk management plans.	• No responsibility in this phase.
Final design	• Update risk management plan. • Update risk register. • Quantitative risk analysis. • Consider higher-ranked risks for mitigation. • Determine risk mitigation options. • Evaluate and implement initial risk mitigation actions. • Prepare list of risks for bidding/contract negotiation and/or award. • Contract documents written; include –Risk register with specific allocation of risk—to contractor, owner, or others (e.g., insurance). –Contract terms specific to the project for allocation of risk and remedies.	• For DBB, no responsibility. • For DB (and similar delivery, such as GCCM or alliancing), contractor has joint responsibility for risk management consistent with the owner's risk management plan and requirements as contractually defined, generally the activities that are shown in the column to the left.

Bidding	• Respond to the contractor's questions regarding risk definition, quantification, and allocation. • Revise contract provisions if needed.	• Review risk register and contract provisions. • Prepare construction risk mitigation plans as required by bidding requirements. • Use risk register and mitigation options to price bid strategy.
Award	• If the contractor's risk management plans are required as part of the contract award evaluation (e.g., best value procurement), evaluate these plans before the award. • Award the contract.	
Construction	• Construction management, supervision, and verification that the contractor's risk management plan is being implemented in accordance with the terms of the contract and applicable codes. • Management: Update the owner's risk management plan, including an assessment that the owner's risk remains consistent with the construction conditions, contract requirements, and established guidelines. • Update insurance provisions as necessary. • Management and mitigation of risks are not the responsibility of the contractor. • Identification and mitigation of new risks are outside the responsibility of the contractor or from third parties.	• Implement the construction risk management plan required by contract or as necessary, including detailed risk assessments (with owner and consultant participation where necessary). • Maintain and update the project's construction risk register. • Document actions taken. • Implement risk mitigation directly (or with others if necessary). • Maintain required insurance.

Risk Related to Contractual Strategies and Delivery Methods

There are contractual strategies and delivery (procurement) methods that facilitate the identification and management of risk, particularly where negotiated procurements, best-value procurements, or methods other than low-bid for the contract award are used. For example, risk allocation by the owner, working with the engineer and other consultants included in the bidding documents, should be based on assumptions regarding the party—owner, contractor, or other—best able to manage the specific risks. The basic goal is to allow the contractor, cognizant of the identified risks, to tender the most advantageous price to the owner that also allows the contractor to most effectively price and manage the identified risks, deliver the work, and achieve a reasonable profit.

Risk during Bidding

A sufficiently comprehensive risk register should be developed during design and fully communicated in the bid documents, with the disposition and allocation of the risks clearly identified. This register allows a clear determination of who is responsible to manage (or own) specific risks and therefore creates a uniform basis for bidding. This risk register should be shared with the contractors in the bidding phase so that

1. There is a common understanding of the risks that have been identified,
2. The benefit of the long investigation time available to the owner is available to the bidders,
3. Bidders can price the identified risks appropriately,
4. Risks that are allocated to the contractor are priced within a competitive environment, and
5. Options for mitigation available to the contractor(s) might be communicated to the owner, depending on the specific procurement approach.

The last item is only possible if there is a mechanism to allow evaluation of, and changes to, the risk management processes and risk allocation during or after the bidding phase. This communication is difficult in a low-bid environment but is possible in best-value or negotiated procurements or other contracting approaches, such as GCCM or alliancing.

The risks identified in the bid documents should be classified in terms of probability and consequence, mitigation actions that have been taken in the planning or design phases, and their disposition (allocation) or status (e.g., mitigation actions that have been identified in the planning or design phases but have not been implemented). This identification allows the contractors to price the work, including the risks allocated to the contractor, in a competitive bidding environment.

Risk Negotiation after Bid

If a bid or negotiated price is significantly higher than the owner expects, and negotiations indicate that the pricing is high to provide for a significant risk or risks, the owner may decide to reduce the contractor's liability for these risks by accepting that the owner will pay for those risks, or share the cost with the contractor on an agreed basis, if they should occur. This reduction allows a measure of protection for the contractor and a lower overall cost for the owner.

General Contractor–Construction Manager and Alliancing

GCCM (also known as CM/GC and sometimes Construction Manager at Risk) is a procurement method in which design work is begun by the owner or a consultant, and a general contractor (selected based upon a combination of experience and price) is engaged to work with the owner and designer to develop and deliver the project. The contractor is responsible for delivery of the project at a guaranteed maximum price, hence the term "at risk."

Alliancing is a form of procurement where the owner contractually works with the engineer and contractor to jointly share the risks and responsibilities in delivering the project. It seeks to provide better value for the money and improved project outcomes through a more integrated approach between the public and private sectors in the delivery of infrastructure.

The alliancing delivery method and, in some cases, GCCM provide that all parties work to deliver the project at or below a specified target cost and, if successful, all share in the resulting savings in defined ratios. If the target cost is not met, all parties to the contract share in the loss. This sharing creates a strong incentive, and requirement, to anticipate and resolve risk as early as possible, by the best means and by the most capable entity.

Summary

Ultimately one simply cannot account for or absolutely manage every risk on a megaproject. The breadth of a megaproject risk profile is simply too large to manage every risk in detail. However, by proactively managing those risk elements that can be identified, quantified, and controlled, the project's owner and stakeholders can significantly improve the chances of meeting the majority of the goals set for a megaproject.

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CHAPTER 3

Megaprojects and the Financial Markets

Christyan F. Malek

This chapter focuses on my personal experience in assessing financial investment in contractors and service companies that are involved in the managing and delivering of megaprojects within the energy industry. Three key topics are central to the overview of megaprojects in a financial context:

1. The evolution of OFS in relation to the global oil sector since 2000. In particular, (i) how the demand and need for resources and equipment has changed across this period relative to previous cycles and (ii) the evolution of risk sharing between contractors and owners and, related to this, the trend in contracting styles and their application across the past decade.
2. How companies in the services sector disclose information to the equity market (primarily targeted at sell-side analysts and investors) and the integrity (or lack thereof) of execution and performance on projects that can, at times, create a disparity between "actual" and "perceived" performance.
3. Finally, the company managements' general assessment of the outlook of their respective industries and how that compares to the broader economic reality and prevailing macro trends. Put simply, how has the industry fared in predicting its own outlook?

When I began financial coverage of the OFS sector several years ago (before which I had covered the integrated energy company sector) as an equity analyst, I will never forget the trouble I had in answering the most basic questions, such as:

- How do these guys make money?
- Why does one need contractors in the energy business when the owners can do it themselves and also vice versa?
- How can you trust that they are genuinely executing these projects properly, and how do these contract values equate to revenue and profit (i.e., is this backlog real or simply virtual, or worse, inflated)?

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LESSONS LEARNED

"One day the lights were on; the next day the lights were off" (Bissinger 2000).

1. The economic crisis of 2008 led to an unforeseen and dramatic collapse in the share prices of the oil field services (OFS) sector that dwarfs any of the falls that occurred in previous down cycles.
2. Those companies that survived and ultimately outperformed their peers possessed common characteristics: healthy balance sheets, strong execution capabilities, solid management, extensive local content, a global reach (and optimal positioning in the "growth regions"), strong relationships with international oil companies (IOCs) and national oil companies (NOCs), relatively "complex" assets, and highly specialized engineering and project management capabilities.
3. Although the boom-and-bust cycle so characteristic of the oil sector may indeed repeat itself once again in the future, the companies that will continue to survive and advance are those that are differentiated in their product offerings, can adapt to change in the demand for oil service skills from both IOCs and NOCs, and can operate and manage a business model that has defensive characteristics and secular capabilities to keep it going through a downturn.
4. Despite a structural advancement in the scale and capabilities of OFS companies, there has yet to be information disclosure and transparency at a standard equivalent to the sector's counterparts, such as the exploration and production sector and integrated energy companies.
5. Whereas there has been some improvement, the energy industry is a long way from securing the full trust of those investors who are all too familiar with profit warnings and unforeseen announcements on execution problems that were often "hidden" from the market until companies could no longer do so.
6. Risk sharing between owners and contractors on megaprojects has improved somewhat: The latter have learned painful lessons of the past and now contract risk in a form that ensures that the worst-case scenario of operational execution issues does not threaten the financial viability of the company.
7. The OFS sector has "grown up" against a backdrop of greater demand for their capabilities (in a world that is short of these very skills), which has afforded them the ability to transfer relatively more risk onto their clients going forward.

- Can you trust the disclosure of these companies? What's the risk that they are having major execution problems and you simply don't know?
- Clearly the theme across these questions borders on skepticism and mistrust! However, in reality, they were challenges that forced me to dig harder and unravel through both quantitative and qualitative means how to assess the investment cases of these listed companies and whether they were worth recommending to buy.

Contractors—Can't Live without Them?

The first major question that in essence challenges the existence of contractors within the energy industry is "Why do we need them?" The answer is obviously not a simple one and depends on the industry (e.g., oil, construction, or power) as well as the type of skills and assets required for the project. To address this issue in a generic form, one should first assess how commoditized, or uniform and plentiful, the service offering of the particular contractor is on a relative basis. Where on the "food chain" does it sit, and where are we in the respective (in the case of energy this would be a commodity or macro) cycle? When economic conditions are tough, the more differentiated the company's technology or skill, the better chance it has that it will be busy—an obvious statement that after the economic downturn would make it easy to identify those companies that are still around versus those that struggled and died, or only continue to live in the shadow of a collapsed share price.

With this notion in mind, turning to the mid- to late 1990s, when the majority of the resource and skill (particularly engineering) lived within the owners' domain, the effect of recession and trough commodity prices drove many owners to shed resources and, in particular, high-value engineering and construction labor. A "skill vacuum" resulted within the domain of the owners that grew tighter across the commodity up cycle in the second half of the decade and became the dynamic upon which the oil services sector thrived as many of these skilled resources were absorbed into service companies that were around at the time, such as Stolt Offshore, Kvaerner, KBR, Schlumberger, and Saipem. In parallel with this situation, the financial market saw a structural increase in energy investment and a record number of final investment decisions associated with much larger projects relative to previous cycles, driven in part by higher commodity prices. This increase, in turn, put greater pressure on skilled labor and assets to deliver and ultimately drove the growth of the oil services sector, measured in a number of ways:

1. Asset size has grown. Our analysis shows that the European oil services have more than doubled the number of ships and vessels under ownership.
2. The enterprise value of companies listed in Europe and the United States has, on average, tripled in absolute terms versus the start of the decade.
3. Arguably, companies have developed superior corporate governance.

After the economic crisis of 2008, many of these companies have suffered, particularly those whose skills sat at the more commoditized end of the services chain and/or where there was a large flux of availability of these vessels around the world. Service companies that invested heavily in equipment and assets, particularly the type that had no special differentiation, witnessed a dramatic fall in usage as global oil investment waned and owners took a far more conservative approach to their outlooks. The outperformers were those that had high-quality engineers on staff and project management capability, those that were exposed to structural growth regions or industry themes in part driven by NOC investment, and/or those that possessed assets with unique capabilities that could be managed within engineering, procurement, installation, and construction (EPIC) projects and with the application of a vertically integrated business model to ensure optimal usage of their resources.

The Risk Ball No Longer Sits Entirely in the Owner's Court

The degree of risk tolerance within the oil services sector has changed since 2000, at a pace far greater than during previous cycles. It has ultimately improved in favor of the contractors, and there has been a structural shift in risk sharing between the owner and the contractor. Assessments of these dynamics stem from the analysis of all execution issues that have arisen for listed European and U.S. OFS companies over the past 20 years, as well as the various types of contract styles that have been adopted. With regard to the latter, analysis of all contracts awarded from 2000 to 2011 shows that the sector remains unchanged in its preference for lump-sum contracting. However, during this period, cost-plus and unit price contracting became popular, accounting for up to 40% of all contracts by 2007, only to fall back to around 10% (levels similar to 2000) by 2011. Execution problems peaked between 2005 and 2006, after which was noted a substantial fall to present day (albeit certainly not to zero!). These two trends are interlinked: As contractors (some of which almost went bankrupt) learned from their mistakes and project managers became smarter and the demand for their resources grew, they put in place greater contingencies to offset unforeseen problems (e.g., worse than expected weather conditions, currency movements, raw material price changes, and supply and scheduling issues). This approach and method of de-risking initially took the form of cost-plus contracting (which drove costs to a peak in 2007). However, as oil service companies became more confident in their ability to risk contracts, they reverted to the traditional lump-sum strategy and ultimately to a consideration that ensures that the worst-case scenario does not threaten the financial viability of the company.

Reporting the Performance of Megaprojects—What You See Is What You Get?

Rapid growth can often lead to lack of accountability and procedure as companies are keen to win contracts and boost their share price and deliver or beat targets provided to the market. To some degree, we still live in a world where the sector's performance can at times be driven by a virtual backlog, such that the stock market may reward a company for winning a relatively large contract and worry about the delivery of the project when the time comes. In the engineering and construction sectors within the energy industry sector, this worry often does not appear before two to three years, given the lead times of projects. And so it is difficult to ascertain the execution performance and profitability of contracts awarded until the company decides to report the outcome and related financial information.

The challenge for the management of these companies is how to make objective assessments of the operational and financial progress of projects that are being executed and know when to record profits based on key milestones that are achieved. In my view, the best of them take a fairly conservative approach and charge the revenue and income toward the end of the project's life on the basis that it has been sufficiently de-risked. In a perfect world, we would also expect them to be completely transparent and notify the market when a problem arises on a project that may see additional cost (in the form of a change order or variation order), irrespective of whether or not the owner will pay for these charges. Although, since 2000, we have witnessed a moderate improvement in the disclosure of contract details (the majority now include the value and where and by whom the contract was awarded), we have seen no fundamental improvement in company transparency with regard to the operational and execution performance of all projects under management. The worst implications of this situation are that profit warnings, that is, announcements that earnings will not meet analyst expectations, on projects continue to come as a surprise to the market and in some cases are reported much later than when the problem actually arises (and at times contradictory to what managers of these companies communicate to their shareholders).

The financial markets remain cautious about the level of integrity throughout organizations from the bottom up and take the view that it is not generally because of malicious intent that issues are not reported in an appropriate and timely way but often because of lack of accountability on projects, poor assessment of the related risks, and in some cases, where the size of the project is too large, no centralized system of monitoring and reporting all problems. The issue for investors, and in particular portfolio managers who have been around to see the boom and bust of OFS companies through previous cycles, is that the performance indicators of a company cannot be purely limited to the rate of contract wins and future backlog potential given at any point when a project (perhaps one that they didn't even know about!) may suddenly fail. In light of the aforementioned risks associated with managing a project, they need to attribute an equal weight in their assessment of future performance to the quality of company management and past operational performance. Even then, it is not an exact science but rather an art of being able to sufficiently trust in management, the business model, and the company's respective positioning in industry.

The Difficulty in Predicting the Outlook for Investment of Megaprojects

This point leads us to the final discussion point of this chapter, which is the degree to which the OFS sector is able to assess its outlook at both the industry and company level. Contractors are known to be inherently positive with regard to the future; quoting Kris Nielsen, chairman of Pegasus Global Holdings, "They are the most optimistic group of companies on the planet." It is no wonder that, at times, it can be hard to differentiate company managements' emotion from reality when it comes to their own economic predictions. When company managements discuss the outlook for their own industries, they tend to focus on the following prevailing indicators:

1. the number of positive conversations they are having with their clients (i.e., IOCs and NOCs) and their own assessments of how likely those conversations are to eventually translate into orders and contract awards,
2. the economic usage of their companies' fleets and resources and to what extent capacity is covered by current backlog (this measurement should provide good enough revenue visibility at least for the short term),
3. prevailing commodity prices and where the managers think the prices will trend in the near and medium term,
4. regional supply–demand balances, and
5. the extent to which NOC investment dominates and final investment decisions are made, largely independent from global macro trends and driven typically by domestic energy needs and political agendas.

In my experience, most of these indicators can be subject to quite a lot of interpretation, and in light of contractors' natural bias to be optimistic, they tend to be presented in a positive light irrespective of how bad things really are at the macro and industry level. This bias can make it naturally quite hard for the market to correctly judge a company's view on the industry outlook, particularly during this recent time of high market volatility and lack of visibility around global growth and the sovereign debt crisis, issues that are all too hard for management to predict well, despite being critical to the forecasts it makes at the micro level.

Summary

As has been seen from the performance of contractors within the energy industry, the stronger the diversification that exists, the greater a company's ability to weather economic downturns will be, particularly in industries focused on a commoditized service. The likelihood for greater success also can be seen in commodity up cycles, as was the case after the late 1990s, when the recession led owners to shed resources, such as high-value labor. Shedding labor led to a skill vacuum as the commodity market drove upward. This skill vacuum has largely been filled through the dramatic growth of the oil services sector, itself an industry that has seen success with the record number of final investment decisions for larger projects that have taken place since 2000. The oil services sector has seen a rise in the use of cost-plus and unit price contracts; however, the lump-sum method remains the preferred contract method for this industry. In all contracts, the use of greater contingencies has been seen as a method to minimize the financial vulnerability of the company in the event of a worst-case scenario. Although there has been improvement in contract transparency, that transparency has yet to be matched by transparency in operational and execution performance. To help mitigate the lack of performance transparency, it is important to give equal weight to the quality of company management and past operational performance. In predicting the outlook for investment in megaprojects, a number of factors must be examined. It is also important to put a contractor's outlook in the proper context because often they may present a more optimistic view than the industrywide market will ultimately bear.

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CHAPTER 4

Project Delivery Methodologies

Peter Hughes

Various options for the delivery of megaprojects are available to the project developer or sponsor. Choosing among them requires sensitivity to the tensions that will exist among the many parties involved in project delivery. The relationships among project delivery parties may require realignment as those involved parties express their individual concerns, limitations, and risk exposure appetites.

Sophisticated owners and developers of megaprojects recognize that cooperative delivery methods with their entire delivery team result in projects that have faster and more trouble-free (and claims-free) delivery, improved economic results, and better whole-life performance. Collaborative delivery methods include well-developed relationships and alliancing models to achieve such goals.

Basic Project Delivery

Simple public projects traditionally are built around a simple delivery model: design–bid–build (DBB). In this model, the public agency hires an engineer or architect to fully design the project, then puts the project with 100% complete drawings out to bid, and then selects the "lowest responsive and responsible bidder" to build and deliver the project. Public construction legislation has used this model for decades as the basis for the legal requirements for the delivery of public contracts: A professional designer is selected on the basis of qualifications, and a contractor is selected on the basis of a low bid. This method is commonly known as "the little Brooks Act" or the "mini-Brooks Act," and it mimics the requirements of the Brooks Act, which the United States passed in 1972 and which requires the U.S. federal government to select engineering and architecture firms based on qualifications, with price being negotiated later in the selection process.

Once the facility is built, it is delivered to the owning agency for occupancy, operation, and maintenance. The construction contractor typically gives a one-year

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LESSONS LEARNED

1. There is a wide range of project delivery methodologies available for megaprojects.
2. The classic design–bid–build (DBB) delivery methodology does not provide seamless warranty coverage for the owner but is still widely used in public megaprojects.
3. The integrated design–build (DB) delivery methodology provides more seamless warranty coverage for the owner, and its use is growing in both public and private megaprojects.
4. There is a growing body of standardized contracting forms that can be used as the foundation for a DB delivery methodology.
5. The integrated design–build–operate (DBO) delivery methodology has become a viable delivery methodology for public megaprojects because it aligns the interests of the designer, builder, and long-term operator of the megaproject.
6. The use of the integrated public–private partnership (PPP) delivery methodology is growing as public entities face difficulties in raising the capital necessary to fund public megaprojects and gigaprojects.
7. The most critical factor in using a PPP is the development of the organizational structure under which the megaproject will be executed and operated over the long term.
8. Ultimately, the use of an integrated delivery methodology coupled with a positive incentive system is proving to be successful globally.

warranty from the date of substantial completion (i.e., the date on which the facility is available for its intended use) on materials, equipment, and construction.

The classic problem for the owning agency with this form of delivery is that the standard for performance of the designer and the warranty given by the contractor do not necessarily provide seamless coverage for the owner. Under the design contract, the designer typically has the professional duty of care, that is, the designer is liable to the extent provided in the contract for deficiencies in the design, as measured against the objective standard of performance for similar professional firms in the market performing design on similar projects. This agreement does not mean that the designer is a guarantor of the project, of the eventual cost of construction, or of the facility's operating performance.

At the same time, a low-cost bidder assumes in the bid that he or she is bidding on a "perfect" project. The contractor does not allow in a low-cost bid for conditions such as late delivery of drawings, owner changes in requirements, defects in drawings or field interferences, excess requests for information (RFIs), unanticipated subsurface conditions, other forms of force majeure delay, or the like. Each of these problems can be the basis for a claim by the contractor against the owner, and the wise owner may budget for up to an additional 20% in costs over the low bid to allow for such possibilities.

Integrated Project Delivery: Design–Build

For economically effective delivery of public projects, the simple DBB model has been under assault for several decades. In the private sector, more sophisticated delivery models have long existed, and those models are now being recognized as more effective for public projects as well. Private industrial clients have used DB or engineering, procurement, and construction (EPC) contracts for many years as their preferred delivery models. Federal agencies, particularly the FHWA, have been seeking more cost-effective delivery systems and have concluded, for example, that on federal highway projects (such as the U.S. interstate system), that DB will be 15% more cost effective than DBB delivery, mainly because of the economies produced by shorter project delivery time.

Since 1990, the FHWA has allowed the state departments of transportation (DOTs) to evaluate nontraditional contracting techniques under a program titled "Special Experimental Project No. 14: Innovative Contracting." Originally, the contracting practices approved for evaluation were cost-plus-time bidding, lane rental, DB contracting, and warranty clauses. After a period of evaluation, the FHWA decided that all four practices were suitable for use as operational practices (that is, nonexperimentally) (USDOT 2011).

SEP-15 is a new experimental process for FHWA to identify, for trial evaluation, new public–private partnership approaches to project delivery. It is anticipated that these new approaches will allow the efficient delivery of transportation projects without impairing FHWA's ability to carry out its stewardship responsibilities to protect both the environment and U.S. taxpayers.

SEP-15 addresses, but is not limited to, four major components of project delivery:

- Contracting,
- Compliance with environmental requirements,
- Right-of-way acquisition, and
- Project finance.

Elements of the transportation planning process may also be involved (USDOT n.d.).

The second recognized advantage of DB delivery is that it aligns the interests and performance of the project designer with those of the constructor. Construction staff are likely to be directly involved in the design phase, and many constructability efficiencies are likely to be introduced into the design process. These efficiencies often result in a further 15% reduction in capital cost, through more efficient construction methods and further improvements in delivery schedule.

As a result of the recognition of efficiencies in project delivery through such alternative delivery methods, most states in the United States have revised their public procurement statutes to permit the use of integrated project delivery methods such as DB for public projects. In some states, this revision has been in the form of granting a broad permit to all state, municipal, and special district agencies to use such forms of delivery (Colorado 2007). In others, the state legislature has permitted such forms of delivery in more limited or experimental circumstances, by limiting it to specific agencies (such as the state DOT), to a limited number of projects, or to a limited set of projects per year, at the end of which the legislature then requires a report on demonstrated results.

One of the other limitations manifested in state legislation for alternative delivery methods has been a desire to protect certain political interests in the state. This political interest can be the consulting engineers of the state, who are concerned about a loss of business if projects move to integrated design–build (Texas Transportation Code 2005), or the general contractors who have similar concerns (as in Alabama), or the specialty trades (as in Pennsylvania). These concerns and interests can delay the broadening of state project delivery methods for many years and can also result in protective requirements for these interests to be included when the appropriate legislation is finally passed.

In the long run, and particularly with the tailwind of federal funding agencies behind it, it appears that the general adoption of permission to use integrated project delivery methods will soon occur.

Several industry groups have published forms of DB contracts, which have reached wide acceptance and are generally available online.

The American Institute of Architects (AIA) publishes DB contract forms that are suited to commercial building projects. These forms include (AIA 2012):

- A195-2008, Standard Form of Agreement between Owner and Contractor for Integrated Project Delivery;
- A295-2008, General Conditions of the Agreement for Integrated Project Delivery; and
- A441-2008, Standard Form of Agreement between Contractor and Subcontractor for a Design–Build Project.

The Engineers Joint Construction Documents Committee (EJCDC) is a joint committee of the American Consulting Engineers Council (ACEC), the National Society of Professional Engineers (NSPE), and the ASCE. EJCDC has a similar set of DB contract forms that are suited to engineered projects. These include (EJCDC 2010):

- D-505, Standard Form of Subagreement Between Design/Builder and Engineer for Professional Services, for use by an engineering subcontractor to a construction company which has taken the prime contract with the owner;
- D-520, Standard Form of Agreement Between Owner and Design/Builder, Stipulated Price;
- D-521, Suggested Form of Subagreement Between Design/Builder and Subcontractor on Stipulated Price Basis;
- D-525, Suggested Form of Agreement Between Owner and Design/Builder on Cost Plus Basis;
- D-526, Suggested Form of Subagreement Between Design/Builder and Subcontractor on Cost Plus Basis;
- D-700, Standard General Conditions of the Contract Between Owner and Design/Builder; and

- D-750, Standard General Conditions of the Subcontract Between Design/Builder and Subcontractor.

In the United States, the Associated General Contractors (AGC) have adopted a set of DB forms that are particularly well suited to large infrastructure projects. Like those of the EJCDC, this set includes suitable forms of subcontract, which match the forms of the primary contracts, plus related project administration documents.

As the AGC states (ConsensusDOCS 2012),

> The advantages of using industry-accepted standard form contracts are significant. If the standard form is a ConsensusDOCS form, industry experts—owners, general contractors, specialty contractors, design professionals, construction law attorneys, sureties and others—have collaborated in the drafting process—an assurance that you have the best minds in the business crafting and scrutinizing each document. ConsensusDOCS solicits input from all segments of the design and construction industry. As a result, a broad range of industry viewpoints are weighed and considered, ensuring an equitable balance of risks and responsibilities and an appropriate baseline for the parties' legal relationship.

The AGC's original DB forms have now been subsumed into the AGC's ConsensusDOCS and include, with their relative document numbers:

400 **Preliminary Agreement Between Owner and Design–Builder:** Intended to be used in conjunction with ConsensusDOCS 410 or 415 to take the project through schematic design only.

410 **Agreement and General Conditions Between Owner and Design–Builder [Cost of Work Plus Fee with Guaranteed Maximum Price (GMP)]:** May be used as a follow-up document to ConsensusDOCS 400 or as a stand-alone document that addresses the entire design–build process.

415 **Agreement and General Conditions Between Owner and Design–Builder (Lump Sum Based on the Owner's Program Including Schematic Design Documents):** Unlike the ConsensusDOCS 410, this document cannot be used as a stand-alone document to address the entire design–build process. It is intended as a follow-up document to ConsensusDOCS 400, assuming schematic design documents are included.

420 **Agreement Between Design–Builder and Design Professional:** Delineates the respective rights and responsibilities of the design–builder and design professional.

421 **Statement of Qualifications:** Provides information to owners to assess the qualifications of a design–builder.

450 **Agreement Between Design–Builder and Subcontractor:** Intended for use where the subcontractor has not been retained to provide substantial portions of the design.

460 **Agreement Between Design–Builder and Design–Build Subcontractor [Subcontractor Provides a Guaranteed Maximum Price (GMP)]:** Intended for use where the subcontractor is retained by the design–builder early in the design phase. Construction is performed based on cost of the work, plus a fee, up to the GMP.

470 Performance Bond (Surety Liable for Design Costs of Work): Bond between the surety and design–builder where the surety is liable for the design costs; includes surety obligations, design liability, dispute resolution, and more.

471 Performance Bond (Surety Not Liable for Design Services): Bond between surety and design–builder where the surety is not liable for the design costs; includes surety obligations, design liability, dispute resolution, and more.

472 Payment Bond (Surety Liable for Design Costs of Work): Bond between surety and design–builder where the surety is liable for the design costs; includes surety obligations, design liability, dispute resolution, and more.

473 Payment Bond (Surety Not Liable for Design Services): Bond between surety and design–builder where the surety is not liable for the design costs; includes surety obligations, design liability, dispute resolution, and more.

481 Certificate of Substantial Completion: Establishes the date of substantial completion of the work.

482 Certificate of Final Completion: Establishes the date of final completion of the work.

491 Application for Payment (Cost of Work with GMP): Used with the ConsensusDOCS 410 and provides for notarization.

492 Application for Payment (Lump Sum): Used with the ConsensusDOCS 415 and provides for notarization.

495 Change Order (Cost Plus with GMP): Used with the ConsensusDOCS 410 and requires design–builder and owner signatures.

496 Change Order (Lump Sum): Used with the ConsensusDOCS 415 and requires design–builder and owner signatures.

The Design–Build Institute of America (DBIA) has produced a balanced set of DB contract forms that are suited for a wide variety of DB projects, commercial, industrial, and infrastructure. These forms include the following:

- **501** Contract for Design–Build Consultant Services
- **520** Standard Form of Preliminary Agreement Between Owner and Design–Builder
- **525** Standard Form of Agreement Between Owner and Design–Builder—Lump Sum
- **530** Standard Form of Agreement Between Owner and Design–Builder—Cost + Fee with an Option for a GMP
- **535** Standard Form of General Conditions of Contract Between Owner and Design–Builder
- **540** Standard Form of Agreement Between Design–Builder and Designer
- **550** Standard Form of Agreement Between Design–Builder and General Contractor—Cost + Fee with an Option for a GMP
- **555** Standard Form of Agreement Between Design–Builder and General Contractor—Lump Sum

- **560** Standard Form of Agreement Between Design–Builder and Design–Build Subcontractor—Cost + Fee with an Option for a GMP
- **565** Standard Form of Agreement Between Design–Builder and Design–Build Subcontractor—Lump Sum
- **570** Standard Form of Agreement Between Design–Builder and Subcontractor (Where Subcontractor Does Not Provide Design Services)
- **E-BIMWD** Building Information Modeling (BIM) Exhibit
- **E-INSWD** Insurance Exhibit—Design–Builder's and Owner's Insurance Requirements
- **E-SUSWD** Sustainable Projects Goal Exhibit (With Provisions on LEED Certification)
- **500-D1** Project Schedule of Values and Design–Builder's Application for Payment
- **500-D2** Design–Build Change Order Form
- **500-D3** Design–Builder's Affidavit of Final Release Form
- **500-D4** Certificate of Substantial Completion Form
- **500-D5** Design–Build Work Change Directive Form

Integrated Project Delivery: Design–Build–Operate

One of the advantages of integrated project delivery methods is that they can encompass more than the design and construction of a project by a single entity. They can also include operation and maintenance of the facility and can be extended to include financing options: design–build–operate (DBO), design–build–own–operate (DBOO), design–build–own–operate–transfer (DBOOT), up to a full operating and ownership franchise. (The sophisticated financing models are beyond the scope of this chapter.)

DBO is now a viable option for public owners in the water and wastewater sector. The project delivery industry in this sector includes a number of players who can design and construct a water or wastewater facility and who are then prepared to operate and maintain them for many years. Recent changes in federal tax law now permit the operations component of a DBO contract to extend for 20 years, with options for further renewals.

The use of a DBO contract has a number of attractions for a public water agency. The first is that it aligns the interests of the designer and constructor with the interests of the long-term operator. The selected contractor may elect to make choices during the design and construction phases that are conducive to both the effective and economical operation and the long-term sustainability of the project through the operating period, rather than perhaps taking short-term advantages for reducing capital costs, which could adversely affect the operations and maintenance phase.

The second advantage to the public water agency is that at the end of the contractual operating period, the plant may be in substantially better condition than if the agency had operated it for that period with its own staff. The DBO contract includes specific provisions relating to the required condition of the plant at the

CASE STUDY 4-1. HOUSTON METRO EXPANSION

The Metropolitan Transit Authority of Harris County, Texas (Houston Metro), has built its first operating light rail transportation (LRT) line, the Red Line, and is now engaged in a major expansion of the system. The next four lines of the system plus maintenance facilities have been awarded for development to a facility provider, as that term is used in the Texas Hybrid Delivery System Act. This megaproject has a projected installed cost of more than US$2.5 billion. The project begins with a development agreement between Houston Metro and the selected facility provider, a major transportation engineering and construction company.

As required by the Hybrid Delivery System Act, Houston Metro initially hired the selected civil engineers to commence system design. These engineering contracts were subsequently assigned to the facility provider, with the position and role of the selected civil engineers protected under the terms of the act.

The facility provider is acting as the leader of a consortium for the project, The development agreement will be replaced with a series of implementation agreements:

- A DB contract between Houston Metro and the facility provider (which will include the selected civil engineers as subcontractors).
- A vehicle supply contract between Houston Metro and the facility provider (with the vehicle supplier as the major participant in a new joint venture for that project element).
- An operations and maintenance (O&M) contract between Houston Metro and a new entity to be formed by Houston Metro and an international transportation operator, with an initial term of five years and optional extensions up to a maximum of 35 years.
- Houston Metro is purchasing the necessary railcars for the system from CAF (Construcciones y Auxiliar de Ferrocarriles, S.A.), a Spanish railcar supplier, with this agreement to be assigned as the vehicle supply contract.
- The vehicle is a metric track light rail vehicle (LRV), two-way with two driving cabs, comprising five articulated body sections supported by two end motor wheel sets under the central station. The LRV floor is low, along with the whole passenger saloon.
- The LRV shall fulfill the Americans with Disabilities Act (ADA) accessibility requirements. To this end, secondary hydraulic suspension shall be fitted whereby the height of the accesses to the LRV can be maintained constant, regardless of the passenger load. In this way, the existing barriers are eliminated along the whole LRV and the entry and exit of passengers from platforms located virtually at the level of the sidewalk is extremely comfortable.

- The primary pieces of equipment are roof mounted. The traction equipment is based on insulated gate bipolar transistors (IGBTs) and comprises three-phase motors. The train and traction control is microprocessor based. High-performance air conditioning equipment is used for passengers. The cab air conditioning equipment is independent from saloon units. Electric service brakes are assisted by hydraulic brakes in all bogies. Emergency brakes use electromagnetic shoes on all bogies. Resilient wheels, couplers that can be stowed behind the body end, destination signs, flanges and track lubrication, and many more amenities are provided (CAF n.d.).
- The facility provider is required to provide a parent company guarantee for the consortium's performance to the project owner.
- The development agreement makes it clear that, although the facility provider is contractually placed in the role of statutory facility provider, it is Metro's expectation that all of the primary contractors undertake responsibility for the design, construction, equipping, financing, and O&M of the project. The facility provider is responsible for management, coordination, and integration until five years after the revenue service date for all facilities, including the resolution of any conflicts among the participating contractors. The various primary contracts (each with Houston Metro as a party) will then be coordinated through an interface agreement among the primary contractors (CAF).

end of the operating period and provides for a condition survey at that time. If the plant does not meet the contractual requirements, the operator has a contractual obligation to bring it up to those standards at its own expense. In addition, the contract provides for regular condition reports and for planned and agreed expenditures on the major maintenance, repairs, and replacements (MMR&R) budget over the operating period. The agency thus achieves more objective control over a third-party operator than it might in fact have over its own staff for the same period.

The third advantage to the public water agency may also be improved efficiency in staffing. The DBO operator is incentivized by the compensation provisions of the DBO contract to staff the plant at the most economically efficient level required for efficient operation, satisfaction of operating, environmental permit (or consent decree) requirements, and satisfaction of the "end-of-term" condition requirements. This level of staffing may be lower than the level at which the agency itself might expect to staff the plant or system because of its relationship with its existing workforce and their unions.

This final factor, in fact, produces some of the tensions that it is important for project sponsors to recognize. Public employee unions are often uncomfortable with DBO operators, with contract operators of existing systems, or with PPP operators (discussed later). This discomfort can lead to union opposition to project delivery systems on a DBO, contract operations, or PPP basis and to workforce resistance on a project. It will require careful negotiation by the operator of continuing union work contracts, and careful staff management. This form of union-led opposition can also manifest itself in nonobvious union funding of "public interest" groups that use collateral laws, such as environmental impact statement requirements, to delay or frustrate private operation of publicly owned facilities or systems. As an example, the Service Employees International Union (SEIU) was eventually revealed to have financed the position of the Concerned Citizens of Stockton, the Sierra Club, and the League of Women Voters in their use of the California Environmental Quality Act provisions to frustrate the city of Stockton's outsourcing of operation and maintenance of the city's water and wastewater system—even though SEIU was not a union representing any workers in the system.

In sectors other than the water–wastewater sector, project delivery on a DBO basis may require that a consortium of delivery companies may need to be performing, each bringing its particular expertise to bear.

- In a highway transportation DBO project, for example, the necessary consortium may consist of a design firm, a construction company, and a highway surface technology company. The highway surface technology company may have proprietary formulations for polymerized asphaltic surfaces that enable it to offer extended highway surface wear warranties.
- In a light rail transportation (LRT) DBO project, the necessary consortium may consist of a design firm, a construction company, a railcar supply company, and an operations and maintenance (O&M) company.

As may be expected, the constitution of such a DBO delivery consortium results in significant internal tensions. Each consortium member is willing to take risk exposure for that element of the project over which it has general control but usually wants to be protected against liability for project elements that are not in its control. The construction company, for example, is willing to take on the responsibility and associated liability for the quality of construction of the facility but wants to limit the duration of its liability to the period of performance plus a normal construction warranty period (typically one or two years). The construction company is not going to be comfortable with a share of what it perceives to be a 20-year liability tail associated with the O&M period of the contract. Conversely, the railcar supplier is willing to take on the responsibility and associated liability for railcar design and performance and may look on the 20-year O&M period as desirable backlog, but it is not going to be comfortable with design or construction risk of the fixed assets in the LRT system.

The result of these tensions is that the owner needs to determine how it desires to allocate liability to its delivery contractor. If it wants single-point responsibility, the owner has two choices: either to require that the consortium members form themselves into a multiparty joint venture, in which all participants have joint and several liability for project delivery and performance, or to require that one of the consortium members (usually the member with the deepest balance sheet) steps up as the contracting party for the full DBO project, with the other consortium members as subcontractors for their specific elements of delivery.

The developer of a megaproject also wants to examine carefully the methods of motivating the DBO participants to align their performance with the owner's goals for the project. Again, the opportunity to use more sophisticated delivery models carries with it the opportunity to use more sophisticated incentives and motivators.

Some owners only attempt to motivate project cost performance through *negative* contractual methods. To control costs, they might use a guaranteed maximum price (GMP) model. In this form, the contractor performs defined services on a cost-reimbursable basis but with a GMP imposed as an agreed cost ceiling. If the contractor reaches the GMP before completing performance, then the contractor is contractually obligated to complete performance without further compensation. Unfortunately, this model conveys all the advantage of well-managed costs to the owner and all the risk of cost overruns to the contractor. Most contractors do not perceive that they may exceed allowable costs until late in the project when cost control methodologies may be too late. The more successful variant of the GMP model uses *positive* contractual incentives, where the owner requires a GMP from the contractor but with a substantial sharing in cost savings credited to the contractor on an agreed basis. The savings sharing can be a simple percentage sharing (e.g., 30–70, 50–50, or 60–40), or it can be more sophisticated, involving collars and caps or varying percentages depending on the savings available.

Similar considerations apply to project schedule. Completion by a date certain may be important to the owner, whether for political reasons,[1] tax reasons, commencement of revenue service and thereby debt service,[2] or for other reasons. Again the form of *negative* incentive that the owner may wish to apply for delayed contract completion is usually in the form of liquidated damages at a specified rate per day (either a fixed dollar amount or a percentage of cost amount) for each day of late completion. Again, most contractors do not perceive that they may be late and may not be able to make up project delays late in the project when schedule makeup may be impossible. A far more effective motivator for schedule performance is the use of *positive* incentives—a bonus—for early completion. This incentive motivates and drives project behavior from the beginning of the project.

The most extreme forms of the use of negative contractual incentives sometimes arise when an early project adviser to the owner focuses too heavily on risk transfer mechanisms as a method of conveying "value" in its own services to the owner. In such cases, the adviser may draft delivery contracts for the owner to issue that attempt to transfer far more risk to the delivery contractor than is feasible or customary in the industry. Typically, a contractor is prepared to accept business risks on

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1 One of my early projects required completion of a microwave communications link between Anchorage and Fairbanks, Alaska, before Jan. 1, 1974. It was eventually determined that the motivation for the selection of that date was that Sen. Mike Gravel had made a political promise to the citizens of Fairbanks that they, as the citizens of Anchorage already had, were to have color television available to watch the Rose Bowl that year in full glorious color. The communications link was placed into service on Dec. 27, 1973.

2 Delayed opening of the Denver International Airport (DIA) in 1994 because of failures in the performance of the baggage handling system cost the city of Denver about US$1 million a day in debt service for more than 300 days, paid for out of the debt service reserve that had been included in the financing facility for the DIA project.

a contractual basis that bear a reasonable relationship to the likely profit that the contractor may make if the project is a success, that is, a reasonable percentage of the contractor's total price for delivery. Some advisers, however, attempt to convey all of the owner's business risk to the contractor, which could even be in excess of the contractor's total price.

In the worst case, this process could include attempting to make the contractor cover the owner's financing cost (debt service) in the event of delayed opening. This situation is a classic form of consequential damages, for which most construction contracts contain an exclusion, not an affirmative undertaking. The capital structure of most construction companies makes it impossible for them to accept such excessive risks, and there is no insurance market whatever for this risk allocation.

The result of this kind of overreaching by advisers is that either the owner receives no responsible bids or the bids received include a substantial risk premium for the contractor, which substantially inflates the cost of the project.

Integrated Project Delivery—PPP

A further advantage of integrated project delivery methods is that they can extend to financing alternatives for public agencies. When an agency needs a new facility to provide a public service but is constrained in the amount of capital debt that it can incur, it is possible for the agency to ask nonpublic providers to design, build, and finance the facility and to provide the benefit of the facility to the agency on a "service provided" basis. This method is often the basis for a Public–Private Partnership (PPP) relationship.

Grimsey and Lewis (2004, pp. 108–110) define the PPP relationship as follows:

> **THE ORGANIZATION OF PPPs**
>
> A PPP is an organizational structure that brings together a number of parties for an infrastructure investment, typically in the form of a "Special-Purpose Vehicle" (SPV) created specifically for the project. The main participants are:
>
> - The public sector procurer (the government, local governments and agencies, state-owned entities);
> - The sponsors who as equity investors normally create a SPV (or project company) through which they contract with the public procurer, and the principal subcontractors;
> - Financiers;
> - Subcontractors; and
> - Other involved parties (e.g., advisers—legal, financial, technical, insurers, rating agencies, underwriters)
>
> In a project, each retains its own identity and responsibilities. They combine together in the SPV on the basis of a clearly defined division of tasks and risks.

CASE STUDY 4-2. CONFEDERATION BRIDGE

One particularly interesting megaproject developed on a PPP basis was the Confederation Bridge, connecting Prince Edward Island (PEI) with New Brunswick, in Canada.

As part of PEI's admission into the dominion of Canada in 1873, the Canadian government was obligated to provide

> efficient steam service for the conveyance of mails and passengers to be established and maintained between the Island and the mainland of the Dominion, winter and summer, this placing the Island in continuous communication with the Intercolonial Railway and the railway system of the Dominion.

After the election of the Progressive Conservative government of Brian Mulroney, with its agenda for regional development through so-called "megaprojects," Public Works Canada called for formal proposals in 1987 and received three offers. These proposals included a tunnel, a bridge, and a combined tunnel–causeway–bridge.

These developments sparked an extremely divisive debate on the island, and Premier Joe Ghiz (the leader of the island) promised a plebiscite to gauge public support, which was held on Jan. 18, 1988.

During the plebiscite debate, the antilink group, Friends of the Island, cited potential ecological damage from the construction as well as concerns about the effect on Prince Edward Island's lifestyle in general and noted that the megaproject model had had limited success in other areas of the world and rarely enriched the local population. Friends of the Island believed that the Canadian government was the pressure behind building a fixed link because they were not willing to shoulder the cost of the constitutional obligations for funding an efficient ferry service. They also argued that a link would be built largely for the benefit of mainland tourists and businesses waiting to exploit the Island.

The prolink group, Islanders for a Better Tomorrow, noted that transportation reliability would result in improvements for the export and tourism industry. The result was 59.4% (total percentage) in favor of the fixed link.

The debate did not end with the 1988 plebiscite, and the federal government faced numerous legal challenges and a lengthy environmental impact assessment for the project. The developer of the single bridge proposal, Strait Crossing Development Inc., was selected (I was a member of a competing consortium), and an announcement that the Northumberland Strait Crossing Project would be built was finally made on Dec. 2, 1992. The developer was required to privately finance all construction through bond markets.

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Shareholders of Strait Crossing Development Inc. included

- OMERS, an Ontario public servant pension fund;
- VINCI Concessions Canada Inc., of Montreal, Quebec;
- BPC Maritime Corporation, of Toronto, Ontario;
- Strait Crossing Inc., of Calgary, Alberta (a subsidiary of W. A. Stephenson/Stephenson Construction International (SCI) Engineers & Constructors Group of Companies); and
- Ballast Nedam Canada Ltd., of Edmonton, Alberta.

The bridge is a two-lane highway toll bridge that carries the Trans-Canada Highway between Borden-Carleton, PEI (at Route 1) and Cape Jourimain, New Brunswick (at Route 16).

It is a multispan posttensioned concrete box girder structure. Most of the curved bridge is 40 m (131 ft) above water, and it contains a 60-m (197-ft)-high navigation span to permit ship traffic. The bridge rests on 62 piers, of which the 44 main piers are 250 m (820 ft) apart. The bridge is 11 m (36 ft) wide.

The speed limit on the bridge is 80 km/h (50 mi/h). It takes about 10 min to cross the bridge.

Tolls are paid only when exiting PEI; as of March 2012, the toll rate was C$43.25 (roughly the same in U.S. dollars) for a two-axle automobile, with other rates for different types of vehicles (Strait Crossing Bridge Limited 2008).

Technical challenges resolved in the design of Confederation Bridge included a shipping channel clearance span to accommodate shipping headed for the St. Lawrence Seaway, the ability of the bridge piers to handle and to clear the drive ice of the strait in wintertime, and protected access within the bridge's box girder for maintenance personnel during severe winter conditions.

The financial challenge of the bridge project was that toll collection alone would not be enough to pay for the construction cost and debt service on the project financing. The bridge would therefore have to be subsidized by the Canadian government. The government already incurred substantial annual costs because of its constitutional commitment to maintain the ferry transportation connection of PEI with mainland Canada. Part of the government's justification for the permanent connection was to fix, optimize, and perhaps eventually eliminate the cost of the ferries. Effectively, the economic challenge for the consortia proposing the project was therefore to bid the minimum subsidy that would be required to make the project financially viable.

Included in this calculus was the possibility for a structure or demand-based tolling system. The main traffic load on the bridge occurs during the

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summer months, when PEI as a vacation destination brings in major vacation traffic. During the remainder of the year, relatively light commercial traffic occurs, mostly PEI's agricultural products. It was therefore possible to consider either a seasonally weighted toll system or a toll system in which PEI residents (or PEI-licensed vehicles) paid a preferential rate and off-PEI vehicles paid a higher standard toll.

Special-Purpose Vehicle

An SPV is simply a separate legal entity, generally a company, established to undertake the activity defined in a contract between the SPV and its client, in this case the public procurer. Execution of the activity generally requires the involvement of a number of parties and the SPV enters into subcontracts with a number of organizations for the execution of these activities. SPVs are used in PPPs for the following reasons:

- To allow lending to the project to be non-recourse to the sponsors by virtue of the limited liability nature of the SPV;
- To enable the assets and liabilities of the project not to appear on the sponsors' balance sheets, by virtue of no sponsor having more than 50 per cent of the shares in the SPV and the application of normal consolidation principles when preparing the group accounts; and
- For the benefit of the project lenders, to help to insulate the project from a potential bankruptcy of any of the sponsors ("bankruptcy remoteness").

Two Approaches

The generic form of the consortium, which is likely to include debt financiers (often in a syndicate arranged through a bank), equity investors and sponsors (who invest in the fortunes of the project and are therefore exposed to both the "upside" and "downside" risks), a design and/or construction contractor, and the operator. In terms of which parties take the lead in organizing the arrangement and putting together the bid, there are two alternative approaches: the traditional construction and facilities management-led approach, and the new financier-led approach.

PPP delivery has been well developed in Great Britain, Canada, Australia, Holland, and other European countries. It is now widely used for hospitals and medical facilities, social housing, toll roads and light rail systems, bridges, tunnels, wastewater treatment facilities, courts, museums, schools, and prisons. Grimsey and Lewis (2004, pp. 1, 3–6) cite examples from 17 countries. In Britain, "The British Government launched its PPP development policy in 1992 under the 'Private Finance Initiative.' Since then, the technique has been applied systematically to virtually every area of significant government capital spending in the UK. Partnership

UK was established in 2000 to promote PPP/PFI [Private Finance Initiative] concepts. It also works on local authority projects" (Grimsey and Lewis 2005, p. 350).

Program Management

The owner of a project frequently finds that it does not have the requisite staff and skill set to manage the development and delivery of the project itself. In that case, the owner is likely to hire a professional project manager. Megaprojects are often clusters of projects that require an even higher level of management than a normal project. For megaprojects, the owner is likely to retain a program manager.

Under a program management agreement, the owner contracts directly with designers and contractors (or design–builders) for the individual projects within the program but also contracts with a program management company to provide the necessary program coordination services for the program as a whole.

Alliances

In the early 1990s, oil companies building megaprojects in the North Sea for offshore oil production became profoundly unhappy with their project delivery methods and the results they were achieving. Led by British Petroleum (BP), they developed the concept of "alliancing" as a method for project delivery, which would be much more effective in aligning the project delivery team with the goals of the project owner while at the same time minimizing disputes and claims on the project.

The first of the alliance projects, the North Sea offshore oil and gas platforms, BP Hyde and BP Andrew projects, were constructed in the early 1990s. Results reported for these platforms were the following:

- GB£450 million (approximately US$712 million in 1990 dollars) first estimate,
- GB£370 million (approximately US$585 million in 1990 dollars) sanction to proceed,
- GB£290 million (approximately US$459 million in 1990 dollars) cost (22%) savings, and
- Completed 6 months ahead of schedule.

In total, four UK offshore oil platforms aggregated savings of GB£550 million, approximately US$870 million in 1990 dollars, or 20% (Reilly 2011).

Australian project researcher Jim Ross had come to a similar conclusion, in particular noting that "claims and disputes have now become an endemic part of the construction industry . . . the problem of claims and disputes in the construction industry is a world-wide phenomenon" (Ross 2003). A project alliance is an operation in which an owner (or owners) and one or more service providers (e.g., designer, constructor, and supplier) work as an integrated team to deliver a specific project under a contractual framework where their commercial interests are aligned with actual project outcomes.

CASE STUDY 4-3. BART EXTENSIONS PROGRAM

The San Francisco Bay Area Rapid Transit (BART) provides rapid transit service to three counties in the Bay Area (San Francisco, Contra Costa, and Alameda), with commuter service to downtown San Francisco and Oakland as its core. The original X-shaped system was built in the 1960s with end points in Daly City, Concord, Richmond, and Hayward.

By the 1980s, the district wished to expand the system by extending each of those lines. This plan resulted in an extensions program under which the Daly City end would be extended to Colma and eventually to the San Francisco Airport (SFO). The Concord line would be extended to Pittsburg/Antioch (PAX), and the Hayward line would fork, with one extension to Warm Springs (WSX) on the Santa Clara County line and a second extension over the hills to the east to Dublin/Pleasanton (DPX). The fifth project in the extensions program was a systemwide controls upgrade. Each of these projects was in the US$600–800 million range, as expressed then, without an adjustment to current dollars.

To manage the program, BART retained Bay Area Transit Consultants (BATC), a joint venture of Bechtel Civil, Inc., Parsons Brinckerhoff Quade & Douglas, Inc., and two minority business enterprise (MBE) firms, J. Warren & Associates and Don Todd Associates. The preamble to the program management contract specifically acknowledges that "the services required for Project cannot be performed satisfactorily by the officers and employees of BART." The services to be provided were "additional preliminary engineering, final systems design, final design management, and procurement, installation, and construction management services for the BART Extensions Program."

The extensions program took more than a decade to complete; BATC provided program management services throughout. For much of that time, BATC had more than 100 people serving in BART's office space in Oakland. The program management contract was subject to annual renewals, with the scope and annual budget renegotiated each year.

Later in the program, BART committed to extend the San Francisco line to the San Francisco Airport and decided that the contract for the extension should be let on a DB basis. That extension would have about the same capital basis as each of the five preceding projects. The decision before BATC's members was whether they should remain in the program management role for the additional extension or whether they should withdraw from program management to be able to compete for the SFO airport extension job. In any event, they decided to remain in the program management role. This was the right decision, since BART did not end up awarding the SFO extension project as a single DB project. Under pressure from the local construction community, the BART board decided to break up the SFO extension into a series of individual projects in the US$30–60 million range, as expressed then, without adjustment to current dollars, on which local contractors could bid as first-tier general contractors.

CASE STUDY 4-4. DENVER INTERNATIONAL AIRPORT

Denver's commercial airport, then called Stapleton Field, had become outdated by the 1980s. It was limited in capacity and growth potential, it was increasingly surrounded by urban development, and it suffered from too many weather closures. As a result, the city of Denver planned a new airport further to the east on open prairie land. The new Denver International Airport (DIA) is now the third largest airport in the world in physical size. It has six runways, and being further from the front range of the Rocky Mountains than Stapleton Field, has clearer weather.

Construction of the airport involved more than 200 contractors operating under a variety of forms of contract. To manage them, the city hired about 15 construction managers. Even then the flow of information was too large for the city's project manager, Ginger Evans, to handle. As a result, she brought in Bechtel Civil to provide her with a monthly "delayed opening" report that would enable her to filter the flow of information down to those items requiring hard management attention as being the most likely to delay opening of the new airport. This report became an important management tool for the airport owner.

For her success in slashing politics and red tape to build the DIA, Ginger Evans was named *Engineering News Record*'s Man of the Year for 1994. At 39 years old, Evans was the first woman to ever win the industry's top prize <http://enr.construction.com/people/AOE-gallery/1990/1990-5.asp>.

Over a three-year period, the delayed opening report started with about 60 items that had the potential to result in a delayed opening. As the monthly report continued, this list steadily shrank. However, delays resulting from the automated baggage handling system were reported from the beginning, and continued to the end, when they manifested themselves in almost a year's delay in the start of operations.

The airport's computerized baggage system, which was supposed to reduce flight delays, shorten waiting times at luggage carousels, and save airlines in labor costs, turned into an unmitigated failure. An opening originally scheduled for October 31, 1993, with a single system for all three concourses turned into a February 28, 1995, opening, with separate systems for each concourse, with varying degrees of automation.

The baggage system, which initially cost US$186 million, as expressed then, without adjustment to current dollars, ended up costing DIA an additional US$1 million per day in additional debt service costs alone during the months of modifications and repairs. Incoming flights on the airport's B concourse made limited use of the system, and only United, DIA's dominant airline, used it for outgoing flights. The 40-year-old company responsible for the design of the automated system was BAE Automated Systems of Carrollton, Texas, a company that was at one time responsible for 90% of the automatic baggage systems in the United States. BAE Automated Systems was acquired in 2002 by G&T Conveyor Company, Inc.

The automated baggage system never worked well, and in August 2005, it became public knowledge that United would abandon the system, a decision that would save them US$1 million per month in maintenance costs (Johnson 2005).

Under traditional forms of contracting, responsibilities and risk are allocated to different parties, with commercial and/or legal consequences for the individual parties where they fail to manage their risks or properly discharge their contractual and/or legal obligations. Under a "pure" alliance, the alliance participants

- assume collective responsibility for delivering the project;
- take collective ownership of all risks (and opportunities) associated with the delivery of the project; and
- share in the "pain" or "gain," depending on how actual project outcomes compare with the agreed targets that they have jointly committed to achieve.

Under a pure alliance, risks are allocated in a precise manner—but this allocation is done through the operation of the risk–reward arrangements, not through legal liability (Ross 2003).

Project alliances have been widely adopted in Australia and are achieving significant benefits for project owners. The core principles for a project alliance are

- The collective delivery responsibility for the project team, including the owner;
- A three-tier management structure under owner leadership, which anticipates unanimous decision making on all project issues;
- The absence of cross-claims or lawsuits on the project;
- Compensation for project participants that includes coverage of direct costs, plus a fee, plus the application of "project modifiers" on a gainshare/painshare basis for cost elements and the application of key performance indicators (KPIs) for noncost elements; and
- Limitation of project participants' liability to the amount of their fee.

An example of alliance delivery is the Australian Water Security Program. This recent Australian project alliance was for the design and construction of four major water supply and planning projects of the Australian Capital Territory (Canberra). A term sheet for an alliance contract that illustrates the application of alliance principles is shown in Table 4-1.

So far, there has not been much use of alliance contracting in the United States. However, some of the experience, particularly with the use of "gainshare/painshare" principles and the design of KPI structures, is now starting to be used effectively.

Table 4-1. Term Sheet for Alliance Contract

Owner (O)	ACTEW (Australian Capital Territory—Canberra)
Alliance contractor (AC)	
Project	ACT Water Security Program—for major water supply
Selection process	O-solicited proposals; quality-based selection
Executive committee management	• Specified managing directors of O and AC • Alliance leadership group (ALG) • Alliance project management team (APMT)
Total outturn cost (TOC) (or target cost estimate)	• *To be determined on a project basis* • Developed on AC's "business as usual" basis • Includes a calculated risk of cost changes, based on Monte Carlo analysis of net risk and opportunity—this sets the "material level of risk"
Alliance principles	ALG: • Set strategy • Review performance by O and AC of their respective obligations • Review performance of all parties against goals in alliance principles • Decisions on matters referred by APMT, including changes and effects • Establish and review continuing appropriateness of KPIs • All parties equally represented (2 senior managers each; led by O's alliance project manager) • Monthly meetings • Unanimous decisions; if not, refer to a technical expert or the executive committee within 7 days • Technical expert selected by ALG; costs are a direct cost APMT: • All parties equally represented (3 project leaders each; O rep as alliance leader) • Weekly meetings, monthly reports • Manage the delivery of the words and performance of operations services • Budgets, plans, and schedules to achieve performance within TOC • Safety plan • Manage changes and effects (no adjustment to project brief, TOC, target date, or KPIs for a change that is not a scope change) Monitor performance against KPIs: • Resolve issues & differences • Unanimous decisions; if not, refer to ALG within 7 days Alliance principles to be developed and agreed by ALG at the foundation workshop

Alliance principles *(continued)*	O and AC agree to conduct all activities for project in good faith—acting fairly, reasonably, and honestly; not impeding or restricting the other; giving as much weight to the interests of the project as to their own interests Parties recognize O's wider responsibilities O's and AC's personnel work to resolve any differences at their level of management; if not, refer up to next level of management
Project phases	TOC development phase: • AC finalizes scope and TOC (within agreed time and budget); ALG agrees on TOC; O decides whether to proceed to works delivery phase (hold point) • AC pays for TOC development; fee is conditional on ALG agreeing to TOC Works delivery phase: • Liaison with government agencies on approvals • Design per project brief—APMT and AC's design team work cooperatively; monthly program updates • Environmental investigations and assessments; surveys • Community engagement per community engagement & stakeholder management plan • Construction and commissioning per project brief and agreed project delivery documents • AC develops and manages the site cooperative use plan for coordinated and cooperative site access and contractor use • Safety and environmental protection Operations services phase: Commissioning + 36 months
Primary responsibilities	O—primarily responsible for site access, approvals, payments, making explicit to AC the O's operation requirements, and making appropriate personnel available to the alliance for the APMT and ALG AC—primarily responsible for design, construction, performance testing, commissioning, defects rectification, and operations performance • Compliance with project brief, project delivery documents, applicable law, codes, and standards, good trade practice; fit for purpose stated in project brief; new, of appropriate quality, and not inherently dangerous or hazardous; professional standard; and all as required to meet project target dates • Procurement management plan —"AC must demonstrate to reasonable satisfaction of ALG that prices obtained from Subcontractors are competitive." —Vendors' warranties: Commissioning + 2 years • Commissioning plan for APMT agreement (includes training of O's O&M personnel) • No interference with existing operations Continuity of key personnel and important personnel

Table 4-1 *(continued)*

Compensation and payment	O engages alliance financial auditor to monitor costs AC compensation = direct costs + project fee + project modifiers • Project fee (% of direct costs) = corporate overhead + profit • Project modifiers = cost factors (gainshare/painshare) + noncost factors (KPIs)
Quality pool & KPIs	
Gainshare/painshare for project cost performance	• Actual outturn cost (AOC) compared to TOC • Owner costs are estimated for inclusion “below the line” in the project alliance AOC, for the purpose of assessing gainshare/painshare adjustment (G/PA) • G/PA mechanism applies to all TOCs; incentive to all parties to keep direct costs down and deliver value for money, to their joint benefit • “Pain”: If AOC > TOC, then “pain” is shared 50/50 by O and AC, up to maximum of AC’s total project fee • “Gain”: If AOC < TOC, then “gain” is shared on a variable basis: —If TOC − AOC < 2.5% of TOC, no gain share —If TOC − AOC > 2.5% and < 10%, then 50% gainshare to AC —If TOC − AOC > 10% and < 15%, then 25% gainshare to AC —Gainshare to AC capped at 5% of TOC • Project fee may be adjusted for over- or underpayment of gainshare/painshare • Gainshare to AC is shared 50/50 to AC member companies
KPIs on “quality pool” model for non-cost performance	• ALG sets KPIs—performance parameters to be monitored and measured to determine whether the alliance has achieved superior or inferior results in completing project • KPIs to be established for —Change management (human resources change + business processes change) —Community stakeholder confidence —Other community outcomes —Reliability of performance —Legacy and internal stakeholder satisfaction • Maximum values for quality pool: —Negatives: −1.5% of approved TOC —Positive if no gainshare: +1.5% of approved TOC • Positive if gainshare: +2.75% of approved TOC
Completion	
Construction completion	• When APMT is satisfied that requirements for construction completion are met, APMT recommends to ALG to issue the project construction completion certificate • ALG issues certificate, or AC works with APMT to satisfy ALG concerns

Commissioning completion	• Commissioning by AC per commissioning plan, in coordination with APMT • Performance tests; remediation by AC if necessary • When APMT is satisfied that requirements for commissioning completion are met, APMT recommends to ALG to issue the project commissioning completion certificate • ALG issues certificate, or AC works with APMT to satisfy ALG concerns
Defects rectification period	• Commissioning completion + 2 years; + 1 further year after any rectification • Cost of work during defects rectification period is a direct cost • Routine maintenance is an O's cost, not a direct cost
Project completion	• At the later of (a) end of defects rectification period, or (b) rectification of all defects, or (c) end of operations services term, then a PMT recommends to ALG to issue the project completion certificate • ALG issues certificate, or AC works with APMT to satisfy ALG concerns
Liability management	
Insurance	• AC carries contracts works insurance (builders' risk), public and products liability insurance (comprehensive general liability or CGL), plant and equipment insurance • Each AC member company carries professional indemnity insurance (errors and omissions) to project completion + 7 years, workers' compensation, auto liability • O carries property insurance on new assets after commissioning completion
Liability	• For projects < AU$100 million, AC liability capped at greater of TOC or AN$50 million • For projects > AU$100 million, AC liability capped at greater of AU$100 million or 50% of TOC • Proportionate indemnity for AC liability for 3rd party PI/PD; uninsured costs are a direct cost • AC not liable for O's consequential losses • O indemnifies AC for preexisting contaminants
Force majeure	• No liability for breach of obligations resulting from an event of force majeure

Project Development

All of the forms of project delivery discussed in this chapter so far have presumed that there is a governmental, commercial, or industrial owner who is pulling the project together. However, there is another form of project origination, and that is project development by project delivery participants who want to "grow their own clients."

A big impetus for project development was the deregulation of the power industry in the 1980s. Up to that time, most U.S. power was generated, transmitted, and distributed by fully integrated power companies (sometimes purely electric power, and sometimes combined gas and electric companies). Deregulation, however, resulted in the deintegration of these companies, and new electric power generation plants were developed by independent power producers (IPPs). This form of project development required new financing vehicles. Previously, an integrated electric utility could finance a new power plant through its corporate finance program, supported by its existing capital base.

MIT's Roger Miller and Donald R. Lessard (2001), in *The Strategic Management of Large Engineering Projects: Shaping Institutions, Risks, and Governance*, found that for many potential projects, a number of partners are brought together to make the project a reality. This includes external financing sources, whether banks, bond markets, or international financial institutions, that can provide the capital necessary for the project. In some cases, firms proposing a project may partner with equipment suppliers in an effort to find the best combination of engineering, technical, and operational experience. The lack of necessary expert resources creates a need to hire consultants or experts. The use of engineering consultants can facilitate the completion of a feasibility study or detailed engineering, among other things; for instance, banks will typically use outside engineers to examine the designs and cost estimates as part of their due-diligence process. The inclusion of governments, regulators, or community groups early in the project's development can allow for the social and political risks of the project to be mitigated by listening and reacting to these outside parties.

Given the potential number of participants included in the process, it is important to use incentives and contracts to appropriately gain control, allocate risks, and limit negative outcomes. Generally the goal should be to allocate the responsibility for a certain risk to the project member most effectively equipped with the skills or resources for such a risk. Project owners can maintain a higher level of control by awarding multiple contracts rather than by awarding the entire project design and construction to a single firm. Contractual risk-allocation can be achieved through special clauses, such as altering timing or certain activities to reduce risk or, in the case of a power plant, adding cost penalties for operating the plant at a below-optimal level.

In the generic structure of a project financing, the developer creates a special purpose entity (SPE), which is a nonrecourse or limited-recourse asset-holding entity. The developer then obtains expressions of interest for participation in the project from the other essential parties to project financing: the equity and debt participants who will provide both construction period and long-term financing, the agency that gives the necessary concession and the right to collect service fees from or on behalf of customers, who are the ultimate source of funds for costs of service and debt service for the capital cost.

Also expected to provide expressions of interest are the lessor of the land on which the facility will be built, permitting and tax agencies, as required, and then—as discussed above for other forms of project delivery—expressions of interest from the designer−constructor, the O&M contractor, and necessary input suppliers.

The SPE may have a direct relationship with customers or may provide its services to an agency or utility on an availability basis, with that entity collecting payments from customers and providing necessary subsidies, as may be negotiated.

In some cases, the architect–engineer, the constructor, the O&M contractor, and possibly input suppliers may take an equity interest in the project. It is also possible that one or more of the above entities can, in fact, be the developer. The equity interest may eventually take the form of a cash investment in the project, or at least a carried interest through a contribution of contract fees as equity.

With expressions of interest in hand, the developer can then negotiate term sheets with each of these major parties. The balancing of interests and tensions among these stakeholders takes place at the term sheet stage. Substantial financial modeling of various risk cases takes place at this phase, along with the negotiation of the payment priorities of the SPE, in the form of a "cash cascade," as well as the various security and reserve funds that the lenders require. One of the major tensions at this stage is likely to be the desire of both lenders and the project lessor that their financial interests take a higher priority.

Once the term sheets are agreed to, then the developer is reasonably sure that financing for the project will be available, and the SPE can proceed to drafting and negotiating each of the contracts represented by the term sheets, as agreed.

The final round of project development is then the layering over these principal agreements of the security instruments, which the lenders require to secure their financial interest in the project. These requirements include a mortgage interest in the physical assets, a "lock box" requirement on income to the SPE, a right of assignment of all project service contracts, the right to be the insurance beneficiary, and various forms of additional security and guarantees. Only when all of these requirements are agreed upon will the project proceed to financial closing and project delivery.

One of the significant problems that has emerged under this form of delivery model is that many large projects are built around the supply of major engineered equipment, and the lenders want to see single-point responsibility for project delivery. In traditional power generating plant delivery, for example, the electric utility provided that single point of responsibility to its sources of finance and then contracted separately for the major project elements. These elements were principally the steam boiler (for example, Combustion Engineering), the turbine–generator set (for example, GE, Westinghouse, ABB, or Siemens), and the balance-of-plant (BOP) contractor (for example, Bechtel, Fluor, or Stone & Webster).

With the deintegration of the power industry, integrated electric utilities were no longer available to provide that single point of responsibility, and the lenders turned to the suppliers to satisfy that need. The problem was that the equipment suppliers were willing to take responsibility for their specific equipment manufactured in their factories but were not willing to take total project delivery risk where they had no site or equipment-integration responsibility. This left the BOP contractors. For the BOP contractor, the major engineered equipment constituted a "black box," the insides of which they did not control, know, or understand and for which they could only obtain and rely on a limited guarantee from the equipment manufacturer.

One result has been that the BOP contractors—both on power projects and on other industrial projects with similar black box equipment—were obliged to provide project guarantees that included the black box equipment and to provide corporate parent guarantees for such projects. In some cases, significant problems developed on those projects, either in equipment performance or in the integration of performance, and the BOP contractors incurred significant losses.

The result of these performance stings is that there has been a downturn in project development and project finance for large industrial projects, and the industry is still sorting out the risk allocation in future project delivery models.

Summary

The infrastructure and industrial sectors of the construction industry provide many successful models for the delivery of megaprojects. These models build on simple construction models by adding tiers of management and control, which are provided by experienced companies and consultants, and by then breaking the megaproject down into delivery components for such effective management and control. The use of integrated delivery models, coupled with the use of positive incentive systems that align the interests of the owner and the contractors, is proving to be successful globally. These models can still be constructed with sufficient competition and transparency to assure the owners—and the public—that their best interests are being served. At the same time, the various models available can be adjusted to reflect the owners' priorities of interests, whether original capital cost, lifetime cost, cost-to-budget, efficient operation, or delivered schedule is the most important. And concurrently, these models can also satisfy the needs of the contracting community for fair compensation, a reasonable allocation of risk, positive incentives for great performance, safety of construction personnel and users, and a manageable workload.

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CHAPTER 5

Are Public–Private Partnerships a Solution to Megaproject Delivery Problems?

Richard G. Little

It has already been well demonstrated throughout this book that infrastructure megaprojects are defined more than simply by size or cost. Although they typically cost more than US$1 billion (and oftentimes much more), they also have major community, environmental, and financial effects, and it is partially their sheer size and effect that has inspired some of the better known recent work on the topic. Of course, large, costly, and affecting constructed works are not a new phenomenon. Arguably, the Seven Wonders of the Ancient World were all gigaprojects of their day, perhaps even bolder in their undertaking than the canals, dams, bridges, and railroads of the modern world.

What has come to distinguish the modern public works megaproject, however, is its unfortunate association with huge delays in delivery time and large cost overruns; to many people, "megaproject" has become synonymous with "boondoggle." Despite the fact that this is an overly simplistic (and largely incorrect) view, this chapter examines some of the reasons why megaprojects, and those undertaken by the public sector in particular, have performed poorly in terms of cost and schedule and looks to innovative project delivery methods, broadly termed PPP, to improve project performance by instilling increased discipline and accountability in the project delivery organization through a better understanding of risk and how it is allocated and managed.

How Do Megaprojects Perform?

A 1999 study by the National Research Council of large construction and environmental remediation projects undertaken by the U.S. Department of Energy found that these projects took longer and cost about 50% more than comparable projects undertaken by other federal agencies or projects in the private sector (National Research Council 1999). Much like Tolstoy's observation that "happy families are all

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LESSONS LEARNED

1. Megaprojects are often associated with huge delays in delivery time and large cost overruns.
2. Studies have attributed megaproject delays and cost overruns to organizational structures that lacked accountability and clear lines of authority.
3. Traditional project organizational structures often lack a real sense of incentive or urgency to complete the project on time or control the project's cost.
4. The effects of risks on megaprojects are greatly magnified because of the large amounts of capital involved and increased public scrutiny of megaprojects.
5. Megaprojects as a class and PPP as a process are subject to a broader range of risks than more routine procurements.
6. Risk identification and management must be core considerations when one plans any megaproject or the use of a PPP process.
7. PPPs provide an opportunity by which public entities can accelerate long-overdue public capital improvements delayed by lack of capital, shortage of in-house expertise, or life-cycle concerns.
8. PPPs can be executed under a variety of contractual approaches, depending upon the needs of the public entity and the ability of the private party to execute the megaproject with the full scope of services identified.
9. Because cost overruns and delays directly affect the profitability of a megaproject, the private partner is "invested" in meeting cost and delivery time goals.

alike; every unhappy family is unhappy in its own way," the National Research Council report cited many reasons for poor cost and schedule performance. However, the overarching finding of the National Research Council report was that these deficiencies in project management could be traced to an organizational culture that lacked accountability and clear lines of authority; quite simply, no one was ultimately held responsible when schedules slipped or budgets grew excessively. The report contains a series of baseline steps that if followed should greatly increase the likelihood of a satisfactory project outcome. Successful projects, like happy families, all seem to share similar traits. Chief among them is being organized for success.

There are countless examples of poorly performing projects, but the Central Artery/Tunnel or "Big Dig" project in Boston has come to exemplify the megaproject gone awry. Ballooning costs and years of delay were among the many problems experienced during the more than 20 years that elapsed between the project's authorization and its final acceptance. A review of the project as it approached completion determined that there was no single cause contributing to the project's high cost and poor schedule performance, although the many years of delay allowed inflation effects to compound, which accounted for an estimated 55% of total cost growth, a figure on the order of US$5–6 billion (National Research Council 2003). This assessment was admittedly limited in scope but did address all the relevant project management issues that would be expected to affect project delivery. The bottom-line finding was of an integrated owner–contractor project organization that lacked any real sense of incentive or urgency to complete the project quickly or control its costs. Without clear expectations for performance and with blurred lines of responsibility and minimal accountability to any oversight authority, there was little driving force beyond simple momentum to actually finish the project. Much like the Department of Energy projects mentioned previously, the Big Dig was not organized for success.

The Big Dig is a prime example of a public project that went wrong between its initial planning and final delivery. Unfortunately, the Big Dig is neither unique nor all that rare. Frick chronicles the reconstruction of the San Francisco–Oakland Bay Bridge, which was seriously damaged by the Loma Prieta earthquake in 1989 (Frick 2008). What began as a relatively straightforward bridge replacement project was essentially captured by local stakeholder interests that then forced acceptance of a costly "landmark" design. This problem was followed by a public retrenchment and re-review after construction had begun that added to already considerable delays. As a result, the cost of the project has approximately doubled to almost US$5 billion, and the replacement of a critical transportation link dictated by seismic safety concerns remains incomplete more than 20 years after the Loma Prieta earthquake. Here again, management and control issues both contributed to expanding schedules and costs.

Poor project delivery is not confined totally to the public sector, however. Other investigators have compiled long lists of large projects that experienced significant delays, large cost overruns, or both. Merrow, McDonnell, and Argüden document the performance of a suite of 52 large projects made up of industrial facilities (mostly process industry, petroleum refining, and resource extraction), power plants, and civil infrastructure and transportation facilities (Merrow et al. 1988). They found that most of the projects studied met their stated performance goals, many met schedule goals, but few were delivered within budget. They concluded that the primary reason for cost growth and schedule slippage in the projects studied were conflicts between the project sponsor and the host government (often one and the same) on issues pertaining to regulation, procurement, and labor. They contend that it is such institutional risks and their effects that differentiate the megaproject from smaller, albeit still quite large, procurements. In a later study, Miller and Lessard examined 60 large international engineering projects with an average size of US$1 billion undertaken between 1980 and 2000 (Miller and Lessard 2000). They found that almost 40% of the projects performed badly (with large delays and cost increases) and were either abandoned totally or restructured after experiencing some kind of financial crisis. Flyvbjerg, Bruzelius, and Rothengatter, in perhaps the most comprehensive study undertaken to date, analyzed the performance of more than 200 large international transportation infrastructure projects (e.g., toll roads, bridges, and rail systems) and concluded, "... over-optimistic forecasts of viability are the rule for major investments rather than the exception" (Flyvbjerg et al. 2003). Cost overruns of 50% to 100% and revenue shortfalls of 20% to 70% were common in the projects studied. In a subsequent work, Flyvbjerg linked poor project performance to systemic underestimation of costs and inflation of expected benefits (Flyvbjerg 2007). Overestimation of the number of users (roads and bridges) and riders (rail) was also described in Flyvbjerg, Skamris Holm, and Buhl (Flyvbjerg et al. 2005). Such systemic underestimates of cost and overestimation of benefits give rise to what Flyvbjerg has termed the "disaster gene" in megaprojects.

Projects Performing Badly

Although all construction carries some element of risk, the effects of risks in infrastructure megaprojects are greatly magnified because of the large amounts of capital, often public tax dollars, involved and the public scrutiny attendant on such large projects. Other risk factors are operative as well. Frick described six characteristics of transportation megaprojects that offer additional insight into the performance challenges they face. Her classification (Frick 2008) of megaprojects described them as

- *Colossal* in size and scope and usually highly visible after construction begins;
- *Captivating* because of the project's size, engineering achievements, and possibly its aesthetic design;
- *Costly* because costs are often underestimated and often increase over the life of the project;
- *Controversial* in that they generate interest on many levels;
- *Complex*, which adds to risk and uncertainty; and
- Laden with *control* issues over decision making, management/operations, and funding.

Although no single one of these characteristics is probably sufficient to explain such consistently poor performance in terms of schedule and cost, taken together they offer multiple opportunities for problems in one area to cascade into others and build into a quite powerful event, something akin to a perfect storm. For example, because of their large size and high cost, there is often a desire "to make a world-class statement" and therefore prolonged and often contentious debate among various stakeholder groups on the best approach.

Controlling Risk in Megaprojects

Both megaprojects as a class and PPPs as a process are subject to a broader range of risks than more routine procurements. As a result, the identification and management of risks should be a core consideration of either. As we have seen from the earlier discussion of megaproject performance, some of the more common risks, as discussed in more detail in Chapter 2, faced by these large procurements include the following (Little 2010):

- *Political risks*, such as the unanticipated change in government, cancellation of a concession, unanticipated tax increases, arbitrary toll or fee imposition or increases, or new and unilateral regulatory policies;
- *Construction risks*, such as incorrect or inappropriate design, delays in land acquisition or escalation of land costs, project delays, labor disputes, unanticipated site conditions, or poor contractor performance;
- *Operation and maintenance risks*, such as the physical condition of a concession facility, operator incompetence, or poor construction quality;
- *Legal and contractual risks*, such as the concession warranty, or incomplete or inadequate contracts;
- *Income risks*, such as inaccurate estimates of traffic volume or revenue, construction of a competing facility that would reduce use or profitability;
- *Financial risks*, such as inflation, local currency devaluation, and difficulties in conversion to hard currency, interest rate fluctuations, changes in monetary policies, or highly leveraged positions; or
- *Force majeure*, such as war, natural disasters, extreme weather conditions, or terrorism.

In light of the likely global need for more and larger civil works in the future, the potential benefits of managing these risks more effectively and systemically improving the cost and schedule performance of infrastructure megaprojects are enormous. For example, the need to adapt coastal areas and their supporting infrastructure to the effects of global climate change and sea level rise will be a costly and long-term investment. If public finances are not to be strained beyond limits for these and other necessary projects, the delivery of infrastructure megaprojects must be improved. The remainder of this chapter discusses whether and how public–private partnering arrangements could bring more discipline to the project delivery process.

Public–Private Partnerships

PPPs are contractual agreements between the public and private sectors wherein the private sector, in exchange for compensation, agrees to deliver physical infrastructure and/or the services it provides. The private sector typically agrees to design, build, finance, operate, and/or maintain infrastructure assets necessary to deliver the services. PPPs have been used for a wide range of infrastructure, including transportation, water and sewer services, solid waste disposal, municipal parking, and "social" infrastructure such as schools, hospitals, and other public buildings.

Governments may choose a PPP option for a variety of reasons, including a desire to accelerate long-overdue capital improvements, an inability to raise necessary capital or credit on their own, a lack of in-house expertise or resources, or a desire to ensure that facilities are appropriately maintained and refurbished over their life cycles.

The following terms, several of which are discussed in more detail in Chapter 4, refer to commonly used partnership agreements (CCPPP 2012). The varying levels of private-sector risk and involvement that are implicit in each option are depicted in Fig. 5-1.

- *Design–Build (DB):* The private sector designs and builds infrastructure to meet public-sector performance specifications, often for a fixed price, so the risk of cost overruns is transferred to the private sector. (DB is a contracting method that is at the heart of private provision of infrastructure, but many people do not consider DB a formal PPP strategy.)
- *Operation & Maintenance Contract (O&M)*: A private operator, under contract, operates a publicly owned asset for a specified term. Ownership of the asset remains with the public entity.
- *Design–Build–Finance–Operate (DBFO)*: The private sector designs, finances, and constructs a new facility under a long-term lease and operates the facility during the term of the lease. The private partner transfers the new facility to the public sector at the end of the lease term.
- *Build–Own–Operate (BOO)*: The private sector finances, builds, owns, and operates a facility or service in perpetuity. The public constraints are stated in the original agreement and through ongoing regulatory authority.
- *Build–Own–Operate–Transfer (BOOT or more commonly, BOT)*: A private entity receives a franchise to finance, design, build, and operate a facility (and to charge user fees) for a specified period, after which ownership is transferred back to the public sector.
- *Buy–Build–Operate (BBO)*: Transfer of a public asset to a private or quasipublic entity, usually under contract that the assets are to be upgraded and operated for a specified period of time. Public control is exercised through the contract at the time of transfer.

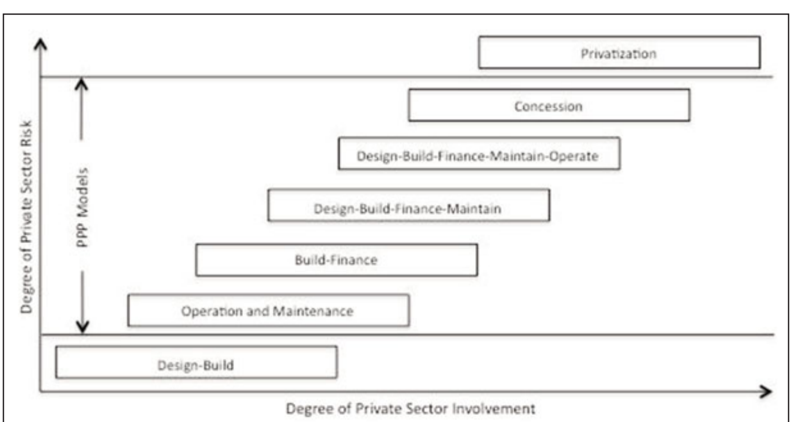

Fig. 5-1. Scale of public–private partnerships

Source: http://www.pppcouncil.ca/resources/about-ppp/models.html. Reproduced with permission from the Canadian Council for Public–Private Partnerships.

- *Finance Only*: On behalf of the public entity, a private entity, usually a financial services company, funds a project directly or uses various mechanisms, such as a long-term lease or bond issue.
- *Concession Agreement*: An agreement between a government and a private entity that grants the private entity the right to operate, maintain, and collect user fees for an existing publicly owned asset in exchange for an up-front fee and sometimes a share of revenues. Although ownership usually does not transfer, certain rights of ownership may.

The choice of approach depends in part on the objectives of the public partner, the ability of the government to fund portions of the project from the central budget, and local capacity to manage complex procurements.

One of the attractive features of PPPs is that they can save significant time in the procurement process by consolidating many activities into a single solicitation. For example, instead of arranging financing, hiring a designer, soliciting construction bids, overseeing construction of the project, and ensuring maintenance and repair over its life cycle, a PPP requires only the identification and retention of a qualified entity or team that can provide the package of services desired. This process can begin with a request for qualifications (RFQ) or other similar exploratory process to identify potential bidders and can save substantial time in the procurement process. Provided that an undue amount of time is not required to negotiate the contract documents, the value of this time saving can be substantial on a large procurement. Otherwise, transaction costs can negate much of the savings achieved through consolidation (Vining and Boardman 2008). The enforcement of performance objectives in the contract is the responsibility of the owner, who must be capably represented in the performance assessment process. As this is often a new function for public agencies, appropriate training must be provided for enforcement staff.

PPP and Risk Management

Many of the problems experienced by infrastructure megaprojects can be found rooted in poor risk allocation and management (National Research Council 2005), and one of the strongest arguments for the PPP delivery model is that the various project risks are allocated to the party best able to manage them. Who actually bears a risk should be determined by which party is in a better position to control it. For example, the government should be responsible for minimizing the risk of a loss of political commitment or future legislation that discriminates against a project, and the private partner should be expected to control construction risks. Rather than the public sector negotiating and executing a series of contracts for design, construction, and other services (typically large public infrastructure procurements are broken into numerous segments and phases, which must be coordinated and managed as a unit), the successful bidder is charged with delivering the project for a fixed fee by a date certain. Cost overruns and delays directly affect profitability, so the PPP contractor is strongly motivated to perform and the public sector less inclined to tinker with the project because the cost implications are direct and transparent. If the revenue risk is to be held by the private party, greater care is likely to be taken by investors in examining ridership or usage projections, as opposed to stakeholders with little or no financial stake in the project, so the degree of "benefit optimism" noted by Flyvbjerg is minimized (Flyvbjerg 2007).

The key to effective risk management lies within the concept of partnership. If risk can be transparently identified, equitably allocated, and costed appropriately, successful projects are far more likely to result. If the objective is to just shift risk away from one party to the other, success is more difficult to achieve. Table 5-1 illustrates how risk allocation can occur for different PPP models and is exemplified by two significant megaprojects.

The Channel Tunnel was privately constructed as a BOOT project by a consortium of engineering and construction companies to design and build the tunnel with financing provided through a separate legal entity, Eurotunnel. Most of the risk, including the 80% cost overrun, was absorbed by the private sector, as would be expected from Table 5-1. The Big Dig, on the other hand, was essentially a traditional DBB project (albeit one of unprecedented size), and the public sector bore the

Table 5-1. Distribution of Risk for Selected PPP Options

Type of partnership	Description	Risk Allocation				
		Public ⟵		⟷		⟶ Private
Design-Bid-Build (DBB)	Design and construction contracts awarded separately to private sector engineering and contracting firms	X				
Design–build (DB)	Combines the design and construction phases into one fixed-fee contract		X			
Design–build–operate–maintain (DBOM) Build–operate–transfer (BOT)	Selected contractor is responsible for the design, construction, operation, and maintenance of the facility for a specified time			X		
Design–build–finance–operate (DBFO) Design build–finance–operate–maintain (DBFOM)	Similar to DBOM but the contractor is also responsible for all or a major part of the project's financing				X	
Build–own–operate (BOO)	The private partner owns the facility and is assigned all operating revenue risk and any surplus revenues for the life of the facility					X

risks (and the costs) of the many breakdowns in procurement, oversight, design, and construction (although some of the costs have been recovered from contractors and the partnership).

The Role of Project Finance

Most PPP ventures for new projects make use of a financial engineering tool known as project finance to structure a leveraged arrangement of debt and equity to build, and usually operate and maintain, the facility. Typically, the private partner brings a portion of the total cost of the project to the deal as its equity share (before the economic crisis of 2008–2009, this share was often as little as 10%; since the crisis, 30–40% is more common) and raises the remainder through commercial loans and other credit sources. For example, the Florida I-595 PPP is a US$1.8 billion, 35-year design–build–finance–operate–maintain (DBFOM) concession on a 10.5-mi portion of the highway in Broward County, north of Miami, that reached financial close on March 3, 2009. The financing consisted of US$781 million in bank debt, a US$603 million Transportation Infrastructure Finance and Innovation Act (TIFIA) loan, US$232 million from the Florida DOT, US$208 million in private equity, and US$10 million in project revenues (Desilets 2009).

A separate corporate entity special-purpose vehicle (SPV), composed of architectural, engineering, construction, and legal entities, is created to build and/or operate and maintain the infrastructure asset on a nonrecourse basis[1] under a long-term concession agreement in exchange for the revenues produced by the infrastructure asset or direct payments from the owner. That is, when seeking debt financing, the SPV pledges only the revenue or fees to be generated by the project as security for the debt. In the event that the project defaults or experiences other financial difficulties, the SPV alone is responsible; the parent organizations have no obligation to be accountable for the financial performance of the project. Obviously, in such circumstances, commercial lenders are highly motivated to analyze the financial details carefully and not as prone to accept the sort of fantasy numbers described by Flyvbjerg.

Despite the nonrecourse character of the SPV, the financial risk shared by the debt and equity investors in a PPP is a strong performance motivator. Unlike the public sector, investors are primarily motivated by financial and not political and social returns. The question of whether revenue expectations are realistic receives careful scrutiny because a "real" balance sheet is involved. Payments typically do not begin until the project is operational, so completing it on time also has "real" financial implications. Similarly, managing to a fixed-fee contract without the expectation of costly change orders can instill yet more discipline into the process. The notion that the PPP contractor has "skin in the game" rather than just being a provider of services fundamentally changes the dynamic of project performance, and each new PPP delivery

1 The financial performance of the project is guaranteed solely by the revenues it generates, not the entities that make up the project company or SPV. There is no recourse to parent organizations.

introduces interesting variants. For example, the SG$1.8 billion (US$1.4 billion) Singapore Sports Hub that reached financial close in August 2010 included two service subcontractors as equity partners (Singapore Sports Council 2011). By spreading both risk and reward among the participants, the entire project team can be better focused on delivering both the project and its services on time and on budget.

However, because of the limited liability inherent in the SPV, the potential loss of equity may not be sufficient to compel the private partner to prevent default if projects experience serious financial difficulties. This flaw is particularly true if the SPV is composed of several private parties whose equity share might be quite small compared to the overall cost of the project. For example, in a highly leveraged deal (e.g., 10% equity and 90% debt), the equity investment or "at risk" capital of 5 equal-equity partners in a US$1 billion project could be as little as US$20 million. Although this amount is not trivial, it does represent the upper bound on the financial risk faced by the private equity partners. Recently, the SPV formed to perform repair and renovation on two lines of the London Underground (Metronet) declared bankruptcy rather than take on the additional risk posed by rapidly escalating project costs (UKHCTC 2008). The public partner here (the UK government) can certainly be considered a sophisticated player in these arrangements, but this sophistication was still not sufficient to prevent the deal from going bad and the private partner walking away. However, in this case, the members of the SPV can hardly be considered "damaged" (Blaiklock 2008), considering that

> It is most likely that overall the shareholders may not have lost any money on the PPP at all (e.g., 20% of £2 billion is £400 million)!! [£2 billion equals approximately US$3.2 billion (in 2012).] It will be just that they—the shareholders—have made less money on the PPP than they had originally hoped!

Does Private Return on Investment Trump Societal Benefit?

Benefit–cost (B/C) analysis was invented to do the type of trade-off analysis inherent in large public works projects, such as flood control. At the most basic level, a B/C analysis discounts $*X* in capital outlays and $*Y* for annual operating and maintenance expenses over the life of the project and compares these costs to benefits totaling $*Z*. If the net present value of the annualized monetary equivalent of *Z* is greater than *X* + *Y*, the project has a favorable cost–benefit structure and is "justified." However, this analytical procedure makes no effort to distinguish between who bears the costs and who reaps the benefits. For example, although all U.S. taxpayers underwrite a portion of the federal share of the costs of flood control, the benefits accrue locally. Although often labeled "national economic development" benefits, these are usually targeted to reach a far narrower audience.[2] Public projects also often claim economic benefits that are widespread and diffuse (e.g., recreation days at a multipurpose flood control

2 For example, the land reclamation projects in New Orleans described later used a mix of public monies to create value for private property owners.

impoundment) or benefits that are not economic at all (improved social well-being as a result of increased recreational opportunities). Over the years, project proponents have become quite skillful at manipulating benefit streams to cast projects in a more favorable light or to make benefits appear more broadly targeted.

The calculation of a PPP investor's return on investment (ROI), on the other hand, is not complicated by such distractions and is much more straightforward. The questions to be answered here are purely financial and far more amenable to hard analysis. This fact does not preclude the inclusion of broad societal benefits in a PPP megaproject; it only requires that they be identified and priced accordingly. The equity of federally funded "projects of national interest" that have mostly local benefit has been debated for years and is not resolved here. However, it will suffice to say that from the standpoint of accountability and risk management, much better alignment of who benefits and who pays is certainly possible, and a PPP project structure could illuminate this notion far more clearly.

When Should Governments Consider a PPP for Megaprojects?

Comparing a PPP approach to traditional public procurement usually centers on a "value for money" (VFM)[3] analysis, wherein the life-cycle costs of both options can be compared on an equal basis. The basic question to be answered is which of the options delivers the desired facility for the lowest total net present value (NPV) of accrued costs. This issue includes the risk-adjusted cost of capital, projected O&M costs, and other costs over the lifetime of the contract. For example, under a PPP model, the project organization is responsible for construction and delivery of the facilities and associated risks, whereas the public entity would bear these risks in a traditional DBB procurement. Similarly, in a PPP, the project organization rather than the public entity would bear most of the risks of labor, material, and utility cost escalation over the term of the concession. The analysis, allocation, and pricing of risk are key components of a VFM analysis and go well beyond more obvious comparisons of the cost of tax-free government finance vs. commercial debt.

The VFM analysis is most descriptive when similar costs can be directly compared. For example, the debt service on municipal bonds or other borrowing can be readily estimated, as can the costs for routine maintenance and repair. What is difficult, and often impossible, to capture in a VFM analysis are the less tangible financial realities or social objectives that a PPP may help address. For example, even if tax-free debt is less costly than commercial credit, if government agencies do not have access to tax-free debt markets, construction of sorely needed facilities may be long delayed, if they are provided at all. Having a modern infrastructure facility available years earlier than it otherwise might have been is a valid benefit that, although

3 Value for money (VFM) is a term used to assess whether or not an organization has obtained the maximum benefit from the goods and services it both acquires and provides, within the resources available to it. Achieving VFM can be described in terms of economy (careful use of resources to save expense, time, or effort), efficiency (delivering the same level of service for less cost, time, or effort), and effectiveness (delivering a better service or getting a better return for the same amount of expense, time, or effort).

difficult to monetize, should be factored into the analysis. Similarly, the schedule of routine maintenance and repair specified in the concession agreement may require the project organization to keep the facility in a better physical state than can routinely be provided because of staffing cutbacks or budget shortfalls. Better routine maintenance can significantly delay the need for more extensive (and costly) repairs and rehabilitation. Finally, risk needs to be allocated to the appropriate party under each alternative and the value of the risk assumed by each party included in the analysis. Because the VFM analysis can be no better than its underlying assumptions, all factors need to be identified and carefully vetted so that, insofar as possible, the alternatives considered differ only in the method of project delivery.

Funding Is Critical

It cannot be overstated that a PPP is a procurement and financing tool that does not represent new money. Although payments to the project organization can usually be structured to accommodate the cash flow realities of the procuring entity, they must be made at some point. Absent revenue from some source to repay the project organization, a PPP is not a viable option, regardless of whether it passes the VFM hurdle. However, if funds are available, PPPs can be an excellent means to accelerate project delivery, lower life-cycle costs, and prolong the useful life of infrastructure facilities, and they should be considered an option to traditional procurement.

Flood Protection in New Orleans

Nature tested the effectiveness of New Orleans' flood control works on Aug. 29, 2005, when a storm surge in Lake Pontchartrain, driven by Hurricane Katrina, entered the city's drainage canals and caused water levels to rise to unprecedented heights—more than 7 ft above mean gulf level. Multiple levee and floodwall failures as a result of overtopping and poor design and construction allowed water from Lake Pontchartrain and Lake Borgne (Fig. 5-2) to flood the city and cause widespread damage and more than 1,000 deaths.

Fig. 5-2. Map of New Orleans, Lake Pontchartrain, and Lake Borgne

Source: Google Maps.

When floodwaters inundated the electrical generators for the city's drainage pumps, New Orleans lost any ability to counter the flooding, which continued until water levels equalized several days later. This section discusses the background of flood protection in New Orleans and the agencies and approval processes involved in providing it over the years and speculates on whether a PPP arrangement might have ensured better performance from this critical infrastructure megaproject.

Established by the French as a deepwater port in 1718, New Orleans remains important today as a major international port and center of oil and natural gas operations in the Gulf of Mexico. From its inception, New Orleans was subject to Mississippi River flooding and the effects of periodic hurricanes. Since most of the city lies just a few feet above sea level, flooding also occurs during the intense spring and summer rainfalls. As a result, for many years development was confined to the higher areas near the Mississippi River levees. However, in the latter part of the nineteenth century, development began to expand into the swampy areas closer to Lake Pontchartrain, necessitating construction of additional levees and a drainage system for the city's lower-lying areas.

Recognizing the drainage problems facing a city with so much land lying near or below sea level, the Louisiana legislature established the New Orleans Sewerage and Water Board (S&WB) in 1899 to construct and operate water, sewerage, and drainage works to be funded by a voter-approved property tax. The S&WB merged with the already existing Drainage Commission in 1903 and began building drainage canals and pumping stations throughout the city. Not surprisingly, this public investment set off periodic private-sector building booms that not only rapidly increased land values but also exacerbated the drainage problem by dramatically increasing the amount of impervious surfaces, such as roads and roofs. This reclaimed land continued to be developed during subsequent building booms after both world wars. Today the S&WB is responsible for draining 95.3 mi^2 of New Orleans and neighboring Jefferson Parish.

The Louisiana legislature similarly established the Orleans Levee District in 1890. The district is responsible "for the operation and maintenance of levees, embankments, seawalls, jetties, breakwaters, water basins, and other hurricane and flood-protection improvements surrounding the City of New Orleans, including the southern shores of Lake Pontchartrain and along the Mississippi River." At the federal level, the U.S. Army Corps of Engineers (USACE) became heavily involved with the city's drainage canals in 1955 after congressional studies that later led to the authorization of the Lake Pontchartrain and Vicinity Hurricane Protection Project (LP&VHPP) in 1965. Through a multiple-jurisdictional partnership, the USACE was charged with designing and building improved levees, the Orleans and Jefferson Parish Levee Districts with levee maintenance, and the S&WB with O&M of the pumping stations. As a result of a judicial ruling in 1977, the USACE was forced to abandon floodgates in favor of raising the height of the levees and began building a series of floodwalls on top of the existing levees. The LP&VHPP was still not complete in 2005 when Hurricane Katrina generated a storm surge in Lake Pontchartrain that caused multiple levee and floodwall failures. Despite the long experience of the many agencies involved and the high consequences of failure, the New Orleans flood works were not designed to withstand the effects of what was actually a highly likely event, were built to an insufficient height because of the use of the wrong data, and were poorly constructed and maintained because of chronic underfunding and reallocation of funds.

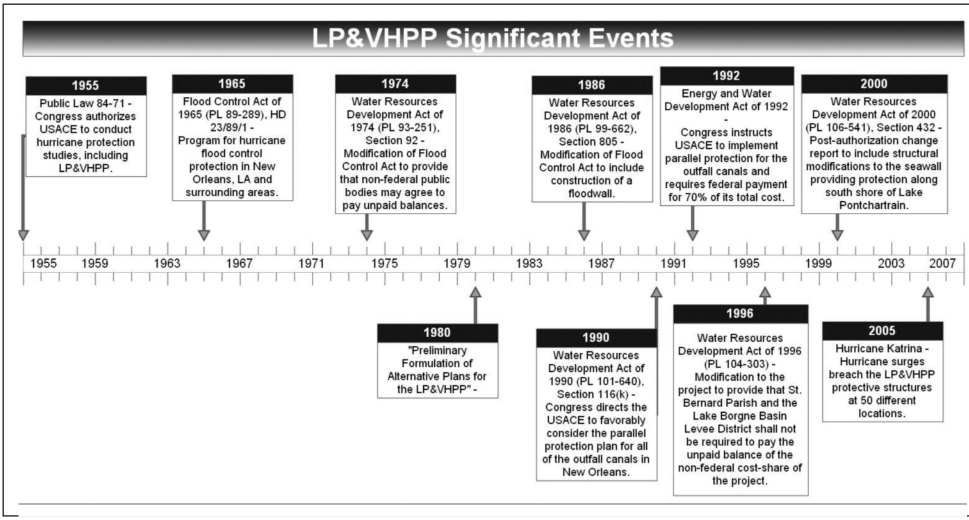

Fig. 5-3. Significant decisions related to the LP&VHPP

Source: Woolley and Shabman (2008).

It was only in the aftermath of Hurricane Katrina that Congress made funding available, and the USACE moved rapidly to rebuild and restore the levees to provide the level of protection first authorized by Congress in 1965. The lengthy and complicated decision process for the LP&VHPP shown in Fig. 5-3 suggests that, despite the great risk to the city, over a period of 40 years there was little apparent sense of urgency in actually completing the flood protection system.

Could New Orleans Have Benefited from PPP Delivery?

As previously noted, one of the most compelling attributes of the PPP is the delivery of facilities and services with schedule and cost certainty and a contractual expectation for maintenance and repair. The slow build-out of the New Orleans flood control works, their intermittent funding, and questionable maintenance all contributed to the failures during Hurricane Katrina. Although it is speculative to assume that flood protection provided through PPP contracting methods would have overcome these barriers to performance, it is difficult to imagine that some improvements would not have emerged. If nothing else had been achieved, it is highly likely that the work would have been completed in less than 40 years and that better maintenance practices would have addressed the most glaring structural deficiencies. Although of little comfort after the fact, liability for failure to perform could have been established and some damages recovered.

Levees, because of their broad flood protection mission, are often thought to be classic public goods—meaning it is impossible to exclude people from using the good and that one person's use of the good does not preclude another person from using it as well—and therefore the responsibility of the public sector to construct and maintain.

The use of a PPP model to provide these facilities and services would not negate this paradigm. It would merely shift the government's responsibility from direct provision to funding and contracting for the work. A proprietary organization could operate and maintain the levees if there were a contracted flow of rent payments. To do this, companies would submit bids to a local government agency; this step has been accomplished to some degree in Great Britain. In these cases, a private consortium received a long-term concession to build, operate, and maintain a series of coastal flood defense works in exchange for availability fee payments. Ownership of the facilities and liability for their failure rests with the government.

At the end of the day, there is no simple answer to this question. Megaprojects, because of their scope, size, and cost have proven difficult for the public sector to deliver efficiently through conventional contracting methods. PPP for flood protection would likely face an uphill battle because of the potential for catastrophic human and economic losses. As Hurricane Katrina so aptly demonstrated, flood control is not child's play. But trusted institutions with decades of experience made deadly mistakes, and maintaining the status quo is not a solution. Questions of whether such an arrangement adequately protects the public interest, which party is liable for what, and the reasonableness of the cost and fee structure are all issues that have arisen in recent discussions of the private provision of what has traditionally been assumed to be public infrastructure. Attitudes in the United States remain deeply conflicted in this regard.

Summary

Although there are many factors that will influence a successful outcome in megaproject delivery if a PPP model is used, if the public and private partners are not in accord on certain key issues, failure is more likely to occur. To achieve outcomes satisfactory to both parties, the following basic elements should apply:

- Clarity—a clear alignment of objectives between the parties and an unambivalent statement of how they will be achieved and measured;
- Transparency—negotiating in open competition with details available for public scrutiny and accountability well defined;
- True partnership—mutual respect for the goals of each party with capable, knowledgeable people on both sides; the private sector must hold a meaningful equity stake, i.e., have "skin in the game";
- Risk management—ensuring that all parties assume responsibility for the risks they are best prepared to manage; and
- Accountability—holding both sides of the negotiation accountable for meeting contract provisions and having predetermined performance goals that are tied to payment schedules.

Going forward, there is much that needs to be learned about how the public sector should procure large construction projects. Although the megaproject is not a new phenomenon, it is increasingly being seen as the solution to complex problems in service delivery. At the same time, the PPP model is in its infancy in the United States, and it will require longitudinal studies that span decades to provide long-term data that can be used in meaningful performance comparisons with other delivery methods. Esty makes a convincing case that despite the growing effect of project finance on infrastructure delivery, there has been little scholarly work devoted to large projects, and research in this area could fill a significant void in the knowledge base (Esty 2004). At the same time, the need for massive infrastructure renewal in the developed world and the demands of urbanization globally require that the many large projects that are necessary are procured in the most timely and cost-efficient manner possible. The PPP model may provide the best means to do this, and both the public and private sectors would be well served by case study and quantitative research in this area.

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CHAPTER 6

The Program Manager's Role

Robert Prieto

Program management is the process of providing execution certainty to meet the strategic business objectives (SBOs) of an owner (Prieto 2008a). It is about meeting the challenges of scale and opportunity while capturing the opportunities of leverage. It is about finding the "sweet spot" in the delivery of a set of projects required to achieve a major outcome.

As illustrated in Fig. 6-1, program management requires a broader, more strategic focus than project management and tighter integration across all elements of the execution process, including organizational enablement; program definition; stakeholder outreach and engagement; establishment of programmatic and technical requirements; development of top-level execution strategies, schedules, and budgets; risk planning and approach to risk management; acquisition and contracting strategy; execution planning; implementation of an integrated management and support tool set; oversight, management, and integration of defined projects; assessment of cost, schedule, quality, and metrics about health, safety, and the environment (HSE); allocation of contingencies and ongoing risk assessment; and ongoing alignment of top-level strategies to achieve strategic business objectives.

As shown in Fig. 6-2, program management may take many forms, ranging from

- "Agency" program management contractor (PMC) services—Under this model, the authority of the PMC tends to be limited, with the majority of program direction channeling through the owner's organization. Some people regard this approach to PMC services as having more of a "body shop" characteristic. This "agency" form of PMC service is declining relative to other forms of PMC where the program manager has increasing responsibility and influence.
- Program management contractor (PMC)—The PMC's responsibility, authority, and influence grow significantly relative to "agency" PMC models. This growth is driven by the maturity of the client's organization, resources required (both level and type), location, and speed of program execution required. Both "agency" PMC and PMC approaches are applied throughout the full range of "mega" programs.

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LESSONS LEARNED

1. The megaproject program manager takes on many of the roles that are traditionally held by the owner on typical construction projects.
2. The most important role is in assisting the owner to develop, plan, and implement the execution strategy for the megaproject. The strategy is a melding of the owner's business goals and objectives, stakeholder goals and objectives, and the execution goals and objectives for the megaproject.
3. Once the execution strategy is set, the megaproject program manager must maintain a strategic focus insofar as the execution of the megaproject strategy, leaving the execution of the elements to those allocated each of the specific scopes of work or elements.
4. From that strategic role, the megaproject program manager is responsible for integration of every project element that makes up the megaproject.
5. It is essential that the megaproject program manager be involved throughout the entire megaproject life cycle.
6. To be successful, a megaproject program manager must build and use a strong governance framework under which the megaproject is to be planned and executed.
7. The management of megaproject risk is a strategic responsibility of the megaproject program manager.
8. It is ultimately the megaproject program manager's responsibility to ensure that the proper management tools are chosen, installed, and fully used by all participants involved in the execution of the megaproject.

- Program management contractor$^+$ (PMC$^+$)—Under the PMC$^+$ model, the PMC undertakes not only PMC responsibilities, but in addition may be responsible for execution of one or more of the projects being managed. These projects typically encompass those that enable or integrate multiple other program elements (such as offsites and utilities in the energy and chemicals sectors) or that provide common elements across multiple projects (such as in cases where extensive modularization is being used). PMC$^+$ may be applied to "mega" programs but is usually a core element in the emerging class of so-called "giga" programs (Prieto 2009) with total installed costs in excess of US$10 billion.

Owners and contractors, across all construction industries, are witnessing the application of program management as one other fundamental change in the form of a broadening of the degree of involvement of the program manager in the program's total life cycle. Several factors are driving this change, including the following:

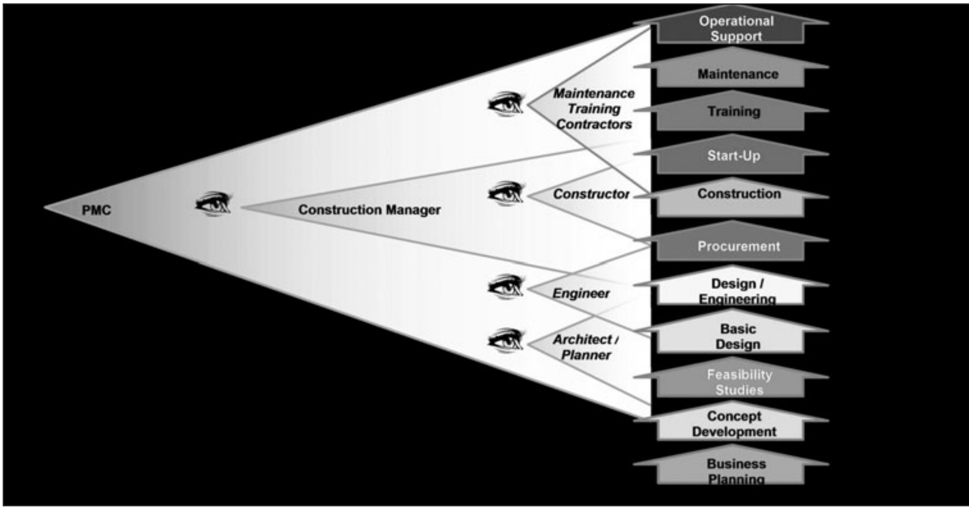

Fig. 6-1. Program management broad focus

Source: Prieto (2011).

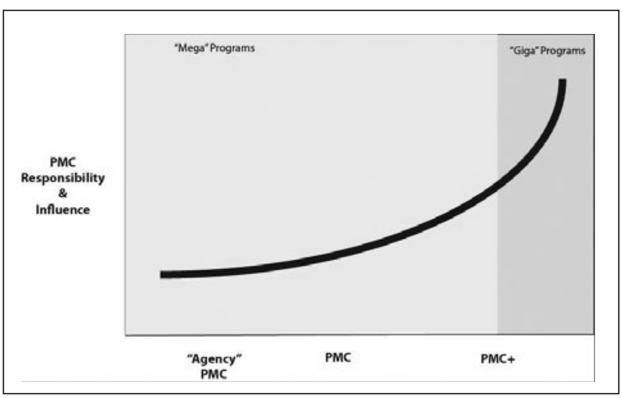

Fig. 6-2. Program management contractor responsibility and influence

Source: Courtesy of Fluor Corp., reprinted with permission.

- Increased linkage of program execution strategy related to capital expenditure (CAPEX) delivery with definition of strategic business objectives and program definition;
- Earlier and ongoing focus on sustainability;
- Growing importance of so-called "soft issues," such as stakeholder management, knowledge transfer, capacity building, organizational development, and industry creation; and
- Strengthened life-cycle focus that extends operations and maintenance (O&M) considerations earlier into the program cycle and extends certain CAPEX strategies well into the traditional O&M cycle (delivered service based procurements vs. capital equipment only procurements). This strengthened life-cycle focus is driven by sustainability considerations as well as the desire to reduce the costs of spare part inventories and warehousing through standardization at the component level.

As shown in Fig. 6-3, this emerging model, referred to as strategic program management (Prieto 2008e), strengthens the partnership between the client and the PMC.

Strategic Business Objectives

Another definition of program management could be achieving strategic business objectives by translating strategy into an integrated set of projects.

Many programs are judged as having failed because at the outset there was no clear, unambiguous agreement on what was to be accomplished. Absent this clear set of objectives, a program at a later stage may be measured against something it was

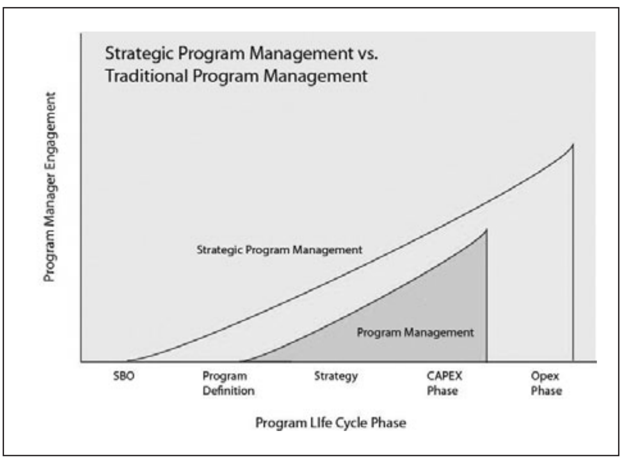

Fig. 6-3. Strategic program management vs. traditional program management

Source: Courtesy of Fluor Corp., reprinted with permission.

Fig. 6-4. Program management strategy

Source: Prieto (2011).

never seeking to address. In that scenario, failure is ensured. Strategic business objectives must not only be defined and communicated, but they must also be translated to strategy. Strategy should not be confused with tactics, which will be touched on later in this chapter. As shown in Fig. 6-4, the program manager's job is to apply the strategy across a portfolio of projects.

Examples of SBOs for a private, for-profit company can include

- Return on investment (ROI),
- Return on equity (ROE),
- Market share,
- Target growth rates, or
- A number of other quantifiable and measurable objectives.

These SBOs may also include other top-level objectives that define the business rationale or approach, such as

- Patents granted,
- New products launched,
- Net zero carbon or other triple bottom line (TBL) objectives,
- or public sector owners.

SBOs include more social and environmental objectives, including:

- Improved access to transportation,
- Reduced congestion,
- Improved access to clean water,
- New jobs created, and
- New industries created.

Link to Strategy

The link between SBOs and overall program strategy provides a key opportunity for the program manager to help position the program for success. In reality, the strategy dimensions available (e.g., labor, finance, and long-lead equipment) tend to influence the setting of SBOs and hence the earlier involvement of the PMC under a strategic program management approach.

Strategy selection is also strongly influenced by stakeholders as well as resources, as shown in Fig. 6-5. Stakeholders can include a wide array of individuals, organizations, and governmental and nongovernmental organizations.

Program Manager as Implementer of Strategy

In many ways, the traditional role of the program manager is as the implementer of the agreed-to strategy. He or she must ensure that the client's SBOs remain clearly in sight and are not allowed to grow or change in other than a controlled manner with full recognition of all the effects this change can have on the program. A key initial

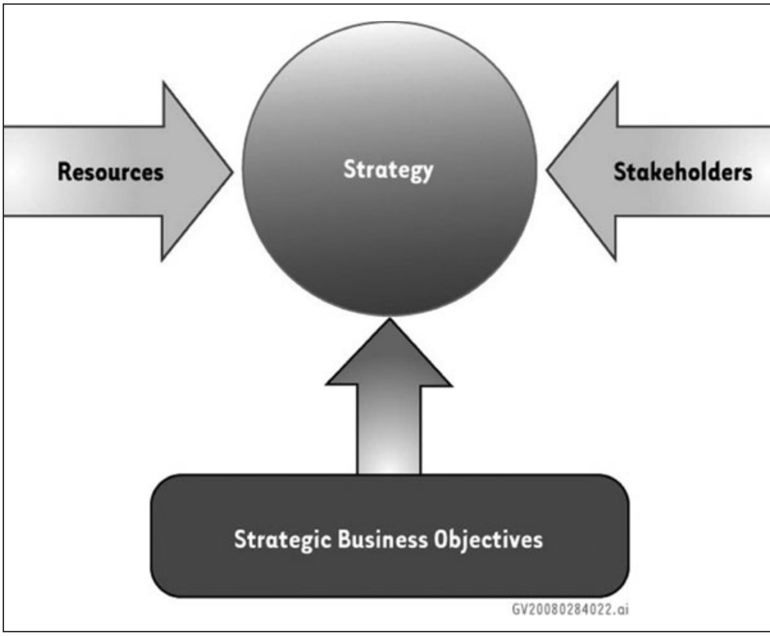

Fig. 6-5. Stakeholder influence

Source: Prieto (2008e).

activity the program manager must undertake is adequately defining the various required elements of the program. These elements include not only a set of projects but also the processes, systems, and tools required to effectively deliver them. The selection of the right projects is important to a successful program and is a step that program managers must ensure has been comprehensively undertaken. Let me use an example to illustrate the point. A state department of transportation (DOT) wishes to move 100,000 people per day from automobiles to mass transit. Deciding to build a heavy rail solution may not be appropriate when all factors are considered.

Just as strategy cannot be developed in a vacuum, its application throughout a program cannot be taken for granted. The program manager must audit the selected strategy periodically to ensure its continued relevance and, equally important, his or her adherence to it. The owner's organization has a role to play here as part of its management role and its own internal program management oversight (PMO) function.

Program Management Governance Framework

> Program management in the engineering and construction industry represents a fundamental re-allocation of responsibilities and authorities between the traditional Owner organization and an engaged Program Manager.... From the Program Manager's perspective, a key factor for success will be the degree to which its responsibilities can be clearly defined and responsibility and authority allocated consistent with these responsibilities and the Owner

organization's own readiness. A well-developed contractual and implementation framework are therefore key ingredients for success but in many cases, even the best developed frameworks are undermined by a poorly defined governance regime and inadequate contract administration capabilities within owner organizations. This later factor sometimes reflects passive resistance to change while in other instances it reflects inadequate organizational maturity to adopt the new delivery regime (Prieto 2008e).

Program management governance thinking has developed across a wide range of industries from government-implemented health-care transformations to enterprise-wide information technology delivery efforts. In the engineering and construction industry, attention to governance issues at program initiation has been to a large degree spotty and inconsistent, and increased attention on aligning governance frameworks with strategic business objectives, strategy, and project execution tactics is required.

In well-executed programs, as illustrated in Fig. 6-6, strong governance frameworks are put in place between the owner and PMC and build on the key factors for success:

- Strong and decisive leadership by senior management is supported by clear and appropriate allocation of responsibility and authority without ambiguity.
- Early, consistent, and direct involvement of frontline staff includes appropriate feedback mechanisms to encourage, collect, and analyze criticism without fear of retribution.

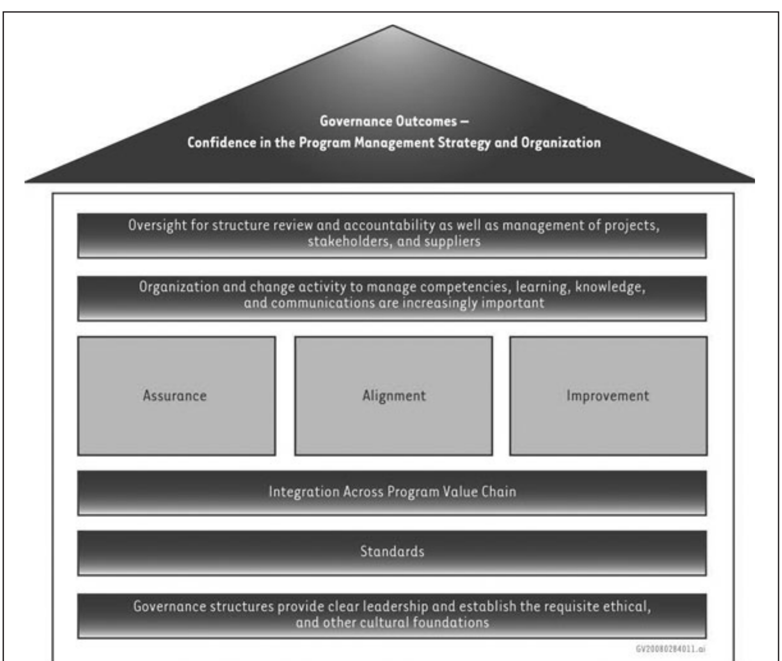

Fig. 6-6. Program management governance framework

Source: Prieto (2008e).

- Engagement and ongoing involvement come from each stakeholder population, both within the owner's organization and externally; communication choke points are avoided even while control points are strengthened.
- Acceptance and projected confidence in the implementation of new strategies and solutions at the early program stage:
  - Leadership by example and strong sponsorship by the program manager are essential to programmatic success, and
  - Areas of concern or uncertainty are monitored consciously, but self-doubt is reserved until supported by information-based decision making.
- Experienced, neutral, external facilitators are used to drive organizational change management and alignment processes; identify latent conflicts for resolution; and facilitate building of the required multidisciplinary team focused on undertaking the program management journey. Team building and alignment processes must be contractual requirements of both the owner and the program manager.
- Many parts of the project delivery system need to be restructured simultaneously for effective program delivery. Governance structure must provide the program manager with the ability to act in parallel versus sequentially within an accelerated change time horizon.
- Key performance indicators (KPIs) and their application are determined collectively. The owner organization must change to an outcome-based management style versus more traditional input control management styles.
- Experienced staff with a programmatic and systemic focus perform comprehensive data analysis and timely reporting of KPIs. Performance assessment regimes require owner oversight staff to adopt new perspectives that are broader than the project-based performance assessment; new skill sets and training must be implemented at an early stage.
- Recognition and reward for success are emphasized over penalty for failure. Governance regimes must increasingly adopt a reinforcing versus punitive framework.
- The program management role has appropriate resources, with sufficient flexibility to migrate the organization structure and skills mix as the program evolves. Program managements' need for a more robust structure and control is understood in light of the larger effect their failure can have.

An important aspect of governance from the program manager's perspective is how it cascades down from the owner's organization through the program manager and into every element of the program he or she is responsible for. This cascade effect is illustrated in Fig. 6-7, which conceptually shows the interrelationship among

- owner's investment decision process;
- program management office;
- strategic business objectives;
- program and program execution strategies;
- various program management activities;
- major projects; and
- cross-cutting processes.

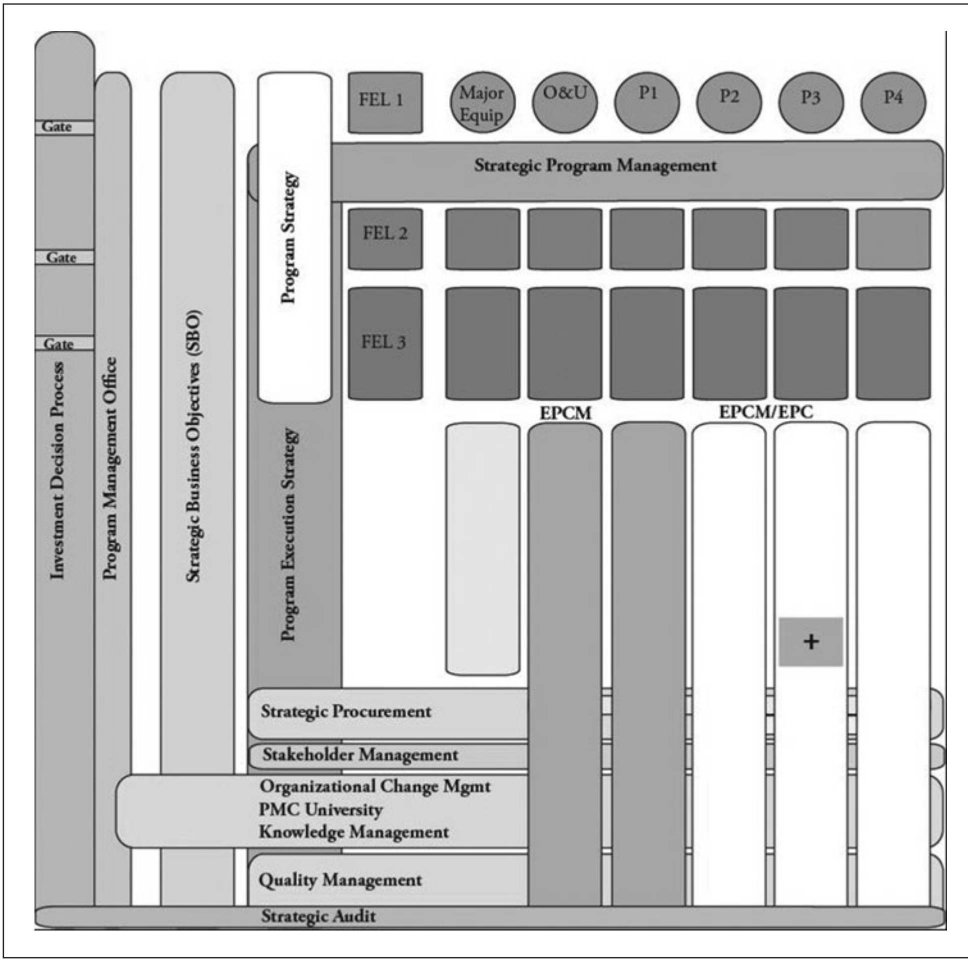

Fig. 6-7. Program management interrelationships

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Alignment and Organizational Change Management

Governance development and rollout on a large program is typically driven by the PMC's alignment process. This process is essentially an activity to support higher-level vision, goals, and objectives. Alignment sessions are often uncomfortable to participants since by nature they are designed to resolve policies and conflicts and drive accelerated decision making and action. Alignment is further reinforced by governance systems and processes.

One of the most uncomfortable outcomes of a good governance and alignment process is the need for the PMC and owner to work together to implement any necessary organizational change management. One of the greatest threats to large programs is the often-unseen passive resistance.

Organizational change management (OCM) is the planned, programmed integration of a new business model into an organization, including adapting the changes so that the transformation enhances relationships among participants and improves business processes. Proactive OCM focuses on innovation and skill development of people, proactively recognizing the effects of change, planning for them, and then helping the participants to develop skill sets and tools to support the change while dealing with the discomfort associated with it (Prieto 2008d).

Some of the change dimensions that the program team must address include the following:

- Changed management roles;
- Changed commercial patterns;
- Changed span of control;
- Increased importance of cross-cultural differences and
- Changed design process (the program is typically driven much more by strategic business objectives and construction than what had been experienced by the owner in previous efforts; ease and facilitation of construction require changed strategies for construction, procurement [program vs. project], and design [standardized, simplified, and changed constraints and opportunities]).

An effective organizational change management program

- Defines the future state and assesses current constraints to achieving it (presenting the business reasons for a change is the first step toward achieving organizational buy-in);
- Engages the primary sponsor; and
- Forms and prepares the project team—management and work process challenges need to be clearly laid out. Emphasis needs to be placed on drawing out the team's concerns, hesitations, and so forth so that these problems may be directly addressed. Barriers to change that are typically encountered include people, process, technology, and communication.

Program Manager as Risk Manager

Another definition of program management could be managing risk to achieve strategic business objectives.

This notion of risk is important, and failure to recognize it, account for it, and actively manage it is a principal reason why programs fail. Risk appears in many forms throughout a program, and part of the program management perspective is to be continually seeking it out and aggressively managing it. In many ways, this seeking is one of the key tasks that fall to the program manager.

Risk exists in many forms and in many places in large programs. Ferreting this risk out is an early, and most importantly, ongoing activity of the PMC.

As shown below, risk can exist within individual projects and contracts but perhaps more importantly, in the "white space" between the various packages. The management of risks in these white spaces falls squarely on the program manager. But one-third of risk exists in large programs and those that are the cross-cutting or systemic risks can affect multiple projects simultaneously. These systemic risks (Prieto 2010c) are constantly evolving but can include risks such as

- Common global demand drivers for natural resources and primary materials;
- Energy security;
- Shortage of heavy marine transport;
- Supply disruption from natural events in major areas of supply;
- Flawed industry financing models;
- Supply chain friction from global events of scale;
- General disruption of major supply chains;
- Failure of critical infrastructure;
- Emergence of new risks associated with changed requirements; and
- Asynchronous program management (in industrial settings) and supply chain (in networked settings) models.

On a mega program, the program manager must pay close attention to a number of risks that are commonly embedded in the mega program environment and are frequently a major cause of program variances. These common risks include the following:

- Lack of realism in initial cost;
- Length and cost of delays underestimated;
- Contingencies and risk reserves too low;
- Geological risks or natural elements not clearly defined; and
- Environmental, safety, and existing conditions unclear.

Primary reasons for these common risks are

- Reluctance to convey bad news;
- Information filtered as it moves up to higher management levels; and
- Information biased at the source.

The program manager has an important role in managing these risks by

- Creating a robust, shared risk register;
- Actively managing risks; and
- Implementing a comprehensive project control framework.

Most importantly, as shown in Table 6-1, the PMC must ensure that program and project baselines (scope, schedule, budget, and level of quality) adequately address the uncertainties associated with each dimension of the program.

In the final analysis, the program manager must ensure that the resulting facilities are "fit for purpose."

Table 6-1. Program Manager Must Manage All Risks

Examples of strategic risk		Enterprise risk
Global risk	Examples of tactical risk	
Effect of potential reduction on available financial resources to fund the program	Local government and regulatory agency issues affecting all projects the program undertakes	Adherence and management of the control base
Quality of program delivery system: governance, people, and systems	Broad political uncertainty, such as regional instability or changes of government	Program and project definition: degree of scope definition in relation to the stage of program and projects
General business provisions that limit choice or action	Public or community opposition to a project or an entire program	Contracting strategy effectiveness
Partners and issues above the program	Global and regional economic trends	Technology selection and design effectiveness
Organizational alignment on program goals		Issues related to compliance with regulatory and local government laws and requirements
Scope: Do the program and projects as represented identify every element that will be required eventually?		Effectiveness of management of change
		Logistics risks
		Procurement (pricing) risks
		Engineering productivity and schedule adherence
		Construction productivity and schedule adherence
		Site and security-related risks

Capturing the Opportunities of Leverage

Strategic program management is about meeting the challenges of scale and complexity but also about capturing the opportunities of leverage. Every mega program, as well as the projects that constitute it, is the subject of a detailed and rigorous risk analysis. This is not only appropriate but also necessary. But to capture the full value inherent in large programs, the program management consultant or PMC must also seek out opportunities in a proactive and ongoing manner.

The PMC's opportunity analysis is best constructed within a framework that ensures a comprehensive view of all aspects of the program. One such framework (Prieto 2010b) uses a construct similar to popular innovation frameworks (Doblin

Research 2012) but with a distinctive focus on those parameters related to opportunities in large engineering and construction programs, as seen in Fig. 6-8.

Additionally, the program manager implements a number of value-improving practices similar to those recommended by Independent Project Analysis (IPA) (IPA n.d.):

- Technology selection;
- Classes of facility quality (project value objectives);
- Minimizing standards, specifications, and practices;
- Process simplification;
- Waste minimization;
- Process reliability modeling;
- Design to capacity;
- Predictive maintenance;
- Constructability;
- Energy optimization;
- Value engineering; and
- 3-D CAD design.

Primacy of Safety

Safety must be of primary importance to the program manager. Not only is it the right thing to do, it is also sound business practice. There is a demonstrable link (Safety and Productivity 2006) between safety and program productivity. A safe project has been better planned, attention to details of the construction process on the part of supervisors and workers has been heightened, oversight has been continuously present, and lessons learned have been quickly fed back into the program's

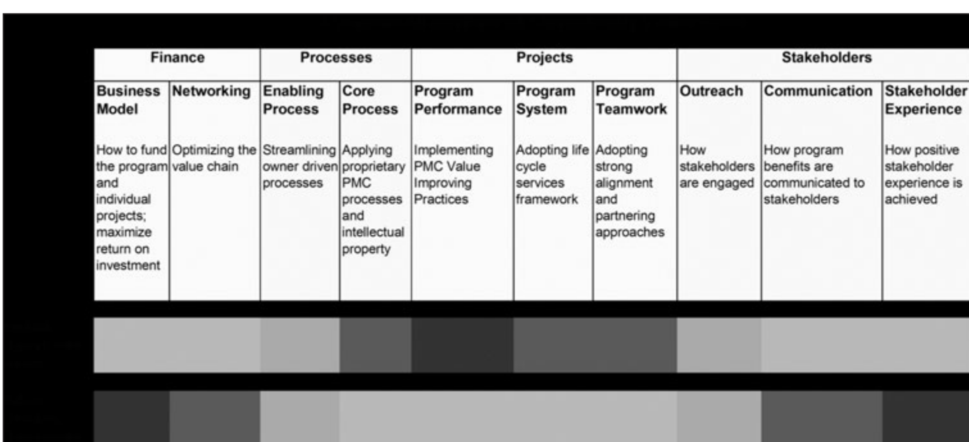

Fig. 6-8. Program management opportunity framework

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processes. Separately, studies on the effect of change during the construction process have found disruption to be the major cost associated with changes during construction. By their nature, unsafe working conditions and practices tend to be disruptive.

Mega programs involve the use of multiple contractors working in close proximity with an ability to affect each other's operations. Additionally, these contractors are drawing on the same labor pools and are overseen by the same inspectors and regulatory bodies. Consistency and best practices are important.

The program manager must ensure the following:

- Programmatic consideration of safety should include the interaction at a human and physical level between all projects, not just within the battery limits or scope of a given project.
- Safety and associated environmental and health standards must be consistently applied across all projects.
- Programs with a phased operation of facilities must consider operational risks to the surrounding construction workforce.
- Safety processes must recognize that the external factors influencing the safety of a given project evolve over time and may not be intuitive to project-related safety operations.

Framework Systems

Successful program management requires the implementation of a comprehensive set of framework processes that transcend those required in a project context. The range of issues to be assessed, managed, and monitored is characteristic of differences between program and project management. Important to successful program management is the degree of integration between each of these processes. Though a range of individual tools exist to implement each framework process, benefits accrue when these tools are as seamlessly integrated as possible.

Framework processes (Prieto 2008c) by their nature are intended to touch upon each of the core elements of program management while providing an execution framework for day-to-day program activities, as illustrated in Fig. 6-9.

Framework systems (Prieto 2008e) typically used by a program manager can be thought of in a manner consistent with the governance framework previously described. Whereas these systems have been categorized by their primary function, in reality, each of these systems extends across assurance, alignment, and improvement activities, as shown in Table 6-2.

Program Manager's Role Reflects Shift in Responsibilities

The application of a program management approach to mega programs requires an evolution of the owner's role (Prieto 2008b) from one that he or she has traditionally played. The effect of this evolution is for the owner's organization to provide

Fig. 6-9. Strategic program management framework

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Table 6-2. Framework Systems

Assurance	Alignment	Improvement
• Audits • Change Impact Assessment (CIA) • Constructability analysis, systemic • Contingency management • Cost estimating • Ethics training and compliance • Insurance • Legal • Operations and maintenance • Project security • Risk management • Safety	• Budgeting, fund management and allocation, expenditure approval, and tracking of funds committed and expended • Configuration management • Construction mobilization • Material management • Procurement	• Construction technology • Knowledge management • Life-cycle cost analysis • Modularization • Productivity • Standardization • Value-improving practices

increased focus on strategic and higher-value efforts with the program manager driving the program execution process. This change process was touched upon earlier in this chapter, and the resulting governance documents and processes further sharpen this new allocation of responsibilities. The application of the framework systems is governed very much by this allocation of responsibilities.

Let's look at a few aspects of the program manager's role as it may be applied to the management of mega programs:

Scope—The program manager participates with the owner in top-level program definition and trade-off activities, providing added specialty resources not traditionally engaged in by the owner organization and bringing a programmatic focus to assessing strategies and effects on overall program schedule and cost. The program manager works in support of the owner to define the level of scope definition required at the study phase while avoiding prescriptive definitions that undermine overall programmatic standardization and procurement leverage activities.

Schedule—The program manager prepares an integrated master schedule clearly reflecting owner activities affecting activities under his or her control. The master schedule reflects a clear programmatic view showing interactions between various projects, allocation of resources across individual projects and to programmatic activities, and changed delivery and procurement activities conducted on a programmatic basis across all projects in the program.

Risk management—The program manager undertakes a significantly more robust risk assessment on a programmatic as well as a project-by-project basis. Increased emphasis is placed on interface risks across all program elements as well as event-driven risks that arise out of the scope of the overall program. Risks associated with scale take on increased importance. Contingency management is partitioned between the owner and program manager, with certain contingency elements retained by the owner, reflecting his or her ability to best manage the associated risks, and other elements of contingency under shared management of the owner and program manager. Contingency management by the program manager is accomplished under a well-structured process, and any contingency releases are reported to the owner as part of periodic reporting and appropriate thresholds established for releases of contingency above which owner concurrence is required.

Budget—The program manager provides robust and comprehensive risk assessments, prepares budget requests that are independently reviewed by the owner's staff, budget performance assessment for activities under the program manager's purview, audit of invoices and other expenditures of costs incurred, and augmented forecasting activities when compared to project-based approaches.

Project management—The program manager provides direct management of all projects and program activities within his or her scope of work. Project management activities are accomplished with a heavy emphasis on identifying opportunities for multiproject sharing and leveraging of resources. Management reporting is consolidated on a programmatic basis and provides both project performance and programmatic views. Project and programmatic reviews are conducted on a scheduled basis with both individual project managers and the owner's functional leadership.

Engineering—The program manager's role in engineering is using increased standardization, consolidated procurement, and constructability considerations to allow definitional and trade-off studies conducted under the owner's leadership and using an enhanced set of planning tools. The program manager is responsible for packaging, procurement, and management of engineering work packages to be provided by third parties, in addition to work performed directly by the program manager. Third-party engineering procurements above a threshold level require owner concurrence. The program manager provides consolidated resource management in constrained situations, design processes, standards, and procedures to be used across all projects making up the program. Interface management takes on increased importance, as does the assurance of comprehensive implementation of programmatic engineering standards.

Procurement—The program manager focuses on the opportunity to achieve increased leverage on total spending (Prieto 2008f) through consolidation of select procurement activities related to major commodities, common equipment, and major services. A program management approach is likely to result in increased usage of common supply contracts to discrete projects. A programmatic procurement strategy increases visibility of common cost drivers and opens up additional management strategies and hedging options. Procurement activities also include more comprehensive and robust activities related to supplier diversity; supplier quality surveillance, including permanent in-shop teams for major suppliers delivering throughout the full program cycle; material management; material transport and logistics, including forward contracts; supplier integration, including increased prototyping, preassembly, and modularization (Construction Users Roundtable 2007); export–import control and expedited customs processes; escalation and hedging strategies; performance benchmarking; warranty provisions and durations; required spares and commissioning support; and implementation of supplier relationship agreements. New contracting strategies are also facilitated through a program approach to achieve strategic business objectives, including use of a master electrical contractor; master automation contractor; dedicated start-up and commissioning team; and procurement of select facilities on a delivered service basis, as opposed to a direct ownership basis (financed off the balance sheet and paid-for usage or availability of service; e.g., power or potable water).

Summary

In summary, the program manager takes on many of the responsibilities that would have resided more traditionally within the owner's organization. This change in responsibilities must be underpinned by well-defined strategic business objectives by the owner, well-developed governance processes, and an early focus on organizational change management. Among the many perspectives and skills the program manager must bring are heightened sensitivity to the changed nature of risk and the primacy of safety.

This changed risk focus must look well beyond the risks embedded in discrete program elements and projects and into the "white space" between these elements.

This perspective on risk must extend from the tactical and well into the strategic risks, which can quickly undermine an entire program. Strategic program management roles extend this risk perspective throughout the complete program life cycle.

The program manager, however, must not only manage the risks associated with scale and increased complexity, but equally important, seek out and capitalize on the leverage of opportunity that is inherent in a mega program.

The tools used by the program manager must certainly be fit for the purpose, but the integration of these tools is even more important. Processes must be aligned with strategic business objectives and governance frameworks and must ensure that root causes are understood at the earliest point.

The program manager on today's mega program must be prepared to challenge convention and bring the systems perspective that is increasingly required.

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CHAPTER 7

Financing Megaprojects

Gerald Tucker

No matter how much a megaproject is needed, no matter how much it will improve the economy or people's lives, if financing is not available, the megaproject will not be completed. The financing of any project is critical to its success, but the level of financial resources necessary for the completion of a megaproject (usually defined as being more than US$1 billion) is especially challenging. This problem is true for any megaproject, whether financed by public entities, private entities, or a combination of the two. The costs associated with megaprojects make it a significant challenge to finance these projects. With the tightening of the credit markets in the recession of 2008–2010, the inability of both public and private entities to finance megaprojects has created even more significant problems.

Public Transportation Megaprojects

The size and scope of public megaprojects, primarily transportation projects, make the financing of megaprojects difficult using traditional pay-as-you-go methods. Because of the size and extended completion time lines of most megaprojects, it is not feasible to cover project costs on a fiscal year basis because of both the total amount of transportation project funding available each year and the presence of numerous competing projects. However, waiting until public financing is available to either start or complete a project inevitably results in increased traffic congestion and additional capital costs.

Many of those costs are then dedicated to preventing further deterioration of existing infrastructure and remediating the public dissatisfaction resulting from increased traffic congestion and other delays and inconveniences.

In the 1990s, the growing need to update the United States' aging transportation infrastructure systems made megaprojects an increasing part of the project mix. Several transportation megaprojects were completed in the 1990s. One was the

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LESSONS LEARNED

1. Financing is the most challenging aspect of any megaproject, regardless of the benefits that flow as a result of that megaproject.
2. Financing public transportation megaprojects is difficult because of both the availability of public funds and the timing of financing.
3. Increasingly, transportation megaprojects are focused on replacing aging transportation infrastructure.
4. Cost overruns in transportation megaprojects appear to be the norm and not the exception.
5. The U.S. government now requires every transportation megaproject using public funding to submit annually updated financial plans.
6. Financial participation in transportation megaprojects by the U.S. government has dropped in recent years. As a result, the use of public–private partnerships to construct transportation megaprojects has increased.
7. Privately financed megaprojects must compete for financing in the open market, which has a limited amount of capital that can be invested in such megaprojects.
8. Privately financed megaprojects face the issue of immediate high invested cost, with returns on that investment then being spread over a long period of time.
9. The history of nuclear power projects from the 1970s through today provides a clear example of the risks involved in private investment in megaprojects.

US$2.4 billion Alameda Corridor, consisting of an express rail line linking the ports of Los Angeles and Long Beach, California. Another major project was the US$1.6 billion reconstruction of 17 mi of I-15 in Salt Lake City, Utah, in preparation for the 2002 winter Olympic games. Some major projects were started in the 1990s and continued into the new century, including the Central Artery/Tunnel project (the "Big Dig") in Boston, and the US$1.3 billion Foothill Freeway project between Los Angeles County and San Bernardino County, California. (All project dollars are expressed as dollars at the time of construction and are shown without adjustment to current dollars.)

Additional megaprojects in the United States that were in process in the 2000s, with some continuing into the 2010s, include the following:

- I-80/San Francisco–Oakland Bay Bridge (east span), California;
- I-25/I-225 Southeast Corridor (T-REX), Denver, Colorado;
- I-95/New Haven Harbor Crossing Corridor Improvement Program, New Haven, Connecticut;
- I-4, Orlando, Florida;

- Miami Intermodal Center, Miami, Florida;
- Tampa Interstate System (TIS), Tampa, Florida;
- Chicago Region Environmental and Transportation Efficiency (CREATE) Program, Chicago, Illinois;
- New Mississippi River Bridge (St. Louis), Illinois–Missouri;
- New Ohio River Bridges (Louisville), Kentucky and Indiana;
- Intercounty Connector, Maryland;
- I-94/Edsel Ford Freeway, Detroit, Michigan;
- Mon/Fayette Expressway Toll Facility, Pittsburgh, Pennsylvania;
- Central Texas Turnpike, Texas;
- I-10/Katy Freeway, Houston, Texas;
- Trans-Texas Corridor, Texas;
- I-64/Hampton Roads Third Crossing, Virginia;
- I-95/I-395/I-495/Springfield Interchange, Springfield, Virginia;
- I-95/Woodrow Wilson Bridge, Maryland, Virginia, and Washington, DC; and
- I-43/I-94/I794/Marquette Interchange, Milwaukee, Wisconsin.

One of the results of these major projects was the realization by public transportation agencies that the complexities inherent in such large projects, the length of time required to complete the projects, the attrition of project staff, and the complex engineering and design issues made it difficult to keep cost overruns from overwhelming the projects.

As a result of the hard lessons learned from the megaprojects started in the 1990s, the U.S. Congress included a provision in its Transportation Equity Act for the 21st Century (TEA-21) that required every megaproject of US$1 billion or more that received federal funds to have its financial plan updated each year. TEA-21 was passed in 1998 and provided funding for projects through 2003, authorizing more than US$200 billion in funding to improve the nation's transportation infrastructure, enhance economic growth, and protect the environment. TEA-21 was designed to create new opportunities to improve air and water quality, restore wetlands and natural habitat, and rejuvenate urban areas through transportation redevelopment, increased transit, and sustainable alternatives to urban sprawl.

In August 2005, President George W. Bush signed the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) into law. This act provided US$244.1 billion, as expressed then, without adjustment to current dollars, in funding for highways, highway safety, and public transportation projects. The act also redefined a megaproject to include projects of US$500 million or more, thus increasing the number of projects that were required to provide annual updates to their financial plans. The focus of the financial plan update process is to provide a comparison of original cost estimates to actual costs and project completion schedules, as well as a reasonable assurance that resources are available to complete the project as currently planned.

Traditionally the U.S. federal government has financed transportation projects by providing grants of up to 80% of project costs (90% on interstate projects), with states and local governments providing the remaining funds. The funding of megaprojects, however, varies significantly, and some of the major projects receive funding of 60% or less. This reduced federal participation highlights the need for state and local governments to make difficult decisions on their use of federal funds. Funding levels are set based on the total needs of the individual government entity requesting the funds, and there are seldom sufficient federal funds to cover all projects. Smaller projects that provide more immediate benefit to citizens tend to be funded first, leaving major projects short of funding.

Two programs have been implemented in the United States in recent years to allow for the funding of megaprojects in a timely manner. First is the Grant Anticipation Revenue Vehicle (GARVEE) Program, a program that is directed specifically toward highway project funding (FHA 2012). Under this program, states can issue debt-financed instruments such as bonds to pay for current expenditures on megaprojects and repay the debt using future federal apportionments. Projects funded with the proceeds of a GARVEE debt instrument are subject to the same requirements as other federally funded projects, with one exception—the reimbursement process. Instead of reimbursing construction costs as they are incurred, the reimbursement of GARVEE project costs occurs when debt service is due.

The second program is the Transportation Infrastructure Finance and Innovation Act (TIFIA). Under this program, federal credit assistance is provided in the form of direct loans, loan guarantees, and standby lines of credit in order to finance surface transportation projects of national and regional significance. TIFIA credit assistance provides improved access to capital markets, flexible repayment terms, and potentially more favorable interest rates than can be found in private capital markets for similar instruments. TIFIA can help advance qualified megaprojects that otherwise might be delayed or deferred because of size, complexity, or uncertainty over the timing of revenues. Each dollar of federal funds can provide up to US$10 in TIFIA credit assistance and leverage as much as US$30 in transportation investment.

An important new trend in the financing of transportation megaprojects is the use of public–private partnerships. This method has allowed construction projects to be completed years earlier than if they had waited for financing through the process of annual appropriations of federal and local funds. As an example, the Trans-Texas Corridor has been proposed to provide surface transportation, utility rights-of-way, and rail service between Mexico and Oklahoma. As part of the financing arrangement for the element of the project between Dallas and San Antonio, a private consortium has agreed to invest US$6.0 billion in a toll road and give the state US$1.2 billion for additional transportation improvements between Oklahoma and Mexico. In return, the firm plans to negotiate a 50-year contract to maintain and operate the toll road.

Risk transfer is another significant benefit of PPPs, according to Robert Poole, director of transportation studies and founder of the Reason Foundation. "Public–private partnerships shift some of the risks involved from taxpayers to the private capital markets and large global companies that can afford and are willing to take those risks under the right kinds of agreements," he says. "The challenge is to develop public–private partnerships that are genuinely partnerships and have benefits for both sides" (Capka 2006).

Private Projects

Like public projects, private megaprojects must compete for funding in a world of limited credit and concerned investors. Though not exclusively so, the majority of private megaprojects are in the energy and power production areas. A number of megaprojects in the energy field had been announced in the 1970s but were canceled as a result of the recession and the decline in energy prices during the 1980s. This pattern is repeating itself today as a result of the current recession and uncertainty concerning future energy prices. Megaprojects can only thrive in an atmosphere of certainty. A megaproject that must depend on long-term commitments over 10, 20, or even 50 years involving billions of dollars and thousands of person-years of effort can only be undertaken with assured finances, good product demand, a supportive and stable political environment, and proven technology. Without this certainty, megaprojects can easily become white elephants.

This situation is no better seen than in the construction of nuclear power plants in the United States during the 1970s and 1980s. Nuclear plants started in this period were subject to enormous changes in the design, schedule, and political environment. Public opinion soured as the costs of the plants increased and especially after the incident at Three Mile Island in 1979. Planned generating units were scrapped after millions of dollars were invested with no possibility of recovering those costs. In the early 21st century, more than 25 years since the last unit was completed, there is an increased interest in the construction of nuclear power generation plants. However, the costs of the units are still a concern that must be addressed to make the units economically productive over the life of operation. By the end of 2011, 13 new nuclear units had been announced in the United States and were awaiting construction approval, and it was announced in early 2012 that Southern Company was granted approval to construct two new nuclear power reactors. Southern Company, which serves 4.4 million customers in the southeast United States, has secured a loan guarantee from the U.S. Department of Energy for the new reactors. As more units are added to the loan program, it is expected that most if not all of the remaining scheduled units will receive loan assistance.

The U.S. Department of Energy's loan guarantee program was established under Title XVII of the Energy Policy Act of 2005. Under this program, the Secretary of Energy is authorized to make loan guarantees to qualified projects. It is believed that accelerated commercial use of new or improved technologies will help to sustain economic growth, yield environmental benefits, and produce a more stable and secure energy supply. The original loan program was set at US$18.5 billion for guarantees necessary to assist in the construction of nuclear power plants. This program is expected to be increased by US$36 billion, for an expected total of US$54.5 billion through 2011.

In a news release on February 16, 2010, the Nuclear Energy Institute (NEI 2010) made the following comment:

> The nuclear industry commends the Obama administration and the Department of Energy for having reached this major milestone in implementing

> the clean-energy loan guarantee program authorized by Congress in 2005. This first conditional commitment demonstrates the Administration's recognition that new nuclear power plants must be part of America's clean-energy portfolio.
>
> This loan guarantee, and others to follow, will act as a catalyst to accelerate construction of new nuclear plants and other low- and non-emitting sources of electricity. By easing access to capital markets for electric companies seeking to build new reactors and reducing the cost of capital for clean-energy projects, loan guarantees reduce the cost of electricity to consumers—a significant win–win proposition in these difficult economic times.
>
> We've already seen the results of the early preparation for building nuclear plants. Over the past few years, more than 15,000 new jobs have been created in the nuclear energy sector. U.S. manufacturers of components for nuclear power plants and fuel cycle facilities are adding to design and engineering staff, expanding their capability to manufacture components, and building new manufacturing facilities in Virginia, Tennessee, Louisiana and other states.

The major challenges to be faced in building these projects in the years ahead will be the control of costs and schedules. Both will affect the continued problems with financing projects in a cost-effective manner.

Among the megaprojects under way today, there are three that are of note in both scale and the major challenges in construction and financing.

The World's Longest Tunnel: Gotthard Base Tunnel

The Gotthard Base Tunnel is a railway tunnel under construction in Switzerland. This project is built and financed by a wholly owned subsidiary of the Swiss Federal Railways. It consists of two separate tunnels containing one rail track each with a total distance of 35.4 mi (56.97 km) for each tunnel. This distance makes this project the longest tunnel project in the world. The project has an expected cost of US$6.4 billion and is expected to be completed in 2017 or 2018. Swiss voters approved the tunnel's construction using government financing in a series of referendums almost 20 years ago. Despite some criticism at the cost—almost $1,300 for every citizen—the proposal passed by a wide margin.

New York City Water Tunnel No. 3

The New York City Water Tunnel No. 3 is the largest capital construction project in New York state's history and among the most complex engineering projects in the world. It is being constructed by the New York City Department of Environmental Protection. The tunnel will eventually be more than 60 mi (96.56 km) long and is expected to cost a total of US$6 billion. Construction on the tunnel began in 1970 and is not expected to be completed until at least 2020. The tunnel lies at an average of 400 ft (121.92 m) underground, reaching a maximum of 800 ft (243.84 m) underground at its deepest and is constructed through bedrock. The concrete-lined tunnel is 24 ft (7.31 m) in diameter and is subsequently reduced to 20 ft (6.09 m) in diameter to provide the necessary pressure to supply 14 supply shafts that connect with the existing distribution system. The project is financed through the New York City Municipal Water Finance Authority, which issues sewer revenue bonds directly to the public and Clean Water and Drinking Water Revolving Fund bonds in conjunction with the New York State Environmental Facilities Corporation for major construction projects.

Panama Canal Expansion

The current Panama Canal has two lanes, each with its own set of locks. In 2006 the government of Panama announced that it intended to expand the canal cargo capacity by installing a third lane through the construction of lock complexes at each end of the canal. The new lock chambers will be 1,400 ft long (426.72 m) and 180 ft (54.86 m) wide, which will increase the ability of the canal to accommodate the larger cargo ships being built today. The project is expected to be completed in 2014 at a cost of approximately US$6.2 billion.

According to the Panama Canal Authority (PCA), the third set of locks is financially profitable, producing a 12% internal rate of return. Its financing is separate from the government's budget. The state, which has a lower credit rating than PCA, does not guarantee or endorse any loans borrowed by the PCA for the project. Assuming that tolls will increase at an annual average rate of 3.5% for 20 years, and according to the traffic demand forecast and construction schedule deemed most likely by the PCA, the external financing required will be temporary and on the order of US$2.3 billion to cover peak construction activities between 2009 and 2011.

The PCA's revenue projections are based on assumptions about increases in canal usage and the willingness of shippers to pay higher tolls instead of seeking competing routes. With the cash flow generated by the expanded canal, investment costs are expected to be recovered in less than 10 years and financing could be repaid in approximately eight years.

The US$2.3 billion financing package for the canal expansion signed in December 2008 in the midst of the global financial crisis includes loans from the following government-owned financial institutions:

- Japan Bank for International Cooperation, US$800 million;
- European Investment Bank, US$500 million;
- Inter-American Development Bank, US$400 million;
- Corporacion Andina de Fomento, US$300 million; and
- International Finance Corporation, US$300 million.

The financing is not tied, that is, contracts can be awarded to firms from any country. The loans are for 20 years, including a 10-year grace period. Under a common terms agreement, the five financial institutions have agreed to provide the same loan conditions to the PCA. Shortly before, the credit rating agency Moody's gave the PCA an A1 investment grade rating.

Summary

No matter how a megaproject is financed, a critical component of success is whether the initial project cost estimate can stand up over time. A true representation of costs is necessary to determine the most appropriate financing mechanism.

Robert Poole, director of transportation studies and founder of the Reason Foundation, has stated that "part of the problem has been an incentive to underestimate the cost because of the fear that people wouldn't approve a project if they knew the true cost." Underestimation of megaproject costs is a concern overseas as well. In a study of 258 transportation infrastructure projects worldwide, Professor Bent Flyvbjerg of Aalborg University in Denmark found that costs were underestimated in 9 out of 10 projects, actual costs of all types of projects were on average 28% higher than estimated costs, and actual costs of road projects were 20.4% higher (Flyvbjerg 2002).

Underestimation of costs at the time of the decision to build is the rule rather than the exception for transportation infrastructure projects. Frequent and substantial cost escalation is the result.

Securing funding and then managing costs (and managing the public perception of costs involved with megaprojects) is the challenge that must be met if megaprojects are to be viewed as successful projects in the future.

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CHAPTER 8

Six Challenges to Controlling Megaprojects

Patricia D. Galloway and John J. Reilly

This chapter addresses control from the perspective of management's ability to actually control the two most critical goals on any megaproject: ultimate cost and the date of completion (Reilly 2010). This chapter does not address "project controls" as the term of art used to encompass the processes and systems in place to capture, monitor, or report on the progress of a project at given points during the execution of a megaproject. There are literally hundreds of references on project control systems and processes. However, what many of those references do not address is how management actually exercises control over a project's cost and schedule using those systems during the execution of the megaproject. In particular, those references do not identify the challenges faced by management in its attempt to exercise control over a megaproject's cost and schedule during execution. This chapter examines the challenges that must be overcome if management is to exercise the maximum control possible on cost and schedule. The authors have identified six challenges to be met and overcome by management during the execution of a megaproject.

Factors in Planning and Executing Megaprojects

Many factors go into successfully planning and executing a megaproject; however, there would be little disagreement that two primary factors are (1) how well the megaproject is *managed* and (2) ensuring that the megaproject can be kept under *control* during planning and execution. Management and control are two different, yet interrelated, factors upon which the ultimate success of the megaproject rests.

Management from the perspective of a construction megaproject is best defined within the PMI body of knowledge: Project management is application of knowledge, skills, tools, and techniques to project activities to meet project requirements. PMI then identifies 42 "logically grouped project management processes" that form the application platform from which project management activities and actions are taken

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LESSONS LEARNED

1. The two most critical control issues on a megaproject are cost and schedule.
2. Measuring cost and schedule performance depends on the expectations set for both cost and schedule at the beginning of the megaproject.
3. Nonparticipatory stakeholders to a megaproject do not hear (or understand) the concept or context of the cost or schedule estimate (at a point in time); they interpret that amount and that date as a promise even though many factors are subject to change.
4. Control is based on being able to trend current conditions and forecast future results assuming the various control responses are available and ultimately applied.
5. Changes and effects do not just ripple through linked work activities on a megaproject; they also ricochet through nonlinked work activities because of the complexity and density of the megaproject.
6. The single most critical factor to exercising control is the engagement of sufficiently experienced and qualified cost and schedule staff.
7. There are powerful tools to assist in controlling cost and schedule. However, they are only tools—people must absorb the information and ultimately make the decisions based on the information.
8. Document management is vital to any proactive control process—and potentially to defend against disputes, claims, and litigation—yet it is one of the most neglected elements in the megaproject organizational structure.

(PMI 2008). Essentially, project management is a process (or set of processes) used to guide and focus work toward achievement of goals that have been set for the project.

Control, however, is not so easily defined. According to *Black's Law Dictionary*, control is "to regulate or govern" the planning and execution of a megaproject (Garner 1999). In more common usage, control means to "1. to exercise restraint or direction over; dominate, regulate, or command; 2. to hold in check; curb." Within megaprojects, control means primarily to hold in check in order to prevent such things as cost overruns and schedule delays or to maintain minimum required quality.

Why is this distinction important? Simply because one can *manage* a megaproject well using all of the best available tools and processes and yet still fail to exercise *control* over the megaproject during planning and execution, which almost always results in the megaproject failing to meet its scope, cost, schedule, and quality goals. Management and management processes are addressed throughout this book by a number of experienced and respected professionals from a number of perspectives from within the construction industry. In addition, there are literally hundreds of books and articles published every year relative to the management of construction projects—including megaprojects—that offer sound advice and direction concerning management processes, systems, and techniques for those projects. For that reason, this chapter does not address management of megaprojects or the processes and system tools that can be used in managing a megaproject. Rather this chapter focuses primarily on control of the megaproject and, specifically, six of the biggest challenges faced by management as it attempts to hold the project in check.

Megaprojects exhibit most, if not all, of the following attributes:

- Cost above US$1 billion (above US$10 billion for gigaprojects);
- Multiple-year execution schedules;
- Multinational involvement of designers, engineers, contractors, equipment suppliers, and specialty material vendors;
- Specialty trade workforces numbering in the thousands of individuals;
- Consortium financing and/or ownership;
- Technical complexity;
- Political ramifications and risks; and
- Social ramifications and risks.

Inattention to any one of those factors, or combinations of factors, can result in losing control of the megaproject, and loss of control at any point during the execution of a megaproject can have devastating effects on achievement of megaproject goals. It would be impossible in one chapter (or book) to examine all of the possible challenges to management's ability to control a megaproject; as a result, we have focused on the two most critical and visible megaproject goals—cost and schedule—and six of the challenges that are critical to overcome if management is to maintain control over the megaproject during execution.

The Six Challenges to Controlling Megaprojects

The six challenges are not the only ones that management must overcome on a megaproject. However, in our experience, they represent challenges that have some unique characteristics when viewed in the context of megaprojects and/or are of heightened importance in a megaproject context. The six challenges to controlling a megaproject discussed in this chapter are

- The ricochet effect,
- Controlling nonparticipatory stakeholder expectations,
- Controlling cultural differences,
- Controlling cost creep,
- Controlling schedule creep, and
- Controlling information overload.

Each of those six challenges has confronted us during our involvement in a variety of megaprojects. Each of those six challenges flowed more from issues related to an inability to control some element of the megaproject, even when the megaproject in question had sound management processes, systems, and experienced management personnel in place during the execution of the megaproject. None of those six challenges are easily managed or controlled during the execution of a megaproject, yet each must be recognized and addressed during the planning and execution of any megaproject.

Challenge 1: The Ricochet Effect

Everyone involved with construction projects generally understands the phenomenon of "ripple effect." For example, the delay to the delivery of a needed commodity ripples through a particular string of schedule activities necessary to complete a specific element of the full scope of work. Ripple effects are likewise common within megaprojects. However, megaprojects exhibit another effect, which we call the ricochet effect. Simply, it is almost impossible to introduce a significant change into one element of work in a megaproject that does not have some *unexpected and unintended* effect on some other element(s) of work in the megaproject. Ripple effects are generally isolated to a particular string of logically related activities within a scope of work, but a ricochet effect bounces through nonlogically linked activity strings in unexpected and unpredictable ways, which results in unintended consequences for those other activities and often the megaproject as a whole.

The ricochet effect exists primarily because of the size and complexity of the megaproject. With thousands of workers attempting to execute complex construction within what are normally confined areas involving huge amounts of equipment and materials, it is easy to understand how one change tossed into the middle of all that activity may ricochet into other elements of the work in progress that may have no direct relationship whatsoever to the element of work to which the change has actually been introduced.

The same optimistic bias (Reilly 2001) that has been identified in megaproject estimates and schedules could be said to exist relative to the management of change on a megaproject. Often project management assumes that the effect of a change will be limited to those activities that are on the same path (cost or schedule) within which the change is to be made. As a result, project management tends to focus on the activity strings that are directly linked to the changed condition, and analysis is limited to how to avoid or mitigate any effects of that change to that specific string of activities. Unfortunately, cost and schedule on a megaproject are especially vulnerable to what we describe as the ricochet effect. Because the ricochet effects are normally unintended and unforeseen consequences of a change to a specific element of work, management seldom takes such ricochet effects into account when examining and estimating the cost or schedule effects of changes on a megaproject. Often management is not even aware of any such effects until cost increases or schedule delays in other activity strings show up that management in retrospect is able to tie to a change that was made to a nonaffiliated activity string.

Let us assume a fairly simple (and not uncommon) example: A single piece of equipment is modified to meet a change in an operational specification, which in turn increases the size and weight of the equipment to be installed, resulting in the "lift" of that equipment being reclassified from moderate to heavy. There is only one crane on site capable of a heavy lift, and it is not situated close to where the new heavy lift will have to be made. To shift the crane will take 24 hours and require work along the path of the crane shift to be stopped in stages as the crane is relocated. In addition, the heavy lift schedule will have to be adjusted, pushing two planned heavy lifts forward in time and delaying four other heavy lifts from their scheduled time. If the effect were limited to just the project activity string of the six affected lifts in the schedule or just the new heavy lift, this change would be a fairly simple adjustment to the flow of the project and the cost and schedule effects to the affiliated activity strings would be straightforward calculations.

Craft labor on a megaproject is an expensive and hard to find (and maintain) commodity. On megaprojects, that labor almost always is working in a "dense environment," meaning that there are few open lanes of travel through the megaproject. To move a heavy lift crane requires substantial clear space, and idling the labor scheduled to work in the path of the crane shift and then back for the four delayed lifts; as a result the labor productivity of the two accelerated lifts and the four delayed lifts does not just affect a handful of the total megaproject labor. The acceleration and delay are likely to ricochet through the labor activities on site that appear to have no direct affiliation to those lifts or that equipment but that are nonetheless in turn accelerated or delayed as an unintended result of the one change that involves moving the heavy lift crane twice. Even something as simple as shifting the location of the large-bore pipe storage and assembly area, which would seem to affect only the piping activities, can result in ricochet effects to other activities in a heavily populated, highly congested megaproject worksite.

Ultimately, there are no simple changes to a megaproject once it is underway, and project management needs to assume that every change has some effect on either cost or schedule, or both. Even one seemingly minor change can idle hundreds of craft labor, and when you affect the productivity of that many laborers, you affect cost and schedule. Those charged with controlling cost and controlling schedule must always be aware of, and looking for, the unintended and unexpected ricochets that can come of even seemingly simple changes in the megaproject. Part of controlling either cost or schedule involves the identification and mitigation of the unintended consequences of decisions made or actions taken by megaproject management.

Change management cannot remain a more or less ad hoc activity, during which only those directly responsible for planning and managing the activity string directly involved in the change are involved. When a change in any work activity string is contemplated, designated "change representatives" from each of the primary participatory stakeholders need to be actively involved in examining the change to determine if there are any ricochet effects that would affect other activity strings thought to be outside of the zone of the change. If any such ricochet effects are identified, then the cost and schedule estimates for that change, and the planning to execute the change, need to reflect the ricochet effects.

Challenge 2: Controlling Nonparticipatory Stakeholder Expectations

For the purposes of this chapter, we have used the two categories of stakeholders to a megaproject, as defined in Chapter 1:

Participatory (direct) stakeholders are those directly involved in the planning and execution of the megaproject, including the owner (including public entities such as departments of transportation [DOTs]), consultants, engineers, constructors, subcontractors, vendors, and suppliers; and

Nonparticipatory (industry) stakeholders are those affected by the megaproject and who can have influence but who have no direct involvement in or control over the planning, management, or execution of the megaproject, including outside investors, regulatory agencies, labor unions, local government departments, the media, special interest groups, and the general public.

Megaproject success is judged on a straight "pass–fail" basis by nonparticipatory stakeholders; the megaproject either met its critical expectations or it did not. Nonparticipatory stakeholders in general have three primary expectations relative to a megaproject: (1) the ultimate cost of the megaproject, (2) the ultimate time to complete the megaproject; and (3) whether the completed megaproject fulfills its intended purpose, all as promised by those promoting and directly participating in the execution of the megaproject. If the promoters and participating stakeholders to the megaproject tell the nonparticipatory stakeholders that the megaproject will cost US$1.5 billion, it will be done five years from today, and it will solve all of their transportation problems, those same nonparticipatory stakeholders will not react well to receiving a constant stream of news that the megaproject cost has increased and the time to completion has been "adjusted out" for progressively later dates. When the ultimate cost of that megaproject reaches, say, US$3.2 billion, it takes seven years to complete, and traffic remains snarled, it is graded as a failure by nonparticipatory stakeholders.

Note the specific use of the phrase "as promised by those promoting and directly participating in the execution of the megaproject" in the preceding paragraph. Even knowledgeable nonparticipatory stakeholders often do not distinguish between an estimate and a promise, and arguing after the fact that they were never promised the estimated cost would be the final cost or that the estimated completion date would be the date the project was finished simply fails to soothe their ire when the megaproject overruns its estimated cost by millions or hundreds of millions of dollars or when the project takes twice as long to complete as originally estimated. It needs to be clearly understood that the majority of nonparticipatory stakeholders set their expectations firmly in what they are told by megaproject promoters and management at the time when those promoters and managers are seeking support and/or approval of their megaproject. Attempting to explain five years later that the cost and schedules were just estimates and as a result nonparticipatory stakeholders should not have interpreted the costs or schedules as promises simply is not acceptable.

Nor will the nonparticipatory stakeholders accept the argument that because the original cost and schedule data were merely estimates, those participatory stakeholders promoting and executing the megaproject cannot be held accountable for the failure to achieve those cost or schedule goals.

Unfortunately, the effect of megaprojects that failed to meet the nonparticipatory stakeholder expectations is not limited to those who are directly involved in any particular megaproject. There have been some spectacular and well-publicized megaproject failures insofar as failure to achieve cost and schedule expectations globally, for example, the Channel Tunnel between the United Kingdom and France, and Boston's Big Dig, to name just two of the most well publicized. Some studies (e.g., Reilly 2001, Flyvbjerg et al. 2002 and 2003, and Salvucci 2003) present data from which one could essentially conclude that cost overruns and delays on megaprojects are not only routine, but they also appear to be inevitable and unavoidable. From the nonparticipatory stakeholder's perspective, it often appears that megaproject costs and schedules are impossible to control. In part, this situation occurs because many megaproject promoters set and publish unrealistic cost and schedule goals for megaprojects.

This perspective is further fueled by the seeming inability of megaproject management to explain why the cost and schedule expectations were not met and the additional confusion that arises when participatory stakeholders engage in disputes both during work and at the completion of the megaproject. During those disputes, the nonparticipatory stakeholders watch while each party involved in the dispute accuses every other party for the failure to meet cost and schedule expectations set for the megaproject. Given the global reporting of these spectacular failures and the confusion sown by participatory stakeholders during disputes, one can understand how nonparticipatory stakeholders have become extremely skeptical of any plan to execute a megaproject, public or private. More and more often, nonparticipating stakeholders who have been continuously exposed to what appears to be a chronic condition under which the cost and schedule of a megaproject either cannot be accurately estimated and/or controlled simply do not believe those promoting a megaproject by extolling benefits to be gained for a named price and within a certain schedule. Cynicism appears to have grown to the point where certain analysts have moved from accusing megaproject promoters of being "overly optimistic" to now accusing those who promoted such megaprojects as having lied as to the ultimate cost and schedule simply to ensure that the megaproject was approved, funded, and executed (Flyvbjerg et al. 2002 and 2003).

Why should participatory stakeholders be concerned about the perceptions of nonparticipatory stakeholders? The answer is clear: Without the investment capital—public and/or private—necessary to execute the megaproject and without the support and consent of those nonparticipatory stakeholders that will be affected by the megaproject, few megaprojects would ever advance beyond the conceptual stage. If you can't convince an investor that the estimates are sound and costs can be controlled, they will not invest. Likewise, by their nature and size, megaprojects, even if privately funded, require various levels of governmental and regulatory approval and oversight; and if enough nonparticipatory stakeholders band together to block a megaproject, they will be heard by those who control the approval processes. Because of that situation, those directly involved in megaproject planning, management, and execution must forthrightly address the perception that the cost and schedule of a megaproject cannot be controlled during the execution of a megaproject.

In general, there are three ways in which the perception of nonparticipatory stakeholders can be changed: (1) improve the accuracy and reliability of the cost and time to completion estimates set for the megaproject; (2) clearly state that a cost estimate is a snapshot at a point in time and is subject to changes that will affect that estimate; and (3) improve the control exercised over cost and time by megaproject management at all levels. Relative to changing the perception of nonparticipatory stakeholders, from our combined experience the following observations and suggestions arise:

- First, as discussed in Chapter 2, improve the way in which uncertainty (risk) effects are estimated for megaprojects. This improvement involves changing how risk is defined, modeled, and analyzed, and ultimately estimated for cost and schedule effects. Megaprojects are not just normal construction projects that have been "supersized." Therefore, risk profiles must be developed and risk management must be monitored, and treatment responses must be done in recognition of those unique risk factors.
- Second, also discussed in Chapter 2, cost and schedule estimates need to include *realistic* projections of risk element effects should those risks actually occur during the execution of the megaproject. Too often in modeling risk on a megaproject, the tendency is toward the optimistic, both in modeling occurrence and effect (showing *optimistic* bias).
- Third, project management must test the "basis of estimate" plans from which cost and schedule goals are set to guard against both the optimistic bias (e.g., "this will be the first megaproject in history that does not encounter any delay in equipment delivery") and setting assumptions within the estimate that do not recognize the additional level of complexity in controlling and coordinating work on a megaproject among multiple parties (e.g., it will not be just one contractor–supplier suffering a delay; it will be multiple delays, with the ricochet effect of those multiple delays affecting a variety of schedule activities in unpredictable ways).
- Fourth, participatory stakeholders must provide much more transparent information to nonparticipatory stakeholders when promoting the megaproject and while executing the megaproject. Nonparticipatory stakeholders need to understand that there are risks in undertaking the megaproject that no one can foresee and that may be to some extent uncontrollable. Participatory stakeholders need to communicate potential cost and schedule issues and effects early and clearly, specifically identifying what project management is doing to mitigate and control those effects. The tendency has been to hold back cost and schedule effect information in the hopes (optimistic bias) that somehow the issue can be dealt with before it becomes common knowledge or before the effects have been quantified. When it finally "leaks out" (and it will, if for no other reason than it

is impossible to keep such knowledge hidden in a project employing thousands of people), it only fuels the perception that the megaproject's management is not to be trusted to tell the truth about the project.

Ultimately, nonparticipatory stakeholders must understand that even in the best managed megaproject, things can go wrong that will make achieving even the most realistic estimates of cost and schedule a challenge. At the same time, management of the megaproject must ensure that those same nonparticipatory stakeholders are provided (1) transparent information relative to risks that could occur that would affect achievement of cost and schedule goals and, (2) as addressed below, continuous updates of those risks and management's actions to manage and control those risks as the project moves through execution.

Challenge 3: Controlling Cultural Differences

Megaprojects are defined by their schedule, cost, and quality goals. Although those elements are crucial to effective cost and schedule control, controlling projects also requires knowledge about dealing with people, organizational options, and communication. However, cultural differences in how those goals and control functions are defined and understood may differ significantly in the diverse cultures that exist around the world. For example, an examination of cultural perspectives of engineers and constructors from Japan finds that the Japanese consulting engineer has traditionally designed and constructed projects in a different manner than that of their counterparts in the United States and Europe (collectively, the Western nations). These differences have centered on management and operation methods and have primarily been based upon Asian values, which from a cultural perspective are quite a contrast to the values perceived to be important in the Western nations. For the purposes of this example, let us assume that a multinational megaproject is heavily weighted toward participatory stakeholders from the Western nations, with a Japanese consulting engineer acting as the project manager.

A book entitled *The Principles of Construction Management*, authored by Masahiko Kunishima and Mikio Shoji was published in Japan in the mid-1990s (Kunishima and Shoji 1994). Despite perceptions that the Japanese have difficulty working outside Japan because of cultural differences and that companies from Western nations have similar difficulties working in Japan or Asia, close review of this book and of PMI's *A Guide to the Project Management Body of Knowledge* (PMI 2008) clearly demonstrates that although individuals may have cultural perspectives that may strongly influence certain actions taken in the course of a megaproject, the basic philosophies and principles toward project management are actually very similar. Therefore, the assumption is that there would be little difficulty for the Japanese project manager in planning, managing, controlling, and executing the megaproject in question.

Yet, one of the difficulties that a Japanese consulting engineer faces on megaprojects involves recognizing and adjusting management to allow for the differences in cultural perspectives of the Western nations' megaproject stakeholders. Kunishima and Shoji (1994) compared the construction management practices in Japan with those found in the United States and Germany. The authors attributed the difference in project management among the three countries to the uniquely Asian values applied in Japan and the Western values applied in the United States and Germany (Nielsen 2005). In an early 1990 report by the president of the Japanese Society of Civil Engineers (JSCE), Horikawa said,

> international competitiveness is now a serious concern for Japanese enterprises in order to compete fairly with others inside and outside Japan. It is needless to say that the construction system in Japan has evolved to the present style through a long history of custom and tradition in order to accomplish the highly qualified construction of various civil engineering structures. However, the present ways and systems in Japan seem to be different from those of other countries, particularly in Europe and the U.S.A. That is why Japanese contractors have experienced bitter difficulties caused by the cultural differences between Japan and client countries. Since we have to open various markets including the construction market in the near future, we should adjust ourselves to these new circumstances. Even in such circumstances we should maintain a dauntless attitude, and we should stay pliable in order to adjust ourselves to different views. In order to reach our ideal circumstances, all of the people have to be well grounded in culture and to respect each other. We should thoroughly investigate the way of thinking and the mode of carrying out work in other countries, and then clearly distinguish the differences among us. Based on the above investigations, we should increasingly devote our effort to let the counterparts in negotiation understand our thinking.

As stated in Kunishima and Shoji (1994), construction management from the Japanese perspective can reasonably be understood to be classified into three steps:

> The **first** step is the choice of fundamental technologies regarding analytical techniques for analyzing productivity and efficiency in terms of time and cost; the **second** one is the choice of practical procedures, in which rules for smoothly and safely directing or leading actual work, such as design and construction, organization, and management techniques, become important; the **third** one is deciding how to judge whether the process of construction project implementation is fair and just, contributes to the public welfare, and provides the client and investors with interest and benefits based on social systems, common sense, ethics, and other criteria.

One of the most significant cultural differences, for example, resides in the difference in perspective between the Japanese contract management basis of "mutual trust" versus the (common) Western contract management basis of "mutual mistrust," which is a major contributor to Japanese consulting engineers having difficulties managing multinational megaprojects with a high level of Western stakeholder participation. Simplistically, "mutual trust" assumes that regardless of what a contract document might state, the parties will ultimately resolve issues "fairly" once the megaproject has been completed. "Mutual trust" leads the Japanese consulting engineer to resist preparing formal written notices of effects that are beyond his or her control, regardless of what the contract document may require. The assumption by the Japanese consulting engineer is that the owner is fully aware of the issue and the effects and will, in fairness, adjust the cost and/or schedule requirements contained in the contract in recognition of those known effects; to submit a formal notice is seen as an insult to that owner, implying that the owner will not act fairly or honorably.

The Western nations have a different view of contracts, which flows from a perspective of the contract as a document establishing, in part, protections for each of the parties from unfair action by the other party; in short, the contract is a document that demonstrates and addresses a "mutual mistrust" of one another. A Western nation uses the contract document "to the letter," which means, for example, that if the other party does not exactly follow the rules laid out in the contract, the party not following the rules loses entitlement to recovery of an effect to cost or schedule. If a contractor believes that he or she has suffered a cost or schedule effect for which they are not responsible, the Western owner only recognizes the possibility of such an effect if the rules within the contract are followed exactly, which means in most cases that an immediate written notification is submitted to the owner. Even if the owner is faced with evidence at the end of the project that the Japanese consulting engineer did suffer an effect at some time during the project, the owner may (and often does) reject that claim because the Japanese consulting engineer did not submit timely written notice of that event, as required within the contract document.

Both parties are acting based upon their cultural perspectives, and both believe that they are firmly in the right. During megaprojects, where effects often have project consequences seen well before the actual final completion of the project, such cultural misunderstandings can have a devastating effect on all expectations linked to project goals and objectives. The cost effects can be measured in hundreds of millions of dollars and months, if not years, of delay. In our example, understanding the cultural perspective differences between the concepts of "mutual trust" and "mutual mistrust" is critical to the success of the Japanese consulting engineer and to the ability of the Western owner to achieve the megaproject goals and objectives.

Though our example was based on one country, Japan, and one region, the Western nations, such differences in cultural perspectives exist around the world and among all countries. Megaprojects by their nature are seldom owned, financed, planned, executed, and operated by stakeholders residing in a single country; megaproject management structures, by their size, breadth, and complexity, involve stakeholders from different countries, each with a different cultural perspective, which influences how that stakeholder executes his or her role within that megaproject management structure. Success of multinational megaprojects demands that those stakeholders recognize, and proactively work through, those cultural differences.

When project management is establishing its cost and schedule management and control processes and systems, it needs to be sensitive to the cultural differences that may affect the effectiveness or efficiency of those processes and systems. In particular, project management needs to ensure that it has sensitized the control staff to the possibility of cultural differences and has established processes and systems that address the areas where such differences are most likely to arise, including the following:

- **Miscommunication.** Miscommunication across cultural lines is usually a primary cause of cross-cultural problems. Miscommunication can have several sources, including differences in body language or gestures, different meanings for the same word, and different assumptions made in the same situation (Laroche 2002). Different languages also contribute to the problem, and frequently, the language barriers seem to be ignored, creating confusion and a sense of mistrust among the parties.
- **Problem Solving.** Another source of cross-cultural problems is related to differing approaches to problem solving. The approaches used by engineers and project managers of different cultural backgrounds to tackle the same technical problem are likely to differ widely. The type of approach used to solve engineering problems is often a reflection of what is emphasized in educational curricula leading to engineering degrees in various countries. For example, in France engineers tend to emphasize theoretical or mathematical approaches over experimental or numerical ones. Other countries, such as Canada and the United States, tend to favor experimental or numerical approaches. Although there is no absolute right way to approach technical problems, issues are likely to arise when engineers with different inclinations work together to solve them. A French engineer is likely to approach a new problem by writing down all of the relevant differential equations and then trying to simplify them to obtain an analytical solution. Meanwhile, a Canadian engineer is likely to start from the simplest expression of the problem and build a model of it, either physical or numerical. When French and Canadian engineers work together, therefore, they are often both thinking that the other is wasting time by approaching the problem from the wrong perspective (Laroche 2002). Project managers from Latin America have the tendency to micromanage projects, whereas U.S. project managers delegate most of the issues and assemble teams to execute the projects.
- **Organizational Cultures.** Cross-cultural problems also arise from differences in organizational cultures. Large companies operate quite differently from small companies, and the same problem occurs with government entities compared to private ones. Some of the most noticeable differences include the way information is shared and distributed, the hierarchy of departments, and approval and decision-making processes. Large firms, as well as government agencies, have the tendency to be more bureaucratic. However, a large U.S. company is less bureaucratic than a large or even small Latin American company. Similarly, government entities in Latin America are more bureaucratic than U.S. government agencies.

To overcome the cross-cultural differences, participatory stakeholders need to be aware of these differences from the onset of the megaproject. Successful communication is essential, including clarification to ensure that the team players understand everything that needs to be done, as well as getting into the details to avoid the temptation of agreements based on general principles that can create major problems in the long run. As a minimum, training is required with respect to doing business in a given country, as well as doing business with people with different cultural backgrounds. Selection of the right people and with the right attitude toward international and multinational assignments should be a top priority of the executive team. Executives, senior management, and management teams should include at least one person originally from the location where the project is to be executed and staff who have experience working with the other cultures represented within the participatory stakeholders on the megaproject.

Challenge 4: Controlling Cost Creep

The two most critical goals on a megaproject are cost and schedule, both from a management perspective and from the perspective of the expectations of nonparticipatory stakeholders. Of those two goals, cost is the goal that garners the most attention from both participatory and nonparticipatory stakeholders. It is true that schedule and cost are closely tied and any significant effect to the megaproject schedule has an effect on the megaproject's cost; but cost is the goal that receives the most attention from nonparticipatory stakeholders because it is the subject with which every stakeholder can identify, and they think they understand it. Nonparticipatory stakeholders seldom have any concept of the complexity of controlling cost on a megaproject from initial estimates to final closeout. To nonparticipatory stakeholders, cost appears as a much more simple issue to understand than schedule because it involves only two numbers: the original price of the megaproject and the final actual cost of the megaproject. Note that we did not say the original "estimate" of the megaproject; as noted earlier, regardless of how many times promoters and managers of a megaproject use the word "estimate," nonparticipatory stakeholders hear the word "price."

This chapter does not attempt to examine all elements of cost control in detail, as each element crucial to cost management and control could consume an entire chapter (and in some cases an entire book) on its own. Rather, we focus on the primary elements of cost control, providing a short explanation of the element followed by a discussion of lessons that we have learned during the execution of megaprojects in which we were involved.

Controlling Cost—Some Basics

First, let us put what megaproject management is attempting to control into perspective. Let us assume a total estimated budget of US$2.97 billion for a megaproject that is to be executed over a five-year schedule:

- The average spent per year will be approximately US$594 million.
- The average spent per month will be approximately US$49.5 million.
- The average spent per day will be approximately US$1,627,397.

Then accept that there may be two to five full-time cost management staff (or fewer) on a megaproject, the vast majority of whose time will be spent simply verifying and processing payment requests from a hundred or more participatory stakeholders, all wanting to be paid their share of the US$49.5 million spent that month. In short, the cost staff is focused on essentially an accounting function, which is a historical function, not a predictive function. It is not at all unusual to find that one person of an entire megaproject control staff has been charged with all of the responsibility to determine current status and forecast the ultimate status of the megaproject cost, and that task is not usually the only task for which the individual is responsible.

Megaprojects are like huge oil tankers that, once underway and up to speed, take miles to turn around or stop. If trending and forecasting are only done when someone in cost accounting happens to notice that a particular contract or budget line item is exceeding its estimate, it is too late to stop or turn the megaproject in an effort to mitigate or avoid the consequences. Controlling costs first requires that trending and forecasting of costs at a more detailed level become an accepted, routine, and continuous management function. It is still the norm to see megaproject monthly progress reports with only a single graphic reporting cost, a graphic that generally has three lines reporting: (1) total planned expenditures, (2) total actual expenditure to date, and (3) total forecast expenditures. Though sufficient for senior management and a board of directors, such high-level data are practically worthless to the megaproject management team simply because a host of events and issues that will ultimately affect the final total cost of the megaproject can be hidden within the vast bulk of the total project cost, and those effects can remain hidden until well beyond the point at which any mitigation or avoidance actions would be effective.

Ultimately, controlling cost on a megaproject cannot be based on identifying the cost anomalies when they finally surface to a level where they are noticeable from accounting records. At a spend rate of US$1,627,397 per day, it does not take long for anomalies to add up to “real money.” Controlling cost on a megaproject requires that project management change from reactive-based cost management to predictive-based cost management.

Controlling Cost—The Givens and Initial General Actions

The First Given

Cost on a megaproject cannot be definitively estimated (as a single number) for the simple fact that no one can foresee economic conditions four to seven years (or further) into the future. In the past 10 years, it has become abundantly clear that the typical historical factors (i.e., average escalation over the previous five years in the construction industry) are not reliable indicators of future economic conditions.

The Second Given

“The economy” is no longer confined or defined by local, national, or even regional location; what happens in one region of the globe can (and does) affect the economy in every region of the globe.

The Third Given

There is nothing that anyone can do to control those two givens, including megaproject estimators and project managers. However, participatory stakeholders can stop making the situation worse when they act by "assuming the best possible outcome" at the start of every megaproject. Originally this tendency to assume the best possible outcome was identified as "optimistic bias" (Flyvbjerg et al. 2003). This bias assumed that participatory stakeholders simply had a (perhaps unrecognized) habit of assuming that of all the possible cost outcomes, their megaproject would achieve the best of those possible outcomes. As data continued to mount through additional studies, the tenor of the findings moved from assuming that participatory stakeholders were simply optimists to assuming that participatory stakeholders used "strategic misrepresentation—i.e., lying" regarding the ultimate cost of the megaproject to ensure that the megaproject they championed was approved and built.

This truth is the reality of the "promised cost" for participatory stakeholders; regardless of how often they may use the word "estimate," the only two data points used by nonparticipatory stakeholders are the original total cost handed out in the promotional materials and the actual final cost at the end of the project. The first action to take in controlling cost, therefore, comes before any real money is spent to execute the megaproject: Do a better job of setting cost expectations for nonparticipatory stakeholders. This action would include never giving a number, a single data point from which a single promised cost is assumed. Risk models are powerful and provide the participatory stakeholder with a probabilistic range of cost results that depend upon certain assumptions. Participatory stakeholders should provide the range and the primary factors that explain the range from best case to at least the most probable case and also higher potential costs. The key is to explain why there is a range, and to identify in particular those risks that the participatory stakeholders cannot control (Reilly et al. 2004). Then they can describe how project management intends to exercise control over that which it controls.

The second action in controlling cost is to recognize that cost control is not the same thing as cost accounting. Cost accounting tells megaproject management where it has been by reporting where money was spent and compares the costs to date against the megaproject control budget. However, once an expenditure has been made and is accounted for, it is history and even the best project management team cannot control what has already happened. Unlike cost accounting, cost control is focused on where the megaproject cost is at a specific time and forecasts where it will be at given points in time in the future based on current conditions, evolving expectations, and the cost performance on the megaproject to date. Computerized cost control tools are amazingly powerful and sophisticated and, if properly populated and used, can provide project management with cost data in almost real time and perform any number of "what if" forecast scenarios from which project management can chart a cost course through the megaproject.

Project management should use the cost information generated at a given time, and forecasts of expenditures anticipated, to identify where management decisions and actions must be taken to maintain control over the cost of the megaproject going forward in time. Because cost management and control (and, as we show later in this chapter, schedule management and control) can only be predicated on anticipated trends and events, and can only be controlled by taking actions directed at maintaining or returning a forecasted cost to its proper limits, management must have the best and most comprehensive information available and readily accessible from the earliest stages of the megaproject through the completion of the megaproject.

For every day that passes between the start of a cost trend and the point at which management recognizes and reacts to the trend, the response options narrow until the point at which management has no choice but to accept the cost increase. The tradition within the construction industry in general is to follow a "monthly report cycle" insofar as cost (and schedule) is concerned. The primary contractor(s) send in a report once a month, which is then consolidated into the overall project monthly report (usually two to three weeks later). Using those project monthly reports over time (generally three months), cost control staff identify significant trends, which once reported, enable project management to analyze and respond to cost issues. In short, three to six months may pass before a cost trend is even identified and management is in a position to take action. For every week or month that passes between the actual onset of a trend and the point at which the trend is recognized, management's response options narrow. The goal of cost control is to maintain project management's access to the widest range of response options possible, which means that the earliest possible detection of a trend is best.

Cost management and control should be focused on trending and forecasting costs. From an organizational perspective, cost control should

1. Be staffed by the most experienced and most skilled management staff on the megaproject. One of the more generic tendencies is to understaff cost control positions. It is not unusual to find only one or two cost control positions for an entire megaproject, yet controlling cost is arguably the single most critical management function on a megaproject from the perspective of judging the success or failure of the megaproject (at least insofar as nonparticipatory stakeholders are concerned). Having powerful cost control tools is useless if there are not sufficient skilled, experienced staff members to use those tools to their maximum potential. Trending and forecasting are not monthly activities done simply to publish in the monthly report; they should be daily activities that give management information on trends as early as possible, enabling management to formulate and execute responses to those trends as quickly as possible. Waiting for a trend to show up across two or three monthly reports on a megaproject can cost millions of dollars, and worse, severely limit management's response options.
2. Use the most sophisticated data gathering, reporting, and forecasting processes and systems available. As noted above, the cost control tools available today are extremely powerful and versatile, with new advances being made constantly. One of the most important management investments that must be made by the participatory stakeholder is to buy the cost control tool that best fits the nature and needs of the megaproject and invest in the detailed training of the cost control staff to ensure that every possible feature of the cost control tool is used and useful.

3. Include access to local, regional, national, and global cost data on a real-time basis. Cost control staff need to be aware of economic data to a degree never contemplated before; the potential price of steel in China over a five-year period is important to a megaproject building a US$5 billion petrochemical refinery. Project management cannot control the pricing of steel in China; however, trending price and economic conditions in the marketplace can give project management earlier warnings of such trends and suggest actions to mitigate the effect of potential cost increases.
4. Require that every participatory stakeholder have and maintain throughout the duration of the megaproject the staff and systems necessary to support the full and timely flow of cost data required by the megaproject cost management system. This item should be a contractual requirement for every significant contractor engaged on the megaproject, and those cost control contractual requirements must be enforced from the first day on the project.

Establish and maintain a comprehensive data collection and reporting capability that can produce not only scheduled and routine reports but can also produce “right here, right now” reports and forecasts responsive to any management need.

Effective cost management and control of a megaproject actually begins before the estimate is complete and the control budget has been set. The stated purpose of any estimate is to produce the most realistic forecast of the final cost of a project. The stated purpose of any estimate for a megaproject is exactly the same; however, given the complexity and duration of a megaproject, production of the estimate is much more challenging and requires many more assumptions as to future conditions than are found in a typical project. It is crucial that megaproject management, and most especially its cost management and control group, understand the detailed basis of the estimate, the assumptions upon which various elements of the estimate were predicated, the level of detail (design definition) available to the estimators in calculating the costs, the variance factors used in setting specific line item costs, and, finally, a confidence level assumed for the estimate in the contingency calculations. Understanding the details behind the estimate provides three immediate benefits to the megaproject cost control team:

1. The megaproject’s cost control group undoubtedly has more direct field experience than those who will be developing the cost estimate for the megaproject. As a result, the cost control group can examine and vet the assumptions upon which the cost elements are based. For example, the estimator uses normative labor productivity factors (adjusted for general location conditions) in preparing the estimate. However, field cost control personnel with experience look beyond normative factors to specific megaproject factors reflective of the exact site and the anticipated work conditions. If, for example, the cost control team knows that movement of heavy, large-bore pipe is difficult and slow, working with the estimating group, the labor productivity can be adjusted to reflect that condition (and others). Given the tremendous amount of labor working on site at any given time, even adding a productivity factor for congestion can result in a swing

of millions of dollars, which can make a significant difference in whether or not cost expectations are met on the megaproject.

2. The ability to understand the assumptive basis of costs is crucial to the cost control team in conducting forecasts for mitigation of effects in situations. For example, we can assume that the estimators calculated the price of copper cable as of the scheduled date of purchase at 10% higher than the overnight price quoted during the assembly of the estimate. If there is a delay to the scheduled date of purchase because of a delay in the completion of detailed electrical design, the cost control team needs to (a) understand the basis of the cable cost line item as originally estimated; (b) determine the delta between the assumptive cost estimate forecast and the current actual price for cable; (c) calculate the delta between the assumptive forecast cost as estimated and the actual current conditions; and (d) be able to forecast the effect the delayed purchase will have on the ultimate cost of the cable. The sooner the cost control team can identify the potential delay and forecast the scenarios to cable prices, the sooner project management can examine its options and take actions to mitigate the effects to the greatest extent possible. The later in the situation that management waits, the less control it can exercise in mitigating effects.
3. Some cost line items are estimated on the basis of detailed technical specifications quoted overnight by prospective suppliers (in effect, the detailed technical specification is the major element of the basis of the estimate for that equipment). Knowing the exact technical specification that served as the basis of the estimate, the cost control team working with the engineering management team can identify alterations in any technical specification and, again working with the engineering team, can "reestimate" the cost of the equipment in question earlier in the process, which again serves to maximize and preserve project management's options and alternatives to mitigate (or even avoid) any cost effect flowing from the changes to technical specifications.

The more the megaproject cost management and control group knows about the estimate, the more quickly it can react to situations that threaten the megaproject cost to complete at the estimated amount. Active involvement in the latter stages of the estimating process can not only improve the confidence level in the estimate itself, it can also identify elements within the estimate that exhibit the highest potential risk to the cost of the project. Active involvement can enable the cost control and management group to both develop early warning protocols to more closely monitor those higher risk elements and prepare various mitigation plans for dealing with those higher risk elements more efficiently and effectively (see Chapter 2). Finally, the ability to produce sound forecasts going forward is in part predicated on knowing the original basis of the estimate, which is best learned during the estimating process and not in attempting to discover the original basis of the estimate two to five years later.

The megaproject control budget is arguably the single most important document on the project, not just from a cost perspective but also from the perspective of every management activity and decision made during the execution of a megaproject. Literally every decision made or action taken during the execution of a megaproject may affect the megaproject control budget, and effects to the control budget that are not properly identified and analyzed against that control budget can have devastating effects on the total cost to complete. Some rules need to be stressed concerning control budgets:

1. Every adjustment made between the cost estimate and the control budget needs to be fully documented. This documentation is necessary because such adjustments imply that project management has made a change to an assumption that was used to develop the estimate. At some time in the future (maybe years later), the assumptions by which the estimate was prepared and the assumptions by which the control budget was set will be subject to testing and review.
2. The *original* control budget never changes; it is the budget against which every decision and action affecting cost is examined, analyzed, and even in some instances, judged. When changes are made to the control budget, they need to be made in the *current working* control budget, but all iterations of the current working control budget need to be maintained. Trend analyses are a crucial element in forecasting cost, and trends need to be analyzed both against the original control budget and the working control budgets to provide management with the best forecast of trends possible from which to make decisions and take actions.
3. Working control budgets must align with the cost accounting system, and vice versa. Management must be able to match the accounting reports (historical project cost data) to both the working control budget and the trend forecasts to identify systemic issues and trends that threaten the megaproject cost goals.
4. Finally, the original control budget and all working control budgets need to be annotated, explaining every change, deviation, or effect to those control budgets.

Megaprojects are complex and take a long time to execute; trends may develop over years rather than weeks or months. Likewise, because of the amount of money involved, effects may go unrecognized well beyond their initial occurrence, simply because there is so much money in the line item that there "seemed to be more than enough" to cover the final cost of the item in question. Nowhere is continuous trending and forecasting more important than in a megaproject, and to execute sound trending and forecasting, the original estimate and the control budgets are vital.

Controlling Cost

Based on experience with megaproject cost issues, we have identified a number of general steps that should be taken on every megaproject if management expects to exercise any real control over megaproject costs during execution:

1. Turn cost trending and forecasting from a special event into a routine, continuous project control function that examines cost at a detailed level.
2. Ensure that adequate, well-trained, and experienced staff are included in the cost control group dedicated to continuous trending and forecasting of megaproject costs.
3. Make sure that cost effect analysis and forecasting become elements of every significant project decision made during the entire life cycle of the project: The

first question that should be asked when faced with any issue or situation or change should be, "What effect will this have on the total project cost?"

4. Treat contingency differently. (Contingency has been defined as "a markup applied to account for substantial uncertainties in quantities, unit costs, and the possibility of currently unforeseen risk events related to quantities, work elements, or other project requirements.") It is not unusual to find project management treating contingency as a single open account from which the project management can draw money needed to cover cost increases. It is rare to find any established, formal procedure that controls or limits project management's access to or expenditure of contingency. It is still normal to hear project management make blanket statements to the effect that a change to the project is approved "because we have the contingency to cover the costs." Contingency should never be perceived as being a first-come, first-used bag of money. Rather, it should be jealously guarded and spent in a miserly fashion, and then only grudgingly as a final resort. Contingency set in the control budget is meant to last the entire duration of the megaproject yet is often gone before the megaproject is anywhere near the completion stages of project execution.
   a. First and most importantly, contingency should never be a single line item in a control budget. Rather, contingency should be allocated to specific task groups such as
      i. Design contingency,
      ii. Procurement contingency,
      iii. Construction contingency,
      iv. Project contingency, and
      v. Owner's contingency.

      Initial control of contingency involves restricting access to the contingent amount, thus producing the thought: "If I don't have access to more than my assigned amount, I need to examine other ways to get what I want or need before I thoughtlessly spend out of my limited contingent amount." This thinking includes owners, who may think of contingency as their own private slush fund for those really nice-to-have upgrades in the project that always seem to arise during detailed design.
   b. Each contingency account should be restricted to use by the task group to which it is allocated and should be expended for the cost issues that arise within that task group and only with the concurrence of the senior megaproject management.
   c. There should be formal written procedures in place for the expenditure of contingency from each of the task accounts established.
   d. Before authorizing a drawdown from any contingency account, senior management should ensure that every other avenue addressing the root cause for the drawdown was identified, assessed, and considered by those requesting concurrence with the transaction.
   e. Every contingency action should be fully documented, not simply to justify the transaction retrospectively, but also to be used in trending and forecasting cost issues and events.

5. Use cost information to conduct interim forecasting. In some instances, several months can pass between participatory stakeholder deliverable dates (many of which are tied to payment conditions). Waiting to analyze cost trends or forecast effects until deliverable dates may make changing the cost course of the megaproject impossible. The cost trend and forecast process needs to be able to access in-process cost information and use that information in conducting interim trending and forecasting.
6. Base change control on "no" being the first response. In essence, too much time is spent on *describing* the change and not nearly enough in *justifying* the change. If one assumes that there is a real danger of any change initiating a ricochet effect within the megaproject, then one can understand that every change needs to be examined not only in terms of its cost and its possible ripple effect; it also needs to be of such value to the megaproject that it is worth taking the risk of initiating a ricochet effect within the megaproject. Likewise, changes need to be subjected to the same rigorous estimating procedure that was followed in preparing the original megaproject estimate.
7. Subject every significant change to a risk management process that reflects the process followed in developing the megaproject's risk profile.
8. Make sure that cost reporting is open, transparent, and uniform across and throughout the duration of the megaproject.
9. Change the mind-set of megaproject management. The megaproject cost budget must be taken by the megaproject management as the firm, fixed point that must be achieved and not a "target." As we note several times, to many of those who pass judgment on the success or failure of a megaproject, the estimate was a promise, not a desire.

Finally, and perhaps most importantly, there will be cost effects on a megaproject. Accept that fact and it will make focusing management's attention on controlling those effects much easier.

Challenge 5: Controlling Schedule Creep

Introduction to the Critical Path Method

Critical path method (CPM) schedules are used for planning and monitoring projects. The CPM schedule breaks a project down into smaller identifiable work components. There are three major components to a CPM schedule:

1. Activities,
2. Duration, and
3. Logic.

The combination of these components results in a network consisting of nodes and arrows. A series of simple mathematical calculations are made, resulting in a project completion date and available float for each activity. Float is then used to level the project resources (money, time, labor, equipment, and materials) and to focus project attention on critical activities. Leveling of resources minimizes fluctuations in resources. Any activity with zero float is critical by definition; therefore any delay to a critical activity delays the project completion date. By identifying these activities, management can focus on ensuring that the completion date is not jeopardized.

In real-world practice, most CPM schedules are entered into a computer software program, and all calculations, including resource leveling, are done by the computer using the criteria selected by the scheduler. Preparation of CPM schedule graphics and tabular reports is standardized within the software, and most allow for the customization of schedule information for both analysis and presentation.

CPM Scheduling for Megaprojects

The megaproject CPM schedule represents both the plan by which the megaproject will be executed (the "route map" to the completion of the megaproject) and the control document against which progress toward completion of the project will be measured. Much like the megaproject cost estimate, the initial megaproject CPM schedule is, in effect, an estimate, which as the megaproject advances, takes on added dimensions and levels of detail. Unfortunately, nonparticipatory stakeholders neither understand nor care about the intricacies of evolving a complete CPM schedule for a megaproject, but they sometimes hold participatory stakeholders to the "promised" completion date reported out of the original CPM schedule and used by megaproject promoters to sell the megaproject to those nonparticipatory stakeholders.

As with cost management, the process of developing, installing, and managing the actual CPM schedule on a megaproject is the topic of many books and articles devoted entirely to that schedule management. And again, just like cost control, much less has been written about or focused on the practical aspects of controlling the schedule on a megaproject.

A schedule defines the activities to be accomplished and start and finish dates for a particular project, including planning, design, and construction. If developed correctly and used throughout the project, a schedule can be an effective management tool and control tool. Viewing a schedule from the perspective of it being a route map (or execution plan) for the megaproject, one must first accept that on a megaproject there can be no such thing as a "little detour" to that route map at any time during the megaproject execution journey. The participatory stakeholders must accept that any (and every) detour from the megaproject plan, the route map, will have an effect on the megaproject goals, and as a result every detour must be controlled, assuming a negative response to the request for such a detour until the point at which it can be conclusively demonstrated that

1. The detour is unavoidable because of events or issues outside of the control of the project (this requirement would include a written directive from the owner and/or project management to take a detour from the plan);

2. The total effects of the detour on all the project goals are known and accurately accounted for, including any possible ricochet effects that may flow from the detour; and
3. Schedule changes during a megaproject may also result in both ripple effects and ricochet effects that the participatory stakeholder has neither anticipated nor prepared to manage and control.

Schedule goals developed during the planning phase set the limits of the megaproject and therefore establish the schedule "points of control" for megaproject management. As with the project cost, a project's scheduled completion date must be perceived by participatory stakeholders as a firm, fixed point that must be achieved and not a target, simply because the completion date provided during promotion of the megaproject will be seen by nonparticipatory stakeholders as another promise and not as a target completion date.

Unlike cost management and control, where there are two distinct elements involved (cost accounting and cost control), schedule management and control are both encompassed in one master document, which reports where the megaproject has been, where it is headed, and the plan for getting to the completion of the project. From that perspective, schedule data are more easily captured, recorded, and distributed than cost data; however, the fact that the data are encompassed in a single schedule may also be one of the significant weaknesses when attempting to exercise control over the schedule. This weakness occurs because of the nature of scheduling and preconceptions relative to CPM scheduling, which have been set over years of experience with CPM scheduling on typical construction projects. For example, unlike a typical construction schedule:

- the megaproject schedule encompasses a much longer total duration than is typical;
- the megaproject schedule has to cover a broader, more complex scope of work;
- the megaproject schedule most likely involves initial input and updating from a higher number of participatory stakeholders; and
- the megaproject master schedule is not easily converted into a document that can be used by separate participatory stakeholders to actually plan, manage, and control their own individual scopes of work.

Just as with cost control, schedule control is dependent on knowing exactly where you are and forecasting where you will end up. Fortunately, the powerful CPM tools available in the industry make trending and forecasting the schedule much less difficult than trending and forecasting costs. On the other hand, the sheer size and mass of the typical megaproject schedule can make that same powerful tool cumbersome to interpret and to use effectively as a control tool.

From an organizational perspective, schedule management and control should

1. Be staffed by both individuals who are technically proficient and skilled in developing and running CPM construction programs and those who are experienced and skilled at planning and executing large, complex construction projects;

2. Use the most up-to-date versions of the CPM programs available to gather and analyze schedule trends and forecasts;
3. Maintain the schedule in as close to real time as possible;
4. Require every participatory stakeholder to support the full and timely flow of schedule data required by the megaproject schedule management system; and
5. Maintain the schedule such that it can produce not only scheduled and routine schedule updates but can also produce specific analytical schedules and sections of the overall project schedule (termed "fragnets"). These sections of the schedule provide megaproject management with "right here, right now" reports and forecasts responsive to any management schedule need.

As with cost control, this chapter does not attempt to examine all elements of schedule control in detail. Rather, we have focused on some of the more critical elements of schedule control on a megaproject, providing a short explanation of the element being examined followed by a discussion of the lessons that we have learned during the execution of megaprojects in which we were involved.

Using the CPM Tool Effectively

The CPM schedule is a management tool; it does not in and of itself control the schedule during execution of a megaproject. But it is perhaps the most versatile and powerful tool available to participatory stakeholders for a megaproject. Like a cost control budget, once set the original master schedule should not be changed or altered. However, because of the power and flexibility of the CPM scheduling tool, the preparation and production of working schedule updates is much simpler and faster than developing updated working cost control budgets. That flexibility and power, however, also pose one of the basic challenges faced by project management: information overload (which is addressed further below).

Delivering a megaproject on time does not just mean signing a contract and hoping that the required completion date will be met. More often than not, the majority of today's construction megaprojects encounter events and/or changes that affect the original plan for executing a megaproject. Furthermore, resources such as labor and material and equipment may be scarce and in high demand and as a result may hamper megaproject execution. Attempting to solve these unforeseen issues during a megaproject without a plan in place to determine the immediate effects is a major risk that can often lead to delay, disruption, and disputes between the parties. Experience during the 1980s and 1990s has demonstrated that a well-developed, updated, and consistently used CPM schedule during a megaproject can increase the probability of a project finishing on time and/or assisting in party-agreed extensions of time.

Tracking critical activities with a CPM schedule throughout the megaproject allows a participatory stakeholder to know when the critical path is changing and what activities are being delayed and provides project management with the flexibility to resequence and/or develop work-around plans for various project activities to avoid project delay. In addition, an accurate and consistently used and updated CPM schedule allows parties to demonstrate the history of how the megaproject was executed and if delays occurred to the project, when, where, and what activities were specifically affected by these delays. Demonstrating how a megaproject was executed and what was critical at the time can be especially useful when one is resolving disputes that may arise as the megaproject progresses, not just at its completion. Both during the execution of the megaproject and at megaproject completion, the negotiation of changes and claims is facilitated through the implementation of a CPM schedule. This process is more cost effective than other dispute resolution alternatives. The net result is improved commercial results.

The following section discusses the merits of using CPM scheduling on construction megaprojects; how and when a CPM schedule should be developed and updated, including how this process has changed in the 21st century; and how to effectively use a CPM schedule both during and after megaproject completion. The section also addresses what not to do in preparing and updating a CPM schedule and the dangers of schedule manipulation.

Benefits of Using a CPM Schedule in Megaproject Management

During a review of all aspects of a construction megaproject, few aspects are of greater significance than time. Time is literally money on a megaproject, which is evident when one thinks of the daily, monthly, and annual spend rate on megaprojects. Keeping a full labor force in the field for an additional month to overcome schedule delays may cost more than most typical construction projects expend on executing the entire project from start to finish.

Consequently, it becomes imperative to have a tool that can assist in managing time. One of the ways to manage time effectively and efficiently is through a thorough understanding of CPM scheduling and its use as a management tool. CPM is a powerful tool that can assist both owners and contractors in the planning and managing of complex megaprojects. CPM schedules were initially developed in the 1950s in the United States to control large defense projects and have since been routinely used around the world. In summary, a CPM schedule is a useful planning and management tool for several reasons:

- It identifies the activities that must be completed as part of a project, thus laying out how a project is to be executed, as well as how it might be resourced. In this way, the CPM schedule helps the parties to monitor progress, productivity, level of performance, and the achievement of project goals.
- It determines what work activities must be performed. A thorough identification of all activities requiring time and resources must be made during the planning process. Activities are chosen based on what is needed to complete the work specified, or they may be required for either payment milestones or pay items.
- It determines what work activities can be performed in parallel. A logical sequencing of these activities must be made, which in turn defines a plan for both owner and contractor activities, required dates for drawing review and approval, material and equipment, and a plan by which the contractor can schedule its resources, including required staff and working shifts.

- It determines the shortest time in which to complete a project. The time required for each activity must be reasonably estimated or determined. This time, in conjunction with the logical sequencing of the activities, then defines the longest path, and thus the total planned duration of the project. This step in turn identifies which activities are critical and need to be closely monitored to avoid time delays to the project.
- It determines the total resources that are needed to execute a project and can generate profiles of how much staff will be required and when.
- It assists in determining the priorities of work to be completed.
- It assists the parties to see where remedial action needs to be taken to get a project back on course should it be delayed.
- It provides the ability to see when and how an activity will be affected if a delay or change occurs to the project and can then serve as a base for work-arounds.
- It provides the most efficient way of shortening the time on delayed projects.
- It allows for continuous evaluation of the planning and progress according to a predetermined schedule and provides the basis for a decision-making process during the project based on realistic actual and projected progress.
- It benefits the parties both during and after project completion by either assisting the contractor in presenting support for time extensions, price adjustments for delays, suspensions, accelerations, and the time elements involved in changes and extra work or assists the owner in presenting or defending against delay and damage claims for late completion.
- It serves as a useful reference document in the event that a similar project is undertaken in the future.

An effective CPM can make the difference between success and failure on complex megaprojects. It can be useful for assessing the importance of problems faced during the execution of the work.

Controlling Schedule

Just as with controlling costs, the first action should be focused on controlling nonparticipatory stakeholder expectations. The problem begins when participatory stakeholders publish "the date" that the megaproject will be completed. Nonparticipatory stakeholders establish that originally published date as the promised delivery date for the megaproject and so judge success by one simple measure: Did the project go into operation on the date originally promised?

The first schedule control issue involves the fact that developing a schedule for a megaproject is an iterative process, which by necessity involves input by participatory stakeholders who most likely have not even been identified at the time when the megaproject is being promoted for approval and the initial schedule for completion of the megaproject is released. Because of that situation, megaproject management is forced into the position of trying to forecast a completion date without having the details that would confirm the reasonableness of the completion date set and communicated to nonparticipatory stakeholders.

The second schedule control issue is that the optimistic bias is actually built into the schedule in the form of the critical path, which assumes no float in that critical path schedule. However, as much as cost is affected by events and issues completely outside of management's control, schedule is even more vulnerable to such effects as can flow from something as catastrophic as an earthquake or as seemingly benign as moving a heavy haul crane unexpectedly—twice.

The third schedule control issue is that schedule is much more sensitive to both ripple effects and ricochet effects than cost, which makes identification, trending, and forecasting more complicated because those effects may pass through hundreds of different and even seemingly unrelated activities on a given megaproject.

Fortunately, some of the most powerful planning and control tools available to project management are specifically designed to address planning, managing, and controlling schedule on what is essentially a real-time basis. Those schedule and control tools, linked to enough properly trained and experienced schedule control staff, provide project management with both a sound trend and forecasting capability that is much less developed than those in use in controlling cost. The issue therefore does not involve the tool used; it rather involves using the tool effectively.

Effectively Using the Schedule during the Project

The schedule should first be reviewed by the participatory stakeholders who will be responsible for monitoring and maintaining the schedule. Then, once accepted by the project team, the schedule is ready for submittal to the owner for final approval, thus serving as the baseline schedule from which progress on the project will be measured. By carefully developing the schedule as outlined above, a work plan for executing the project is developed that

- conforms with the imposed constraints (i.e., milestones and/or project completion);
- uses resources efficiently;
- identifies when specific materials and equipment are to be delivered;
- coordinates external actions (e.g., submittals, reviews, and approvals) and interactions with other work or projects;
- allows for generation of project spending and/or earnings plan and budget;
- provides the basis for tracking actual performance against the planned performance;
- gives visibility to the need for corrective actions as work is performed;
- provides forecasts of project completion dates;
- provides proper definition to each activity so that all of the activities can be controlled or updated without guessing;
- serves as a basis upon which the effect of changes to the project scope and/or specifications can be evaluated; and
- is a plan upon which to evaluate the effect of delays to the project plan and timetable.

The initial schedule once developed serves as the megaproject baseline. Regular monitoring and progress measurement against the schedule allow all participatory stakeholders to determine how far ahead or behind the activities are with respect to the planned milestone dates and/or megaproject completion. Monitoring is typically done on a monthly basis, with the schedules submitted as part of the monthly progress report by the contractor to the owner. However, it is possible to update a CPM schedule (in whole or in part) on a weekly or even daily basis for critical path or affected path situations. This flexibility gives the megaproject management team a powerful advantage in the early identification of trends, forecasting effects and actually designing "work-arounds" specifically aimed at mitigating schedule effects. To accurately measure progress against the baseline, only actual start and finish dates should be entered into the computer program. No major logic changes should be made to the baseline schedule because these logic changes may or may not change the critical path and may reflect change to critical activities that may not be reflective of true problems occurring on the megaproject.

Only when the actual progress and events on a megaproject have changed so dramatically from that planned and/or changes have occurred to the megaproject that necessitate major changes be made to the schedule in the form or either added or deleted activities, changes in sequences, and/or planned durations, should the schedule go through a major replanning. A new schedule issued on the megaproject should be termed a "revised baseline" schedule. Any time the critical path of the megaproject changes, the parties need to reassess whether a revised baseline is necessary. This point is again important because delays to the megaproject are measured against the critical path of the megaproject. The revised baseline schedule should go through the same steps as discussed above in the schedule development along with documentation of all assumptions used in its development. In many instances, the original baseline schedule is a contractual document and therefore may require owner permission before updating. It is also vital to maintain the history of the project activities, noting in a log within the CPM computer program the actual start and finish dates to each of the activities and all sequence changes that were made throughout the project.

As CPM scheduling has evolved, so have the techniques applied in development, updating, and postevaluation of the CPM schedule. With the onset of the computer, many individuals have entered the CPM industry who do not have the same training or understanding of CPM as was required when CPM was first applied in its initial decade of use. Though universities in the United States started offering courses in CPM scheduling in the 1970s, other universities around the world did not teach project management concepts until just recently, in the late 1990s and 2000s, before relying solely on apprenticeship training for personnel involved with CPM scheduling. Even today, there exists quite a disparity between educational training and the application of CPM scheduling for today's internationally constructed projects. As a result of the diversity among schedulers' personal backgrounds and experience and the extreme variance between opinions of expert witnesses over the past 20 years in "determining" what happened on a project after the fact, a global concern has arisen as to the need for international CPM scheduling standards—both in definition and in methodology—in order to achieve a consistent approach and application.

Basic scheduling standards already exist in the PMI *PMBOK* (PMI 2008). However, although these standards serve as a reference in developing and maintaining a schedule, the current *PMBOK* standards do not provide the scheduler with precise definitions and applications for a CPM schedule either during a megaproject or after a megaproject has been completed. Thus PMI, with the guidance of PMI's Scheduling Community of Practice, on which one of us (Dr. Galloway) was on the board of directors (www.pmi.org), has embarked upon the development of American National Standards Institute (ANSI) standards that will provide both definitions of CPM scheduling terms and standards for how CPM schedules should be developed, monitored, maintained, and used after completion relative to analysis concerning project progress. Further concern has arisen regarding the qualifications of personnel actually developing and maintaining a CPM schedule. Lack of thorough understanding of CPM scheduling can result in inaccurate completion and progress projections and schedule manipulation, as discussed later. As a result, organizations such as the American Association of Cost Engineers International's National Planning and Scheduling Committee have established a certification program for the planning and scheduling professional (PSP) that will qualify individuals by both experience and examination. This PSP certification will then provide both owners and contractors a mechanism to evaluate personnel who would potentially be selected for CPM scheduling roles and responsibilities.

Dangers in Schedule Manipulation

Unfortunately, in today's construction environment, many schedulers have become so sophisticated with their computer software that there is a tendency to try to outwit the other participatory stakeholders and to portray certain areas of work as critical and other areas of work as not critical to serve their own purposes. Schedule manipulation can take many forms and should be carefully monitored should the following events occur during the project and/or with the submittal of the initial schedule:

- The inclusion of imposed date constraints on activities: An imposed constraint on an activity means that either a specific imposed date has been applied to either the start or the finish of that particular activity. By imposing a constraint, the computer software recognizes the imposed constraint first and uses this constraint as the priority, overriding any logical relationships with other activities. There are certain instances where an imposed date is justified: the project completion and/or contractual milestones. It may also be reasonable to impose a constraint to an activity that may be severely affected by weather, such as typhoon season where work could not proceed if not completed before the start of the typhoon season. However, any other imposed constraints necessarily give a false criticality and may show a false critical path.
- Shortening of future durations: Often a contractor sees himself or herself in a bind when delays occur for which the contractor is responsible. One method of demonstrating to the owner that the project is still on schedule is by shortening future activity durations. However, unless the contractor is planning to add more resources or additional shifts for completion of the work, seldom does the

reduction of activity durations represent reality. Thus, at some point in the future, the schedule becomes unattainable and the parties find themselves in conflict with each other, further resulting in a potential dispute.

- Revision of logic: Though logic revisions may become necessary throughout the project because of changes in the work or project work-arounds to recover delay, contractors often, as with the reduction of future activity durations, manipulate the activity logic to show a different critical path, and/or to give a false impression that the project is still on schedule. Although the contractor may believe that the owner will not discover the changes made and though the contractor may believe that he or she can lure the owner into a change order granting additional time and/or money, this game is very dangerous and one that can have dire consequence to the contractor, especially if it is discovered that the changes were made intentionally to mislead the owner. Such actions are highly discouraged.

Schedule Specification Consistency

If facts regarding schedule requirements can be determined before bidding and are properly outlined in the specifications, it will be easier for the contractor to prepare his or her bid. Clear and concise specs eliminate doubt and misunderstanding and result in better prices. If the contractor is to prepare the schedule, an owner must be careful in specifying the method and detail of scheduling required. Sophisticated scheduling techniques can cost thousands of dollars for the contractor. Noninclusion of this cost in his or her estimate or bid cause lost profits and less than full scheduling cooperation with the professional construction manager, owner, and other prime contractors.

The following issues should be addressed by the megaproject management team when preparing specifications for scheduling:

1. Technical terms or words should be interpreted with their technical meanings unless context shows contrary intention.
2. Each part of the specification should be interpreted with reference to the whole.
3. The scheduling technique to be used and submittal timing must be stated.
4. The party who is to prepare the schedule must be identified.
5. Instructions must be included as to how and when the schedule will be updated.
6. The responsibilities of the prime and subcontractors for the schedule must be identified.
7. The scheduling of shop drawings must be addressed.
8. Any contemplated use of the schedule to determine progress payments must be identified.
9. The procedure for reviewing the schedule must be identified.
10. A statement must be supplied as to whether or not time extensions will be granted for delays not affecting the critical path.
11. If a written narrative progress report will be required, the specification must state who will prepare it, when, how, and what it will say.

The scheduling requirements should be described fully and the expected performance should be reviewed at the prebid and preconstruction meetings. This timing allows contractors to evaluate the scheduling detail required and accurately estimate the cost. The owner must allow sufficient time between the notice of award and notice to proceed so that the contractor can thoroughly plan his or her work. The participatory stakeholders must ensure that all project personnel are trained in the use and application of what is required.

Trained Personnel

The combination of a delay or disruption to the planned sequence of work and the requirement that the extent of delay be established through the use of the CPM schedule necessitates the early involvement of a scheduling expert. Unexpected surface and subsurface water problems require a hydrologist. Problems of rock and soil conditions need the services of a soils engineer or geologist. These experts are widely accepted and used when problems are encountered during construction of a project. The same logic and necessity dictate that a scheduling expert be used when the project is affected by delays, disruption, and interferences to the planned sequence of work.

A scheduling expert must be able to assist project personnel in day-to-day records of work in progress. The expert must devise codes for computer sorting related to network activities and must produce an as-built schedule; he or she must provide guidance and advice on what action should be taken to minimize the cost effects of delays, disruptions, and similar interferences to the performance of the work. The expert's responsibilities also include a time impact analysis and serving as an expert witness if arbitration or litigation becomes necessary.

Documentation

A schedule is only a tool that is used during a project, and documentation must be kept to support it. Original and updated schedules are critical to ascertaining the construction history of the project in the future. Therefore, the scheduler must keep copies of all schedules and updates furnished. An appropriate notation must be included concerning the date received, from whom and by whom, and any accompanying instructions. In addition to schedules, other project documentation that must be retained includes such things as correspondence between the owner and contractor, contractors' detailed estimate and cost records, job photographs, change order files, shop drawing logs, contract documents, daily reports, visitor records, meeting minutes, and progress payments.

Time Impact Analysis

As each change order, interference, strike, act of God, claim, delay, or any unusual influence occurs, a time impact analysis must be conducted to document the effect on the project schedule. The time impact analysis is a disciplined approach for demonstrating effects of delays and produces positive results. An up-to-date network is essential to aid in determining the effect of the delay. The responsibility for delay is best determined by high schedule visibility. It must be combined with the determination of the effect of the delay at the time the delays are identified.

When a change or delay is incurred, the person conducting the time impact analysis must go through the following steps:

1. Study the scope of changes or the extent of the delay.
2. Review all reference material, such as drawings, sketches, specifications, field directives, correspondence, and cost estimates.
3. Determine that all affected contracting parties comply with the change.
4. Determine each activity affected or logically restricted by the change.
5. Review and determine the duration computations for all affected activities. Use the last update relating the notice to proceed to the date of change.
6. From daily sources of information, determine the status of activities in progress that are affected when a change is issued or when a delay occurs.
7. Prepare an added-activity analysis of the sequence of activities to perform work required by the change or which identifies the delay.
8. Prepare an independent schedule analysis.
9. Check to ensure that the resulting time extension is the product of the change, not the result of any time the project is behind schedule for other reasons, plus the time effect of the change order or delay.
10. Document the time effect of the delay or change.

To aid participatory stakeholders in preparing and resolving time effect claims, the following suggestions are offered.

1. A contractor who requests a time extension or adjustment to the schedule must do so in writing and in a timely manner. Supporting network data should also be included.
2. Network diagrams must be current.
3. During update meetings, both parties must insist that additional activities and/or network changes be incorporated to reflect actual conditions and plans for completion.
4. The owner and contractor should try to reach a settlement on the issue of time for each change, considering the maximum and minimum positions they are willing to accept.
5. Detailed minutes should be kept for all negotiation sessions. All offers and counteroffers should be included.
6. When time extensions or network adjustments are denied by the owner, the contractor should go on record as having disagreed with this decision.
7. Summary time-scaled networks should be used as visual aids in presenting any schedule claim.

Challenge 6: Controlling Information Overload

To this point, we have focused primarily on producing information in a timely and effective manner. As noted above, control of cost and schedule means generating the right information when it is needed, analyzing and interpreting that information expediently, then making control decisions that provide the megaproject participatory stakeholders with the best chance of achieving the megaproject cost and schedule goals. However, one of the paradoxes of megaproject management and control is that so much information is generated on a daily basis by the participating stakeholders that the actual volume of information becomes its own barrier to effective or efficient cost and schedule control. For some perspective, we can consider that a supercritical pulverized coal power generating plant may have the following attributes:

- Regulatory oversight, approval authority, and reporting demands from multiple governmentally empowered bodies (i.e., environmental bodies, permitting bodies, and utility regulators);
- Multiple investment stakeholders (private and/or public), each with application and reporting requirements;
- Multiple general and specialty engineering consultants, each generating huge volumes of technical documentation (i.e., specifications, process design, and detailed designs) and in turn reporting general progress to the other participatory stakeholders and the normal administrative documents (i.e., invoices, notices, letters, memos, and change requests);
- Multiple equipment suppliers and material suppliers (globally), again producing volumes of technical documentation as well as reporting general progress to the other participatory stakeholders and the "normal administrative documents" (i.e., invoices, notices, letters, memos, and change requests);
- Multiple general and specialty contractors producing schedules, progress reports, earned value reports, and the "normal administrative documents" (i.e., invoices, notices, letters, memos, and change requests); and
- The megaproject management, which is not only receiving, reviewing, and responding to the documents generated by the other participatory stakeholders, but is also producing its own reports, communications, and analyses.

In short, literally thousands of pages consisting of various documents are generated daily on every megaproject. Out of those thousands of pages, project management has to find those that will enable it to exercise the maximum control over cost and schedule (and though cost and schedule are the focus of this chapter, those are just two of the full slate of megaproject goals and objectives that project management must meet). As a result, the most important point of control, and the one that in our experience receives the least attention, is document control. The goal of a sound document control process is to get the right information to the right person (or persons) at the time when it is most needed and most useful. One of the most common mistakes made by megaproject participatory stakeholders is in underestimating the sheer volume of documents that quickly and completely inundate the project management team.

Over 30 years of experience in managing, reviewing, and auditing management performance on megaprojects, we have the experience of actually watching the volume of documentation grow substantially, in part because of technological advances, such as personal computers, computerized engineering and design, and scheduling and cost control systems, and in part because of the increased demands for information relative to every element of a megaproject. Those demands have grown in response to governmental, regulatory, and public access requirements and to a large extent in response to the increased contractual requirements for detailed reporting on every aspect of a megaproject. However, of all the management processes involved in controlling a megaproject, it often appears that the least advances have been made in controlling documents and information. During on-site reviews at megaprojects, it is still normal to see individual offices stacked dangerously close to the ceiling with documents, many of which have not been processed through any formal document control system or process.

At least once during every review of a megaproject's management, we hear something like the following: "We all hope that Tom (or Mary) doesn't die, or we will never be able to find anything in this mess." Likewise during performance reviews and audits of megaprojects, it is not at all unusual to hear of instances wherein notice of some critical issue was documented in time for management to have acted with its full response arsenal, only to find that the information never reached someone who would have recognized the true importance of the information. To state the point one more time: Exercising control over megaproject cost or schedule (or any other element of megaproject execution) first requires the right information reaching the right person, at the right time, to take the right response action. If project management thinks of document control as simply a desk where communications are "stamped in," sorted, and passed around, it has already failed to exercise any true control over the megaproject.

Here are the more important (and common) elements relative to document and information control:

1. Adequate and well-trained staff. Even as of 2012, document control is often left as an "other duties" line item on a job description. The document control staff is no less important on a megaproject than is a cost engineer or a schedule engineer.
2. A professionally organized document control procedure, tailored to the megaproject structure and organization. This procedure is not simply a "chain of command," it is a procedure that titles and describes every document, identifies the process for receipt and recording of the document, the distribution profile of the document (including routine and nonroutine communications), and to whom the document is to be routed (along with a backup should the primary recipient be absent).
3. A computerized tracking system for documents, which not only controls distribution but also maintains the "record copy" of each document through the system. That system should include specialized information on "response due" documents, "analysis required" documents, and "contract demand" documents.

4. A "trip wire" function that alerts the document control manager when required documents (i.e., progress reports or change order responses) have not been received as expected.
5. A centralized, computerized document storage and retrieval system to ensure that megaproject documents do not get lost in the piles scattered throughout the offices of the participatory stakeholders, never to be seen again.

Document control seems like such a minor element in the grand scheme of things that are critical on a megaproject. However, from a legal standpoint regarding defending claims that may arise and regarding Freedom of Information Act requests, especially on publicly funded projects, without proper document control, megaproject participatory stakeholders can figuratively drown in an ocean of documents while being unable to exercise control over the megaproject adrift in cost overruns and schedule delays.

Summary

Control is the key; management is simply making sure that one is in the best position to exercise control. Management is taking actions that ensure that project management has what it needs to identify threats to megaproject goals as quickly as possible so that all of the control response actions are available to project management. Controlling a megaproject begins with better control of nonparticipatory expectations and does not end until the megaproject is meeting its intended purpose. Control is improved by focusing resources on the future from their position in the now. Control comes from doing the little things, such as document control, well, spending the money and paying attention to each step in the process. Control is based on justification, not desire. Control is recognizing that every effect can ripple and ricochet beyond expected boundaries, and to the extent possible anticipating ripple and ricochet effects. Perhaps most importantly, control is a mind-set based on project management's ability to focus on the future while managing the present.

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CHAPTER 9

Managing the Design of Megaprojects

Thomas R. Warne

Critical to the timely delivery of a megaproject is the engineering design that precedes the field construction work. The value of good design cannot be overstated. Sound design, coupled with competent input from the construction–contracting elements of a megaproject, results in optimal solutions that save money, reduce the project schedule, and result in a higher-quality project in the end. With too much design, precious time is wasted. With too little, expensive effects can occur. This issue becomes a balancing act for the project manager, who needs to leverage his or her engineering resources to the benefit of the overall project.

Most people think of design as occurring just before construction when, in fact, design elements, including cost estimates and scheduling, are embedded within the project development process from its inception. Three phases typically encompass the design process through the life of a project: planning and environmental–preliminary engineering, final design, and postdesign, or construction support, services. Each phase has its own unique issues and contributions to the overall success of the delivery of a megaproject and is discussed separately in this chapter, with emphasis on the last two, given their integral role during actual delivery.

Planning and Environmental–Preliminary Engineering

Lost in the landscape of the project delivery process is the significant amount of work that goes into preparing for the engineering and eventual construction of the work itself. Depending on the project and owner, a variety of planning and environmental processes must be addressed. In the United States, this step may also involve obtaining permits from various governmental resource agencies, such as the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and state agencies with similar interests.

Design during this stage consists of the engineering required to satisfy the requirements of the National Environmental Policy Act (NEPA) or other planning

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LESSONS LEARNED

1. Engineering a megaproject is a collaborative effort involving the owner, the engineer, and the constructor.
2. Good engineering starts in the planning and environmental phase and continues through the postdesign services after construction begins.
3. Effective management of the design process includes having a design manager, using over-the-shoulder reviews, holding regular task force meetings, and having an issue resolution process in place to deal with areas of disagreement.
4. Engineering on a megaproject is the lead element of the fast-track execution schedule by which the majority of megaprojects are planned; delaying engineering often delays the completion of the megaproject.
5. A key to achieving a design that meets the owner's requirements and is constructable is to involve both the owner and the constructor in the design process from the beginning.
6. Attempting to reduce the cost of a megaproject by reducing engineering staff too quickly, or to a level that cannot efficiently and effectively support construction, can cost the megaproject more than it can save the megaproject.

needs and is typically limited to preliminary work. The level of design needed for approval is dictated by national, state, and local requirements to advance a project to the point where it receives the clearance necessary to advance to obtain final funding approval and then to the final design and construction stages.

Management of the design process during the planning and environmental phase requires knowledge of the various agency requirements to balance them with the need to limit engineering expenditures in this area until a measure of certainty is achieved in the project design criteria. The project manager monitors this balance so that unnecessary design efforts are not expended prematurely on a project.

One of the trends noted on megaprojects is the growing tendency of resource agencies and governmental planning organizations to require higher and higher levels of design, including preliminary cost estimates, schedule, and demonstrated public involvement, in order to obtain approvals and permits. Clarity of the design level needed to obtain these approvals allows the project manager to organize and leverage design efforts in ways that are productive to the project and efficient in their execution while still meeting the permitting agencies' requirements.

During the planning and environmental–preliminary engineering phase of a project, there is likely to be substantial pressure to define the final cost of the constructed work. This pressure is driven in the public sector by political forces that want to set parameters for budgetary and planning purposes in the public arena. In the private sector, investors, boards, and others apply the same kinds of pressure on engineers to establish a project value that can be taken to secure private investment capital. The challenge for the engineer is to provide a cost estimate that is accurate and reliable, given the preliminary information available at the time.

Cost estimates during the planning phase are different from final costs for a variety of reasons:

- Scope creep because of political imperatives or requests;
- Owner-induced scope creep; and
- Unforeseen economic factors, such as commodity price increases, as have occurred with liquid asphalt, cement, and steel in years past.

One lesson that has been learned time and time again is that the public never seems to forget the originally published number for a project's cost, regardless of the circumstance that caused it to change. A good example of this was Arizona's Regional Area Road Fund, which was established in 1985 through a voter referendum in Maricopa County. The original plan was for 231 mi (371.75 km) of new interstate to be built for a cost of US$6.2 billion. When the recession of the late 1980s hit Arizona and the program was scaled back and project costs were adjusted, the public's memory of the promised 231 mi (371.75 km) was firm. In Utah, the original cost estimate for the I-15 Reconstruction Project in the planning stage was just over US$900,000. This preliminary number was carried publicly for several years and was not updated before releasing the requests for proposals (RFPs). Even though the state had a new estimate, this new number was not disclosed to the public given the speed of the procurement process. In retrospect, this estimate should have been divulged before the RFP so that the final proposals would have been more accurately compared in the public arena with the actual estimates created by the Utah Department of Transportation. In fact, the proposals compared favorably with the "unpublished" state estimates, but the publicly acknowledged number remained at US$900,000, and some people felt that more accuracy should have been achieved.

One of the difficult parts of this phase is determining the project schedule. The challenge here is that the designer or project manager must estimate time frames, over which they have little control. In reality, the construction phase of the project is perhaps the easiest to determine because of the long experience that designers and engineers have with this part of the work. Of greater difficulty are the other parts of the project, over which the designer has little control but for which others have great expectations. Some of these other parts include schedule effects caused by funding and revenue issues, litigation, and other actions that come about during or after the NEPA process, changing priorities by governing bodies, and other factors. Again, the published schedule becomes firm in the minds of those who anticipate the completed project without regard for the variables that can influence its overall duration.

Final Design

Final design consists of the engineering required to produce the plans and specifications necessary to build a megaproject. This design is the work that most people attribute to the designers on megaprojects. With the proper approach, final design efforts of the engineers can "make money" for the megaproject through their innovative ideas, creative solutions, and past experience. These ideas that save money cannot be incorporated into a project unless the designers are given some measure of license to pursue concepts that meet the owners' requirements and are efficient for the construction contractor to implement.

At this point, it is appropriate to mention that many megaprojects are primarily delivered using methods, as discussed in Chapter 4, including design–build (DB), construction manager at risk (CM@R), or construction manager–general contractor (CMGC) methods. Often these approaches are referred to as alternative delivery methods, as opposed to the more traditional approach of design–bid–build (DBB). In each case, the designer and builder or contractor have a relationship that allows for substantial collaboration and interaction, as opposed to the relationships that are formed under DBB, where the owner performs the design in the absence of substantial input from the contractor, who then builds the facility. This opportunity to collaborate offers additional benefits to the project by allowing the designers and constructors to help each other find better solutions to the specific challenges of a megaproject.

Final design on megaprojects, whether for a public entity or private company, is typically completed in a relatively short time, compared to the time for the construction work to be performed. This need is driven by the fact that most megaprojects either serve some crucial public purpose or result in significant financial benefit to the owner such that any time spent doing design work that slows project completion is seen as undesirable. Hence, design firms involved in megaprojects find the pace and intensity of the work to be much higher than on other projects for which they provide the same services. Examples of this pace of design are found in large transportation projects, like the I-15 CORE work in Utah. This project involved the complete reconstruction of 24 mi (38.62 km) of interstate freeway, including 40 new bridges. The design for this US$1.3 billion project was completed in approximately 15 months using more than 200 engineers and technicians. Private megaproject facilities face financial pressures to speed completion as well, requiring engineers to work at a pace not typical of the industry on other projects.

To achieve this fast-paced design on megaprojects, a number of processes are typically established. Most common among them are the practices of over-the-shoulder reviews (OSRs) and design task force meetings.

OSRs encompass a process where designers and reviewers engage in a collaborative effort to resolve engineering issues as they arise during design, as opposed to waiting until plans are submitted for review. At its basic level, OSR finds designers and the owners' reviewers communicating on a regular basis in formal meeting settings as well as informally before final submission for approval. Design issues and challenges are raised and discussed. Solutions are considered and either adopted or set aside. Ideas are exchanged in a nonthreatening environment. The design progresses with this ongoing input so that when it is completed and submitted to the owners' reviewers, it is the product of the joint efforts of all those involved. This notion is not to say that the designer on a megaproject has somehow skirted his or her duty as the engineer of record. Rather designers complete their designs with valuable and timely input from the owners' designers and reviewers.

OSR is a powerful tool, and many examples of its benefits and effective application can be found. Where it works well, the submission of a set of plans or a design package is a "nonevent" in the overall design process since the reviewers have been engaged in the engineering all along. In these cases, the review can be done in a matter of a few days rather than the multiple weeks or more often required when OSR is not used. It has been noted that the submission of a plan set for review should not indicate the beginning of the communication process but rather yet another step in what has been an ongoing collaborative effort.

Unfortunately, some projects suffer from the effects of poor leadership and management of the design and review process in one or both of the organizations. On a recent project where executives from both the owner and contractor were present in a meeting, it was reported that one design package had gone back and forth 13 times over a four-month period before it was approved. Obviously the designers and reviewers had failed in their application of the OSR process. That said, it also represents a failure of leadership. Why didn't someone step in after the fourth resubmittal and bring control to the process? Or after the fifth resubmittal? On megaprojects, the team has no time to waste in exercises like this.

A separate but equally important part of the design process on megaprojects is the design task force meetings, which occur on a regular basis during the production of the engineering plans for construction. These meetings are typically held according to discipline (e.g., structures, drainage, and utilities). They are chaired by the contractor's designer, and attendance includes engineers involved in either the production or the review of the final design. Often held weekly, these meetings provide an important venue for communication of critical design issues and for raising any challenges encountered in the designs, as well as for coordinating designs among disciplines. These task force meetings are not a substitute for the informal collaboration that occurs within the context of the OSR process, but they serve as an important support element for it.

Lessons learned from years of experience working with design task forces include the following:

- The right people need to attend, people with both authority and appropriate responsibilities;
- Nonessential people should not attend as they are a distraction;
- Regular meetings, especially early in the design process, are important; and
- Other disciplines need to be identified and included, depending on project needs.

Effective design task force meetings are an essential element of the engineering process leading to efficient megaproject construction.

Complete final design plans need not be submitted and approved in order to start construction under the alternative delivery methods. Depending on the project and the owner, early elements of the design (e.g., foundations and drainage) may be completed and approved. These early plan sets are typically approved before the final design is completed so that the contractor can start work earlier and accelerate the megaproject. Under ideal conditions, the completed design would be the most desirable work product to take to the field. But, as noted earlier, most megaprojects have an urgency to them that requires engineers and constructors to find ways to complete activities in parallel.

The early drawings are sometimes referred to as "early release for construction" drawings. They are the result of the kind of relationships between designers and reviewers that allow a high level of confidence in those elements of work in that what is built before the design is final is right. Sadly, where this level of confidence and trust does not exist, many of the benefits of collaborative design processes derived on megaprojects are lost and never regained.

Staffing the design side of the megaproject organization happens with great urgency at the beginning of the project, and the reverse is true as well when the design is nearing completion. Here again, the project manager must find a balance between controlling costs incurred by designers who are producing essential engineering plans for construction and the need to shut down the design and its attendant costs as soon as is practical.

Effective management of the final design process nets substantial benefits to the megaproject contractor and the owner. Overall project quality is improved, money is saved, and project schedules are enhanced.

An important component of the final design phase is the production of a final cost estimate for the completed construction. This cost estimate is based on the refinements that occur between the preliminary design efforts that occur in the planning phase and this phase. Essentially, the engineers take concept-level information and create an initial design in the planning phase and then take detailed design attributes and develop a final cost estimate in this phase. Often these estimates differ for a variety of reasons—not the least of which is the ability to be so much more detailed at this point in the project. A lesson learned here is that updated estimates should be publicly disclosed as they are developed to avoid the situation described earlier with the I-15 Reconstruction Project in Utah.

Another lesson learned is that many owners and their engineers are using individuals from the contracting community to develop the final cost estimates for megaprojects. Although many engineers have significant experience in the estimating process, these construction industry veterans bring years of real-life estimating experience and lessons learned from trying to make their budgets on actual projects. Their use of built-up estimates, where crews, equipment, and work processes are estimated in great detail, often provides the most accurate assessment of what a project will really cost. The value of these individuals is being recognized more and more by owners with experience in delivering megaprojects.

Postdesign Services

After the design has been completed, it is incumbent on the contractor to retain access to a certain number of designers to assist with issues that might arise during the course of construction. These designers must be familiar with the project, must have access to colleagues who did the actual design who have left the site, and must otherwise provide support services to the field construction efforts.

The role of the designer in the postdesign services phase is often overlooked. Too many megaprojects have their final design approved and immediately reduce their design staffs to less than ideal levels during construction. It is false economy to prematurely eliminate designers from the megaproject or staff their postdesign services function at too low a level to be efficient or effective in responding to questions that arise during the construction of a megaproject. Too many contractors have learned that the cost of engineers is minimal in the overall budget picture when compared to the cost of "iron" (or equipment) sitting idle, waiting for an engineering clarification or change.

Even after the design is done, having the engineers who prepared the plans available to the project allows for timely decisions to be made where engineering issues arise. The circumstances under which their services are needed vary and may include involvement with field design changes (FDCs), nonconformance reports (NCRs), and notices of design change (NDCs).

An FDC is necessary when something in the field doesn't quite match what was included in the plans. The designer needs to be brought in to clarify either the intent of the design or some detail, offer a newly required design, or perform some element of engineering to create a workable solution in the field. No initial design is perfect, so NDCs occur on even the best-designed project, and unless their number is inordinate, they do not represent a problem on a megaproject.

An NCR is initiated when something is constructed in the field that does not conform to the plans or specifications. Typically it is something that may be left in place or that needs an engineering solution for the work to progress. The designer working in the postdesign services role researches the issue, determines a course of action, prepares new plans, and coordinates with the field personnel so that whatever wasn't done right can be corrected.

An NDC occurs after the design is completed and approved and when the contractor decides that a different approach or design would serve the intended purpose. The NDC provides for the documentation necessary to allow field personnel from both the owner's and the contractor's organizations to know what must be built under the new design condition. Producing a large number of NDCs is not a desirable condition. However, it should be understood that on megaprojects, NDCs do occur and must be dealt with professionally and efficiently.

Organization

Megaprojects require a different organization and structure than would typically be required for a smaller, individual project to be effective in the design effort leading to construction. Most megaprojects have large consulting firms, with experienced and talented engineers performing the design work. Often smaller firms are brought on board to handle specialty engineering. These individuals are integrated into the overall organization for management purposes and, if properly used, provide excellent service to the contractor's team.

A trend that is becoming more and more prevalent throughout all industries is for the contractor to dedicate a member of his or her own organization to be the design manager for the project. This person is usually an employee of the contracting company who has had experience managing similar design efforts. They work to resolve conflicts that might arise between designers and reviewers. They also coordinate the submission of plans and other work products for review to align approvals with field construction activities. By placing one of their own managers into this position, the contractor is removing an element of risk to the delivery of the megaproject and ensuring the effective management of the design process.

Resolution of Design Issues

At a glance, the design process on megaprojects sometimes appears to be fraught with conflict and disagreement. This appearance comes in part from the fact that no matter how good the owner's design criteria might be, issues arise that need to be resolved. When it comes to DB or other alternative delivery methods, the following is usually true: The good news is that the owners get what they ask for. The bad news is that the owners get what they ask for. No perfect set of design criteria exists, and every engineering issue encountered on the megaproject is not just a simple application of past practices. Omissions occur that must be addressed, conditions might not be those that were anticipated, designers may have preferences not expressed in the owner's standards, and other changes may be necessary to deliver a megaproject that has all the desired attributes.

Engineers must design according to their professional training and experience. Sometimes the designer and reviewer disagree on their approaches or solutions. It is more than likely that they are both technically right, but a resolution to their disagreement is sometimes elusive. In this case, the design team and the owner must have in place a process to escalate the issue to a level in their respective organizations where either a technical engineering or a commercial decision can be made and progress on the design can be continued. Failure to make timely decisions in the design process prevents the process from contributing to the overall success of the megaproject.

Leadership is an important component of a successful design process and the resolution of issues. On too many projects, the designers representing the owner and the contractor are unable to resolve issues that may have policy or commercial implications that are unresolvable by these individuals. Or there may be technical issues on which the two parties are polarized. At this point, project management must step in and bring resolution to these problems. In the example earlier, when a design package went through the review process 13 times in a four-month span, project management from both sides should have seen the futility of such an exercise and stepped in after the first couple of iterations and brought resolution to the disputed matters.

The number of design-related issues that must be resolved during the postdesign phase of the megaproject often confuses those not familiar with megaprojects. By their nature, megaprojects are complicated, requiring sophisticated engineering and involving unique solutions to challenging problems. Finding the answers to each of these problems is the key to moving the process forward. Experience has shown that the sheer number of issues is less of a problem than the ineffectiveness of the issue resolution process used to advance the problem to a solution.

Managing the design process for a megaproject is an important task for the project manager. Done effectively, the project can benefit in savings of time and money and an improved quality product. A successful megaproject starts with competent design long before the first piece of equipment ventures out on the jobsite.

Summary

The design efforts on a megaproject occur from the earliest concept and planning stages through the postdesign services provided during construction. At each stage, the designer plays a key role in delivering the megaproject to its successful completion. Designs, cost estimates, and scheduling information become progressively more detailed and refined over the life of a project. The products of this progression should be transparent to all parties involved. Megaprojects demand a more aggressive management of the overall design effort than do traditional capital improvements of a much smaller nature. Properly managed, the design on megaprojects nets the owners and contractors many benefits and results in a more successful project.

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CHAPTER 10

Procurement and Construction Management

James Crumm

The types of capital projects that are the subject of this book involve engineers—civil, mechanical, electrical, and chemical. Engineers like to engineer things, and all too often they forget that critical to the success of the project is the procurement and delivery of services and materials to somewhere in the world where a group of people, sometimes numbering in the thousands, are waiting to construct something. The procurement and delivery of material and engineered components and the costs of assembling those components into an operational facility typically represents 85% of a project's total cost.

The Project Execution Plan

This chapter lays out what my experience has demonstrated to be important in successful megaproject construction: the project execution plan, project staffing, procurement, decisions regarding subcontracting and contract administration, and construction closeout. It is incumbent upon the executive management of the entity responsible for procurement and/or construction of a megaproject (or some megaportion of the megaproject) to recognize and then convey to the project team that the procurement of material and the construction of the project are the main drivers of the project execution plan and ultimately the project's success. Procurement managers, construction managers, and construction project control managers (planning and scheduling) must be equally represented on the project team from day one to ensure the successful development of the project execution plan. Day one means the day you decide to request funding for a project or when you decide to bid on someone else's project.

This chapter is written from the viewpoint of the contractor, the company that has the final ability to determine whether the project meets its expectations. The contractor's view is typically not as "formal" or even "polite" as other phases of a project. As such, this chapter's voice is expressed in a different "tone" from that of

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LESSONS LEARNED

1. Whether all the planning, design, and financing are done right, if the procurement and construction are not executed right, the project will fail.
2. Executive management must have a clear idea of what their expectations are before they send thousands of people out to meet those expectations.
3. People build projects; everything else is just "stuff." Good people can execute good projects. The best people execute winning projects. Beg, borrow, or steal the best people who can be found.
4. Even the best people need a written plan. Write one that meets expectations and then stick to it.
5. Contracts cover everything that is bought and most likely what is sold. Embrace them, understand them, and enforce them.
6. A megaproject is a great adventure. The project team should have fun successfully spending billions of dollars. If they are not having fun, the project will face problems.

other chapters in order for the reader to gain an appreciation of the frustration often felt by essentially "the end of the stick" to a project's execution.

It cannot be stressed too many times: The project execution plan must be written *before* the start work release date for the project. The project execution plan (PEP) is not a "work in progress"! The PEP *defines* all activities needed to complete the project—everything from engineering, procurement, shipping, construction, subcontracting, modularization, and heavy lifting to the location and timing of all personnel functions. By the time actual project work starts, the bid or cost estimate must have been converted into a project budget and the initial Level 2 plus schedule used for pricing and bidding should be in the final stages of conversion into a detailed Level 4 interlaced and man-loaded schedule, as discussed later in this chapter.

A recently reviewed billion-dollar power plant project in the United States on which I was involved is a case in point. Progress was "guesstimated" by outside consultants to be approximately 50% complete. The project team did not know where they were because the PEP was still a work in progress and the schedule was still a Level 2 plus without manpower loading. Needless to say, the project was late and overran its original budget by a significant amount.

Once written, the PEP is never rewritten; it is "revised" to reflect changes in strategy forced on the project by external forces. Revisions must be clearly marked with revision numbers next to the original language, just as drawings are revised. Revisions must be approved in writing by the overall project leader and the project control leader at a minimum (my experience suggests that the entire project team's management sign off). It is also recommended that a senior executive approve any revisions. Unless you are the self-performing owner, most contracts will or should require client approval of the original PEP and approval to revise the PEP.

If the owner of the project is different than the entity doing the engineering, procurement, and contruction (EPC) for the project, the owner must review, understand, and accept the contractor's PEP. Having accepted the PEP, the owner must ensure that the PEP is followed to the letter.

The term "owner" is used in this chapter to refer to the entity that "owns" the megaproject or has taken a contract for a significant portion of a megaproject or, in fact, any other portion of the megaproject of significant size and/or importance.

However, if you are anyone except the owner (the one with the money), you need to keep two schedules. The first one, to be shared with the client, shows the original contract schedule plus any additional time from approved change orders. The second schedule is private and indicates what you believe is really going to occur, which is hopefully much shorter than the first or "client" schedule. Why two schedules? Because it is difficult to convince a project owner that you need an additional two weeks added to the completion date because of a hurricane when your schedule says that you are two months ahead of schedule.

In this chapter, there are numerous comments about not accepting the lowest possible bid from a vendor, supplier, or contractor. Why? Megaprojects, by the nature of the huge amounts of money involved, always have significant penalties for failing to deliver the project on time. Significant can be as much as US$100,000 per day or more. In addition, the cost of keeping a construction management team in the field can exceed another US$100,000 per day. Now, balance US$200,000 per day against a US$50,000 purchase order that has the effect of leaving a vendor or supplier with no profit incentive to finish your order because he or she is not working on someone else's "profitable" work. Be tough but *fair*; negotiate hard, but make sure you incentivize successful performance.

Nowhere is the following statement truer than in the procurement process of a megaproject, with all its bits and pieces: The hiring of others to execute all or part of a project does not absolve the owner of the project (or any piece thereof) from any responsibility for failure.

Project Staffing

Regardless of wonderful plans, great technology, positive marketing studies, committed CEOs and boards of directors, and lots of money, it will all come to naught without a dedicated team of energetic, motivated people. The best teams are made up of individuals who have worked together before on other successful projects. They know how to work together and build upon each other's strengths and backfill the weaknesses.

I was able to take key people from an advanced power generation pilot plant project funded by the U.S. Department of Energy; to a chemical plant revamp project in Louisiana; to a US$50 million natural gas to hydrogen plant project in Venezuela; to a design contract, construction management contract, and lump sum turnkey contract within a US$4.6 billion upgrader refinery in Venezuela. With each new project, more and sometimes better people joined the growing team, and the profitability improved.

A properly organized megaproject has most of the following positions filled. The responsibilities and relationships of the following positions have been spelled out in the PEP.

The Executive Sponsor

It is strongly recommended that an executive sponsor be named as executive management's focal point for the project, as well as being identified as the project team's focal point for guidance and support. He or she is also in a position to keep management and the board of directors advised about project status and problems. The executive sponsor also fills a key role as final arbitrator of disputes that the overall project leader and his or her team cannot resolve. He or she becomes the "court of last resort" for any internal project disputes. He or she fills the same arbitration role in the dispute resolution process between you and the owner.

The executive sponsor needs to be authorized and able to mobilize key company resources in the event that the project encounters the kind of problems that the normal project staff would not be expected to resolve.

Last of all, the executive sponsor needs to be able to step in and run the project in the event the overall project leader becomes unavailable or unable to complete the project.

The Project Team

A megaproject is a "company" that spends a billion or more dollars, often including taxpayer money, over a three- to five-year period. This company negotiates and contracts for hundreds of millions of dollars' worth of equipment, material, and services in a dozen different currencies. They arrange to move equipment and material by rail, ship, airplane, truck, or oxcart from wherever in the world it is located to wherever it needs to be, arriving at the time it needs to be there. In today's global business environment, the company contracts with thousands of workers to assemble the components of the megaproject into its final form. And those workers may not be able to speak, read, or understand the instructions or drawings written in a nonnative language and in many cases may not be able to read or write in their own native language.

As such, the project team at its core must be composed of business managers who have the contracting, procurement, and construction experience to achieve success. The specific talents of this core group depend on the kind of project being built and where it is located.

Executive management *must* have confidence in their project team. Executing a megaproject is a scary proposition; after all, you are spending a billion-plus dollars of the owner's, the investors', the financier's, or the taxpayers' money. Furthermore, if the megaproject isn't delivered according to expectations, your career is essentially over and your company may go bankrupt. If the project team has the confidence of management, they will act with confidence as they execute the project. If they are afraid of being second-guessed, they cannot concentrate on executing the PEP.

The project team *must* be encouraged to raise problems to the executive level immediately after they are identified. The quicker a problem is identified, the faster the entire company can be mobilized to act on it. There is another reason to communicate bad news quickly that involves the confidence of executive management in the project team. Nothing erodes confidence worse than having the president of the company call you and tell you that he or she "understands that the QBV fell off the deck of the transport ship in the middle of the South China Sea, and the project is facing a three-month delay and the potential for US$25 million in liquidated damage costs for late delivery of the project." And they are furious that you did not call them (management) to advise them of the problem. The only thing worse is to admit to the president, "It is news to me!"

Executive management should monitor, not meddle. Executive monitoring should compare actual results against the PEP, its budgets, and its schedules. Are the objectives of the PEP being met, and if not, why not, and how can executive management help correct the problem(s)?

Personnel

Regardless of where the project is being executed, there are fundamental positions on a megaproject team that your company must fill. The comments below are basic but slanted toward the needs of the construction effort.

Overall Project Leader

This person is a savvy businessperson who can identify, lead, and motivate a core team of 20 to 25 senior people directly, another couple of hundred semidirectly, and potentially thousands of people indirectly. The overall project leader needs to have the discipline to demand a solid, well-vetted execution plan and then stick to it. He or she must understand the relationships between costs of procurement and construction versus overall project cost and realize that the majority of the PEP and its embedded schedule involve procurement and construction. If execution starts to go off track, he or she needs to lead the team's efforts in finding the best solution and implementing that solution to get back on the PEP.

Since these projects are all about buying goods and services, the overall project leader should have a solid understanding of contracts and global procurement. Having an engineering background is only necessary to ensure that he or she cannot be led astray about what is being purchased or what is going on with the project. The overall project leader must be a person who is comfortable interacting directly and on a daily basis with the project team, as well as the owner's project team. This is a hands-on job—no kings or queens need apply!

Secondary attributes to those above are experience in the country where the project is being constructed, a basic knowledge of the workings of the facility being built, and some field construction experience.

He or she needs to visit the site starting with project award or approval and needs to permanently relocate to the site when equipment starts arriving. The overall project leader needs to stay until the facility has been put into service.

The overall project leader's interaction with project control is almost continuous. Envision the overall project leader as a blind person in a minefield, and his or her only hope for survival is the person on the other end of the cell phone. That person is the project control leader. Experienced project control people have seen it all at one time or another—the good, the bad, and the ugly. The best project control people, if you are lucky enough to have them, can "smell" a project starting to go wrong *and* figure out what to do to get it back on track.

Furthermore, this person needs a title that commands respect, especially if the project is for a government entity or in a foreign country. A title of vice president costs little or nothing except the printing of a business card but has a significant effect on how your project leader is viewed and received by others.

Project Control Leader

Regardless of which side of a project you are on, owner or builder, the next most important person after the overall project leader is the project control leader. The project control leader is the eyes and ears of the overall project leader regarding progress toward project completion.

Executive management needs to understand the difference between project accounting and project control. Project accounting tells the project team how much money is committed and how much has been spent. They pay the bills authorized by procurement and project control. They bill the client based on instructions from project control. If project accounting tells you where you have been, project control tells you where you are going and what you must do to get there.

This person *must* have a strong working knowledge of the company's cost accounting system and of computerized CPM schedule programs, such as Primavera, the essential scheduling and workforce-loading tool for any major capital megaproject. Ideally, this person has extensive experience in the country where the project is being built, as well as having built that kind of project.

Project Procurement Leader

This individual, along with his or her support staff of buyers and expeditors, determines through his or her work whether the project has a chance of being a financial success. If the project procurement leader cannot buy services and material within budget expectations, executive management needs to know that fact as soon as possible (ASAP). During the first 6 to 12 months of the project, this person is the third most important person on the project team. It is important that his or her background include experience in the kinds of materials and engineered components contained in the megaproject.

Although he or she may share responsibility with the overall project leader, the project procurement leader must be an excellent negotiator. This person must also have a global view of procurement and be comfortable dealing with companies all over the world that may be motivated by different factors than the project owner.

Project Traffic Manager

This person, who typically works for the project procurement leader, is responsible for using in-house resources or a professional freight forwarding company to get all the material and engineered components that have been purchased ready to ship to the jobsite on time and in one piece. Before starting on a megaproject, executive management must ask the question, "Do we really have the personnel and the systems to move all this stuff ourselves?" Many companies may think that they have the resources until they become involved with megaprojects and find out that they do not, often too late.

You could count on one hand the number of companies that build megaprojects that are capable of managing the delivery of the thousands of shipments associated with a megaproject; most still hire a company to assist them. On a reasonably complex foreign project, let your freighting decisions be guided by your response to the following scenario:

UPS calls you and says they need to take all their computer systems off-line in three weeks, and they would like you to take over their large-package business—everything over 20 lb. They will let you have their operating personnel and all the ships, planes, trucks, oxcarts, etc., and all you need to do is get everything delivered to the right place on time. If your answer is, "No problem!" then consider managing your own freight forwarding.

For everyone else, hire a freight forwarding company. There are four to six heavyweights in the business that have the qualified personnel and the logistical systems to move all the bits and pieces of a megaproject to their destinations.

If you choose to hire a forwarding company, then your project traffic manager becomes the project's coordinator with the freight forwarder.

And, finally, do not forget to buy insurance on all your major irreplaceable shipments.

Project Construction Leader

Once construction is fully mobilized, this person supplants the project procurement leader as the third most important person on the project. Construction leaders are the individuals with dirt under their fingernails, possessing solid, hands-on construction experience. They must have experience wherever in the world this facility is being built. Experience on the Texas Gulf Coast does not equate to experience in Russia, the Middle East, South America, or Southeast Asia.

It would also be great if this person has at least been part of a team that has built one of this type of megaproject facilities before. If this attribute is not available, then greater care is going to be required in choosing construction discipline leads, project control leads, and subcontracting leads who do have that level of experience.

Furthermore, the project construction leader needs to be in the home office ideally from the time the project is planned or at a minimum before the project starts until site prep is complete and real construction work is ready to begin. The construction leader needs to make visits to the construction site during the interim period from project start until moving to the project site.

Home Office Project Manager

This is the person in the home office responsible for producing the engineering deliverables that support procurement and construction. The actual progress of bringing engineering deliverables to the project is tracked and reported by project control.

This person becomes the home office's leader responsible for finishing any remaining work on all engineering deliverables to the site and providing those deliverables to all vendors and suppliers when the overall project leader moves to the construction site. He or she is also the person who responds to questions from the site during construction, unless there is a person on site with this responsibility.

Modularization or Heavy Lift Expert

If the project requires modularization or heavy lifting, this person should have been involved in the original project pricing because these two items can either save or cost you a lot of money. Modularization should be used when a shortage of skilled craftspeople is anticipated at the construction site. This method allows you to move the skilled labor work to where the skilled labor force is available.

The bigger the pieces to be moved and lifted, the more limited the resources are to pick them up, move them, and then put them in their final places at the jobsite. This effort is expensive. If the project is being built in the Third World, then any heavy lifting or heavy hauling equipment will have to be shipped in and set up for the project. This type of equipment typically has to be reserved at least a year in advance.

Heavy hauling or lifting includes the use of special ships that do nothing but haul big, heavy items all over the world. Some of these ships even have their own cranes capable of lifting heavy cargo from the dockside onto the ship.

Do not forget to leave a space on the plot plan to place the heavy lift equipment and a pathway to get the items to be lifted to the lifting equipment.

To control this cost, consider doing all of your heavy lifting in a single time window. This plan means that some items will arrive and have to wait to be lifted. Construction laborers can use this time to complete the item to be lifted to the maximum extent possible (with such things as painting and/or insulation, platforms and ladders, instrumentation, or piping) while it is still on the ground.

Negotiate with heavy-lift contractors on the basis of a specific time window, starting with a large block of time that becomes shorter and more closely fixed in time as actual delivery dates of the equipment to be lifted become clearer. You should negotiate a fixed price for a certain number of days, during which time they will lift anything you can put under the hook as well as a fixed per diem price for each additional day you have to extend because a piece to be lifted is late.

Site Procurement and Subcontracting Leader

This person is responsible for buying material in-country and contracting for the services of individual personnel and companies that do the actual construction work. This person needs broad in-country experience and should be fluent in the local language as well as understanding the host country's customs and culture.

Local language here means *local*, in country. The author once had a corporate audit team (one Puerto Rican, one Mexican, and one Spaniard) come to Venezuela to audit one of my projects. The audit took twice as long as normal because the audit team could not understand the Venezuelan "Spanish"-speaking accountants and vice versa.

Based on the framework laid out later in this chapter for contracting, the site procurement and subcontracting leader and the project construction leader (during visits to the construction site) need to begin early to negotiate local or regional subcontracts for construction services.

Furthermore, this person and the human resources and business manager should be the first two people on site, especially in a foreign country. Together they build or lease construction office space and arrange transportation and housing for the growing number of people relocating to the construction site. They must also identify local personnel for the project team while they continue to update the overall project leader on the status of the individuals and companies that will be involved in the construction of the megaproject.

Human Resources and Business Manager

The human resources (HR) and business manager is an extremely important person no matter where your project is being built, but critically so if the project is being built outside of your home country. His or her presence serves three main purposes—to find and hire local personnel to fill out the project team, to develop a support system for the team members in the local area, and to protect the company from costly personnel and business practices in the local area during megaproject construction. On foreign construction sites, the HR and business manager must ensure that the in-country needs of the key company personnel (and any project expatriates you have hired) are being provided. Those services might include providing or arranging for work visas, housing, banking services, and transportation and arranging for medical services and schooling for children.

For a project in your company's home country, the above activities can usually be taken care of by the home office HR department. If the project is not being executed in the project owner's home country, then additional staffing may be necessary to successfully execute the project, including attorneys who deal with local labor and HR.

Local Labor and HR Attorneys

Attorneys who are familiar with local labor practices and regulations need to be available to the project team. The HR and business manager is typically responsible for managing this interaction. Local labor and HR attorneys are necessary because they know the country's case law with respect to labor issues. They are also aware of changes in labor law and local labor practices and how they might affect your specific project. Over a three- to five-year project life, there can be a lot of changes—especially when governments change.

Some large and smart companies have made expensive labor law mistakes. Here are a few examples:

- Employees can sign an employment contract but under appeal parts of the contract end up being voided by local law.
- Most of the world's workers respond in a job interview to the question, "How much are you being paid?" with a total compensation number. Do not confuse this with salary or wages.
- Subcontractor personnel can end up being treated as your personnel, retaining their rights under both companies without a proper labor "firewall" in place.

- Government-mandated severance pay at the end of a job can equal more than 100% of each individual's salary if it is based on total compensation and not actual salary.

Project Personnel Incentives

Project incentives are especially important for the construction phase of any project, and they are more important in megaprojects. The construction phase of a project is where you have the largest number of transient, contracted personnel. The motivational emphasis for construction personnel incentive is "acquire and then retain." You want them to "quit the job you have now" with that other company and come to work for you but "stay to the end of our job—stay until it is finished." This requirement means that construction personnel incentives, whether in the United States or overseas, need to have a signing bonus and a completion bonus format, as well as having a performance bonus component to their employment contracts. In the United States, these incentives are typically limited to the executive sponsor and the project manager; however, overseas projects may expand incentives to the entire project team, especially when relocation from their homes is expected for an extended time.

The project owner's permanent employees need project performance incentives that are in line with the company's overall performance-based bonus system. However, care must be taken that these people do not end up getting less incentive than the contracted personnel on a successful project. Most construction personnel work *and are paid* for more than 40 hours per week, with 50 hours per week written into many employment contracts. They often work 60 hours weekly during key periods. Therefore, overall project incentives need to be adjusted so that construction personnel (including supervisors) do not end up getting more money than the overall project leader and his or her key staff.

Also, be alert to any laws specific to the country in which you are building a project that may require incentive pay, profit sharing based on gross compensation, or special perks like trips home. Your permanent employees generally do not take advantage of these perks, but contract people always do.

Most companies mobilize site construction too quickly because construction people do not like to be cooped up in the home office when they could be out starting the incentive plan's clock, playing in the dirt *and* getting that overtime and those foreign perks. Do not mobilize people to the site until there is an accumulation of work, and then deploy only those needed to address that accumulation. Two exceptions to early deployment are, of course, the HR and business manager and the site procurement and subcontracting leader.

Home Office Procurement

Most of the megaprojects discussed throughout this book, covering all industries, involve the procurement of components designed and fabricated by others. A component could be a single compressor or a grouping of pumps, or it could be structural steel or piping spools or a module containing all of those items. Therefore, guard against procurement activity restricting the flow between the engineering and delivery of those components and everything connected to them to the construction site in a timely manner.

Price is really only an issue if that price exceeds the budgeted cost. For every case where the supplier is gouging, there are nine cases where the specifications were changed between the initial budgeting process and the final placing of the order. If you can get a deal without jeopardizing the project, that's great, but be careful of strangers bearing gifts!

Procurement is all about getting all deliverables associated with a given component from a high-quality supplier ASAP for the lowest, fair price. The key deliverable for the type of project envisioned by the authors of this book are the *drawings*. Not your drawings, the drawings from all the engineered component suppliers.

Remember, your engineers cannot produce their drawings (and should not be allowed to try) until they get the final, approved vendor drawings.

For example, you may buy a multiple-stage, motor-driven compressor. Your civil designers cannot finish their foundation drawings until they are provided the final baseplate drawings and the forces created by starting the motor, and your piping designers cannot produce piping isometric drawings until they get the nozzle sizes for all the connections and allowable stresses. Electrical designers cannot produce wiring diagrams or motor control center specifications without final drawings and specifications, and instrument engineers cannot specify all the wiring or draw the control schematics. This list is only a partial list of the possible effects on the project for the lack of one component supplier's drawings. On a megaproject, there may be hundreds or even thousands of similar components to procure and deliver.

Owners typically want to put equipment delivery penalty or bonus clauses into a component supplier's purchase order, but that misses the point. Suppliers buy the materials they need and build your component as soon as they have access to *approved drawings*. They do not even start the process without those drawings. If you offer the bonus for the *drawings* and approve them rapidly, the component will arrive on time. Why? Because once the component supplier starts buying material and assembling components, they are out of pocket and the cost of money eats into their profits. Additionally, your "stuff" is taking up space they can use to build something for someone else.

Once the supplier drawings are in house, procurement and project control must monitor and expedite the comment and approval turnaround cycle. If everything is not approved by the end of your second comment cycle, the procurement leader (and possibly the overall project leader) needs to call a meeting of the reviewers, put the drawings on the table (along with a large club), and get the drawings approved. The club is for the person who sent a drawing back without reviewing it and marked it "unapproved" because the drawing was the wrong size! Don't laugh; it happened!

The PEP must contain definitions for all components engineered and fabricated by others. That definition for each component includes process requirement specifications and a listing of all the various component-appropriate engineering specifications for the entire project—civil, mechanical, electrical, instrumentation, painting, even insulation and fireproofing. The PEP should also include any proposals and/or quotes from vendors that were used to develop the project price.

Here I offer a word about engineering specifications that you supply with requests for proposals from vendors and suppliers. Some people may think it is amusing to send a vendor a 3-ft stack of 8.5 × 11-in. specifications (or the CD equivalent) for everything from piping and valves, to grout, to paint, to electrical and instrument wire and tell the vendor or supplier to follow whatever standards are applicable. I will repeat what I said in the first section of this chapter: The hiring of *others* to execute all or part of a project does not absolve the owner of the project (or piece thereof) of *any* responsibility for failure. Help the vendors and suppliers get it right from the start for your sake. You are much more familiar with your specifications, so help them identify what is applicable to their items of supply. Your pain will be a hundred or a thousand times greater than the vendor's or supplier's if there is an error or omission that you could have prevented.

Make sure that you specify things that are real and obtainable. Always ask vendors and suppliers if they see any item or requirement that is not standard or that may present a production or procurement problem. Piping systems are the worst offenders: Yes, someone in the world probably makes a 24-in. forged tee where the stem of the tee is 8-in. pipe in 2.25% chrome alloy. By using the word "forged," you have probably delayed the delivery of that piece of piping material until after you retire! Leave the word "forged" out, and the vendor can simply weld an 8-in. pipe with reinforcing into the side of a 24-in. piece of pipe, heat-treat it, and then do a 100% X-ray, and he or she is done in a couple of days.

Who Buys?

The more important an engineered component is—because of cost, schedule (critical path), or complexity—the higher up the overall project execution organization chart the purchase should be made. The owner and his or her subcontractors must have the common goal of delivering the project by the agreed delivery date for the amount of money in the bank. The owner of a project needs to evaluate each major component purchase and determine what procurement strategy will yield the highest probability of delivery success.

Whether you're a megaproject owner or a megaproject contractor, major component development and pricing should have been developed during the bid (or pricing) stages to the point where placing the order with the preferred component supplier is only a formality once the project gets the green light.

Sole Source

One way to speed up the procurement process is to buy items from a known vendor or fabricator that has the proven experience to deliver the needed item on time. Too often companies become obsessed with getting multiple bids even though the past 10 times they bid an equivalent item they ended up buying it from the same company.

Remember, it is all about getting the drawings ASAP! Gaining two months by eliminating the bidding cycle is two months gained for your designers to make or finish their drawings and two months earlier that the component gets to the construction site.

Shop Inspections

It is highly unlikely that your company has the resources to inspect all of the fabrication work for engineered components at the many inspection points that every item requires as it goes through the fabrication process. That means that you are going to hire individuals or companies to do many of the inspections in facilities all over the world. It is usually unwise to use inspectors from the same country where the supplier is located, except in Western Europe, the United States, and Canada. Suffice it to say that the ethical values of people in countries around the globe may not meet the same standards of behavior your company expects of its employees at home.

Consider sending home office engineering personnel to do inspections of fabricated components at critical inspection points. Although more expensive than local people because of travel and living costs, this use of engineering personnel offers many benefits. It is a double check on your regular inspector and allows a more comprehensive review because an engineer knows more about the component than what is on the drawings. It can also be a learning experience and a perk for many engineers, who may rarely get out of the home office.

Progress Payments

Payments to component vendors and suppliers should be used to motivate them to gratify your needs; however, keep the payment schedules simple. In addition to offering bonuses for getting drawings out early, offer a progress payment greater than the value of the actual work performed on the drawings. Suppliers cannot order material or do any physical work without approved drawings, and you cannot finish your design engineering for that component without those drawings.

Once any drawing is approved that allows a vendor or fabricator to buy material, you want to make sure the purchase orders are placed. Your goal is to ensure that material deliveries are not an impediment to progress. Therefore, tailor payments to cover the full cost of material as it arrives so that the vendor or fabricator is not out of pocket for material costs.

Having paid to get drawings and material procurement completed, pay only for completed work. If you are forced to make interim payments, make them for completed work: e.g., pump casings cast, tube sheets drilled, or 100% of the burners completed. Avoid paying "progress payments" for percentage of work complete; you should be saying, "If it is done, I will pay for it; if it is not done, I will not pay anything."

The idea here is to get the vendor or fabricator motivated by cash flow. You overpaid for drawings and material but are not paying the cost of all the labor to complete the work, so the vendor or fabricator is out of pocket until the work is complete. Once an item is complete, inspected, and accepted, pay quickly to cover his or her costs.

Remember to reserve money for the warranty. Ten percent is a reasonable holdback amount for important mechanical components. Consider a five percent holdback for things that do not "move." If they balk at the large amount, consider using a step-down retention: Retain the full amount for six months, half that for the next six months, and the remainder for the final period.

Many components are delivered long before the facility is completed and ready to start up—especially if there are project delays. It is prudent to negotiate a price during the bidding stage (when you have leverage) to extend the warranty in the event that there are start-up delays. If those delays are your fault, you can cover your liability or exposure by paying for the extended warranty yourself; if the delays are someone else's fault, the project owner must either release you from the liability or pay for the extension with a change order.

Forced Purchases

It is common for project owners in Third World countries, and even in the United States, to face the forced purchase of components from local component vendor or suppliers. Usually foreign companies have in-country subsidiaries that offer high quality and high standards. If there are truly few opportunities to buy in country, you can push back, but it may cost you the contract. Another approach is to initiate a process called adoption—the mentoring of smaller, in-country companies through providing management and technical and financial support. Mentoring companies can win kudos from local politicians while satisfying contract requirements for a small premium over the costs of buying elsewhere, shipping, and paying import duties.

Construction—Self-Perform or Subcontract

A project owner may choose to execute an entire megaproject in three ways: (1) directly with his or her own staff (often augmented by contract personnel); (2) by dividing the project into smaller pieces, executed by different EPC companies' project teams under the owner's oversight; or (3) through hiring a general contractor under his or her oversight. Within these three options, there are infinite variations. There are many reasons for choosing one or the other method or some variation in between, but cost should not be the primary one.

Most project owners do not have adequate construction-savvy personnel to completely staff a megaproject without outsourcing. Outsourcing to free agents is acceptable as long as the number of those individuals does not exceed the project owner's ability to train them on the project owner's systems and subsequently to monitor them to ensure that each person really knows his or her job.

When a project is in a foreign country, the cost of moving a large number of the project owner's employees' families and providing such things as housing, transportation, security, and schooling for children and home leave can be prohibitive. Some key people also opt out of the project because they do not want to relocate their families to a strange place for two or three years.

These are some of the considerations that usually force megaproject owners to choose either option 2 or 3, as described in the first paragraph of this section. No matter the nature of your megaproject, there are many companies headquartered in Asia, Europe, and North America that can either do a whole megaproject or provide EPC services. Retaining those companies also helps overcome the inevitable problems with cultural and language differences in a foreign location.

Outsourcing the entire project to a single company appears to be a simple answer, especially if the project owner either lacks the experience to build a megaproject or has no experience in the foreign county where the facility is to be located. However, this approach can sometimes introduce cultural differences that lead, for instance, to misunderstandings on how to keep the owner's costs low while maximizing the contractor's profit. These motivational differences could take the entire project to resolve, so great care must be taken in choosing the single-company option.

This option also requires the most complete and comprehensive contract in order to define all aspects of the project's execution and exactly what the final constructed product will look like when it is up and running.

One middle-ground option is augmenting a small project owner's staff with a contractor under an engineering, procurement, and construction management contract. The project owner uses the EPC management company's personnel and systems. This option is especially popular if the project is in a foreign country.

Another option is to divide the project into smaller EPC contract pieces that you can either manage yourself or manage with the assistance of a separate construction management company. This option opens up the bidding to more and smaller EPC companies, an important consideration if there is local government pressure to hire local companies. This option, however, requires you and your EPC management company to provide supervisory oversight management for each contractor. The size of each management group can be kept small if you demand a comprehensive plan from each contractor and then simply monitor against that plan.

This method also has another advantage: With multiple contractors, you have the luxury of shifting work from a contractor who is not performing well to one who is. This is a lot easier than dealing with a single large general contractor who is not performing.

Contracting Methodology

Regardless of your choice to perform the construction yourself, hire multiple contractors, or hire a general contractor (or something in between), a project owner is faced with deciding which form of contract to use. Here again there are two extremes and an infinite middle ground: lump-sum turnkey or time and material.

Time and material contracts are not really practical for a megaproject. That is not to say that there aren't parts of the work that can be awarded on that basis, but the high cost of monitoring this type of contract limits the portion of the project that should be awarded.

Never award time and material contracts and lump-sum turnkey contracts to the same company on the same site.

This leaves contracting under the lump-sum turnkey methodology. Because of time constraints and the cost of capital, no owner, except perhaps a government entity, has the time or the money to do a true lump-sum contract, i.e., 100% of the engineering complete and frozen and all major equipment purchased. Therefore, a lump-sum contract does not mean a lump sum for all the work to be performed on a megaproject, but it is more a price based on identified scope at the time of the bidding with a costing framework for all the work that has not yet been defined.

Even if you could do a true lump sum, executive management would be naive to think that there would be no changes. The old joke in the construction industry is "The only perfect lump-sum turnkey project ever executed was when God created the world in six days, and that job still has warranty issues." So that leaves you contracting with one or more construction contractors, who may also be doing engineering and procurement. You want to start the bidding process by short-listing the five companies that best meet your project's needs for experience and resources, unless you are forced by government regulation to take bids from everyone.

Why a maximum of five? The best contractors have work already and therefore do not need to waste their bidding resources against 10 or 15 other bidders. Having any more than five bidders indicates that you do not know what you are doing and that you are going to waste a lot of your time and everyone else's time in the bid selection process.

Once you have identified the most qualified bidders by type of project, location of project, and availability of their resources, you are now ready to proceed to negotiating a price and the contract terms and conditions. Notice the use of the word *price,* as opposed to *cost*. You will know the cost when the project has been completed and is operational.

Since this book is meant to cover a wide variety of construction industry project types, there is no clear answer as to what point in the process of design and engineering you are ready to start working on price. There are, however, some basic parameters. The person giving the price must have most of the equipment bid and ready to purchase and at least 30% of the engineering work completed before a realistic price can be developed. As more preliminary drawings from vendors are available and more engineering design and layout become available, the pricing offered can be more complete.

At this point in the process, you should ask for a bid. This request serves three main purposes. First, it tells you if they understand the material you have given them; secondly, it tells you which bidders are still as interested in the project as they were at the start of the process and which bidders are no longer interested (they may have gotten another big job); and third, it begins to tell you if your estimate of the cost for this project is anywhere near where the market says it should be.

You should request final pricing when the identified scope of work reaches approximately 70% complete. Negotiations are now ready to proceed on final terms and conditions and price.

Negotiation of a megaproject contract is an effort to determine a fair price for the identified scope of work under acceptable contractual terms between two parties that respect each other and recognize that they are going to be "married" to each other for a number of years.

Therefore, the lowest price for the identified scope may not be the best price if another bidder has better resources and more experienced people who will be committed to your project. Another nonprice criterion may be a company's better financial condition, which would allow them to withstand costly problems on the project if they arise.

Standardized Subcontract Provisions

Time and material contracts are generally straightforward. The contractor does the work and gets paid based on time sheets. If their productivity is not at the specified level, you pay anyway. If they perform their work incorrectly, they do it over at their cost. For all other contracting, the lump-sum turnkey format offers the greatest chance of success if properly drawn up.

Aside from the standard boilerplate clauses in a contract, the real effort in crafting the contract needs to go into the clauses that deal with time delays and the scope growth from the 70% level identified at the time of contract award to the 100% identified when procurement and engineering are complete.

Again, executive management needs to recognize that a lump-sum bid is just the starting point, even after you have identified what you believe to be 100% of the scope. There will be delays (read, $$$), there will be errors that need correcting (also $$$), and there will be scope growth beyond the 100% engineering point (again, $$$). Contracts need to be structured to recognize this reality and must also contain a structure to mitigate and contain such uncertainties.

To do this, you must understand your contractor's or subcontractor's cost structure. The contractor mobilizes to site at a cost. Once work starts, the contractor has his or her project team of *X* people and overhead that is sized to the 70% scope you gave him or her. The contractor expects to have that team on site for *Y* days of work. He or she expects to have the necessary construction equipment on site *Z* days. He or she then has a demobilization cost.

Those *X* management people can, if they work hard, do more than the 70% scope in the *Y* time frame. Both parties know you need to pick up 30% more scope to get to 100% of scope. So you want the contractor to agree that there will be no claim for extra management unless scope grows beyond 100%. I usually ask for 20% additional growth beyond that. The contractor will raise his or her management and overhead price to *X* + *Z* people, but you have now covered the work plus any reasonable growth. If scope grows more than 20%, you will want unit pricing for more management of people.

If the scope of work grows more than 20%, additional people may not help; it may just take more time. So, you will need to negotiate a per-day unit price for each additional day's work and a per-day unit price for keeping any equipment on site. If you are supplying the engineered components and material, you now have this contractor's costs contained up to the full expected scope of work and a defined structure for additional work or delay on your part.

With unit prices for the actual labor and consumables that the subcontractor is supplying, you will now have all the bases covered. Don't forget: If the contractor is also supplying materials, unit pricing will be necessary for all the types of material you expect them to supply.

Force majeure usually buys you only time, not the cost associated with the delay. However, if you are the party that will be claiming force majeure or if you are the project owner, you may both want a limit on the duration of a state of force majeure. Recognize that some events (e.g., hurricanes, earthquakes, or volcanoes) may disrupt the project so much that it must be restructured. For such cases, work out a long delay and/or exit strategy in the contract—do not wait for it to happen.

Do not accept consequential damages unless you have no options for executing the contract, and even then limit the liability. Do not accept liquidated damages for late delivery unless you get a bonus for early completion. If you have taken liquidated damages, try to lay off part of the pain to the vendors or suppliers and contractors that are the most likely to place you in a damages situation.

If your portion of the project is part of someone else's bigger megaproject, then you should push for a sitewide labor agreement. Otherwise, you will find yourself bidding for resources against other subcontractors on the same project to the detriment of the overall project owner.

Contract Administration

If you are not the megaproject owner, then you will have a contract with that owner or his or her representative. The administrators of that contract for you are the project control group. Claims against your client start on day one; expect your subcontractors to operate in the same manner.

Never take claims personally—this is a business! However, it will become personal if you lose your incentive bonus, your reputation, and/or your job by not claiming compensation for valid changes.

Every key member of the project team should have a copy of the contract and read it. They should be on the lookout for anything that affects the project's price structure or schedule, and they must feed that information to project control. Project control, with the agreement of the overall project leader, will decide whether a valid claim exists and, if so, how much money and/or time to claim. If a claim is "almost valid," it can be presented anyway with the intent to "trade" that claim in the future.

Present the client with each claim *quickly*. Quickly means a written notice within a week and a fully developed claim within 30 days. Resolve claims immediately. Engineers have a tendency to want to find an answer that eliminates the problem to avoid confrontation with a client. This is the reason that the earlier description of overall project leader in the key personnel section states "businessperson" first and engineer somewhere after that.

There should be a log of claims—when they were presented and their status. This log should be part of any monthly progress report. The executive sponsor should review this list at least monthly and should force resolution of any claims that have not been resolved quickly.

Subcontractors need a single contact person who interacts between the project team and the subcontractors. Without having that identified person, subcontractor representatives may walk around a construction office getting opinions from anyone and everyone. This focal point should be the project procurement or subcontracts leader and his or her team.

Force majeure is referred to in the construction industry as “a gift from God”! If you are looking at liquidated damages on a megaproject—US$100,000 per day is not unusual—every day in the schedule that you can gain by a force majeure claim is potential money in the bank.

A few examples of these gifts:

- It snowed 50% more than “normal” (according to the National Weather Bureau) on the truck route between Oklahoma (equipment vendor) and Wisconsin (construction site), stopping all deliveries (one week).
- It rained 500% more than “normal” for two months in Cordon, Venezuela, turning the construction site into an unusable mud hole (two weeks).
- A special heavy haul ship traveling from Japan to Venezuela lost four days dodging two typhoons (one could have been expected) and lost its “gate pass” through the Panama Canal (three days).
- Two freighters collided in heavy fog in the South China Sea, and the one with my cargo on board caught fire. The fire, which was in the forward compartment below decks, got into two containers of “mag” automobile wheels. The magnesium–aluminum alloy burned through all the containers under them and then through the bottom of the ship. The project cargo, in the aft compartment, was offloaded to another ship and continued on its way (two weeks).

Cost, Schedule, and Progress Management

Project accounting tells you where you have been, and that is all. Accounting cannot tell you the future. The field construction operation needs to have accounting department people on site. The accounting representatives need to enter every payment and every commitment of *money* that is made in the field within a few days of that commitment. This accounting group needs to be tied into the home office accounting system in real time. Procurement, regardless of whether it is home office or field activity, needs to be tied directly to the accounting system so that commitments as they are generated show up in real time. If you cannot do this, you are not ready for a megaproject.

As described in more detail in Chapter 8, project control tells you where you are going, when you will get there, and how much the megaproject is estimated to cost as of *today*. Project control continuously compares the project commitments against the project budget. Construction project control tracks subcontractor progress (percent complete) versus budget. Any subcontractor’s claims that are approved must be signed off by project control because they have to adjust the percent complete figures and the project budget based on the revised scope of work.

All schedules on a megaproject must be Level 4 and completely *interlaced*. Interlaced means that when a schedule change is entered into the system, that change and every associated item are also corrected. The project schedule must be loaded with the estimated workforce to complete each task. If you cannot do this, you are not ready for a megaproject.

Determining the progress of a project involves a lot of personnel on a construction site. The smaller the pieces that you divide progress into, the more people it takes. Your goal with all fabricators and subcontractors is to pay for the biggest, most complete piece you can get. For example,

- The fabricator of a pump would like to be paid for each piece of the pump (e.g., impeller, shaft, bearings, casing, coupling, or motor) as each individual component is completed. For an order of 20 pumps with 10 items per pump, you have 200 payment points that have to be observed and paid against. Pay the provider 20% upon receipt of each pump's drawings (because you need the drawings to complete your engineering), 70% when the pumps are inspected and ready to ship, and 10% when the warranty period is complete. Now you have 60 payment points.
- With piping contractors, pay only a small percentage when all spools of a line are in the pipe rack and the large percentage when the line is completed (welded, X-rayed, and hydro tested).

Construction Closeout and Project Closeout

Most people think that when a project is handed over to the project owner the megaproject is over. It is not over, and the PEP needs to address all of the things that follow construction completion. Many contracts are now written with secondary completion dates, with liquidated damage penalties for a facility not becoming operational because of operational failures. Therefore, if your work causes the facility to miss those dates, you pay.

You need to impose the same type of warranty responsibility on your vendors, suppliers, and subcontractors as are imposed on you to limit the cost of warranty claims against you. To overcome the problem of normal equipment warranties expiring, obtain a price during bidding for an extended warranty.

As indicated earlier, incentive pay for any construction management personnel who are not company people should entice those who are needed to stay until project completion as a condition of receiving their bonus money.

Until such time as the facility owner puts the facility into operation, you need to keep a portion of the project team on site. Why? Because there are always problems encountered in trying to make the project operational. If you are not there to protect your own interests, others will resolve the issues at your expense whether they were your fault or not. Operations personnel always try to blame equipment and system failures on the absent contractor who built them.

If there are problems with something you bought and installed, you and your staff have an existing working relationship with the vendors and are therefore more likely to get a rapid vendor response, whereas the facility owner may not. If you are facing liquidated damages, this factor can be critical to keeping your money.

Once the facility becomes operational and punch list items are resolved, everyone can go home, everyone *except* for someone nearby to continue to protect your interest. Remember, your warranty may extend a year or more past this time. If the facility you just built is 1,000 mi away from the home office, someone can jump on a plane and go address the problem. However, if the facility is 5,000 mi or 10,000 mi away, this is not a practical solution.

Depending on the type of facility you have just completed, you may want to keep a couple of representatives who are experts in the operational disciplines that are most likely to be the source of any problems. This is cheap insurance against bigger claims. Also consider offering the paid services of your experts to the client if they are not actively dealing with issues that are specific to you. An additional plus to this type of arrangement is that you may end up getting a maintenance services agreement out of this kind of relationship.

Summary

Procurement and construction management begins with a well-formulated project execution plan that defines all activities for the project, including staffing, procurement, contracting, location, and more. The information contained in this chapter should be helpful and should lead to the successful completion of your megaproject. A lot of companies know the methodology of successful project execution; they have road maps and volumes of project lessons learned and best practices. Many can even put all that experience and learning into a project execution plan. But more often than not, their projects fail to meet expectations because they lack the discipline to stick to the plan. With a well-written and defined plan, a solid and capable team, and proper contracts in place, a successful megaproject is ready to complete.

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CHAPTER 11

What about Culture and Ethics in Your Multinational Megaprojects?

William P. Henry

Are all multinational megaprojects subject to corruption and filled with unethical behavior? Do all infrastructure megaprojects have to serve as vehicles for bribery, fraud, and corruption?

No. But they have the potential to be just that.

What can you do about corruption on your megaprojects? Let's take a good look at proven methods to minimize and eliminate corruption in your organization and on your megaprojects.

Some have said there are three parts to corruption (J. Boyd and J. Diaz-Padilla, personal communication with the author, 2009):

- Demand—those asking for corruption;
- Supply—those supplying corruption; and
- Condoning—those who know of it but do nothing.

The author disagrees; you're either in or out. Corruption has only two sides—supply and demand. Condoning corruption enables it to continue and is as detrimental to megaprojects, firms, individuals, and the public to be served as participating in corrupt acts. Most firms want to be out. Why? Corruption kills people with poorly constructed projects and eliminates funds needed for important infrastructure projects. It is incompatible with sustainable development.

How can you keep your megaproject from becoming corrupt and unethical? You can be sure your management systems and your corporate culture identify and deal with potential corrupt acts when they arise. A management system that includes anticorruption modules that address both the procurement and the execution of projects, and an ethical corporate culture, which regularly engages all employees in discussions about ethical behavior and its importance, are the best tools known to keep corruption out of your megaproject. The power of your management system and an ethical corporate culture are the essential tools. However, they are only effective when they are

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LESSONS LEARNED

1. The construction industry is exposed to the highest levels of corruption and unethical practices internationally.
2. All multinational megaprojects are likely targets for corruption and unethical behaviors.
3. Parties engaging in corrupt or unethical behavior risk personal, professional, and criminal penalties for their actions.
4. Anticorruption and ethical practices are critical at all levels of an organization, public or private.
5. Defeating corruption and ensuring ethical behavior require that one learns the “vocabulary” of corruption.
6. Defeating corruption and ensuring ethical behavior require that an organization install practices and systems throughout the organization that encourage ethical behavior and make engaging in corrupt practices difficult.
7. Defeating corruption and ensuring ethical behavior require that an organization install a culture that demands employees at every level understand and live by an ethical code of conduct.
8. There are professional organizations across the construction industry and around the world that have developed and will share processes and systems specifically aimed at defeating corruption and promoting ethical behavior in the construction industry.

pervasive throughout your organization so that all employees know them and live by them daily. Controlling corruption is a line management activity—not something to be delegated to a staff legal department.

There needs to be a constant dialogue among managers, between managers and staff, and among staff on ethical issues. Though the amount of dialogue may not match time spent on how the local team is doing or what good movies are playing, it can match the time spent talking about technical issues, safety, costs, and deadlines. And the beauty of this dialogue is that you have the ability to foster the management system that includes anticorruption modules and an ethical corporate culture in your organization because of your leadership position there.

To have ethics be a topic of regular communication and discussion, you’ll need some common vocabulary, so that you and all your employees speak the same language. But there’s no need for you to “reinvent the wheel”! By knowing what others are doing to promote ethical behavior in their organizations, you can more efficiently ensure that your organization has the needed management systems and organizational culture to keep corruption at bay. This chapter provides both the needed language and information on what have been found to be the best anticorruption practices.

As you move through this chapter, keep focused on the ways to promote ethical behavior in your organization. While doing that, never forget the dire consequences to yourself, your firm's good name, your employees, your profession, your clients, and the people whose lives will be made better by your megaproject if you fail and have a megaproject noted for corruption. Doing the right thing is your prime motivator, but remembering that the punishments for corruption—bad publicity, personal ridicule, heavy fines, loss of licenses, and jail time (things you sincerely want to avoid)—may also give you a needed boost to keep the formation and implementation of an ethical management system and ethical corporate culture at the top of your agenda.

Getting Started with Vocabulary

It's clear that ethical behavior is what we want. Talking about ethical behavior, though, is pretty esoteric. So, let's begin by talking about the opposite of ethical behavior—corruption. Here we find words and concepts to which we all can relate.

Webster defines corruption as the "impairment of integrity, virtue, or moral principle" (Merriam-Webster 2008). The dictionary also notes that corruption means an inducement to do wrong by improper or unlawful means. Another way to define corruption is the misuse of official power for personal gain. No matter how you define it, corruption denotes activities that reflect poorly on your organization and our profession. In our engineering and construction industry, corruption can take a variety of forms because there are so many types of organizations involved in every megaproject:

- Public owners;
- Private owners;
- Engineers;
- Constructors;
- Lenders;
- Material suppliers;
- Equipment suppliers; and
- Regulatory and permitting agencies.

There are numerous possible interrelationships among these parties on a megaproject. This fact means that, since corruption requires at least two individuals to act together in an unethical manner, a megaproject has lots of potential interactions that could result in a corrupt practice during the procurement and/or the execution phases.

In the engineering and construction industry, the main forms of corruption are

- Kickbacks and bribery;
- Front companies;
- Bid rigging and collusion;
- Conflicts of interest; and
- Fraud.

Each of these forms is discussed in more detail to "enrich" and define the vocabulary.

Kickbacks and Bribery

Kickbacks and bribery are two sides of the same coin. A kickback is a demand for payment by someone in a position of power in return for making a decision favorable to the prospective payee. Bribery is an offer to pay someone in a position of power to make a decision favorable to the offeror. The person in the position of power seeking the kickback may be a purchaser—a government official; a private owner; or a purchasing agent buying materials, equipment, engineering services, or construction services—or an engineer, a constructor, or a supplier selecting subcontractors. The person in the position of power could also be a lender seeking a kickback for making a decision to lend to a given owner, or a regulator seeking a kickback for making permitting or inspection decisions favorable to an applicant. The person offering a bribe may be an engineer; constructor; material supplier; or equipment supplier seeking business, permits, or inspection approvals; or an owner seeking funding. No matter what role you play on a megaproject, or what phase the megaproject is in, there are opportunities for kickbacks and bribery.

Front Companies

Front companies are companies established in secret to provide little services to a megaproject while earning substantial fees. The front company may be set up by a corrupt owner or by corrupt staff. They are usually new companies, with no available track record. Another common attribute of a front company is that it offers a variety of diverse, unconnected services. These two traits—being a new company and offering diverse, unconnected services—are also common traits of legitimate joint venture companies. The biggest difference between a front company and a legitimate joint venture company is in the ownership records available. A legitimate joint venture has clear, open ownership records. A front company has few records of ownership because the owners, obviously, do not want to be known. A front company often serves as a local agent on a megaproject so that it does not have to produce substantial work products.

Bid Rigging and Collusion

Bid rigging and collusion can be accomplished by all members of the megaproject team: owner, engineer, constructor, lender, supplier, or regulator. Owners can rig bids by setting extremely short bid periods so that only the firms they notified illegally are able to submit detailed, responsive bids, or by excluding qualified firms from bid lists that include only favored firms. There can also be collusion between the owner's and constructor's personnel. The owner's staff may allow contract modifications or change orders that raise the contractor's revenue, lower the cost, or both.

Constructors and suppliers can engage in bid rigging and collusion by agreeing on which firm will get the work on each of a series of projects. On each project, the "designated winner" submits an artificially high bid, and the others submit even higher bids. This process gives excess profits to firms and reduces the funds available for the megaproject.

Bid rigging and collusion can also be parts of more complex corruption schemes.

Conflicts of Interest

All types of conflict of interest are forms of corruption. The most obvious is where a decision maker gets a direct personal gain from the decisions he or she makes on the megaproject. Less obvious conflicts of interest are ones where friends or family members of the decision maker get the direct personal gain from the decision. All participants in a megaproject have the potential for conflicts of interest.

Fraud

There are many opportunities for fraud in megaprojects and they are open to all megaproject participants. Some of the most common fraudulent acts are

- Embezzling funds from project accounts;
- Taking vehicles, computers, other project equipment, or materials for personal use;
- Using project funds, equipment, and/or materials for nonproject uses such as building or remodeling houses or taking vacations;
- Selling project equipment or supplies for personal profit;
- Setting up employment and collecting paychecks for “ghost employees”;
- Substituting lower-quality materials or equipment than that called for but billing at the contract prices; and
- Billing for workers at rates higher than their pay grade calls for.

These are but a few examples of fraud that can take place on a megaproject.

If kickbacks, bribery, front companies, bid rigging, collusion, conflicts of interest, and fraud are not part of your vocabulary and the vocabulary of your staff, you have some training to do so that all understand the terms. Once the terms are understood, it is easier to communicate about corruption and the activities that could reflect poorly on you, your organization, and our profession.

Tools and Programs to Promote Ethical Behavior

By now, you’ve realized that corruption and megaprojects can go together like summer and heat or winter and cold. But, just as you can don the appropriate clothing for heat or cold, you can also make sure that your organization dons the appropriate protective gear to thwart corruption. The gear includes management systems that are open, transparent, and implemented throughout your organization. It also includes an organizational culture in which all employees, from the chairman to the newest hire, know the potential for corruption on your megaprojects, the actions they must take if they find it, and your overall stance on ethical performance.

Organizations have developed practical, economical, and successful management systems that prevent corruption on megaprojects. Some important systems are

- *Constructors*—The major global constructors have been joined by other global companies in developing the program known as the Partnering Against Corruption Initiative (PACI) through the World Economic Forum.
- *Consulting engineers*—The consulting engineering firms, through the International Federation of Consulting Engineers (FIDIC), have developed strong anticorruption programs for engineering and procurement activities of firms in their Business Integrity Management System (BIMS) and Government Procurement Integrity Management System (GPIMS).
- *Construction observers*—Transparency International (TI), a longtime observer of the global engineering and construction industry, has developed business principles, guidelines, and implementation and verification plans for countering bribery, as well as a Corruption Perceptions Index and a Bribe Payers Index.
- *Lenders*—Major international lenders such as the World Bank, African Development Bank, Asian Development Bank, Inter-American Development Bank, European Investment Bank, European Bank for Reconstruction and Development, and the International Monetary Fund have standardized their approaches to dealing with corruption and are developing proposals to assist countries in combating corruption.
- *Professional societies*—Major professional societies, including the World Federation of Engineering Organizations (WFEO), Asian Civil Engineering Coordinating Council (ACECC), ASCE, and Engineers Australia (EA), have programs to help both firms and individuals better keep corruption out of their work.
- *Independent industry groups*—The Global Infrastructure Anti-Corruption Centre and the Anti-Corruption Education and Training (ACET) program also have valuable, well-developed materials available for use.

This broad array of material available for your use in formulating or improving and implementing an anticorruption program in your organization and strengthening the ethical focus in your organization's culture is detailed in the following pages.

Partnering Against Corruption Initiative

In 2005, the firms in the engineering and construction section of the World Economic Forum launched PACI Today, in which more than 140 companies from 39 countries have agreed to the PACI Principles for Countering Bribery. PACI is a private-sector, supply-side initiative to establish multiple-industry principles and practices to level the playing field for project procurement and performance. The principles and practices are based on integrity, fairness, and ethical conduct. Under PACI, the chief executive officer of each participating company commits, in writing, to do two things:

1. Commit the company to a zero-tolerance policy for bribery; and
2. Implement a strong, active anticorruption program to guide the behavior of the company's employees.

A firm may join PACI without joining the World Economic Forum. Details can be found at the PACI website (http://www.weforum.org/en/initiatives/paci/index.htm).

The website has an outline of the PACI three-stage process to develop, implement, and verify your company's anticorruption program.

International Federation of Consulting Engineers

FIDIC chose to identify their products with "integrity management" because the term identifies that ethical integrity is needed to fight corruption and that a strong management system is needed to control a firm's activities and verify its ethical performance. FIDIC's BIMS has all the necessary management documents, along with examples from companies, on CDs. BIMS is tailored to the engineering units of a firm and can be independently verified as an ISO 9000 management system. GPIMS is tailored to the procurement practices of a government procurement agency. The FIDIC website (http://www.fidic.org) has more detailed information.

Transparency International

TI's 2008 Bribe Payers Index (Branigin 2009) noted that public works and construction were seen to be the most corrupt industry sectors. In 2007, TI published its Project Anticorruption System (PACS), which contains standards and templates to target both bribery and fraud. PACS allows the user to implement programs that include independent monitoring, due diligence, contract terms, procurement requirements, government commitments, corporate programs, programs for individuals, training, reporting, and enforcement. PACS has been distributed to TI national units, engineering and construction associations, banks, and governments. For more on the products available from TI, go to their website (http://www.transparency-usa.org).

Lenders

The major lenders are in the process of developing proposals to assist countries in strengthening their anticorruption capabilities. Although these programs may not be directly applicable to your organization, they provide good information on the changes governments may be making in project procurement procedures and the roles and activities of regulatory and permitting agencies. Checking on how a government agency does business is always part of complete due diligence.

Professional Societies

WFEO, ACECC, EA, and the ASCE all are active in addressing corruption in the engineering and construction industry. They are all societies whose membership is composed of individuals—not companies or agencies. As such, they offer material and opportunities that focus on the individual engineer, including training in avoiding and dealing with corruption, and opportunities for networking with others from different parts of the engineering and construction industry and from different countries. They also offer materials that can make beneficial contributions to your organization's corporate culture.

WFEO has a standing Anti-Corruption Committee with members from each continent. The committee holds annual meetings where the latest information is shared with all in attendance as well as workshops dealing with addressing corruption in your business dealings. You can learn of their activities at their website (www.wfeo.org).

ACECC also has a standing Anti-Corruption Committee with members from each member country. Like the WFEO committee, they hold meetings and workshops. Information on ACECC activities can be found online at www.acecc.net. Both WFEO and ACECC can provide readers with anticorruption information useful in your marketing and professional development programs.

EA has been active in revising the National Code of Practice for the Construction Industry in Australia. Firms working on government-funded megaprojects there must be in compliance with the code, including all its provisions for ethical behavior. You can learn how to be in compliance with the code by visiting their website: www.abcc.gov.au. This website also provides ideas on the contents for your anticorruption management systems.

ASCE offers many resources for both management programs and ethical information. It has a comprehensive continuing education department that delivers technical, management, and ethical courses via seminars and webinars. Its code of ethics contains the elements needed for a strong anticorruption culture. You may review this material at www.asce.org.

Industry Groups

The Global Infrastructure Anti-Corruption Centre (GIACC) was founded in May 2008 by two experienced construction attorneys in England. GIACC is an independent nonprofit organization that promotes implementing anticorruption measures as part of managing companies, agencies, and projects. It models its approach to managing corruption similar to the ways in which safety, quality, and risk are controlled: by using procedures, training, monitoring, and enforcement. The GIACC website (www.giaccentre.org) contains a wealth of useful information. There are descriptions and examples of corruption that are useful for your vocabulary and training exercises. There are examples of anticorruption programs suitable for agencies, companies, and lenders. A complete PACS designed to prevent and detect corruption on projects is presented. In addition, an array of anticorruption tools is presented, including the following:

- A claims code;
- Example contract terms;
- A corporate code;
- A discussion of due diligence procedures;
- Example employment terms;
- A gifts and hospitality policy;
- Suggested procurement activities;
- Suggested reporting requirements;
- Organizational rules to consider;

- Training needs and programs; and
- Ideas for achieving transparency in your organization.

The GIACC website provides you with materials that are useful for starting an anticorruption program in your organization or for benchmarking your current program against other well-thought-out, practical programs. Of particular use on megaprojects is the information on due diligence. It covers the country of the project, its laws, the reality that the project is necessary and conceived for a legitimate purpose, the owner's history, your potential business partners, subcontractors, suppliers, and agents, and the tools available to help you be sure that corruption will not be part of your project. On the website, you will also find the details of the British Standards Institute (BSI) Standard 10500—Specification for an Anti-Bribery Management System—that was recently adopted.

A second industry group project that offers valuable information for your use is the ACET program. This program was created by an international group of participants in the engineering and construction industry who believed that a good training program for practitioners (and students) would be a valuable contribution to the profession. The ACET team raised the funds, hired the writer and producer, and with them, developed the script for a 42-minute DVD drama entitled *Ethicana*. *Ethicana* depicts corruption in the procurement and production of a megaproject. The complete *Ethicana* package contains the DVD, classroom materials, trainer materials, and a "Train the Trainer" module. *Ethicana* is suitable for use with both procurement and project staffs. It reinforces the vocabulary needed to have an ongoing dialogue on anticorruption in your organization. It exposes the attendees to situations they may face on megaprojects. The situations depicted were developed from the experience of the ACET team members. Having faced these situations in a classroom, and having discussed them with senior personnel and peers, makes your employees better able to handle the situations properly in their work. *Ethicana* is a training program to develop and improve the ethical standards of your staff because it shows them "why" they should act ethically while following the anticorruption program of your organization, which tells them "what" to do. Information on *Ethicana* is found on the ASCE website (www.asce.org).

Summary

Megaprojects are vital to people who need the facilities that will be provided. Megaprojects are important to agencies in performing their missions and to lenders and firms to keep their businesses thriving. All indications are that there will be more global infrastructure megaprojects in the future than ever before. Many are forecast to be in the developing countries, where corruption has been systemic. It will take vigilance and ongoing management attention to keep corruption at bay on your projects.

The most effective tools for ethical practice are two:

1. An organizational culture that is founded on ethics, embraced by all levels of management, and communicated to all employees and business partners, and

2. Strong management systems that start from the highest echelons of the firm and whose implementation is regularly verified throughout your organization.

In order for the first tool to be effective, all employees must have the ability to talk with a common vocabulary that is understood throughout the organization. The importance of a common vocabulary cannot be overstated; it is the difference between having people talk with each other and having them talk past each other. It facilitates regular discussions on ethics among managers, between managers and staff, and among staff. It is the cornerstone of the ethical component of your organizational culture. Your culture is a defining property of your organization.

This chapter has presented many sources of available anticorruption tools, as well as training programs, that give real-life meaning to the words via realistic examples of corruption.

Management systems that demonstrate a firm purpose in keeping corruption away from your organization and your projects are the day-to-day guardians against corruption. If you have these systems in place, it is wise to benchmark them against what others are doing. If you don't have these systems, now is the time to develop and implement them. There are many sources of information on effective management systems for your use. The systems can be developed in stages. The important thing to remember is that these systems are only words on paper if they are not implemented with top-down authority and if their proper use is not verified on a regular basis.

At the start of this chapter, there were three questions:

1. Are all multinational megaprojects subject to corruption?
2. Do all infrastructure megaprojects have to serve as vehicles for bribery, fraud, and corruption?
3. What can you do about corruption on your megaprojects?

The answers for your firm and your megaprojects are up to you.

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CHAPTER 12

Dispute Resolution

John Hinchey

Several early-intervention dispute resolution methods have proven successful in avoiding the necessity of arbitration or litigation, including on-the-job initial decision makers, dispute review boards, dispute adjudication boards, mediation, and conciliation.

"Complexity" is a term frequently linked with large construction projects and construction disputes. It is true. Construction disputes, especially those deriving from megaprojects, are complex, typically involving a matrix of multiple parties and issues. All modern infrastructure projects are characterized by thousands, if not millions, of electronic and hard-copy documents and many megabytes or gigabytes of electronic data. Infrastructure projects, and the disputes that are generated by those projects, can and often do involve many different public and private business organizations, consisting of government agencies, corporations, partnerships, and joint ventures. Also typically involved are banking, lending, and financing parties, including guarantors, sureties, and insurers. Then add to this mix the government-owned or -controlled special-purpose legal entities, all of which can intersect in a variety of legal relationships. As the final layer, the applicable construction-related laws, regulations, and industry norms are often quite extensive and diverse, involving statutory and regulatory schemes, and international, state, and local building codes of one or a combination of different countries, provinces, municipalities, and local governments, often coupled with great discretion and latitude for interpretation of those laws and codes by government officials (Practical Law Company 2009; Peckar 2010). Indeed, it is not too much of an overstatement to say that there are few subjects of law or life that do not at one time or other bear upon a large global construction project.

The contracts for major construction projects typically involve multiple sets of documents (FIDIC 1999a), in numbers and quantities that could fill many file cabinets or even a document room, often having been prepared by different parties to the construction process[1] and typically incorporating by reference other documents

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1 Typically, the employer–owner prepares the basic agreement and business conditions; the engineer or design professionals and their subconsultants prepare the drawings and specifications; the contractor and its subcontractors prepare the schedules and detailed portions of the work; the lenders prepare the payment schedules; and the insurance advisors prepare the insurance specifications.

LESSONS LEARNED

1. Resolving megaproject disputes is complex because of the multiple layers of contractual documents, conflicting sources of contractual rights and obligations, and the many stakeholders involved in the execution of the megaproject.
2. The international and multicultural aspects of many megaprojects also add to the complexity of resolving disputes that arise during and after execution of the megaproject.
3. The designated "seat" or venue of an international arbitration is likely to have a significant effect on the law and procedures controlling how the dispute is heard and the possible results that can be expected.
4. International commercial arbitration practices and procedures can and do differ between various areas of the world, but there is movement toward alignment of those different arbitration practices and procedures.
5. There is a movement toward standardization of technical customs and practices occurring internationally.
6. As the global economy worsens, disputes on troubled megaprojects are expected to increase.
7. Arbitration is often criticized as taking too long and costing too much; however, on the international scene, arbitration is still preferable to litigation in local courts.
8. To avoid unnecessary costs and time, disputes should be addressed at the earliest possible moment and the resolution processes should be tailored to the specific problem at the heart of the dispute.

or contracts.[2] The package of contract documents typically includes (1) a basic agreement with the business terms spelled out, such as the names of the parties, description of the project, and the contract sum; (2) the general and special conditions of the contract, stating the basic rights, duties, and obligations of the parties; (3) the tender documents or request for proposals, together with the responding proposal; (4) the design drawings and specifications; (5) time and cost schedules; and, not least, (6) a grab bag of clarifications, qualifications, exceptions, manuals, protocols, payment schedules, and multiple other exhibits and appendices. It would not be unusual that no one has undertaken to review, coordinate, and consolidate the multiple components of the contract to avoid gaps, inconsistencies, and ambiguities, any or all of which can lead to serious and costly disputes.

The International Chamber of Commerce Final Report on Construction Industry Arbitrations (ICC 2001) also notes several characteristics of modern international construction industry delivery systems that often lead to disputes:

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2 Letters of credit, surety bonds, and guarantees typically incorporate by reference all or portions of the construction contract.

- Sophisticated methods of procurement, typically placing greater responsibility on the contractor, now less a builder and more a manager or facilitator (e.g., engineering, procurement, and construction [EPC] agreements);
- Combinations of main contractors and subcontractors in joint ventures to offer a greater range of experience, skills, and services;
- With the increase of computerization, technical disputes are arising;
- Multiple layers of entities and parties, such as program managers, project managers, construction managers, and a host of specialist consultants acting on behalf of the owners, as well as the contractors;
- Great influence of the financiers and lenders, together with their advisors and consultants; and
- Great choices and variations in contract forms, many of which contain elaborate dispute resolution "filters" and procedures designed to avoid, if possible, and resolve disputes, typically with a drastically reduced dispute resolution role for the engineer or design professionals.

The inherent challenges of construction and dispute resolution are compounded by the fact that global construction projects can be monumental in size and scope, sometimes reminiscent of various wonders of the world. Lists of the global superlative construction projects are annually published in the *Engineering News-Record*, which periodically lists and describes such curiosities as the "tallest building ever moved," "heaviest building ever moved," "longest running projects," and "largest work forces"; it occasionally lists the most famous human-made structures ("Digital wire report" 2010).

Because many of the international construction works are performed in developing countries, the development and installation of major infrastructure projects, such as dams, bridges, roads, and water and sewage systems, are the kinds of projects that by their nature lead to contract disputes of some magnitude.

The international aspects of infrastructure projects also add complexity to the elements of dispute resolution (Hinchey and Harris 2008). Not surprisingly, geographical and temporal distances between parties, counsel, witnesses, and other project participants tend to be greater, so language and cultural differences should be expected. Determining the applicable countries' laws can be even more challenging than in domestic legal systems. The place or "seat" of an international arbitration is vitally important with respect to such matters as the nature of evidentiary hearings or written versus oral argument and discovery (Hinchey and Harris 2008). Site selection can also influence the following (Bruner and O'Connor 2002):

- The agency willing to administer the arbitration;
- The arbitrators willing to serve;
- The law governing the arbitration process;
- The language of the proceedings;
- The cost of the arbitration; and
- The enforceability of the award.
- To a lawyer trained in the Anglo-American tradition, the international arbitral and dispute resolution procedures may be more challenging because of the limitations

on or absence of document and witness discovery and the emphasis on written presentation of evidence in the arbitration hearing (Hinchey and Harris 2008). Perhaps even more important are differences among countries and their treatment of awards. Bias in national courts is potentially a greater problem in international transactions than local biases in U.S. courts, given the natural tendency of experts in one legal system, including judges, to assume the superiority of that legal system over other legal systems (Mason 1994).

Although there are distinctive characteristics of international construction dispute resolution, it is also accurate and fair to say that there are important similarities (Bockstiegel 2009). The trend toward convergence or harmonization of international commercial arbitration practices and procedures is currently reflected in the similarity of the various international arbitral institutional rules (Chang 1992), changes encouraged by the adoption of the Rules on the Taking of Evidence in International Commercial Arbitration and adopted by the International Bar Association Council (IBA 2010). The traditional use of standardized contract forms for international construction projects such as the FIDIC documents is now more common than formerly (Bunni 2005). To be sure, there are important differences in the various "standard forms," and one must take into account that the forms must be adapted to local conditions. Still, the forms are clearly an important factor in the harmonization of construction practices and principles (Gaede 1991, 1998; Molineaux 1997; Hoellering 1998; Hoyle 1999; Bruner and O'Connor 2002). Even the distinctions between the civil and common law systems (Laeuchli 2007) have tended to blur, as observed by an experienced international construction lawyer and consultant:

> The differences ... between a civil code basis for the law and a common law basis for legal systems are not as important today as they once were. For example, the Brazilian legal system is modeled essentially after the Italian code and as a result is very formalistic procedurally. The legal system foundation in the US, UK and India, etc., is common law based, and procedurally complex, but not as formalistic. Today, most international arbitrations and their arbitrators have experience with both systems. This result has been occurring for decades, and thus, procedural practices have evolved and today are typically a blend of both systems.
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> A limited exposure to global construction has also engendered fear by public organizations and private companies who have heard "horror" stories about the excessive cost of discovery and the lengthy time that discovery takes. While the stories may be true, today most international arbitrators practice [a] "blended" form of discovery ... [meaning] ... that most international arbitrators today will grant "limited discovery" that falls somewhere between what would be allowed under civil law jurisdictions and allowed under common law jurisdictions (Nielsen 2007).

The commonality found in differing construction arbitration and dispute resolution practices and procedures may derive from the fact that a construction professional is typically experienced in and aware of the problems of working in an interdisciplinary environment. And it is generally accepted (Shilston 1987) that

> construction working practices do not differ greatly throughout the world. Constructors and designers from different countries nowadays frequently work together in joint venture activities. Construction industry practitioners have in common the obligation to establish a procedural approach to solving a problem which involves the most effective blend of time, cost and quality. So it is with commercial arbitrators from a background of sustained working experience within the construction industry.

Other factors contributing to the harmonization of international construction practices and procedures are the growing use of international technical standards, customs, and practices, such as the ISO 9000 standards, which are widely accepted in Europe as well as in the United States and in many other regions of the world (Roht-Arraza 1995; LaPlante 1996; Thompson and Thompson 1997; Bruner and O'Connor 2002).

Construction Dispute Resolution Methods

The construction industry has creatively devised a variety of methods or processes to avoid or resolve construction-related disputes, some in "real time" (while the construction work is being performed) and some after the work may have been completed. Generally these methods can be divided into the following categories:

- Avoidance techniques, such as rational, balanced risk allocation, alliancing, integrated project delivery, and partnering;
- Mandatory negotiation and document exchanges;
- Initial determinations by designated initial decision makers, including engineers and architects;
- Dispute adjudication boards (DABs), expert determinations, and statutory adjudication;
- Processes that are nonbinding[3] on the parties, such as mediation, conciliation, minitrials, and dispute review boards (DRBs);
- Arbitration; and
- Hybrids of nonbinding and binding decision making, such as "med-arb" or "arb-med."

3 The term "nonbinding" is used here in the limited sense that though the parties may be contractually or legally obligated to go forward with the process, i.e., the process is a mandatory requirement, the parties are not bound to resolve or accept a recommendation for resolving their dispute.

Avoidance

Perhaps it should be obvious that parties to construction contracts should structure their relationships and take appropriate action to avoid or prevent disputes from arising on the job. From a conceptual standpoint, these avoidance measures include rational, balanced, and appropriate risk allocation in contracts with the use of incentives for exceptional performance (Carbonneau and McConnaughay 2007), partnering (Carbonneau and McConnaughay 2007; Busch and Hantusch 2010), project alliances (Wilke 2007), and use of a neutral project counsel to assist in negotiating and drafting the contracts (Kemp 2007). These techniques should not be confused with procedures to resolve disputes once they arise. Clearly, in any regime of relational contracts, construction contracts being prime examples[4] (Macneil 1975; Stipanowich 1996), the parties should always begin with efforts to prevent disputes. Then, if disputes do arise, parties should concentrate on pursuing the most effective, fair, and economical means of resolving the disputes, short of arbitration and litigation.

Required Negotiation and Document Exchanges

If a construction dispute cannot be avoided, then it must be resolved, if possible, without resort to adjudication, arbitration, or litigation. It is difficult to argue against the proposition that parties should first attempt to meet and negotiate solutions to their disputes, as they normally do in any other situation. A prime cause of construction disputes is insufficient knowledge held by either or both parties to the dispute. The more facts that can be placed on the table, the more discernible the solution to the problem. In fact, information exchange is at the heart of construction dispute resolution because in most instances, the truth of the matter is usually found in the contemporaneous documentation. The starting place to provide for the exchange and communication of data relative to the dispute is in the construction contract itself. The contract may require that the parties prepare, maintain, and preserve certain categories of records and other sources of information with respect to the project—for example, tender estimates, accounting records, job meeting minutes, change order logs, reports of weather conditions, and test reports. More to the point, the contract can require that these categories of documents be presented to the other party as a contractual condition to asserting a claim (Hinchey 1991). It is easier and far more economical for the parties to exchange information and documents at this early stage of the dispute, rather than under the formal requirements of discovery in the context of a lawsuit, or even arbitration.

A required exchange of information and documents can be combined with contractual requirements for the parties to meet and negotiate (Abramowitz 2009; Thomas 2009). In fact, Thomas (2009), in a paper published by the Society of Construction Law, concludes that

> where the parties to a major construction project wish to establish an agreement to negotiate, careful thought must be given to whether that agreement

4 Professor Ian Macneil first treated the concept of "relational contracts" and the principles that the parties use in such relationships to maintain flexibility and avoid or resolve differences.

> is intended to be enforceable. If so, attention must be given to ensure that the agreement regulated the process of negotiation (and does not amount to an agreement to agree on open terms); the essential terms of the agreement are complete; there are express terms regulating the parties' discretion to withdraw from the negotiations; and there are explicit consequences which flow from a breach of the agreement.

A typical provision is that the party's project executives will meet, together with other persons having knowledge of and/or interest in the dispute, at mutually agreed times and places, in a good-faith effort to compromise or resolve the claim. The agreement can also provide that the failure or refusal of a party to follow such a mandatory negotiation procedure will constitute a waiver of the right to later arbitrate the claim.

Decisions by Engineers and Architects

The traditional construction decision maker of first resort has been the project engineer or architect. Despite the close association between the owner or employer and the design professional, most U.S. and UK construction contracts, both public and private, have traditionally given the design professional broad decision-making powers (Myers 1996). There are a number of reasons given for the development and continuation of this system in the United States. First, the stature and integrity of the design professions have traditionally given all parties to the construction contract confidence that the decisions will reflect technical skill and basic elements of fairness (*Zurn Engineers v. State Department of Water Resources* 1977). Second, the design professional's role in design before construction should equip th
e design professional with the skill to make decisions that will successfully implement the project objectives of the owner–employer. In some sense, the role as interpreter and judge is a continuation of that of design (Sweet and Schneier 2009). Third, owner–employers are often unsophisticated in matters of construction and need the protection of a design professional to obtain what they had been promised in the construction documents (Sweet and Schneier 2009).

The AIA standard forms have been revised, on average, about every decade. For several decades, continuing with the 2007 revisions, the forms have required that all claims submitted by either the owner or the contractor must first be submitted to the project architect for an initial decision within 21 days after the claim arises or the party asserting the claim first discovers the condition or occurrences giving rise to the claim[5] (Lesser and Bacon 2008, Bruner 2009, and Sapers 2010).

Similar to the AIA contracts, the earlier versions of the Institution of Civil Engineers (ICE) standard forms of contract allocated an initial decision-making role

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5 AIA (1987), Sweet (1970). In the 2007 edition of the AIA A-201, the concept of an initial decision maker (IDM) was introduced to provide for an initial decision on claims. The IDM's decision is subject to mediation, then, failing settlement, to arbitration or litigation. Questions have been raised in commentary as to whether the IDM was intended to be a design professional, contractor, specialist, or lawyer; what guidelines exist for the decision-making process; and what, if any, weight should be given to the engineer's or architect's prior review and determination on issues going to the IDM.

to engineers and architects (Jenkins and Stebbings 2006). Typically, the forms have provided that the engineer as the design professional for the project receives claims and disputes arising under the construction contract between the owner–employer and the contractor and makes initial decisions on those claims, subject to rights on the part of the disagreeing party to proceed with mediation, arbitration, or litigation. In the international arena, earlier editions of FIDIC (1977) (Bunni 2005) incorporated this traditional arrangement:

> If any dispute or difference of any kind whatsoever shall arise between the Employer and the Contractor or the Engineer and the Contractor in connection with, or arising out of the Contract, or the execution of the Works, whether during the progress of the Works or after their completion and whether before or after the termination, abandonment or breach of the Contract, it shall, in the first place, be referred to and settled by the Engineer who shall, within a period of ninety days after being requested by either party to do so, give written notice of his decision to the Employer and the Contractor. Subject to arbitration, as hereinafter provided, such decision in respect of every matter so referred shall be final and binding upon the Employer and Contractor and shall forthwith be given effect to by the Employer and by the Contractor, who shall proceed with the execution of the Works with all due diligence whether he or the Employer requires arbitration, of as hereinafter provided, or not. If the Engineer has given written notice his decision to the Employer and the Contractor and no claim to arbitration has been communicated to him by either the Employer or the Contractor within a period of ninety days from receipt of such notice, the said decision shall remain final and binding upon the Employer and the Contractor.

As of July 1, 2004, however, the ICE contract forms were revised so as to substitute, for the engineer's previous decision-making responsibilities, a series of alternative dispute avoidance or problem-solving measures (Barrett et al. 2005). Apparently, these changes were made in response to industry pressure because the engineer, in his or her role as the employer's agent, would find it difficult to render a truly impartial decision. Changes were also necessary because of the conflicts and inconsistencies between this process and the statutory adjudication requirements (Barrett et al. 2005). Similarly, the latest FIDIC form contracts have effectively removed the engineer from a decision-making role in disputes and replaced them with a five-tier resolution process that includes submission to a dispute adjudication board (DAB), followed by arbitration or litigation (Barrett et al. 2005).

Clearly, the prevailing trend in both domestic and international construction resolution is to remove or relieve the design professional as the owner–employer's agent from the role of a decision maker in disputes between the owner and the contractor. The newer process has substituted a series of tiered dispute resolution processes designed to either nip disputes in the bud or resolve them in "real time," on an interim or permanent basis, and by means of standing neutrals and dispute boards.

Dispute Adjudication Boards

Most international construction standard form contracts have relieved the engineer or design professional of the traditional obligation to perform an adjudicative role in disputes between the employer and contractor[6] (AIA 2007d). This statement is also generally true of the construction contracts in the United Kingdom. According to the ICE (FIDIC 1987, 1995, 1997; Barrett et al. 2005),

> this change was made in response to industry pressure. The engineer had come to be viewed as the employer's creature: there was a widely held view that, as the employer's agent, he would find it difficult to give a truly impartial decision notwithstanding the contractual requirement on him to make his decision in a fair and unbiased way. As the ICE Notes for Guidance say, "The Engineer's decision, although historically very effective in resolving disputes without recourse to arbitration, has in recent years been perceived to have lost credibility as a belief in the engineer's independence has dwindled in the face of modern commercial and litigation pressures. The emphasis has therefore been transferred to pre-dispute problem-solving measures."

Through 2012, all the standard FIDIC forms of contract between the employer and contractor now provide that disputes should be resolved in the first instance by a DAB[7] (Bunni 2000). A DAB is distinct from and performs different functions from a dispute *review* board, in that the DAB is empowered to make binding interim decisions[8] (Bunni 2005).

> The role of a Dispute Adjudication Board (DAB) in dispute settlement is neither consensual nor amicable in nature. It is a decision-making role, like that of the traditional engineer under clause 67 of the Fourth Edition of the Red Book. When FIDIC adopted the Dispute Board concept in its 1996 Supplement to the 1992 Edition of the Red Book, it was in fact reallocating the role of adjudication of disputes, which had belonged until then to the

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6 The new generation of AIA forms, for example, has left it to the parties as to whether to designate the architect or another party as an initial decision maker.

7 These FIDIC forms now include the New Red Book (1999a); the New Yellow Book (1999c); the Silver Book (1999b); and the Green Book (1999d).

8 Bunni described this change from the earlier versions of the FIDIC contract forms: "The popularity of the Dispute Boards increased further when FIDIC adopted the Dispute Board mechanism in the dispute resolution clause, clause 20 of its Orange Book, issued in 1995 for design/build projects. It is appropriate, however, to mention that the type of Board chosen by FIDIC was not a Dispute Review Board, but a Dispute Adjudication Board. Then, almost immediately, FIDIC published its Supplement to the Fourth Edition of the Red Book in November 1996, by which it provided for the establishment of a Dispute Adjudication Board to replace the engineer's traditional role of a decision maker or quasi-arbitrator in the settlement of disputes. This significant change in FIDIC's policy towards the role of the engineer occurred as a result of the strong criticism in the preceding years of the role of the engineer or adjudicator or quasi-arbitrator [i.e.,] ... the engineer was appointed by the employer with the contractor having no say in that appointment."

traditional engineer under clause 67, to an independent, impartial and neutral Dispute Board.

Under the FIDIC Conditions of Contract for Construction, the parties enter into a "dispute adjudication agreement," which provides for the qualifications, appointment, replacement, duties, responsibilities, and payment of the DAB member or members (FIDIC 1999a). Section 20.4 of the FIDIC Conditions (1999a) provides in broad terms that

> If a dispute (of any kind whatsoever) arises between the Parties in connection with, or arising out of, the Contract or the execution of the Works, including any dispute as to any certificate, determination, instruction, opinion or valuation of the Engineer, either Party may refer the dispute in writing to the DAB for its decision, with copies to the other Party and the Engineer. Such reference shall state that it is given under this Sub-Clause.

Following submission of the dispute, within 84 days after receiving such reference, or within such other period as may be proposed by the DAB and approved by both parties, the DAB is required to give a reasoned decision, which shall be binding on the parties, unless, within 28 days thereafter, either party gives a "notice of dissatisfaction"[9] (FIDIC 1999a). If the DAB has given its decision, and no notice of dissatisfaction has been given as required by the FIDIC Conditions (1999a), the decision of the DAB shall become final and binding on both parties. Where the notice of dissatisfaction has been given as required, both parties are further required to "attempt to settle the dispute amicably" before the commencement of arbitration. But, unless both parties agree otherwise, arbitration may be commenced on or after the 56th day after the day on which the notice was given, even if no attempt at amicable settlement has been made (FIDIC 1999a).

The use of DABs has also been incorporated into the World Bank construction contract forms (Jaynes 2006; Bunni 2000; Barrett et al. 2005; Gaitskell 2005). Effective September 1, 2004, the ICC issued its Dispute Board Rules, administered by the ICC Dispute Board Centre, which are a freestanding set of rules that may be adopted for inclusion in any construction contract (ICC 2004). Instead of having to select either a DRB or a DAB to resolve construction disputes, the ICC Dispute Board Rules permit the parties to choose a hybrid form of dispute board called a combined dispute board (CDB) (ICC 2004). The CDB may issue nonbinding recommendations as in the case of a DRB, or if the parties agree that it may do so, the CDB may issue a binding decision (ICC 2004). If the parties disagree on whether the CDB shall or shall not issue a binding determination, the CDB can decide whether to issue a binding decision, taking into consideration, for example, the urgency of the conditions and whether a binding decision would facilitate performance of the contract (ICC 2004). One inherent difficulty with a decision of a DAB, at least at the

9 The notice of dissatisfaction may also be given if the DAB fails to give its decision within 84 days. The notice shall state the reasons for dissatisfaction.

international level, is the lack of a treaty-based framework that addresses the potential difficulties of enforcing a DAB's decision, given that it is a product solely of contract. In the United Kingdom, the annexure to the Arbitration Act of 1996 (Arbitration Act 1996) provided specific enforcement procedures, albeit that in practice enforcement has been effected simply by suing on the award and seeking summary judgment, arguably easier to do at a domestic level than on the international stage (Scott 2004). Notwithstanding the difficulties of enforcing decisions of DABs on the international plane, the likelihood is that DABs will continue to be increasingly incorporated into international contracts, both as a process to avoid disputes by encouraging the parties to resolve their own issues before a DAB is called upon and to reach at least an interim resolution of disputes that cannot be negotiated.

Expert Determinations

Quite a few construction disputes result from discrete technical issues, such as whether certain work meets specified standards of quality or performance, or, perhaps, differences over what is the value of a structure or what are "reasonable" costs for work performed. If the technical issue is relatively isolated and separable from more broadly gauged contractual questions, it may be feasible to submit that issue to an expert for an opinion or decision. In 1976, the ICC established the ICC Centre for Expertise and later adopted the ICC Rules for Expertise (ICC 2003). The ICC Rules for Expertise provide a variety of procedures and services, administered by the ICC Centre, for assisting parties to find relevant expertise from the ICC panels, to appoint experts when requested, and to administer the expert proceedings (ICC 2003; Bunni 2005). Under Article 12 of the ICC Rules for Expertise, the expert, having consulted with the parties, states his or her scope of undertaking, including the language of the expertise proceedings, the procedure to be followed, and a timetable. An expertise proceeding or expert determination can either be binding on the parties or not, depending on the parties' agreement. Additionally, expert determinations are normally conducted on the basis of written submissions, with no hearing in a formal sense, and generally do not require a rigorous application of the rules of natural justice or due process.[10]

The use of experts to make determinations has occurred on a few major global infrastructure projects, such as the Channel Tunnel (or "Chunnel") and the Boston Central Artery/Tunnel ("Big Dig") projects (Redfern and Hunter 2004). Even on smaller projects, the use of a neutral design professional can be useful, for example, in monitoring repair work to ensure that the work is being carried out according to specifications or to make decisions of the reasonableness of repair costs (Kemp 2007). The use of experts to make binding determinations on construction projects has, to date, been quite modest in relation to the increasing use of mediation, conciliation, DRBs, and DABs as prearbitral dispute resolution processes (Gaitskell 2005).

10 Hunt (2000) notes that "it is the form of the inquiry conducted by the expert (rather than the contents of the agreement for appraisal or assessment) which will be determinative of whether or not what has been conducted was an arbitration rather than an independent expert appraisal. If an inquiry of a judicial or quasi-judicial nature is conducted, then the process is an arbitration," citing *Hammond v. Wolt* (1975) VR 108, 112-113.

Adjudication

The special sense of the term "adjudication" in the construction industry has reference to certain statutory procedures that have been enacted by states or government bodies, requiring certain types of construction disputes to be decided by an adjudicatory style process. The most prominent of these statutory adjudication procedures was established in the United Kingdom pursuant to the Housing Grants, Construction and Regeneration Act, 1996 (HGCRA) (Housing Grants, Construction and Regeneration Act 1996).

The HGCRA legislation (referred to variously as "the act," or "statutory adjudication," or "adjudication") has had a profound effect on the UK construction industry and legal profession. Since May 1, 1998, when statutory adjudication came into effect, the mandatory procedures have necessitated major changes to preexisting dispute resolution clauses in most UK standard form construction agreements. A number of important issues have been decided by the English courts; more than 12 handbooks or treatises have been published on the subject of statutory adjudication (Bailey 2008; Coulson 2008; Fenn and O'Shea 2008); and a whole new industry of organizations has been spawned to train, recommend, and nominate adjudicators to decide construction disputes (Riches and Dancaster 1999; Uff 2001; Simmonds 2003). It has been said that the underlying purpose of statutory adjudication is to provide a "pay now, litigate later" process or a quick-fix solution to a construction claim on the assumption that anything that goes awry with adjudication can be cured in subsequent litigation or arbitration (Chan et al. 2005). Without question, the number of construction disputes referred to statutory adjudication has continued to grow, and the indications are for a significant reduction in construction litigation and arbitration, at least for domestic cases[11] (Scott 2004; Gaitskell 2005). The English experiences with adjudication, both good and bad, will undoubtedly be drawn upon by other countries, particularly the United States, in deciding whether or what aspects of statutory adjudication can or could be transplanted, either into domestic contracts or legislation.[12]

Under the act, a party to a "construction contract" as so defined has the right to refer a dispute arising under the contract for statutory adjudication using specified procedures (HGCRA 1996). A construction contract is broadly defined by HGCRA (1996) as

> an agreement with a person for any of the following–(a) the carrying out of construction operations; (b) arranging for the carrying out of construction operations by others, whether under sub-contract to him or otherwise; (c) providing his own labour, or the labour of others, for the carrying out of construction operations.

Under statutory adjudication procedures, any party to a construction contract may refer a "dispute arising under the contract for adjudication under a procedure

11 The number of adjudications reported each year continues to increase; see statistics from Adjudication Reporting Centre, Glasgow Caledonian University: www.Adjudication.gcal.ac.uk/report7.doc.

12 It has been proposed that an adjudication model could be implemented for Canadian construction contracts (Kirsh 2009; Rana 2009; Tackaberry 2009).

complying with [the Act]" (HGCRA 1996; Scott 2004). The act mandates that the construction contract will contain at least the following provisions (HGCRA 1996), sufficient to

- Enable a party to give notice at any time of his or her intention to refer a dispute to adjudication;
- Provide a timetable with the object of securing the appointment of the adjudicator and referral of the dispute within 7 days;
- Require the adjudicator to reach a decision within 28 days of referral or such longer period as is agreed by the parties after the dispute has been referred; however, the adjudicator may extend the period of 28 days by up to 14 days, with the consent of the party by whom the dispute is referred;
- Impose a duty on the adjudicator to act impartially;
- Enable the adjudicator to take the initiative in ascertaining the facts and the law;
- Provide that the decision of the adjudicator is binding until the dispute is finally determined by legal proceedings, by arbitration (if the contract provides for arbitration or the parties otherwise agree to arbitration), or by agreement; and
- Ensure that the adjudicator have certain immunities from acting as such in the proceedings, unless in bad faith.

In the absence of any directions by the adjudicator relating to the time for performance of the decision, the parties are required to comply with the decision immediately upon receipt.[13] Most participants and commentators on statutory adjudication have observed that, because of the short time frames and truncated procedures, justice is meted out as with a machete, rather than a scalpel. But, notwithstanding the "rough and ready" or "rough justice" nature of the proceedings, it has been decided that rules of "natural justice" do apply, and the proceedings must be conducted with fairness to each party as time constraints permit.[14]

Mediation and Conciliation

Mediation and conciliation are generally considered to be private, confidential, and informal processes in which the disputants are assisted by neutral third parties to reach a negotiated settlement of the dispute. The mediator or conciliator interacts with each party and their representative to listen, clarify, and test negotiating positions, offer and communicate possible solutions, and often tries to persuade or cajole the parties to resolve their dispute (Carbonneau and McConnaughay 2007). The terms "mediation" and "conciliation" are frequently used as synonymous terms for a process whereby a neutral party is chosen by the disputants to facilitate and assist them in reaching a voluntary settlement (Junker 1988). However, on the inter-

13 Statutory Adjudication Scheme, §§21 to 23. Statutory adjudication decisions are enforced by actions for summary judgment (Lloyd 1999).

14 For a thorough analysis on possible court challenges to statutory adjudication and other ADR processes, see Britton (2009).

national plane, conciliation is the term most often used, and some observers have seen clear differences between mediation and conciliation. For example, Bunni (2005) distinguishes between mediation and conciliation:

> The difference between mediation and conciliation lies in the role played by the neutral party. In one, he simply performs the task of persuading the parties in dispute to change their respective positions in the hope of reaching a point where those positions coincide, a form of shuttle diplomacy without actively initiating any ideas as to how the dispute might be settled. In the other method, the neutral party takes a more active role probing the strengths and weaknesses of the parties' case, making suggestions, giving advice, finding persuasive arguments for and against each of the parties' positions, and creating new ideas which might induce them to settle their dispute. In this latter method, however, if the parties fail to reach agreement, the neutral party himself is then required to draw up and propose a solution which represents what, in his view, is a fair and reasonable compromise of the parties. This is the fundamental difference between mediation and conciliation.

However, most U.S. construction professionals, neutrals, and lawyers would not define or restrict the mediation process so narrowly because, in their experience, mediators frequently perform a more active role, by "probing the strengths and weaknesses" of each party's case, as well as making suggestions, giving advice, and attempting to think "outside the box" in efforts to find creative solutions to problems (Carbonneau and McConnaughay 2007). Over the past 15 to 20 years, conciliation has been introduced to the wider international commercial community, as demonstrated by the various sets of published rules for conducting conciliations (McCaul 2001; Bunni 2005; Phillips 2008) so that it is now fair to state that mediation and conciliation have established a firm place in the pantheon of proven processes for resolving international construction industry disputes.

Standing Neutrals and DRBs

The U.S. construction industry has commonly used "standing neutrals" of various types, including DRBs, to resolve disputes on the job (Carbonneau and McConnaughay 2007). The parties typically appoint the standing neutral or DRB members, either in the construction contract or at the commencement of the project. In each case, the person or persons selected to serve on the DRB are kept informed about the project and its progress, and they are expected to make themselves available on relatively short notice to facilitate resolution of any dispute (Battelle 1995; McMillan and Rubin 2005; Bunni 2005). First used in the 1970s on tunneling projects, the DRB process has also been used on other types of construction, including heavy civil engineering and industrial and conventional building projects (Battelle 1995; McMillan and Rubin 2005; DRBF 2007). Most DRBs in the United States have operated under procedures developed by the ASCE Guide

Specifications for DRBs (DRBF 2007). In North America, the DRB process has been used on more than 1,000 projects, and 99% of those projects were reportedly completed without resorting to arbitration or litigation (DRBF 2007). A related process has been used successfully on government projects in Hong Kong, where a dispute resolution advisor (DRA) who has general construction experience was jointly appointed by the government and the contractor to assist the parties in resolving disputes on the job (Luk and Wong 2007; Kirsh 2009). The DRA's role was to become familiar with the design and construction of the project, attend monthly meetings with the government owner and the contractor, and be prepared to assist the parties in resolving any noticed disputes on short notice. If the parties could not resolve the dispute by the DRA's assistance and negotiation, the DRA was charged to assist the parties in finding and implementing a binding form of dispute resolution, including arbitration. According to virtually all surveys and commentary, party satisfaction with DRBs is high. Those who have used the process on one project tend to use it repeatedly. The high level of satisfaction is usually attributed to the "real time," on-the-job resolution of the dispute where all involved parties are available and the work can continue to move forward (McMillan and Rubin 2005).

Arbitration

Submitting construction disputes to the arbitration process has a long tradition in the U.S. and UK construction industries (Stipanowich 1996; Bruner and O'Connor 2002). However, in the first decade of the 21st century, complaints have been made that arbitration is becoming too much like litigation in that it is beginning to take far too long and is too expensive (Grigera Naón 1999; Bunni 2005; Stipanowich 2007). These concerns have led to a major change in the U.S. AIA standard construction industry contracting forms. As of October 2007 and for the first time in several decades, the AIA revised its standard set of general conditions to no longer make arbitration the default process for final resolution of construction disputes. Instead, the ultimate dispute resolution process, unless affirmatively agreed otherwise by the parties, will be court litigation (AIA 2007a, b). Similarly, in the United Kingdom, the decline in popularity of domestic construction arbitration was reflected in the Joint Contracts Tribunal 2005 suite of construction contracts, wherein the default provision for dispute resolution is litigation rather than arbitration (Bell 2006).

It was because of the unique and challenging aspects of international construction arbitration that the ICC established a special "Construction Arbitration Section" to investigate and make recommendations for improving methods and techniques to control construction arbitration (ICC 2001). The ICC final report observed that although the actual construction disputes that are referred to arbitration may be characterized in familiar ways (e.g., claims for delayed completion; claims resulting from unforeseen conditions; claims for design flaws; or claims based on increases in scope of work), there are three typical characteristics of construction disputes (ICC 2001): First, the costs of any construction arbitration are generally seen as significant. Second, the disputes are likely to be relatively intractable if they cannot be resolved by a prearbitral filter, such as a required negotiation, conciliation, mediation, DRB, or DAB. Third, and on a more positive note, the disputes are likely to have been refined or refocused by any construction prearbitral dispute resolution processes so that the points at issue are clearer than they would have been without construction arbitration.

Consequently, with the growing universality of prearbitral methods of dispute resolution, it is likely that future construction arbitrations will normally deal with disputes that cannot be resolved short of arbitration, either because they raise important questions of principle or because they are too complex to be resolved satisfactorily by a DAB or DRB, and almost certainly the amounts at stake will be significant (ICC 2001).

Med-Arb

Med-arb is an acronym for mediation-then-arbitration, the use of which is not uncommon in international commercial disputes. Like all mediation processes, the med-arb process begins with an initial joint meeting between the disputants and the mediator. The parties use this initial phase to air their views and to educate the neutral about the case. After the initial joint meeting, the mediator continues either with the mediation in a joint meeting or in caucus. The two sides then work on designing a resolution. If all issues are resolved, an agreement is drawn up and signed, and the process is concluded. On the other hand, if the mediation has not resolved all issues, the disputants may not walk away from the process at will but must proceed to binding arbitration. This requirement serves as a strong incentive for the parties to resolve their issues in the mediation phase. The arbitration phase of med-arb is like traditional arbitration, except that fact finding and the education of the neutral have already been accomplished (Flake 1998). The med-arbitrator then hears arguments on all remaining issues and renders a binding decision. The central advantage of med-arb over "pure" mediation followed by "pure" arbitration, in which different neutrals serve as mediator and arbitrator, is the effort to save costs and promote efficiency. In the event that mediation fails, the parties need not educate another neutral because the neutral who has been serving as mediator already knows much if not all of the information he or she needs to make a decision (Hill 1997). The assumption of med-arb is that mediation is more likely to produce a settlement with the immediate prospect of an impending arbitration.

Nevertheless, there are valid criticisms of med-arb proceedings: Its essential vice is the potential of overlapping or confusion of roles occurring when the same person is acting as mediator and later on as arbitrator (Buhring-Uhle 1990; Love 1997). Quite obviously, disputing parties who know that the mediator also has decisional authority are likely to be less candid than they would be with a "pure" mediator about such matters as how they prioritize their interests and the least they will accept to resolve the dispute. The parties are also likely to be unwilling to be candid about any matters at issue because they fear that if no agreement is reached, then the mediator-turned-arbitrator will use their disclosures against them (Flake 1998; Telford

2000). Furthermore, because the mediator-arbitrator is likely to have less information at their disposal than a "pure" mediator, the parties may feel that they are less likely to obtain mediated settlements. Additionally, the typical "reality testing" as a key element in successful mediation may be compromised in the med-arb process (Dendorfer 2004). A variation on the process of med-arb was successfully used to resolve property damage claims totaling billions of dollars arising from the World Trade Center tragedy of September 11, 2001, and was reported to have saved many months of testimony and expense (Wulff 2007).

The reverse arrangement of med-arb is, of course, arb-med, whereby the parties initiate an arbitration and most likely anticipate that the arbitration will proceed to a final award (Dendorfer 2004). However, during the course of the arbitration, it may become readily apparent to the parties and arbitrator that the dispute can and should be settled by agreement. At that point, and upon request by the parties, the arbitrator can be invited to assist the parties in reaching an agreed resolution of the dispute. Thus, the arbitration is, with the express consent of the parties and arbitrator, converted into a mediation or conciliation proceeding (Peter 1997; Dobbins 2005).

In summary, med-arb and arb-med have become, essentially, "bridges" between the nonbinding forms of alternative dispute resolution (ADR) and the binding process of arbitration with distinct advantages and disadvantages, along with their corresponding proponents and critics. To the extent that final and binding decisions are made by the mediator-turned-arbitrator, and to the extent that all of the relevant conditions and requirements of arbitral awards are followed, the resulting arbitration award by the mediator-turned-arbitrator should be recognized and enforced under international arbitration law and treaties.

Arbitration of Global Megaprojects and Gigaprojects: Pros and Cons

Arbitration is still the dominant method for finally resolving construction disputes in Anglo-American countries and is for all practical purposes the "only game in town" for final binding resolution of international construction disputes. However, in the case of large infrastructure projects in developing countries, few of the foreign participants involved in the construction project would be willing to submit any disputes that may arise to the determination of the local courts. There are positive reasons for choosing arbitration to resolve international construction disputes—reasons that are even more pronounced in major international cases than in domestic cases (PricewaterhouseCoopers 2006; IAS 2010). These pros and cons, combined with predictions for the future of international construction dispute resolution, are briefly discussed in the following sections.

Enforceability of Awards

Because of the widespread adoption of the New York Convention, international arbitration awards are generally recognized and enforced throughout most of the world (Hinchey and Harris 2008). The same cannot yet be said of state court judgments[15] (Ambrose 2003; Friedland 2007). Particularly in the case of construction projects, where co-obligors (e.g., joint venture partners and parent guarantors) are common, there is an obvious advantage to having one award that can be enforced in multiple jurisdictions, depending on where the award-debtor has assets[16] (IAS 2006, 2010).

Party Control and Flexibility

The greater degree of control over the dispute resolution proceedings that parties enjoy in domestic arbitration, as compared with court litigation, the greater their value will be on the global scene[17] (Mistelis 2004). Subject only to such requirements as may be imposed by the applicable legal regimes, the parties are free to agree on virtually any aspect of how their dispute will be resolved. The number and qualifications of arbitrators, language of the arbitration, procedures to be followed, schedules for exchange of information and hearings, and the admissibility of evidence may all be negotiated. This flexibility permits tailoring the process to suit the dispute and is of great logistical value when the parties, witnesses, and arbitrators necessary to participate in conferences and hearings are in several different locations, as is common in large global construction disputes.

Decision-Maker Expertise

An oft-cited advantage of arbitration over court litigation is the opportunity arbitration presents for the parties to select their own decision maker (PricewaterhouseCoopers 2006; IAS 2010). This flexibility is particularly important in construction cases—domestic as well as international—which very often turn on complex technical questions of engineering, accounting, and scheduling that are outside the normal work fare of state court judges. The importance of being able to choose one's decision maker is particularly important in international construction arbitration, where the parties and witnesses may be of different cultural backgrounds. Being able to choose arbitrators who are not only knowledgeable about technical and legal issues presented but also experienced in dealing with a variety of cultural backgrounds is a significant potential benefit over state court litigation.

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15 Except for the European Community, until last year, in 2009, there was no international convention or multilateral treaty in force, providing for transnational enforcement of court judgments. On January 19, 2009, the United States signed onto an international agreement for the reciprocal recognition and enforcement of foreign judgments, the 2005 Hague Convention on Choice of Court Agreements (http://www.hcch.net/index_en.php?act=conventions.text&cid=98). However, it remains to be seen whether this convention will obtain worldwide acceptance on anything like the scale of the New York Convention. There are proposals for such a convention for enforcement of court judgments.

16 Enforceability of awards was ranked by the recent PricewaterhouseCoopers survey as "the single most important advantage" by the highest number of respondents.

17 A "flexible procedure" has been ranked highest in the hierarchy of reasons given for preferring arbitration as a process for resolving international commercial disputes.

Time Efficiency

The time required for an international arbitration, from the time of filing to the award, has been at the top of concerns expressed by corporate users (PricewaterhouseCoopers 2006; Fulbright and Jaworski 2007; IAS 2010). Compared with litigation in U.S. courts, international construction arbitration can be efficient because the amount of prehearing discovery is extremely limited. In fact, both the ICC and the American Arbitration Association (AAA)/International Centre for Dispute Resolution (ICDR) claim that, in the majority of their cases, an award is rendered within 18 months from filing a request for arbitration (Mistelis 2004; PricewaterhouseCoopers 2006). On the other hand, unlike a judge who may have limited time and no inclination to grant parties' requests for extensions of time, arbitrators and counsel, perhaps having no incentive to move things along, can, if not pressed by the parties themselves, drag out proceedings and thereby create inefficiencies (Hobeck et al. 2008; McIlwrath 2008; McIlwrath and Schroeder 2008; PricewaterhouseCoopers 2008; IAS 2010). Construction cases tend to be fact-specific, involving multiple issues, and obviously the more issues to be resolved and the greater the quantum of proof required, the longer the proceedings will be. Yet in the final analysis, the optimum time required for arbitration depends on arbitrators who are good process managers and parties and counsel who are committed to moving the process along without unnecessary delay.

Convenience

Particularly in complex international construction cases where parties, counsel, and witnesses are often in different locations, the convenience associated with the flexible procedures of arbitration can hardly be overstated.[18] Before the hearing on the merits of the case, most communications can be accomplished via telephone or videoconferences, electronic mail, and overnight express mail. Arbitration offers the opportunity to hold hearings at any agreed or convenient location, notwithstanding that the "seat" or designated "place" of arbitration may be otherwise specified in the construction contract. The parties and arbitrators can also choose the dates and times of the hearings, and the order of witnesses, so as to best accommodate their individual schedules and diaries. Compared with the inconvenience of required physical attendance at routine status conferences with state courts, the relative conveniences associated with arbitration are self-evident.

Cost

Arbitration can be either more expensive or less expensive than traditional state court litigation. State court judges, their clerks and officers, and the courtrooms they use are publicly supported. With arbitration, the tribunal members, the institution administering the arbitration (e.g., ICC or the London Court of International

18 The PricewaterhouseCoopers survey (2006) cited "flexibility of procedure" as the most widely recognized advantage of international arbitration; see §2.2; see also IAS 2010.

Arbitration (LCIA)), and the hearing facilities come with significant fees. On the other hand, having a panel of experienced and expert decision makers, limited prehearing discovery, flexible procedures, and limited opportunity to challenge an arbitration award can easily compensate for the added expense of a private proceeding and is generally less expensive than litigation. The expense of international arbitration is of great concern to users of the arbitral process and is generally stated as the greatest disadvantage[19] (Wilson 1990; Gurry 1995; Buhring-Uhle 2005; Gotanda 1999; Smith 2001; McIlwrath and Schroeder 2008; PricewaterhouseCoopers 2008; IAS 2010). The ICC has been particularly proactive in bringing cost considerations and curative measures in international and domestic arbitrations to the attention of parties, counsel, and arbitrators. In 2006, the ICC Commission on Arbitration issued a special report on techniques for controlling time and costs in arbitration.[20] This ICC report (2006) indicated that the costs incurred by the parties in presenting their cases constituted the lion's share of the total arbitration costs. The report noted that, on average, the costs of arbitration broke down as follows:

- Costs incurred by the parties to prepare and present their case–82%[21];
- Arbitrators' fees and expenses–16%; and
- Administrative fees and expenses–2%.[22]

The conclusion drawn by the report (ICC 2006) was that

> if the overall cost of the arbitral proceedings is to be minimized, special emphasis needs to be placed on steps aimed at reducing the costs connected

19 PricewaterhouseCoopers survey (2006), §2.2, says that 70 out of 80 respondents to the survey cited cost as one of their top three concerns; 50% of the respondents ranked cost as the top concern. Fulbright and Jaworski (2007, www. Fulbright.com/litigationtrends, p. 26) commissioned an independent research firm to survey senior corporate counsel in the United States and the United Kingdom on their experiences and opinions regarding various aspects of, inter alia, international litigation and arbitration. The results showed that those corporate counsel believing that there is little difference between the costs of international arbitration and litigation increased from 53% to 75% from 2006 to 2007.

20 "Techniques for Controlling Time and Costs in Arbitration," Report from the ICC Commission on Arbitration (ICC 2006). The ICC set up a task force on reducing time and costs in arbitration, cochaired by prominent international arbitrators Yves Derains and Christopher Newmark. The task force consisted of many representatives from countries around the world who produced the ICC time and costs report setting out "a large number of techniques which can be used for organizing the arbitral proceedings and controlling their duration and cost. This document can provide valuable assistance to the parties and the tribunal in developing appropriate procedures for their arbitration. It is intended to encourage them to create a new dynamic at the outset of an arbitration, whereby the parties can review the suggested techniques and agree upon appropriate procedures, and, if they fail to agree, the tribunal can decide upon such procedures."

21 These costs included lawyers' fees and expenses and witness fees and expenses, including fees of experts.

22 ICC (2006), Introduction. A calculation by Winston & Strawn (2007) attempted to compare the relative administrative costs of a hypothetical arbitration, with $10 million in dispute, under the cost schedules of six different arbitral institutions, including the ICC, SCC, Swiss Chamber, AAA (International Rules), the LCIA, and the WIPO.

with the parties' presentation of their cases. Such costs are often caused by unnecessarily long and complicated proceedings with unfocused requests for disclosure of documents and unnecessary witness and expert evidence. Costs can also be unnecessarily increased when counsel from different legal backgrounds use procedures familiar to them in a manner that leads to needless duplication.

Privacy and Confidentiality

The usual expectation is that arbitral proceedings are private, or closed to third parties. This concept is a hallmark of most arbitral institutions and institutional rules. Privacy is also ranked highly by users of international arbitration and is considered an effective way to keep business practices and certainly the arbitration proceedings out of public scrutiny (PricewaterhouseCoopers 2006; IAS 2010). Although parties may have a general expectation that arbitration proceedings will be private, guaranteeing the confidentiality of the proceedings, materials prepared for the arbitration and any ensuing award is more complicated (Collins 1995). Some arbitral institutional rules, such as Article 20(7) of the ICC Rules and Article 30 of the LCIA Rules, address confidentiality, but the question is an open one in many jurisdictions and parties should not automatically assume that proceedings will be treated as confidential in the absence of an express agreement of confidentiality and privacy among all the parties (Mistelis 2004; Hinchey and Harris 2008).

Discovery, Disclosure, and Consolidation

International arbitration provides either limited or no opportunities for disclosure and discovery of evidence from opposing and third parties compared to U.S. domestic arbitration procedures.[23] Although exchanges of documents are generally encouraged and sometimes required, the scope of the document exchange is typically limited to those documents that are intended to be introduced as evidence and are clearly relevant and material to the dispute. The attitudes and cultural orientations of the arbitrators bear to a great degree on the scope of permitted discovery. For example, arbitrators from common law jurisdictions are inclined toward a broader scope of discovery than those from civil law jurisdictions, although the divide between common and civil law procedures is becoming less pronounced in the context of international construction arbitration. This being the case, the parties and their counsel must be much more focused on requesting information from the arbitrators. They must also depend on their own devices for obtaining evidence and should be prepared to go forward with less than complete information. Perhaps this is not such a bad development, when the cost benefits of "full discovery" are taken into account.

Another challenge for parties in construction arbitrations is the fact that arbitration is typically structured as "bipolar," meaning that only the direct parties to an

23 For a full discussion on the limitations of discovery and disclosure in international construction arbitration, see Hinchey and Harris (2008), §§8.33 to 8.39.

arbitration agreement can be required to arbitrate a dispute arising out of the underlying contract. However, many construction disputes necessarily involve more than the parties to the same contract; quite often such disputes implicate third-party design professionals and trade contractors, who cannot normally be compelled to join in the same arbitral proceedings because they are not typically parties to the same arbitration agreement. This situation can present the attendant risk of additional proceedings, greater cost, and the risk of inconsistent results (Hinchey and Harris 2008). Although this challenge can perhaps be addressed with attention to the arbitration agreement, the opportunities to do so may not be present or overlooked.

Future of Global Construction Dispute Resolution

International construction at the end of the first decade of the 21st century has been challenged by a sharp downturn in the global economy. Nevertheless, Patrick O'Connor, coauthor of *Bruner and O'Connor on Construction Law* (Bruner and O'Connor 2002), has predicted some exciting "transformational trends" in the global construction industry for the decade to follow (O'Connor 2007):

- Sustainability—The design profession is beginning to embrace the concept that design must take into account broader interests so as to reduce global warming and conserve scarce resources;
- Integrated Project Delivery—Design and construction is too fragmented. Delivery approaches that break down separate responsibility silos in favor of cross-disciplinary cooperation promise greater efficiency;
- Building Information Modeling (BIM)—This technological innovation is an enabler to greater collaboration among the design and construction disciplines. Building a structure virtually before actually building it reduces design conflicts, RFIs (requests for information), and disputes[24] (AIA 2007d);
- Modularization—Technologies like BIM permit greater reliance on dimensioning information which in turn allows for more construction to occur off-site where greater efficiencies can be achieved;
- Globalization—The flattening of world economics presents immense challenges for the construction industry. The rise of China as a major global presence together with the growth of Chinese construction companies creates competitive challenges for domestic players and further burdens already constrained resources;

24 Building Information Modeling (BIM) "is a 3-dimensional model linked to a database of project information, and is considered one of the most powerful tools supporting IPD. Because BIM can combine, among other things, the design, fabrication information, erection instructions, and project management logistics in one database, it provides a platform for collaboration throughout the project's design and construction. Additionally, because the model and database can exist for the life of the building, the owner may use BIM to manage the facility well beyond completion of construction for such purposes as space planning, furnishing, monitoring long term energy performance, maintenance, and remodeling."

- Workforce Constraints—The industry suffers from severe labor shortages at both the top of the managerial and professional levels as well as the skilled and unskilled labor pool. Current immigration issues complicate this picture, with more foreign-born workers, thus placing a premium on developing effective communication strategies;
- Organic Dispute Resolution—The construction industry continues to be plagued by disputes and inefficient mechanisms for resolving controversy. While mediation has proven somewhat effective it usually occurs after the parties have expended considerable resources. Arbitration has become more cumbersome and litigation is often worse. In general disputes arise too often and are often resolved too late. A more organic process is needed, whereby most disputes are resolved close in time to their origin by persons most knowledgeable about the circumstances;
- Lean construction techniques—Applying proven manufacturing efficiency principles of just-in-time delivery and efficient management practices to cut waste and redundancy in the construction process holds great promise for enhanced efficiencies;
- Alliance arrangements—While a form of integrated project delivery, the alliance contracting model is sufficiently novel to merit separate mention. By closely aligning all major project participants' interests in shared outcomes rather than individual gains, greater collaboration is achieved resulting in better project outcomes; and
- Rational risk allocation—The industry has grappled with fashioning coherent risk allocation models. Contract forms developed by industry organizations have helped, but dislocations still exist. There is a growing awareness that risk and reward must balance.

Alongside these "transformational trends" and the massive expansion of international construction still abide the inherent and characteristic risks of international construction, including the following (Bruner and O'Connor 2002):

- Language barriers to communications;
- Cultural sensitivities inherent in working with multinational parties in local communities;
- Variations in the availability, productivity, and skill of labor;
- Effect of local political and religious customs and practices;
- Potential economic and political instability;
- Unfamiliar forms of disease, plant, insect, and animal life;
- Unusual civil and criminal laws;
- Extended lines of supply and transportation;
- Unfamiliar local weather;
- Unfamiliar local geologic conditions;
- Potential double taxation by the host country and by the United States;
- Currency fluctuations and restrictions;
- Possible arbitrary local government regulation;
- Local corruption;
- U.S. regulation and restriction of international conduct of U.S. contractors;

- Local civil strife and unrest;
- Variations in the difficulty of obtaining adjudication of claims and enforcement of contract rights;
- Problems with insurability of international risks;
- Problems in collecting and securing payment; and
- Extended duration and large size of certain international projects.

The global construction industry has indeed entered upon a new era of transformational changes in the manner and mode of delivering projects. These changes, combined with economic constraints in the allocation of capital to major infrastructure projects, all will be tested in the crucible of the traditional risks and uncertainties that attend building projects across differing cultures and jurisdictions. How will the inevitable disputes arising from this new era best be resolved, and what is the future of international construction arbitration?

Although construction arbitration in domestic settings, most particularly in the United States and the United Kingdom, is being increasingly criticized as costing too much and taking too long, ("Mediation" 2000; Gaitskell 2005; Whiteman 2006; McIlwrath 2008; McIlwrath and Schroeder 2008; PricewaterhouseCoopers 2008), international construction arbitration seems to be alive and well, if not thriving. Recent PricewaterhouseCoopers surveys (McIlwrath and Schroeder 2008; PricewaterhouseCoopers 2006; PricewaterhouseCoopers 2008) of the attitudes of major corporate counsel toward the existing and future use of international arbitration to resolve commercial disputes revealed the following conclusions (PricewaterhouseCoopers 2006):

- 73% of respondents prefer to use international arbitration, either alone (29%) or in combination with ADR mechanisms in a multitiered dispute resolution process (44%);
- The top reasons for choosing international arbitration are flexibility of procedure, the enforceability of awards, the privacy afforded by the process, and the ability of the parties to select the arbitrators;
- Expense and the length of time to resolve disputes are the two most commonly cited disadvantages of international arbitration. Other concerns include the risk of court intervention in the arbitration process and the difficulty of joining third parties to proceedings;
- 95% of corporations expect to continue using international arbitration, and an increase in cases is expected; and
- Corporations appear confident that arbitration law and practices will generate the solutions required to meet future challenges.

For the foreseeable future, arbitration will continue to be the preferred process for the final resolution of international construction disputes.[25] Even so, mediation

25 As concluded in Mistelis (2004), "The future of international arbitration is quite rosy. Corporations identify specific issues which have to be addressed, including cost, multiparty disputes, and enforcement, but they appear confident that the law and practice can generate adequate solutions."

and conciliation have proven to be demonstrably effective in resolving construction disputes. As international communities outside the United States and the United Kingdom become more familiar with these nonbinding ADR processes, the use of such procedures will continue to grow in use and popularity. Still, it should be recognized that mediation, conciliation, and related ADR procedures are not "either–or" alternatives to arbitration. Instead, these structured negotiation procedures are most effectively used as a prelude—as first steps or "filters" to arbitration or litigation. Hence, many international construction contracts now, and in the foreseeable future, will require mandatory negotiation, mediation, or conciliation as conditions to proceeding with final arbitration or litigation. The probable and desirable consequence of this tiered approach to dispute resolution is that only the most intractable and difficult disputes will go to the more elaborate, costly, time-consuming, and trial-like arbitration procedures.[26]

Of course, the inherent shortcomings of any predispute resolution contract provisions are that in most instances the process is decided upon and incorporated into the contract long before the nature and quality of the claims and controversies are known. Ideally the entire array of dispute resolution tools should be available to or adapted for use in resolving a dispute, but only insofar as the dispute requires and only after it has come into full bloom. Although mediation or conciliation is generally favored by the construction industry, these procedures may not be ideal to resolve a case presenting a recurring or pivotal issue of law. Mediation also requires some time to prepare for and execute. Perhaps an interim binding determination by a respected neutral subject to de novo review by an arbitration panel would provide a more timely and just result. Although DRBs and DABs are effective, they are expensive to put in place and maintain, so perhaps an expert determination on a discrete issue would serve as well. In certain construction cases that are heavily laden with complex fact patterns and contract interpretation issues, the full panoply of litigationlike processes may be more appropriate, whether in the context of an arbitral or a judicial forum. However, in other cases that raise merely quantum or quality issues, due process has little or nothing to add to the traditional role of arbitrators who are acting essentially as appraisers. To deal with these inherent shortcomings of predispute agreements, some forward thinkers in the construction industry have envisioned the creative design of dispute resolution processes, *after* the dispute arises, in an effort to more perfectly tailor the process to the problem (Hinchey and Perry 2008; Mitchell 2008; Rivkin 2008; Stipanowich 2009; Stipanowich 2010).

A promising approach to decreasing the cost and time of resolving construction disputes is "real-time" dispute resolution[27] by "rapid responders" who are capable, experienced construction professionals who would be prepared to meet with the parties within a period of a few days. These professionals would then gather the pertinent information and recommend a specifically tailored process to best suit the problem. Most ADR and arbitral institutional providers still offer only the traditional

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26 For an excellent analysis of the pros and cons of "tiered" or prearbitration dispute resolution processes on international construction projects. (Baker 2009).

27 Stipanowich (2010) gives an excellent discussion of real-time dispute resolution, referring to popular author Malcolm Gladwell's (2005) use of the concept of "thin-slicing."

panels of mediators and arbitrators, who are prepared to follow only traditional methods, usually requiring many weeks and months to put a process into place and bring the dispute to a conclusion. In contrast, a rapid response team would be prepared to do the following (Bruner 2008):

- Make an early assessment of disputes and recommend either creative or traditional methods (or a combination of both) to resolve disputes. For example, if a dispute were keyed to an engineering or accounting issue, the neutral might recommend an engineering expert or accountant to make an expert determination that would be either binding or nonbinding. A similar approach could be adapted to legal issues and perhaps a "minitrial" might assist in resolving factual disputes.
- When the traditional processes of mediation, conciliation, or arbitration are appropriate, the neutral would be prepared to put those processes in place and move the process forward as rapidly and efficiently as the parties would permit.
- A standing panel of capable, experienced construction experts could be established to provide either nonbinding recommendations or binding decisions.
- If arbitration is appropriate, the tribunal would be prepared to act decisively and courageously to move the process along, if possible, on a fast-track basis. They could accomplish this by limiting discovery of documents, limiting the taking of depositions to what is demonstrably relevant and material to the outcome of the dispute, dealing effectively and economically with electronically stored information, taking evidence by written statements, encouraging the disposition of issues by motion rather than full hearings, and finally, issuing awards promptly

Another developing topic that raises correspondingly interesting and challenging questions is to what extent if at all arbitrators should facilitate a settlement or otherwise assist the parties in trying to resolve a dispute while that dispute is pending before them (Kaufmann-Kohler 2008). From a German perspective, arbitrators are expected to assist in amicable settlement of a dispute.[28] The Centre for Effective Dispute Resolution (CEDR) has recently issued their "CEDR Rules for the Facilitation of Settlement in International Arbitration," designed "to increase the prospects of Parties in international arbitration proceedings being able to settle their disputes without the need to proceed through to the conclusion of those proceedings" (CEDR 2009). The CEDR settlement rules can be incorporated on an ad hoc basis by agreement of the parties either as part of an arbitral institution's rules or within a contract clause providing for arbitration. The CEDR settlement rules also provide for a proactive role by an international tribunal to facilitate resolution of a dispute, including giving preliminary views on the merits, providing preliminary nonbinding findings on law or fact, offering suggested terms of settlement, or where requested by the parties, chairing settlement conferences.

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28 Section 32.1 of the German Institution of Arbitration (DIS) rulesprovide that "At every stage of the proceedings, the arbitral tribunal should seek to encourage an amicable settlement of the dispute or of individual issues in dispute" (Kreindler 2009).

In contrast, the AAA/ICDR has concluded that arbitrators should not play an active role in settlement talks or mediation but rather has promoted clauses that call for the mediation process to run in parallel tracks with the arbitration (ADR 2009; CPR Commission on the Future of Arbitration 2000). A third approach was put forward by Judicial Arbitration and Mediation (JAMS) in November 2009, whereby a "Mediator-in-Reserve" will be appointed in international cases to "streamline the transition to mediation for parties involved in arbitration" (JAMS 2009). Under the JAMS policy, within one week of the commencement of an international arbitration at JAMS, a suggested list of mediators is sent to the parties, who will be encouraged to select a mediator from the list. The mediator so selected essentially stands by and remains available to the parties in the event that at any time during the arbitration the parties want assistance. However, the arbitrators in the proceeding have no knowledge of the identity of the mediator-in-reserve or whether the parties may have elected to engage the services of the mediator-in-reserve (JAMS 2009).

Summary

As the global construction economy worsens, more disputes will develop on troubled projects. The construction industry is legitimately concerned that the traditional ways of resolving construction disputes are taking too long and costing too much. At the same time, it must be remembered that processes that lead to cost and time savings may derogate from the quality of arbitration as a means of reaching a fair and just result. For example, costs can be saved by having a sole arbitrator rather than three or by not having an arbitral institution administer the proceedings. Sole arbitrators may also dispense with terms of reference or award scrutiny by imposing strict limits on either written submissions or the number of witnesses or rounds of witness statements, or by issuing a truncated award without reasons. Each of these cost savings measures does not necessarily contribute to and may negatively affect the quality of the process, in that in some cases, justice may not be done.

Time can be saved by implementing an accelerated or fast-track timetable for the arbitration, but cutting time may result in prejudice to one or both parties. Thus, a cost–benefit–risk analysis should be done for virtually all procedural choices that are made in the context of arbitration. Concerns about excessive time and cost for international arbitrations are legitimate, and in response to these concerns there are new procedures and techniques that are designed to seize upon the dispute at the earliest moment and design a tailored process to solve the specific issue.

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Part 2

Recognizing Cultural Differences in Managing Megaprojects

Megaprojects and gigaprojects will become more common and much larger in the future. The lesson of the past is that if someone can dream it, someone will build it, and that is still true. Increasingly, megaprojects are international efforts, combining the talents and expertise of several nationalities on a project location that may well be foreign to all of them.

The history of these projects is that the techniques and products have changed dramatically in several ways. The Panama Canal is a good example—it was basically a pick-and-shovel operation at the start. Over the lifetime of the project, new blasting techniques, new engineering methods, new surveying techniques, and the emergent science of project management entered the scene and became part of every subsequent project until, of course, a new technology or better method once again superseded the old methods.

A modern example—in the early 2000s iPods were in their infancy and iPhones and iPads did not yet exist, yet by the end of the decade iPods, iPhones, and iPads were commonly used by many people, with apps designed to simplify a countless number of tasks that would have been unthinkable just years before. With megaprojects and gigaprojects typically being constructed over a similar period of time, roughly 10 years, how do you think 10 years of technological change will affect a current project that is now in its infancy?

In the 1990s, the Middle East was considered to be a series of stable autocracies. How does the rise of representative governments (or religious autocracies) in the Arab world affect a project that is currently under way, and how do you assess and minimize risk in these unknown cultural and regulatory environments?

In the 1990s, money flowed freely between markets, and financial risk was hidden in reporting and assessment structures that were arcane to most investors—investors who relied on rating agencies or internal bank analysis for their investment information. Today, financing is commonly international and many times private, spreading the risk across a series of investors, none of whom could individually absorb any dramatic financial risks. How would your two-year-old megaproject plan react to the recent drying up of public capital?

The most important issue in all the above situations is that they all may well happen in a culture or a country whose culture is dramatically different from yours. Many future megaprojects and gigaprojects will be resource-extraction projects with little or no public financing and development time lines that stretch through the better part of an engineer's career. And it all may happen in an unfamiliar country with important business partners who come from a completely different culture than you do.

As Kris Nielsen has said,

> Virtually every megaproject is planned and implemented within a unique set of social, economic, and environmental contexts, which can have intended and unintended positive and/or negative impacts. The megaproject management team has to consider the project in its cultural, social, global, political, and physical environmental contexts. To do so requires more than just gathering a general management team that has sound experience in megaproject management knowledge and skills. One must also develop within the megaproject management team skills which include an understanding of the importance of historical background, culture, and customs in each nation or region.

In Part 2, we invited representatives from around the world to talk about their projects. Our authors are as varied as the megaprojects and gigaprojects they talk about.

- **William Kerivan** gives us some insight into the construction world of the Middle East and the different cultural conflicts that occur there.

- **Claudio Dall'Acqua and André Steagall Gertsenchtein** discuss a megaproject in the São Paulo area and how they balanced social and environmental questions with the need to build a massive transportation project.

- **Shunji Kusayanagi and Rajendra Niraula** offer their insights into megaprojects and gigaprojects in Asia, concentrating on the Bosphorus Crossing railroad tunnel.

- **Antonino de Fina** takes a look at megaprojects and some of their dramatic failures in Australia.

- **Steve Roswell and John Mason** give us an overview of megaprojects in the United Kingdom and the Eurozone context.

- **Albert Bates Jr.** gives us some insight to common project delivery systems and weighs the risks and rewards of megaproject engineering, procurement, and construction contracting in North America.

- **Charles W. Whitney, Annalisa M. Bloodworth, and Antony L. Sanacory** discuss the ultimate gigaproject, nuclear power construction, permitting, and regulatory structures in the United States.

The increasing presence of megaprojects and the rise of gigaprojects in the future present everyone involved with unique problems and issues. The fundamental nature of these types of projects is that they are unique by definition. But the mistakes of the past will be less painful if the lessons drawn from those mistakes can provide a foundation for a new era of projects that serve their investors, satisfy a genuine public need, and live gracefully within a set of social and environmental paradigms. We hope that our book can provide a solid platform from which to move forward into a future where the issues of the past are harmonized and megaprojects and gigaprojects are viewed with the public acclaim and respect with which they were once lauded.

CHAPTER 13

Megaprojects in the Middle East

William Kerivan

The Middle East region conjures up many images. Inside the region, there is a debate in society reflecting the differences between secular and fundamentalist Muslim values. Outside the region, there is a perceived competition between Arab and Western values.

The U.S. Department of State adds the North African countries to their definition of the Middle East and terms the Middle East as the Middle East and North Africa (MENA). For the purposes of this chapter, we use the State Department's definition as the working definition for the term *Middle East*. It is a must for all individuals traveling or working in the Middle East to be aware of State Department alerts and advisories. On January 24, 2012, a "worldwide caution" was issued. The following commentary must be considered by all Western personnel and entities that are working or planning to work in the Middle East. The issues expressed must be an integral part of any risk management program (State Department 2012):

> Credible information indicates terrorist groups also seek to continue attacks against U.S. interests in the Middle East and North Africa. For example, Iraq remains dangerous and unpredictable. U.S. military forces have withdrawn as of December 31, 2011 but the threat of attacks against U.S. citizens, including kidnapping and terrorist violence, is expected to continue. Methods of attack have included roadside improvised explosive devices, mortars, and shootings. Security threat levels remain high in Yemen due to terrorist activities there. The U.S. Embassy has had to close several times in response to ongoing threats by al-Qaida in the Arabian Peninsula (AQAP). U.S. citizens as well as other Westerners have been targeted for attack in Yemen. U.S. citizens have also been the targets of numerous terrorist attacks in Lebanon in the past (though none recently) and the threat of anti-Western terrorist activity continues to exist there. In

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LESSONS LEARNED

1. Spend the preplanning and scope definition time wisely. Any delays in construction caused by poor planning cause additional expense and frustrate the owner and all involved parties.
2. Read the contract carefully if you are an engineering and construction (E&C) contractor and be proactive in those areas where you are able to effect reasonable change. Where you are unable to negotiate changes in contract language, price the risks accordingly.
3. To attract high-quality contractors to bid and perform work, an owner must be willing to provide and accept reasonable contract terms and condition alternatives. The marketplace is becoming more sophisticated, especially when dealing with specialty contractors.
4. Contractors must study and understand contract payment terms. You must know when work will be considered eligible for payment. Also, will materials be paid for upon delivery or upon incorporation in a final deliverable?
5. Contractors need to establish a banking relationship within the host country that is tied to a banking institution in the contractor's home country. This relationship is necessary for bank letters of credit that secure advance payments by the owner.
6. Owners and contractors must employ a management team experienced in directing a large, uneducated workforce to ensure that the project safety program, standards, and monitoring will be effective. Constant follow-up and vigilance are necessary.
7. The labor agent whom you choose to work with should be able to provide you with information and contacts to assist in organizing and managing your local labor requirements.
8. The risk profile of a megaproject executed in the Middle East is not the same as that of a megaproject executed in the company or individual's home country. Most of the risk differences will not be technical issues; they will be based in the culture of the host country.

Algeria, terrorist attacks occur regularly, particularly in the Kabylie region of the country. In the past, terrorists have targeted oil processing facilities in both Saudi Arabia and Yemen. Some elements in Iran remain hostile to the United States. U.S. citizens should remain cautious and be aware that there may be a more aggressive focus by the Iranian government on terrorist activity against U.S citizens.

Engineering and construction (E&C) contractors who perform megaprojects in the international marketplace are used to the risks of working in a difficult environment, often under hostile conditions. In my experience, successful E&C contractors recognize the risks and anticipate and plan for contingencies.

This discussion considers how parties to a world-class complex are dealing with the challenges of design, engineering, procurement, construction, labor and project personnel, and in the end, delivering a high-quality project.

Setting

This typical project may be located within any of the Persian Gulf states known as the Gulf Cooperation Council (GCC). As shown in Fig. 13-1, the GCC is made up of the states of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE). Noticeably missing from the GCC are the states of Iraq and Iran. Within this territory, there is an agreed agenda to enact similar regulatory schemes to encourage the growth of the economies, while sharing similar financial, trade, customs, and tourism standards. There is a unified military agreement, and there is a goal to establish a common currency. Each country's government is a type of monarchy, the state religion is Muslim, and the state language is Arabic. The English language is widely spoken, and media sources are also available that speak and write in English.

Fig. 13-1. Gulf Cooperation Council member states

Source: Wikipedia http://en.wikipedia.org/wiki/File:Persian_Gulf_Arab_States_english.PNG (accessed May 8, 2012).

Cultural Considerations

Because 90% of the people in the Middle East are Muslims, it is important to understand the regional and local traditions before conducting business in the region. There are many books that can provide extensive information regarding the cultures of the Middle Eastern countries. In a short review of key points, please know the following:

- Friday is the Islamic holy day and is the equivalent of Sunday in the United States and Christian nations.
- Women in the workplace are a relatively new occurrence and still not nearly as common as in the West. Women tend to dress conservatively and shake hands only when offered.
- Face-to-face communication is a preferred method. Respect must be conveyed. Business card and other exchanges should be made with the right hand as the left hand is reserved for personal hygiene and considered unclean.
- Agents with influential connections and status will ensure that you and your company meet the decision makers who matter.
- Always assume that decisions will be made by a few powerful men.
- Change comes slowly.

The Project

An example project is the development of a new, world-class airport, port facility, or resort with supporting facilities. It is being designed by representatives from a leading architectural firm. The engineering and project management is being carried out by one of the world's most well-known E&C firms. Management oversight of the project is carried out by the owner's team of selected consultants.

Planning and Execution of the Project

The planning and execution of the project were intended to be carried out in stages that reflect the approved conceptual planning and design development. Initial site preparation activities and the start of construction used a delivery method that included individual construction packages reflecting a common work scope. The project was further divided into multiple delivery areas. Subsequent to initial conceptual design and agreement with the owner as to the scope of work, there was extensive redesign and expansion of the scope of the work. This has caused delays in engineering, procurement, and construction.

Project Framework

The project's contracts serve as the framework for the commercial relationship between the owner and the various contractors. The contract document used widely in the GCC by government owners is the 1987 FIDIC Red Book edition (FIDIC 1987). Typically, clauses are rewritten to suit the individual project. By way of comparison, U.S. contracts by governmental owners also tend to be form agreements. The U.S. Army Corps of Engineers uses the federal acquisition regulations (FAR) model, and this agreement can be modified by the agency contracting officer. The main distinction between the GCC model and the U.S. domestic model is that there is a broad base of regulations and case law in the United States that can assist in resolving questions if and when a question, claim, or dispute occurs. There is not a similar body of reference to assist in interpretation of contract claims or disputes in the GCC.

Additionally, the GCC contracts typically follow the model of design–bid–build (DBB) or design–build (DB) with the cost element being covered using a bill of quantities (BOQ). A BOQ tendered work contract is priced by a unit of work that is built up using an itemized listing of the costs included to complete the particular unit of work identified within the tender documents. This approach can be effective for the contracting parties as the work scope is redefined (number of units is increased) and costed at award. It has been my experience that large-scale design and scope change makes the model somewhat problematic. Difficulties occur most frequently when new work is introduced and new costing takes place. Scope change causes a significant amount of philosophical turmoil. The owner desires the same fixed price that had been agreed at award, and the contractor wants to recover costs of the changed work and reconsider the pricing for the remaining work. Because there is an absence of government-established cost regulations that typically assist the parties in the determination of what costs are reasonable, allowable, and allocable, unrestrained attempts to renegotiate new prices of the contract work and systems will result.

- A matter of significant GCC interest was the UAE member Abu Dhabi's adoption in 2006 of a hybrid version of the 1999 FIDIC Red Book for use in its government contracts. This version, which comes in two forms—Build Only, and Design and Build—contains the following features:
- Any foreseeable risk that is within the contractor's scope must be defined.
- The employer (owner) must provide information that it is able to meet its payment obligations and must inform employees of any changes in its financial condition.
- The employer (owner) has 56 calendar days to settle payments.
- Notice requirements must be strictly enforced.
- The employer (owner) must receive additional performance security through the use of "on demand" bonds.
- A provision that the employer (owner) may terminate with 14 days' notice;
- A contractor must follow a process before it may terminate. It takes 132 calendar days before it may file for termination.
- There is an established cap on liquidated damages, raised from 10% to 20% of the contract sum. (Note that liquidated damages can and are punitively applied by GCC owners.)
- The engineer or engineering firm is deemed to be working for the employer (owner) unless stated to the contrary in the contract. This is a major difference from the 1987 Red Book (FIDIC 1987) in that it states what was previously presumed.
- Soil and ground conditions must be carefully studied to understand risks assumed by each in the tender process.
- The contractor's liability to the employer (owner) is to be limited to a sum inserted in the contract. Contractors must study this limitation and ensure that insurance coverage, subcontractor risk, and its liability are well known and identified.
- The engineer is obliged to respond to claim notices within a fixed period.
- The resolution of disputes must be handled by a dispute adjudication board (DAB). The DAB is to be in place from the start of a project. Alternatively, the engineer may be charged with performing a dispute resolution function.

Commentator reaction has been that these changes impose harsher obligations on the contractor. Contractors will certainly consider these new modifications and obligations when pricing their tenders. All parties contracting with the Abu Dhabi model have been cautioned to review the new contracts carefully.

Similarly, Qatar's Public Works Authority has modified its General Conditions of Contract which is a version based on the International Federation of Consulting

Engineers (Fédération Internationale des Ingénieurs-Conseils, or FIDIC) 1987 Red Book. These modifications were accomplished in May 2007. The changes introduced need to be examined in conjunction with the Qatar Civil Code because the civil code is controlling. Unlike the UAE, Qatar's general contract conditions require judicial action. The UAE has had its disputes adjudicated by arbitration using common-law principles even though it is a civil code jurisdiction.

Project Financing

The GCC construction market accounts for 75% to 85% of all construction contracting in the Middle East. Currently, the largest market is the UAE, followed by Saudi Arabia, Qatar, Oman, Kuwait, and Bahrain. The number of projects that have been affected by the global financial crisis has been dramatic. Since the duration of the global financial crisis is unknown, it is impossible to determine when the projects whose execution phases have been delayed because of financing issues will be resumed. If market conditions do not improve in the short term, it would be reasonable to believe that financially motivated mergers and consolidation of E&C contractors will occur. This event could affect market conditions and the pricing of future tenders.

Middle East project financing has suffered for two reasons: falling oil prices and the U.S. subprime mortgage collapse. Banks are fearful of banking failures, customers are withdrawing funds, and lending has dried up. In the Middle East, domestic banks have relied on international banks to fund loans. The regional banks were not a dominant part of the lending process. When European, Japanese, and U.S. banks suffered, they reduced their participation in Middle East offerings.

The Middle East currently relies internally on large owners and sponsors to self-finance. This method works well in the GCC for state-sponsored infrastructure projects. Oil and gas sponsors require a different kind of project finance for joint ventures because of joint liability issues. This route requires a multidisciplinary approach to structure the project agreements. The design, construction, use of various technologies, and offtake agreements (agreements to purchase most or all of a product produced by a project) need to be carefully drafted so that the lending institution understands the "deal." It is also necessary that the transaction is compatible with Sharia law. Because of the lack of participation by European, Japanese, and U.S. banks, investment is currently being underwritten by Middle East government institutions and Islamic banks. The change in the customary and typical financing process means that oil and gas projects will be affected, along with smaller projects. It appears that GCC governments are considering additional infrastructure projects to keep market economics functioning and E&C contractors working in the region.

In the GCC model, the contract provides the framework for financing any E&C work agreed to. The contract provides the following structure:

- The contractor is to provide a schedule or program, along with a cash flow estimate.
- Advance payments are made as set forth in the contract. These funds are generally secured by a bank guarantee.

- Monthly payments are made after review and approval by the resident engineer and the owner.
- Retention money is withheld, and upon issuance of the initial acceptance certificate, one-half of the retention money will be paid. Upon issuance of the final acceptance certificate, the remaining half will be paid unless there is remaining maintenance work to be accomplished.
- Should payments not be made as provided in the contract, it is common that interest is paid on the overdue payments. It is my experience that owners do not like to pay interest on overdue amounts.
- A final accounting is usually called for within 30 days of issuance of the final acceptance certificate. Typically, the owner is obliged to pay within a 90-day period after receipt and certification by the engineer.

It is fairly typical for European contractors to cover themselves with an arrangement that ensures that a specific rate will be paid against the euro. This arrangement protects against currency devaluation, which can and does occur. As the GCC currencies are pegged to the U.S. dollar, it is unnecessary for U.S. contractors to seek this currency cover.

Construction Safety

Construction sites can be hazardous work environments. In 1970, the U.S. Congress passed the Williams–Steiger Occupational Safety and Health Act (OSHA). Under this legislation, each state was allowed to pass its version of OSHA. If the state passed legislation that was at least the equivalent of the federal OSHA, the state would be the exclusive enforcement agency. If the states did not meet the equivalency test, then federal safety inspectors enforced the OSHA requirements. The U.S. Department of Labor is the agency from which OSHA operates. The result of regulating safety in the construction workplace has been that owners, constructors, and construction workers have long been directly involved in what is required to establish and maintain a safe construction site. This long involvement has led to a construction industry that is well informed and experienced in what it takes to maintain a safe work environment.

The Middle East does not have that same level of experience or knowledge as to what it takes to establish and maintain a safe construction worksite. The labor force on megaprojects in the GCC often exceeds 20,000 workers. These workers may be untrained and unfamiliar with construction projects. The task of training a workforce to follow safety and health regulations is formidable. Additionally, most of the workforce may be using personal protective equipment (hard hats, safety shoes, and ear and eye protection) for the first time. A contractor must be vigilant in the implementation of this safety program and constantly refresh and reinforce training lessons. Furthermore, contractors must be mindful that unsafe equipment is to be excluded from the worksite.

My experience has been that weekly safety inspections and walkdowns assist the contractor in keeping the workforce focused on safety. However, as mentioned above, the inexperience of the workforce creates opportunities where intuitive knowledge so familiar on worksites in the United States and Europe is not available. This problem manifests itself in dropping tools, equipment, and materials from on high; nonobservance of tripping hazards; and failure to erect and observe barriers to serve as protective zones. Securing boards in a safe manner before attempting to move a load is often not carried out correctly. Covering openings in unfinished areas and erecting barriers to signify dangers are often not monitored, thus exposing employees to an unsafe condition. Contracts include safety requirements as part of the obligations on most large projects; however, there tends to be widespread disregard of safety requirements unless they are imposed by contract and enforced by the employer. This area requires constant vigilance.

Project Personnel

GCC contracts typically require the following with regard to the contractor's employees:

- The contractors make the necessary arrangements for the employment of all labor in accordance with local labor, social insurance, residence, and other regulations.
- The key personnel are professionally and technically competent, and these people may not be substituted without owner approval or by replacement with an equivalently qualified person. It is typical for the owner to demand a 60-day notice before a change can be made.
- The owner and the engineer typically reserve the right to request the removal of contractor personnel. The contractor is required to replace the employee with someone who has equal or better credentials.
- Contractors are charged with providing sanitary housing (usually in a camp environment), transport facilities (usually this is mass busing), and health care.
- The contractor is charged with providing supervising engineers, technical assistance, quality assurance and quality control engineers, safety engineers for safety and cleanliness of the site, and skilled, semiskilled, and unskilled labor to carry out the work.
- The contractor must provide a list of the personnel they retain along with any other personnel information that the owner may require.
- The contractor must maintain harmonious labor relations so that work is performed efficiently and without disruptions.

These requirements appear to be reasonable and necessary; however, when there are 20,000 to 40,000 people who require recruitment, work visas, travel to the country, local health clearance and project induction, housing, and transportation, the complexities become quite challenging and formidable. The project I was working on in 2011 employed 43,000 people from 56 countries who spoke 32 different languages.

Miscellaneous Issues of Interest to Those New to the Middle East

Although some contractors have been doing construction projects in the Middle East for a long time, it is normal that a significant portion of the project personnel being sent to execute a contractor's newest megaproject in the Middle East do not have previous experience in that region of the world. During my stay in the Middle East, various risk elements were noted that would likely not be readily considered by contractors and their employees who are unfamiliar with the local laws, rules, and customs. Below is a discussion on decennial liability, sponsorship, privilege in alternative dispute resolution, and climate and heat-related issues.

Decennial Liability

Decennial liability is a legal remedy that various European and Middle Eastern nations have enacted to deal with defects found in structures that occur during the first 10 years of the structure's existence. The origin of this remedy is found in the French civil code, and variations have been adopted by Belgium, Bolivia, Brazil, Cameroon, Chile, Egypt, Indonesia, Italy, Kuwait, the U.S. state of Louisiana, Malta, Morocco, Oman, Paraguay, Peru, Philippines, Qatar, Romania, Spain, Sweden, Syria, Tunisia, and the UAE.

Decennial Liability Example—Qatar Civil Code

The Qatar Civil Code enacted, with Law No. 22 in 2004, a decennial liability responsibility for contractors and engineers. It provides in Article 711 as follows:

Article (711)

1. The contractor and the engineer shall jointly guarantee the total or partial collapse or fault in the buildings they have erected or in the fixed constructions they have constructed, even if the collapse or the fault has resulted from a defect in the land itself, or the employer has approved the defective buildings or constructions, and this guarantee shall cover whatever defects shall appear in the buildings or constructions which threaten its sturdiness and safety.

2. If the two contracting parties have intended for the building or constructions to remain for the period less than ten years, the guarantee shall apply for the lesser period, and the period shall commence in all situations from the date on which the work has been received.

3. The provisions of this article shall not apply to the right of recourse which the contractor shall have against the subcontractors.

Additionally, Article 715 voids any contrary agreement that would exclude this decennial liability. It provides as follows:

Article (715)

1. Any condition intended to exempt the engineer or the contractor or to limit their liability shall be void.

Essentially, the Qatar Civil Code provides a no-fault remedy to an employer requiring both contractors and engineers to "guarantee" their work for 10 years. A finding of negligence in determining fault is not required. However, this obligation lapses according to Article 714 if not acted upon within three years of the collapse or discovery of the defect. The article provides as follows:

Article (714)

1. The guarantee referred to above shall lapse with the passage of three years from the time of the occurrence of the collapse or the discovery of the defect.

A troubling point is that there is no definition of what constitutes a defect that "threatens the sturdiness and safety" of a building. It is likely that disputes will occur over this point and that the courts will make this determination on an individual case basis.

Observations

Commentators have suggested that the decennial liability requirements fall outside the coverage of contractors' all-risk insurance policies and professional indemnity insurance. These conclusions would be proven by the fact that decennial insurance in countries such as France and Egypt is available where coverage is mandatory.

It would also appear that insurance coverage may be available in the Middle East. Coverage is estimated to be expensive, and it can reasonably be inferred that contractors and engineers are not likely to undertake decennial insurance coverage unless mandated by contract or law.

Finally, decennial liability statues have overruled the choice of law contract clauses formerly used to interpret contracts. Rather, the applicable law of the country where the site is located is applied in the case of conflicting contract requirements. Again, local civil code provisions would control.

Sponsorship

A sponsor is an individual or a group that provides support to an event, organization, or person within the host country. The sponsor may provide financial support, products, or services. We are familiar with the use of sponsors who pay entertainment and sports celebrities to endorse or in some fashion be spokespeople for their products or services. The trade organization International Sponsor Council (ISC) represents the interests of major corporate sponsors, such as AT&T, Coca-Cola Company, Honda, and MasterCard. The darker side of the sponsorship industry is that practices such as kickbacks, free tickets, hospitality suites, and other nontaxed benefits have occurred in the past and have created a negative perception of sponsorship.

In the Middle East, the local laws require that a citizen or citizens of the country in which the project is being built act as a sponsor by taking a majority shareholding with a foreign person, company, or entity in a limited-liability sponsored entity that is then established as a local joint venture company. As part of this process, the local sponsor and the company agree through a service agreement guaranteeing the following:

- Sponsor's share (if any) of the profits;
- Sponsor's capital contribution;
- Sponsor's role in running the business;
- Sponsor's capacity as a company representative for contract negotiations;
- Sponsor's salary or remuneration for services provided;
- Sponsor's level of assistance in business-related functions dealing with local government; and
- Sponsor's assistance in bringing local knowledge and networks to the company for business development purposes.

The use of sponsors in the Middle East is mandatory to comply with local law and contributes to successful business ventures. There are consulting companies who work with local sponsors and who regularly provide advice to companies in search of a sponsor. These services are fee based and are typically paid annually.

Privilege in Alternative Dispute Resolution

In non-GCC countries, alternative dispute resolution (ADR) is frequently used to resolve disputes before the matters reach litigation in the courts. ADR is often preferred because of many factors: speed, efficiency, cost, and provision of a private, not public, forum for argument. To further ensure confidentiality of the proceedings, the parties often enter into confidentiality agreements. Also available in the United States are protective orders issued by state and federal courts on a finding of good cause.

In the Middle East, ADR proceedings and the matters presented and stated therein are not privileged and thus can be used in a subsequent litigation. Accordingly, ADR participants must be aware that mediation and negotiation become complex. It is unclear whether a confidentiality agreement would remedy this situation.

Climate and Heat-Related Issues

The GCC has among the driest and hottest environmental conditions anywhere on earth. During the summer months of May through September, the daily temperatures exceed 40°C (104°F) consistently, and often the temperatures exceed 50°C (122°F) during the workday. Because these high temperatures pose a health hazard often referred to as "heat stress," many of the GCC nations require adjusted work hours during the months of June through September. For example, Qatar requires that project personnel are removed from the worksite during the hours of 11:00 a.m. to 3:00 p.m. When there are a significant number of workers on the site, this change in worker activity must be considered and well planned. Employers must be on constant alert to determine if the following conditions are observed and, if so, timely treated: dehydration, cramping, heat exhaustion, and heat stroke.

Summary

When a company (or an individual) agrees to work offshore from its home country, its technical expertise and experience will be tested. The company is a guest in a country that not only appears strange but also where ignorance of the country can place the company (or individual) in the path of risks that may not be included in the typical risk profile for megaprojects executed in its home country. Differences range from the purely physical (such as the heat), to the contractual, to the cultural and can and often do affect the company's (or individual's) ability to execute its roles in the megaproject to achieve the goals established for the megaproject. Expect the Middle East to challenge your company and your expatriate employees in many ways. It is my experience that the lure of financial rewards has enticed and will continue to entice contractors to take on these challenges.

It would be impossible in a single book to identify all of the risk elements that confront a company or individual working in the Middle East. This chapter presents simply a sample of various categories of risk elements about which one must be sensitive when attempting to work in the Middle East, or anywhere else in the world that is not "home." That is not to say that the risks are any greater, but those risks will often be different or carry a different effect than those with which one may be familiar at home. The first rule is to learn about those risks. The second rule is to learn how your host country expects you to react and respond to those risks. The final rule is to allow any Middle East experience to enrich your understanding of this place.

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Megaprojects in the São Paulo Metropolitan Region

Cláudio Dall'Acqua and
André Steagall Gertsenchtein

Since the second half of the twentieth century, São Paulo's growth has been intense. One of the more significant indicators of this growth is its population, which jumped from a little less than 3.8 million inhabitants in 1960 to 11 million in 2008 (Fig. 14-1).

In addition to this population increase, it is evident that there has also been a large increase in the vehicular traffic fleet, together with greater soil occupation (additional roads and buildings), which resulted in greater soil waterproofing (less ground absorption of water). Such growth has brought both floods and heavy traffic into the living routine of the inhabitants in and around São Paulo.

The excessive soil waterproofing, which in turn is the outcome of excessive occupation, has resulted in greater rainwater surface runoff volume and speed. The

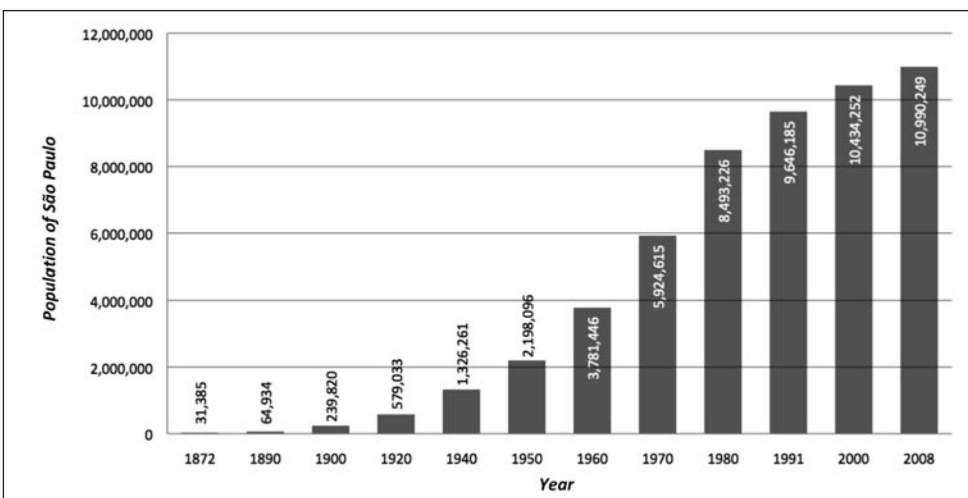

Fig. 14-1. Population of the city of São Paulo from 1872 to 2008

Source: São Paulo Prefecture (2000).

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LESSONS LEARNED

1. Some megaprojects are driven by necessity, regardless of the challenges posed or the risks faced.
2. Some needs are so large, and the responses to those needs so complex, that to resolve them requires a program of interrelated megaprojects, all with a common purpose, but each of which in its own right is a megaproject.
3. It is possible to develop, execute, and coordinate a series of megaprojects under a well-conceived and -planned program that has at its heart a common goal and purpose.
4. With proper planning, it is possible to execute infrastructure megaprojects in densely populated cities while minimizing the risks to the residents of that city.
5. Even megaprojects that are in part targeted at improving or correcting environmental problems have their own environmental impact risks, which must be addressed.
6. One element of any megaproject that has to be addressed is the effect on those who live or work within the footprint of the megaproject. Those effects cannot simply be ignored, and resolution of those effects must be included in the planning and execution of the megaproject.
7. On megaprojects, addressing long-term environmental issues must outweigh the immediate cost or complexity of the megaproject.

concentration time of the watershed basins possessing high waterproofing rates tends to decrease, creating larger surface water flows in the bodies of water that receive the entire runoff (specifically in the case of the Tietê River).

On warm days, the excessive soil waterproofing also generates air masses next to the surface, which are heated by radiation, rise quickly at a specific time of the day (through convection), and are briskly cooled when they reach colder masses, resulting in rainfalls that come in large volumes in a short period of time. They are the "summer rains," which are common in São Paulo during January and February.

Because of these events, the Tietê River channel, which drains a large portion of the surface water runoff coming from rainfalls in São Paulo, does not have sufficient capacity to carry its storm overflows in addition to its regular flows, often flooding the riverside highways and neighboring areas.

This flooding results in huge damage to residential and commercial communities, as well as adding to São Paulo's traffic, which is already overburdened on the best of days. On flood days, traffic jams can stretch as long as 250 km (155 mi).

With the purpose of addressing both growth-related effects—floods and jammed traffic—the government of the state of São Paulo conceived and carried out two megaprojects: lowering the Tietê River channel and carrying out the south segment of the Metropolitan Highway Belt.

The Lowering Project of the Tietê River Channel

The Brazilian Tietê River is 1,150 km (714 mi) long and crosses the entire state of São Paulo as well as running through the city of São Paulo, the state's capital.

The Tietê originates in Salesópolis, at the Serra do Mar, at an altitude of 1,120 m (695 mi). Although just 22 km (13 mi) away from São Paulo, the steep slopes of the Serra do Mar area force the Tietê River to run inland from the coast, crossing the state of São Paulo from southeast to northwest in its course until it discharges into a reservoir formed by the Jupiá Dam in the Paraná River in the municipality of Três Lagoas, about 50 km (31 mi) downstream of the town of Pereira Barreto.

Along its banks are the so-called *marginais*, the riverside highways that are vitally important to the passage of passenger and commercial vehicles in the state of São Paulo. Also, because of São Paulo's high soil waterproofing, the Tietê River receives more instantaneous water during the heavy rain season in the summer months.

São Paulo, which is affected most heavily by the floods, had more than 14,000 km (8,699 mi) of paved streets carrying an estimated 965,000 vehicles in the 1970s; 40 years later, there are 17,300 km (10,749 mi) of paved streets, carrying an estimated 6 million vehicles. The amount is increasing rapidly, with about 200 km (124 mi) of new streets and avenues built every year, further increasing the soil waterproofing. The capital city shows yet another contributing characteristic: A population density of a little less than 4 m^2 (13 ft^2) of green area per inhabitant (the United Nations recommends at least 12 m^2 of green area per inhabitant—39 ft^2). The lack of green areas and the increasing soil waterproofing result in the almost immediate flooding of São Paulo when the summer rains fall.

The need for greater channel capacity within the Tietê River to move the floodwater was the main reason the government of the state of São Paulo carried out the first of the two megaprojects addressed in this chapter: lowering and widening the Tietê River channel.

The purpose of the megaproject was to lower the river channel by about 2.5 m (8 ft) and to widen the river channel at certain locations, thus very much increasing its flow capacity. The megaproject was divided into two phases, the first one outside the urban region of the Município de São Paulo (the São Paulo county area), and the second one inside it.

During the first stage, which was concluded in 2000, the channel was deepened by 2.5 m (8 ft) on average, increasing the flow capacity of the Tietê River from 700 to 1,180 m^3 (2,296 to 3,871 ft^3) near the Cebolão (an important traffic intersection) and from 840 to 1,440 m^3 (2,755 to 4,724 ft^3) near the Edgard de Souza Dam. This part of the project covered 16 km (9 mi) of the Tietê River between the Cebolão intersection and the beginning of the impoundment lake of the Edgard de Souza Dam. During this portion of the project, more than 4 million m^3 (13 million ft^3) of rock and silt were removed.

The purpose of the second phase of this project was, again, lowering the Tietê River channel about 2.5 m (8 ft), but this time from the Penha Dam to the Cebolão intersection, a distance of 24.5 km (15 mi), effectively doubling the flow capacity of the river.

The Phase II works were carried out from 2002 to 2006 and brought a significant increase in flow capacity and flood reduction to the Tietê River channel (Figs. 14-2 and 14-3).

- The main Phase II characteristics were as follows:
- Beginning date: April 10, 2002;
- Ending date: March 18, 2006;
- Channel length: 24.5 km (15 mi);
- Number of lots of the work: 4;
- Soil excavation: 6 million m^3 (19.6 million ft^3);
- Rock excavation: 800,000 m^3 (2.6 million ft^3);
- Retaining wall length: 15 km (9 mi);
- Concrete: 100,000 m^3 (328,000 ft^3);
- Tie rods: 21,120 m (69,291 ft);
- Mechanical equipment: 220 tons;

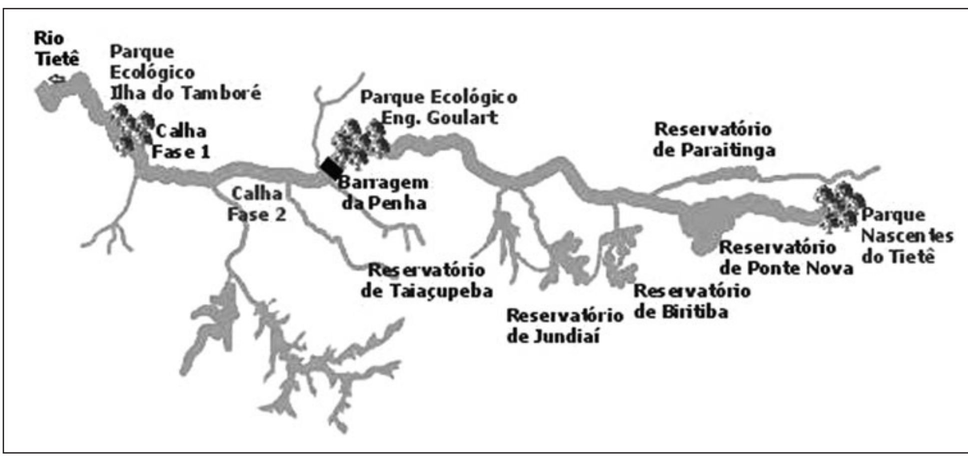

Fig. 14-2. Location of Phases I and II

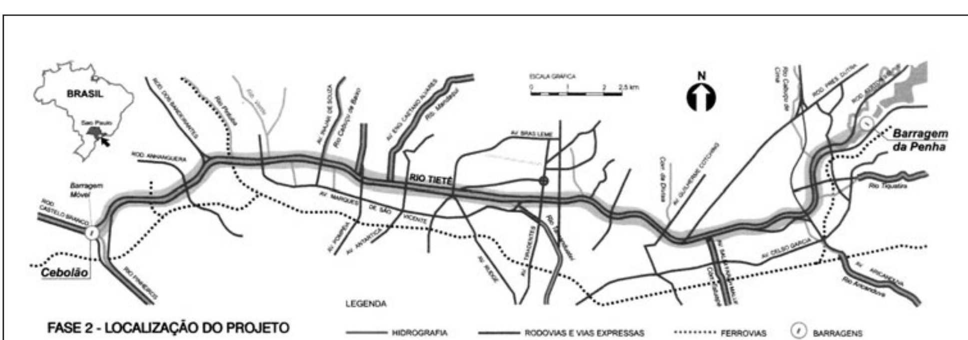

Fig. 14-3. Detailing of the location of Phase II with interferences

- Number of discharge tributary streams: 66;
- Number of galleries and culverts: 600;
- Bottom discharger: 1;
- Navigation locks: 1;
- Tires: removed 100,000 units of the predicted total of 120,000 units;
- Capybaras (a semiaquatic rodent) removed: around 40; and
- Design volumes: final volume of the total excavation exceeded 9 million m^3 (29.5 million ft^3) (DAEE 2009).

The construction of the navigation lock under the Cebolão intersection is also part of Phase II. The navigation lock will make the Tietê River navigable from this point all the way to the Penha Dam.

Difficulties in Phase II

The execution of the work in Phase II was much more complex than that in Phase I because of the quantity of bridges, water mains, water and sewage piping, electric power, and telephone and tapped gas lines. But the largest issues were caused by complications introduced by the presence of the busy riverside highways and the presence of urban and commercial communities close to excavation blasting.

To blast the rocks, it was necessary to use explosives. Of course, the caution demanded by the use of explosives in an urban area was extraordinary, but the additional time and cost were justified. All the inspections and monitoring were effective, and the outcome was exceptional: No adverse incidents were reported as a result of the blasting.

The design required precautionary inspections on a strip of land 250 m (820 ft) wide on both sides of the river. It also required the use of three geophones to measure the effect of the vibrations on the buildings and the subsoil. Measurements were also made of the pressure waves carried through the air as a result of the blasting. The difficulties were made much worse by the existence of large areas where the Tietê River meanders (before straightening). Also, the composition of the soils (mostly residual or alluvial soil) is effective at transmitting the vibrations caused by blasting.

The logistics of removing and transporting almost 9 million tons of materials from the riverbed to a landfill are also worth mentioning. This material was transported in barges on the river itself and discharged at unloading ports, then trucked from the ports to a controlled sanitary landfill. If the fill was contaminated, river sediment was carried to a pool for remediation and then carried to the neighboring municipality of Carapicuíba, where the clean fill was used to build a park.

As noted above, in addition to deepening the channel, the other purpose of this project was to broaden the channel from 20 m to up to 46 m (65 to 150 ft) in some places, creating an inundation, or side channel area (as shown in Figs. 14-4 and 14-5) capable of absorbing all the additional flows introduced during heavy rain days.

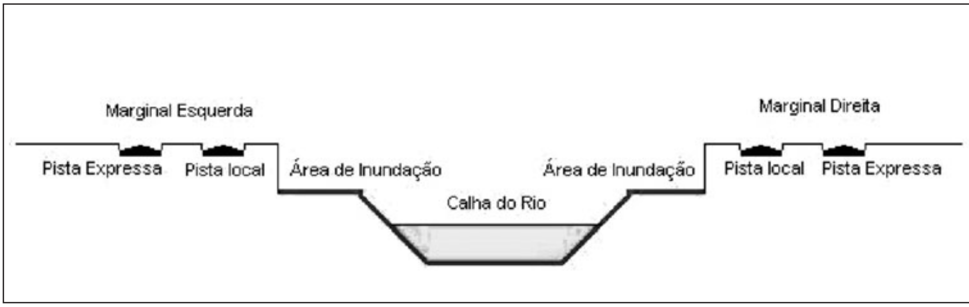

Fig. 14-4. Channel of the Tietê River working with a normal regime

Source: Wikipedia, http://pt.wikipedia.org/wiki/Ficheiro:Tiete_Transversal_normal.svg; reproduced with permission from Andre v.

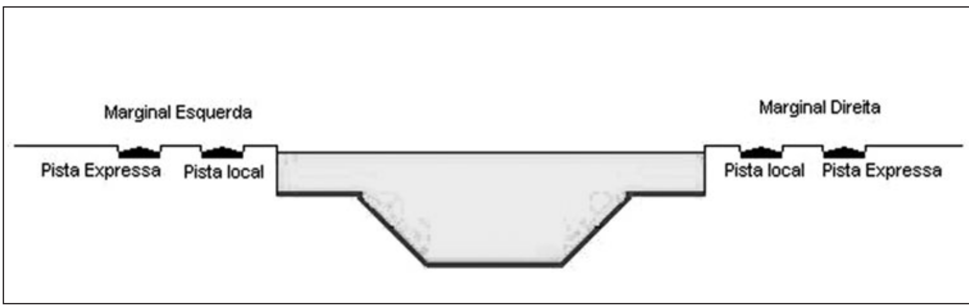

Fig. 14-5. Channel of the Tietê River working with a flood regime

Source: Wikipedia, http://pt.wikipedia.org/wiki/Ficheiro:Tiete_Transversal_cheia.svg; reproduced with permission from Andre v.

Project Results

The Tietê River channel lowering project is part of a broader project, which encompasses the construction of several flood absorption or sidestream reservoirs (called *piscinões*, big swimming pools) to handle the increase in the amount of sewage collection and treatment in the Município de São Paulo. Today, 90% of the generated sewage is collected, and 63% of it is treated—higher treatment rates than those in Spain. The result of the channel lowering increased the channel flow capacity from 640 m^3/s to 1,048 m^3/s under the Cebolão intersection (road junction of the *marginais* with the Castelo Branco Highway).

The success of the finished project (Fig. 14-6) depends, however, on more than the completion of the megaproject. For example, the citizens of São Paulo must become aware that they need to reduce the waste abandoned on city streets because it ends up transported by floodwaters into the waterway, which then provokes silting (the accumulation of solid residues) at the bottom of the river. Through contracts with the private sector, Departamento de Águas e Energia Elétrica (DAEE—the Department of Water and Electricity) removes approximately 32,000 m^3 (104,000 ft^3) of channel residue every month. The river receives a daily polluting sediment load of more than 1.1 thousand tons of organic matter and 300 tons of solid residues.

It is also important to finalize the plan to construct the aforementioned sidestream reservoirs (*piscinões*) along the tributary streams of the Tietê River to reduce the concentration time in the Tietê River basin.

Even though there was some flooding in the Tietê River in 2009 and 2010 (because of the abnormally intense rainfalls caused by the "El Niño" phenomenon), there remained no doubt that the lowering of the channel was a big success. Without the increase of the channel flow capacity, the quantity and frequency of the flooding would have been much greater.

Fig. 14-6. Tietê River Channel after Phase II Works—Urban Segment

Source: Departamento de Águas e Energia Elétrica

The Mário Covas Beltway

The second megaproject discussed is the "Mário Covas Beltway" (Rodoanel Mário Covas)—in honor of São Paulo's former mayor and state governor Mário Covas, who died in 2001. São Paulo has been suffering from traffic jams for many years. Almost all of its highways come to the metropolis via the riverside highways, the Marginais Pinheiros and the Marginais Tietê. All the cargo traffic that circulates through the metropolis, even if its final destination is not São Paulo, used to come and go through these riverside highways. In addition, the roads must carry the light vehicles (up to 3 tons) of the Município de São Paulo, which reached 6 million vehicles in 2009.

The government of the state of São Paulo decided to design an ambitious peripheral highway belt to remove the heavy truck traffic from the riverside highways. The new truck highways were designed to interconnect with the highways that arrive in São Paulo. The total length of the beltway will be more than 170 km (105 mi) when it is concluded. The west segment, a privately managed toll road, has been in operation since 2002, and the south segment opened in 2010.

West segment—On October 14, 2002, the government of the state of São Paulo opened the west segment of the 32-km (19-mi)-long highway belt interconnecting the Raposo Tavares, Castello Branco, Anhanguera, Bandeirantes, and Régis Bittencourt highways, a system of roads with a daily traffic of about 240,000 vehicles.

The primary purpose of the west segment of the highway belt is to divert the traffic traveling through São Paulo bound for the port of Santos but not stopping in São Paulo. Besides the south segment (discussed below), east and north segments are expected to be completed by 2014.

South segment—The south segment crosses large environmental preserves, and the permitting process required long discussions with residents and environmental groups about how best to mitigate the effects of placing a major freeway through such an area. On February 24, 2006, after more than five years of discussions, the Secretaria Estadual de Meio Ambiente—the Brazilian state agency for the environment—granted a preliminary environmental permit to begin the works. On May 28, 2007, more than two years later, the work on the south segment was actually started. Fig. 14-7 shows the work in the south segment for the Rodoanel Mário Covas. The total length of all the segments is 57 km (35 mi), not counting the 4.4-km (2.7-mi)-long interconnection with the Avenida Papa João XXIII, which will bring the total to 61.4 km (38.15 mi). With an initial cost estimate of R$3 billion (approximately US$1.64 billion), the amount will in fact reach R$4.18 billion (approximately US$2.28 billion) because of land expropriations, human resettlement, and the environmental mitigation measures required by the environmental permit. The south segment roadways will be 52.1 km (32.3 mi) long, and the bridges and viaducts will be 9.3 km (5.7 mi) long. Some 41.7 km (25.9 mi) of roadway will be in flexible pavement (asphalt), and the remaining 19.7 km (12.2 mi) in rigid pavement (concrete).

Fig. 14-7. Works of the South Segment of the Rodoanel Mário Covas

Source: Leonardo Andrade/Portal Transporta Brasil, http://www.transportabrasil.com.br/2008/10/lote-5-rodoanel/

The agency of the government of the state of São Paulo responsible for contracting the works is DERSA (Desenvolvimento Rodoviário SA), the state highway agency. Funds to carry out the works come from the Brazilian federal government (33%) and the government of the state of São Paulo (67%). The south segment was opened in mid-April 2010 (its planned date was March 2010).

The environmental issue of the south segment—The proposed environmental impact mitigation actions for the south segment of the rodoanel were arranged in environmental programs. Doing so allowed for the implementation and management of the mitigation plan throughout three planning stages: project preconstruction, construction, and operation.

Twenty-six separate environmental programs were included, 5 of which applied to the preconstruction stage, 13 for the construction stage, and 8 for the highway operation stage. These programs do not necessarily terminate at the stages they are linked to, but they can be extended further into one or more stages. The 26 environmental programs incorporate 109 separate measures: 35 at the preconstruction stage, 47 at the construction stage, and 27 at the operation stage.

According to the original EIA/RIMA (the environmental impact assessment/Relatório de Impacto Ambiental, or environmental impact report), the cost of implementing the environmental programs would be R$190 million (approximately US$103 million), though it is estimated today that it will cost R$500 million (approximately US$273 million).

Among the environmental compensation measures proposed, the Programa de Criação e Apoio a Unidades de Conservação (the support program for the conservation areas) stands out. The program oversees the creation of four conservation units in the São Paulo county area and the implementation of the environmental management plan of the Pedroso Municipal Natural Park in Santo André. Funds for the operation will be allocated to support land regularization[1] and the implementation of the management plan of the Fontes do Ipiranga and Serra do Mar state parks (São Bernardo). It was determined that the total altered or damaged area, estimated to be 212 hectares, should be compensated by a factor of five through additional conservation and planting in other regions. DERSA will constantly monitor noise and air quality in the areas near the south segment to ensure compliance with program standards. During the actual construction, a team of 250 technicians was responsible for monitoring the environmental impacts of the project.

Highway interconnections—The south segment of the rodoanel will connect with the Anchieta and Imigrantes highways, both of which connect São Paulo to the coastline of the state and the port of Santos. The Regis Bittencourt Highway, which connects São Paulo to the south of Brazil, will also connect with the south segment. The rodoanel will also provide the interconnection of the other highways that are already connected to the west segment: Raposo Tavares and Castello Branco, both of which connect São Paulo to the western portion of the state, and the Bandeirantes and Anhanguera highways, which connect São Paulo to the north of the state.

Expropriations—The sheer size of the south segment of the rodoanel meant that DERSA was required to relocate many people. The total displacement area was close to 11.34 million m^2 (37.2 million ft^2). The government of the state of São Paulo established a housing program consisting of 714 units to lodge those displaced families. In addition, another 803 families received reimbursement in cash.

Alignment—The alignment and design of the south segment meant that the construction would use bridging as opposed to using cut and fill processes to minimize effects on the conservation areas. Although this method is more expensive, this design results in shortened construction times, as well as decreased environmental impact. Additionally, the project supports 132 works of art, one of which is part of a 1,775-m-long bridge (1.1 mi) (with a center clear span of 107 m—351 ft), crossing the Billings Dam.

Some interesting metrics for the south segment of the rodoanel: The construction of the south section

- Employed 41,000 workers;
- Poured 800,000 m^3 (2.6 million ft^3) of concrete, the equivalent of 266 21-story buildings;
- Used 50,000 tons of steel;
- Displaced 3,500 households;
- Constructed two 1,755-m (5,757-ft), 32-pillar viaducts over the Billings Dam;
- Built 40 piles, 45 m (147 ft) high and 90 cm (35 in.) in diameter;

1 "Land regularization" is a process by which the government legally verifies who owns the physical area in question. It establishes the person, company, or organization that has the legal certificate of property over the land area through which the roadway will pass. This process is necessary for the consolidation of property rights, warranting the expropriation rights for the owner, and is the first step in assuming the land for public use.

- Used 832 precast girder sections weighing 90 tons apiece, which were transported to the site by ferry and then hoisted 20 m (65 ft) using hydraulic jacks; and
- Moved more than 60 million m^3 (196 million ft^3) of earth.

Concession to private initiative—On January 20, 2010, the government of the state of São Paulo released the concession model for the operation of the south segment of the highway belt once the works are concluded. It is expected that the toll booths of the south segment will collect R$2 million (approximately US$1.1 million) per day, or R$26.8 billion (approximately US$26.8 billion) over the 35 years of the concession period. The object of the concession will be not only the operation of the south segment but also the construction and operation (under a Build–Operate–Transfer agreement) of the 43.5-km (27-mile)-long east segment, which will interconnect the south segment of the highway belt to the Presidente Dutra Highway (which connects São Paulo to the east and subsequently to Rio de Janeiro). It is expected that the east segment will cost approximately R$5 billion (US$2.7 billion).

Effect on traffic—The opening of the south segment of the rodoanel should reduce the traffic of heavy vehicles (or vehicles in excess of 3 tons) on the Marginal Pinheiros by 43% and reduce the heavy truck load on the Avenida dos Bandeirantes by 37%, two important thoroughfares in São Paulo. This improvement will bring about positive consequences to the entire road network of the capital city.

Summary

The two megaprojects described in this chapter are considered highly complex, both from an engineering point of view and because they are located in one of the largest metropolitan regions in the world. That factor alone demanded close attention to all aspects of city planning, political realities, social questions, and environmental impacts, as well as effects related to road traffic during the execution of the works.

Estimates show that after both megaprojects are concluded, São Paulo drivers will spend 25 million hours less time per year in traffic jams, greatly reducing fuel consumption (about R$260 million, or US$142 million, per year) and contributing in a significant way to reducing atmospheric pollution, improving the air quality from before the project began by an estimated 6% (accounting for CO, CO_2, and NO).

Given both the financial and human resources required to plan and execute these megaprojects, the decision to undertake them was neither simple nor quick. In addition to the normal risks faced during any construction project, the risks facing the megaprojects described above included technical, political, social, and environmental risk elements that all had to be addressed during the planning and execution of the megaprojects. However, the risks that have been overcome and the results already achieved in executing these megaprojects demonstrate the ability of a dedicated, innovative, and responsible engineering and construction team committed to preserving the environment and managing the physical, financial, and human aspects of a megaproject in one of the most densely populated cities on earth. The successful completion of these megaprojects will provide for the positive economic development of São Paulo, provide for the benefit of her citizens, and provide an ethical framework for the construction of other megaprojects throughout Brazil in the future.

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CHAPTER 15

Megaprojects in Asia in the 21st Century

Shunji Kusayanagi and Rajendra Niraula

One of the multinational megaprojects being carried out under an engineering, procurement, and construction (EPC) contract actually is intended to link Asia and Europe: The project is the Bosphorus Crossing railroad tunnel. The planning and basic design team for this project includes Japanese and Turkish consulting groups, and a Japanese and Turkish contractors' consortium is operating as the EPC contractor. This project requires quite a high level of technology for design and construction. This megaproject represents the fact that, moving into the 21st century, Asia remains actively involved in the execution of megaprojects both at home and globally.

Asia made great economic development in the last 20 years of the 20th century, and the area continues to develop into the 21st century. Asia was the most active area in the world in the mid-2000s, despite the global downturn in the economy experienced near this time.

Needless to say, without proper development of infrastructure, a country cannot be developed. Japan has been acting as the leader of economic development in Asia since the middle of the 20th century. In the 1950s, it was one of the least developed countries based on the gross domestic product (GDP) per capita in the world, but it made remarkable progress in development from the 1960s through the 1980s. During that time, the Japanese construction industry developed many construction technologies. Those technologies have been expanded and transferred to other Asian countries through commercial activities that were often assisted by the Japanese ODA (Official Development Assistance) program.

The Bosphorus Crossing railroad tunnel is just one example of megaprojects in Asia that are being carried out with the construction technologies created by the Japanese construction industry. Indeed, most megaprojects in Asia have been built with construction technologies developed by the Japanese construction industry. But nowadays other Asian countries, such as Korea, Taiwan, and China, are catching up with the current levels of the Japanese construction industry.

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LESSONS LEARNED

1. Asia continues to be the most active construction area of the world, despite the global economic conditions in the mid-2000s.
2. In the second half of the 20th century, Asia focused on the creation of construction technologies necessary to build needed infrastructure megaprojects in Asia.
3. Many of the world's largest and most innovative infrastructure megaprojects are being executed in Asia.
4. Even domestic megaprojects can be influenced by international political and economic conditions that are outside of a particular country or region of the world.
5. Into the 21st century, Asia has moved the use of the technologies created from a primarily domestic market to the global megaproject market.
6. Although Asian advanced construction technologies moved well to the global market, the Asian construction industry has been less successful in managing and controlling cost performance on megaprojects. This problem has affected the industry's ability to establish its overall competence in the international megaproject market.
7. The most difficult issues working outside of Asia involve social and cultural issues, not technical construction issues. Such social and cultural issues must be included in the megaproject planning phase of the project.
8. The biggest challenge now facing Asia in the 2010s is to improve project and construction management efficiency and contract administration to complement the advances made in construction technology.
9. Moving into the 21st century, Asia will continue to be actively involved in the execution of megaprojects at home and globally.

There are now many big infrastructure projects under construction in Asia, and the challenge before us is how to find the best construction technology that will be required for the execution of megaprojects. The execution of megaprojects requires not only advanced pure construction technologies but also advanced project management technologies as well.

Because the size of infrastructure projects is getting bigger and the content of the projects is getting more complicated, the risk effects are going to be bigger. This chapter introduces some megaprojects and the movement of project management technology development in Asia.

Infrastructure Development Projects in Asia

Contemporary Situation in Asian Countries

The history of GDP of the six major economic regions in the world is shown in Fig. 15-1. As shown in the figure, the three regions that are making the greatest contribution to the economic development in the world are the European Union (EU27), the North American Free Trade Agreement countries (NAFTA), and the Association of Southeast Asian Nations (ASEAN) countries plus China, India, Japan, South Korea, Australia, and New Zealand (ASEAN+6). Most interesting is the upward movement of the ASEAN+6 from 2000 on. This region has a much higher percentage of the economic development than the other two regions.

The history of population increases in the regions is shown in Fig. 15-2. ASEAN +6 has not only the biggest population but also the biggest population increase compared with the other groups of countries. Two countries, China and India, are the

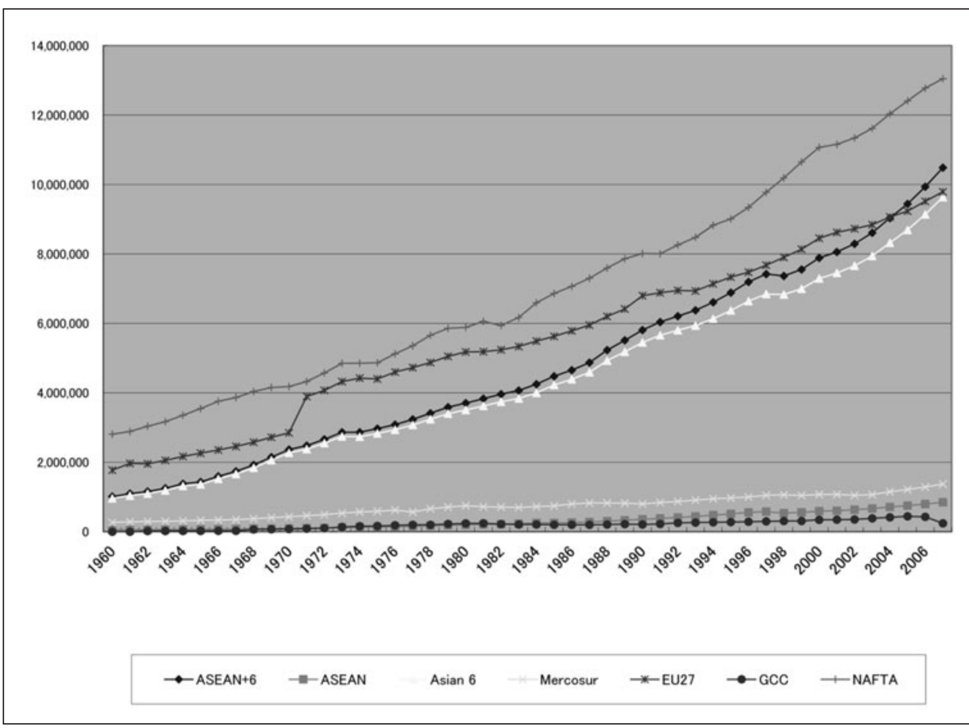

Fig. 15-1. History of GDP of the six regions in the world

Note: ASEAN includes Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. ASEAN+6 consists of the ASEAN countries plus China, India, Japan, Korea, Australia, and New Zealand. Asian 6 includes China, India, Japan, Korea, Australia, and New Zealand. Mercosur includes Argentina, Brazil, Paraguay, Uruguay, and Venezuela. GCC includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. NAFTA includes Canada, Mexico, and the United States.

Source: Data from World Development Indicators 2008.

major contributors to that growth in population. ASEAN also has a larger population, as reflected in Fig. 15-2.

It is necessary to go into more details about the economic activities in the region of ASEAN+6. Fig. 15-3 shows the history of GDP of countries in the region. Although the new leaders in Asia, such as Korea, China, and India, are producing a larger amount of GDP than in the 1990s, from the 1960s and up to the middle of the 1990s, the majority of the share of total GDP created in this region was created by Japan. Japan has long been a prime mover in Asia in terms of total economic development.

After World War II, the Japanese construction industry, like other Japanese industries, was spending a great deal of effort to create practical and effective construction technologies for infrastructure development in Asia. Those technologies were transferred and expanded into other countries in Asia as Japanese involvement in megaprojects in the region grew. The first step for transferring and expanding advanced construction technologies from Japan to other Asian countries was through the reconstruction of infrastructure projects destroyed in the war. Actually, you can see many kinds of advanced construction technologies now applied to megaprojects in Asian countries. The Bosphorus Crossing railroad tunnel project is one of the many examples of megaprojects that use the sophisticated and advanced design and construction technologies now common in Asia. The details of this project are introduced later in this chapter.

Future Infrastructure Development in Asia

Needless to say, proper infrastructure development is the most essential element of economic development. According to our study, the total amount of construction investment in Asia is more than US$2 trillion per year, almost twice as much as in the NAFTA countries.

One of the many megaprojects that are now planned in Asia is the high-speed maglev train that will run between Tokyo and Osaka in Japan. The construction cost of this project is assumed to be US$111.4 billion. China, India, and Vietnam are also planning to build new high-speed railways, and Indonesia has already committed to build a subway in Jakarta. Asia is the most exciting area for infrastructure development in the world now, and this situation is sure to continue through this century as well.

The problem is how to develop and equip the project owners and contractors with the proper project management technologies in this region. In future movement of infrastructure development to other less developed countries in Asia, modern technologies will come to those countries. Fig. 15-4 shows the history of population increase in the ASEAN+6 countries. The size of the growth rate of China's and India's population is higher by far than other countries in the region. Judging from the two factors of GDP and population growth, it is certain that China and India will be the focus of infrastructure development in Asia for the near future.

Considering the future infrastructure development in this region, it is necessary to transfer to the new projects not only the pure construction technologies but also project management technologies as well. From this point of view, Korea and Taiwan also will have important roles to play in the development of infrastructure in China and India.

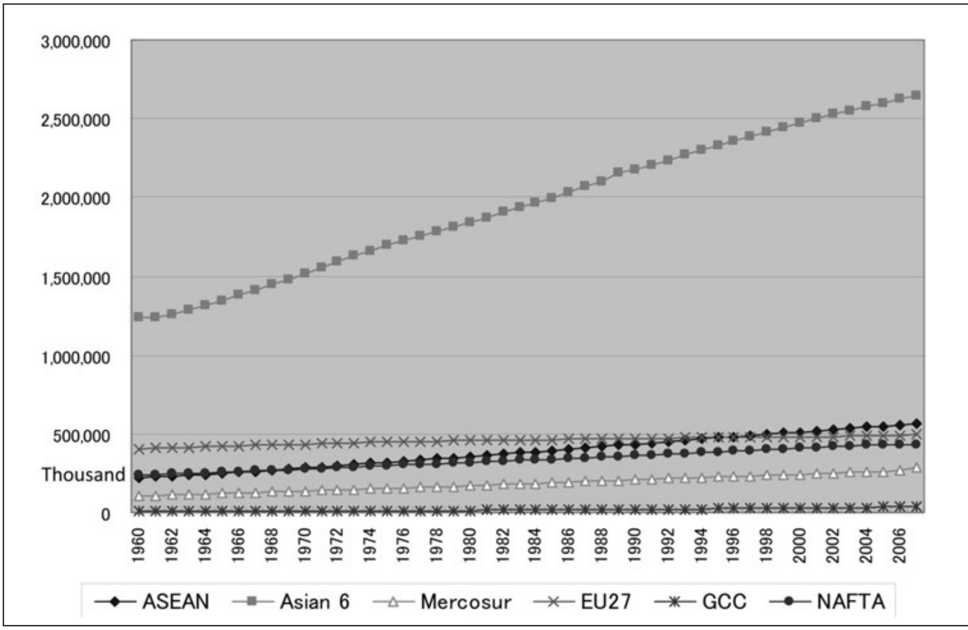

Fig. 15-2. History of population increase in regions

Source: Data from World Development Indicators (2008).

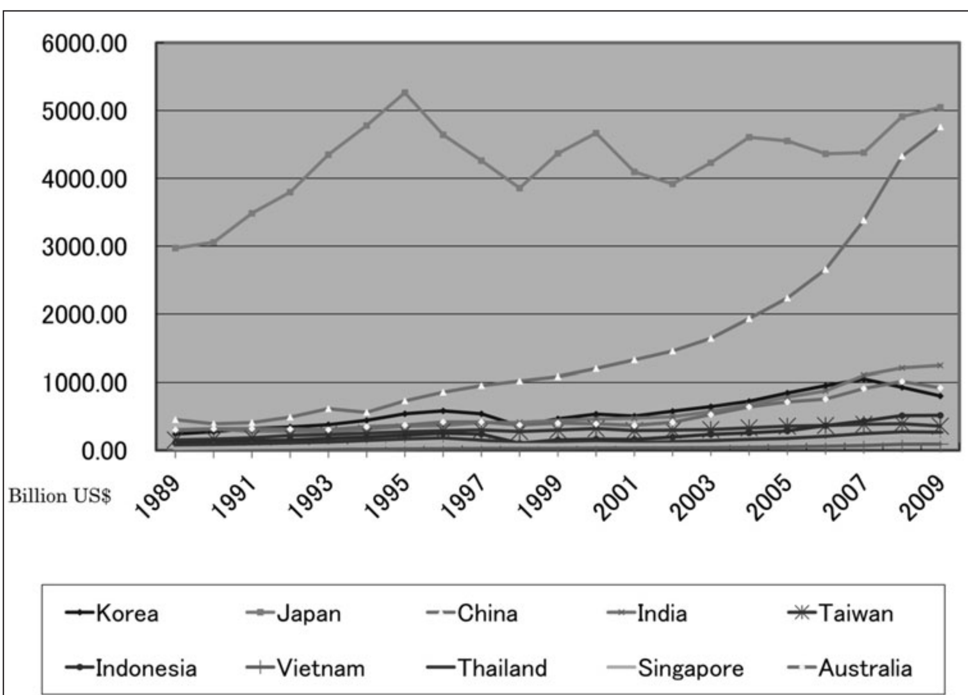

Fig. 15-3. History of GDP of main countries in ASEAN+6

Source: Data from World Development Indicators (2008).

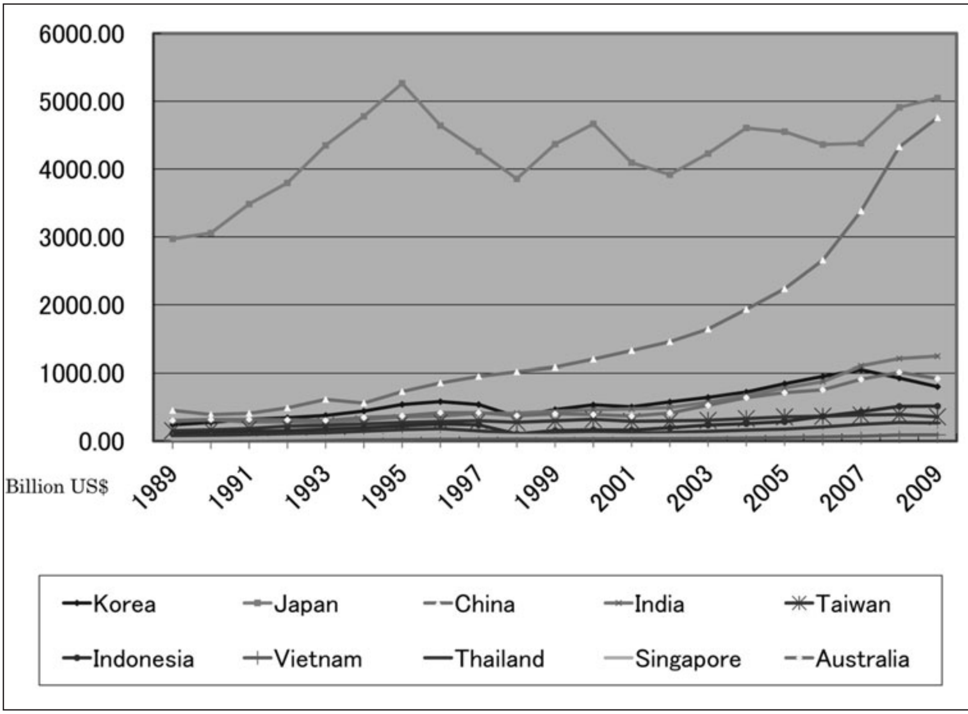

Fig. 15-4. History of population increase in ASEAN+6

Note: ASEAN includes Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. ASEAN+6 consists of the ASEAN countries plus China, India, Japan, Korea, Australia, and New Zealand.

Source: Data from U.S. Census Bureau (http://www.census.gov/ipc/www/idb/informationGateway.php), Population Statistics, the Netherlands (http://www.populstat.info/), and the World Economy, Japan (http://ecodb.net/country/MM/imf_persons.html).

Megaprojects and Gigaprojects in Asia

Taiwan High-Speed Rail

As pictured in Fig. 15-5, Taiwan High-Speed Rail (THSR) is a high-speed railway network, privately constructed under a build–operate–transfer (BOT) contract with the government of Taiwan. The THSR railway network is approximately 340 km (211 mi) long, and it connects the capital city, Taipei, and the second biggest city, Kaohsiung, in Taiwan. It runs along the west coast of Taiwan with a maximum speed of 300 km/h (186 mi/h). The THSR is based on the Japanese Shinkansen (bullet train) system, which originated in Japan in the early 1960s. The Ministry of Transportation, Taiwan's governmental transportation authority, started studying the feasibility of constructing this megaproject in 1990 but decided to execute the project under the BOT scheme in 1993. The Taiwan High Speed Rail Consortium

Fig. 15-5. (a) Taiwan High-Speed Rail; (b) map of service route

Source: (a) Wikipedia, http://en.wikipedia.org/wiki/File:Taiwan-HighSpeedRail-700T-testrun-2006-0624.jpg; (b) http://en.wikipedia.org/wiki/File:TaiwanHighSpeedRail_Route_en.gif

(THSRC) was selected as the special purpose company (SPC) in September 1997 for the construction of this project.

The original SPC plan presented to the government was based on the high-speed Eurotrain technology platform, but in December 2000 THSRC finally decided to select the Japanese Shinkansen system. The Japanese Shinkansen system had many advantages specific to the project. Most of the civil structures such as bridges, viaducts, and tunnels can be downsized, unlike the European systems of Train à Grande Vitesse (TGV) France and Intercity-Express Germany. The rolling stock of the Japanese Shinkansen system generates less inertia and has much higher resistance to the pressures that arise when the train is going through tunnels.

However, the civil works had already started in March 2000 before the system was shifted from the European system to the Shinkansen system. The THSR is using track maintenance devices manufactured in Germany, even though the rolling stock is based on the Shinkansen system.

The total cost of this gigaproject was estimated to be US$18 billion (2010 dollars). Operation of the system began in March 2007. In the case of a train composed of 10 cars, the Shinkansen trains can carry one and a half times more passengers than Intercity-Express Germany and 1.7 times more than TGV. Although the project has these advantages and the construction work was well managed, it is still difficult to say whether or not the operation is going well. The total accumulated loss up to 2009 is approximately US$2 billion—almost 66% of the yearly capital costs. This project may be one of the cases where a gigaproject had problems making decisions because of political issues.

Honshu–Sikoku Link Bridges in Japan

The Akashi-Kaikyo Bridge, as pictured in Fig. 15-6, spanning Akashi Strait (also known as the "Pearl Bridge") contains the longest center span of any suspension bridge in the world. The total length of this bridge is 3,910 m (2.4 mi), and it has a center span that is 1,991 m (1.23 mi) long. The bridge was opened in April 1998 at a total construction cost of approximately US$5 billion and is a part of the Honshu–Shikoku Highway, linking the city of Kobe on the main island of Honshu to Awaji Island. Awaji Island and Shikoku Island are connected by another bridge named the Onaruto Bridge. The preliminary planning and feasibility studies for the Akashi Strait Bridge were started in 1955 by the Japanese National Railways. The Ministry of Construction (now the Ministry of Land, Infrastructure and Transport) commenced the planning and investigation for building this bridge in 1959, and planning continued for about 10 years up through the late 1960s.

A special organization named the Honshu–Shikoku Bridge Authority was established in 1970 to oversee the execution of the project. Many kinds of trial construction methods were carried out in laboratories and at the bridge construction sites. The authority spent almost 20 years developing the basic design, investigating the site, and preparing the construction works. The original design of this bridge used double decks to accommodate both vehicles and rail traffic, but the plan was modified from two decks to one deck only for road use to reduce its cost. Many capable

Fig. 15-6. Akashi–Kaikyo Bridge

Source: Wikipedia, http://en.wikipedia.org/wiki/File:Akashi_Bridge.JPG.

engineers working in both the public and the private sector were hired by the bridge authority. The bridge construction works were started in May 1988, and it required another 10 years to complete the construction works. Late in the construction stage in 1997, a 7.3 magnitude earthquake occurred in this area. The epicenter of the earthquake was located just under the bridge, and the bridge span was expanded 1 m because of seabed movement. However, damage and problems to the bridge itself were not observed. Finally the bridge was opened in April 1998.

Three bridge connection routes were built in between Honshu and Shikoku Island. Akashi Strait Bridge is one of the key links known as the Akashi–Naruto link.

The Onaruto Bridge

There is another bridge at the south end of Awaji Island named the Onaruto Bridge, as pictured in Fig. 15-7. That bridge connects Awaji to Naruto on the northwest tip of Shikoku and contains a 1,629-m (approximately 1 mi)-long center span. Construction work on the Onaruto Bridge was started in July 1976, and the bridge was completed and opened in June 1985. This bridge was constructed with two decks, one for vehicles and the other for a railway, but only the upper deck is being used at this time. The lower deck was designed to use the Shinkansen high-speed railways and has not yet been used. Considering the design of the other bridges in the transportation system, it remains a mystery why the bridge authority did not change the design from two decks to one deck. The authority says that the rail deck will be used when either a commuter rail bridge or a tunnel is constructed between the mainland of Honshu and Awaji Island. Nobody knows when this may happen. In 1998, the total cost of this end of the Akashi–Naruto link was about US$15 billion.

Fig. 15-7. Onaruto Bridge

Source: Wikipedia, http://en.wikipedia.org/wiki/File:Big_Naruto_Bridge04n3872.jpg .

The other two links that are similar to the above links are the Sakaide–Kojima link (road and railway), which cost US$11.2 billion in 1988, and the Onomichi–Imabari link (road only), which cost US$6.9 billion in 1999. The Honshu–Shikoku Bridge Authority had been accumulating heavy debt since the start of its operation. The Japanese government decided to assume the authority's debt in May 2003.

The Tokyo Aqua Line

The Tokyo Bay link road named the Tokyo Bay Aqua-Line connects the city of Kawasaki in Kanagawa prefecture and the city of Kisarazu in Chiba prefecture. The link is 15.1 km (9.38 mi) in total length and consists of a complex of an undersea tunnel, an island, and a bridge. This link road was originally planned in 1966, but construction was started in July 1987. Before the construction work began, a special project execution organization named the Trans-Tokyo Bay Highway Corporation was established. The gigaproject was completed in March 1997, taking nine years and eight months to complete.

This gigaproject required the creation of many new kinds of construction technologies and eventually cost US$14.4 billion in 1997. For comparison, that amount is close to four times as much as the Øresund Bridge project that was built between Copenhagen in Denmark and Malmö in Sweden.

The Japanese capital city of Tokyo has two subsidiary cities, Yokohama and Chiba. The Tokyo Bay Aqua-Line was planned to reduce the volume of traffic between these two cities that flowed through downtown Tokyo, but its effect has not yet been as great as expected. The reason is the high toll rate. Because of increases in the construction cost, the toll rate had been set at ¥4,000 (approximately US$40) for normal-size sedan vehicles.

Though this gigaproject created and developed many kinds of new construction technologies that can be applied to projects not only in Japan but also in other countries in Asia (like the Bosphorus Crossing railroad tunnel), several questions arise if it is evaluated from the project management point of view.

The first question is why this road link does not have a commuter rail component. It takes about 1 h 30 min to travel by commuter train from Kisarazu station to Tokyo station, but from Yokohama station to Tokyo station, it takes about 30 min. It takes about 2 h from Kisarazu station to go to Haneda Airport, which is mainly used for domestic airlines. However, Yokohama station to Haneda Airport takes only 35 min. If the road link had a railway, it could make a loop line around the Tokyo Bay area, and the time from Kisarazu station to Tokyo station would be roughly 40 min and to Haneda Airport would be only 20 min. Moreover, it takes 1 h 30 min to go from Yokohama station to Narita Airport station, but it will be possible to commute from Kisarazu station to Narita Airport station in 50 min when the loop line is built. Kisarazu's city area will be convenient and will be one of the best areas to live for people who want to work in the capital of Tokyo.

Although the Tokyo Bay Aqua-Line has room for expansion from two to three lanes for vehicles, it does not have room for building a railway. People say that since the national railway was revitalized, discussion for the coordination of or codevelopment of roads and railways has been difficult.

The second question is why the Tokyo Bay Aqua-Line and Honshu–Sikoku link projects became so expensive. To have a better understanding of project expenditures, it is essential to analyze circumstances like the international political environment at the time when these megaprojects were executed. In 1985, negotiations on the trade imbalances between Japan and the United States started at the vice-ministerial level between Japan and the United States. The results of these negotiations were incorporated into the Structural Impediments Initiative (SII) beginning in 1989 and ending in 1993.

In these negotiations, the United States asked Japan to allocate 10% of total Japanese GDP to domestic infrastructure development projects. The Japanese government responded to the U.S. demand and expressed their willingness to allocate approximately US$4.3 trillion in equivalent yen to domestic infrastructure development projects over a 10-year period. The negotiation ended in 1994 with the final amount increased upward to about US$6 trillion in equivalent yen.

As already mentioned, the Trans-Tokyo Bay Highway Corporation was established in 1986; construction on the gigaproject started in 1987 and finished in 1997. The Akashi Bridge construction works were started in 1988 and completed in 1998. These gigaprojects also were executed under the high influence and pressure of huge geopolitical economic issues.

Although the Japanese construction industry had a proven ability to create advanced technologies in pure construction methodologies, the industry has shown less awareness about the issues of managing and controlling cost performance on gigaprojects. Consequently, the industry had a problem establishing its overall competence in the international market.

Seikan Undersea Tunnel

Tsugaru Channel is located between Honshu Island and Hokkaido Island. People who wished to travel to and from Hokkaido needed to use a ferry system to cross the channel between Hakodate and Aomori. However, it was not a safe trip because of frequent turbulent waters in the channel. In September 1954, a big typhoon hit the channel and five big ferries were sunk in the sea. One of them, the *Toyamaru,* was carrying more than 1,200 passengers, and most of them were killed, raising the total number of victims killed in the typhoon to 1,430 people. The people's desire to pass safely between the two islands was heightened by this disaster.

The plan to connect Hokkaido and the main island of Honshu by an undersea tunnel was conceived before World War II. This ferry accident occurred just nine years after the war ended, when Japan's culture and economy were still in chaos.

The Japan Railway Construction Corporation was founded in 1964, and the work related to the investigation of the inclined shaft on the Hokkaido side was started by the corporation. The corporation carried out the necessary preliminary planning and engineering along with the construction of the inclined shafts and the pilot tunnels by itself. It also had performed the preliminary engineering of the work tunnel before contracting with several groups of contractors for both the work tunnel and the main shaft tunnel.

Many difficulties and failures had to be overcome before the main shaft tunnel could be opened. In March 1985, the main shaft was opened and service was started in March 1988.

Fig. 15-8 shows the tunnel section profile. There are actually three tunnels: a pilot tunnel, a service tunnel, and the main rail tunnel. This tunnel is the longest tunnel in world; the total length of the tunnel is 53.85 km (33.5 mi), and its undersea portion is 23.3 km (14.5 mi). Incidentally, the total length of the Channel Tunnel

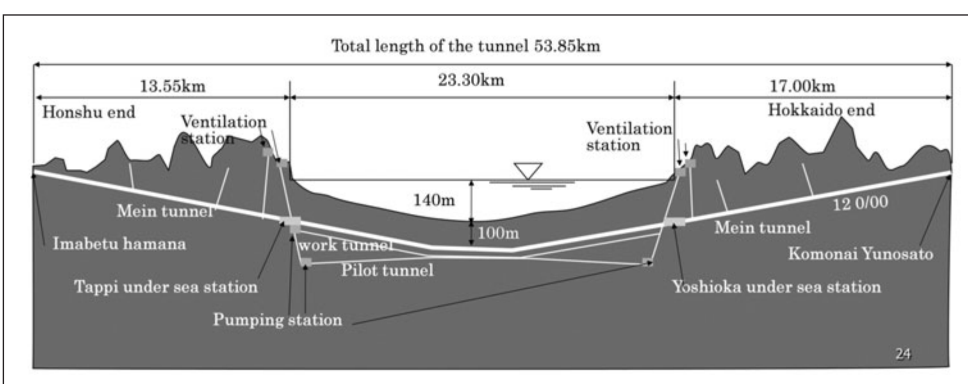

Fig. 15-8. Seikan Tunnel section profile

(between France and England), which opened in 1994, is 50.5 km (31.4 mi), and the undersea portion is 37.9 km (23.5 mi) long. The tunnel was designed to meet Shinkansen (bullet train) specifications, and the main tunnel gradients are approximately 1.2%, though Shinkansen trains do not use the railway at this time.

We found that the general conditions of contract used in the early 1960s were adopted for use for the Seikan Tunnel project. Up through 2012, the Japanese construction industry had just one type of contract in use for large projects like the Seikan Tunnel, and that contract was based on the lump-sum contract model. However, it was a surprise for us that the general conditions of contract that were used for the Seikan Tunnel project were based on what is referred to in Japan as a "remeasurement contract." We found that it was quite similar to the FIDIC general conditions of contract for civil works (often referred to as the *Red Book*), and it had incorporated reasonable conditions for price adjustments that had to be made through the term of the megaproject.

Although the tunnel's overall cost was US$6.9 billion in 1998, and despite the fact that the conversion to the Shinkansen train system has not yet happened, the function of this tunnel is justifiable if only for its ability to provide safe journeys for people.

We studied the Honshu–Sikoku Link, the Tokyo Bay Aqua-Line, and the Seikan undersea tunnel as typical megaprojects in Japan. We found that it is a common practice to execute megaprojects by establishing a special project execution body, like the Honshu–Shikoku Bridge Authority, the Trans-Tokyo Bay Highway Corporation, and the Japan Railway Construction Corporation.

These special-project organizations carry out preparatory engineering and research functions at the starting phase of the project, such as basic planning, financial arrangements, conceptual design, land acquisition, and geological exploration. They also perform trial construction programs to execute some initial parts of the proposed construction works to determine appropriate construction methods and schemes. During execution of these preliminary activities, project management attempts to discover any unforeseen conditions that exist and develops solutions to those problems. In other words, project execution organizations try to mitigate considerable risks before they hand a project over to the contractors. This method is currently used for constructing megaprojects in Japan, and it is the reason that megaprojects run smoothly and precisely in Japan. However effective the process may be from the pure construction point of view, the project must still be evaluated from a cost-effectiveness point of view.

The Bosphorus Crossing Railroad Tunnel

As already mentioned in the introduction, one of the megaprojects currently under construction in the world is the Bosphorus Crossing railroad tunnel. This project is being monitored and funded by the Japan International Cooperation Agency (JICA) through a Japanese ODA loan agreement with Turkey.

The Bosphorus Strait is located between the Sea of Marmara and the Black Sea, as shown in Fig. 15-9, ultimately providing one of the two passages from the Black Sea to the Mediterranean Sea (the other passage is the Dardanelles, or the Hellespont).

Its total length is approximately 30 km, and the strait separates Istanbul into two parts, one lying on the Asian or eastern side, the other lying on the European side. There are bridges that connect the Asian side and the European side across the Bosphorus, both approximately 1,050 m (3,500 ft) long, but the city has no railway connection lines. Since there is no light rail, the people in Istanbul only use vehicles as the means of transportation. Consequently, Istanbul is plagued with chronic traffic jams and heavy air pollution. The construction of this undersea railway tunnel will also benefit the environment through better air quality and increase the quality of life for the people in the city of Istanbul.

Fig. 15-9. Bosphorus Strait

Source: NASA, http://earthobservatory.nasa.gov/IOTD/view.php?id=4466.

The planning and basic design for this project were undertaken by a consulting team consisting of three Japanese consulting firms and one Turkish consulting firm. A Japanese and Turkish contractors' consortium is carrying out the design and construction of the main civil works using the EPC model for contracting the actual work. The main civil works portion of this project required an extremely high level of technology for the design and construction of the undersea portion of the tunnel.

The project area is located in an earthquake belt where seismic intensities of a 7.5 magnitude or above are not uncommon. The Bosphorus Strait is one of the most congested international marine traffic waterways in the world, with approximately 55,000 ships and 260,000 local vessels passing through each year. The main part of this tunnel is an immersed tunnel connecting 11 elements totaling a length of 1,387 m (0.86 mi).

This tunnel will be the world's deepest immersed tunnel, lying on the ocean bed under 60 m (196 ft) of water at the deepest point. Each element or section of the tunnel is made of steel-reinforced concrete 135 m long, 15.3 m wide, and 8.6 m high (442 ft long, 50.2 ft wide, and 28.2 ft high). The individual sections will be prefabricated in a dry dock and then towed from the dry dock to the construction site, placed in position 60 m (195 ft) beneath the bottom of the sea, and then connected to each other.

The tunnel elements will be set in a 3-knot current speed, and in case of the highest flows, the current may be as high as 6 knots, depending on the general level of the Mediterranean Sea. Moreover, the flow of the high-salinity lower layer is in reverse phase with that of the upper layer.

A complicated system of security control and risk management is necessary to manage the passage of international and local strait traffic during the construction of the tunnel. In actuality, many new technical developments were made by the EPC contractor to execute their work under the difficult site conditions. All 11 tunnel elements were successfully set in place by October 2008. By 2011, the megaproject was still in its complicated construction stages. For instance, the connection is not yet made between the immersed tunnel and the tunnel boring machine tunnel, but the contractor has already developed innovative methods and special technologies to accomplish this important connection. The EPC contractor consortium has been in a difficult situation since the megaproject started even though they had sufficient technical capacity for carrying out the megaproject. The consortium has had to cope with many difficulties, not only pure technical matters but also social concerns that arose during the initiation of construction.

The main civil contract was signed in May 2004, and the contract amount was approximately US$1.3 billion. The general conditions of contract applied to this megaproject were the FIDIC EPC–turnkey contract, the so-called *Silver Book*. The original construction period stipulated in the contract was 56 months, from August 2004 to April 2009. However, the time to completion was extended from 56 months to 110 months, and the contractual completion for turnover has been extended to October 2013. The main reason for extending the construction schedule was the discovery of a complete ancient seaport during the first parts of the megaproject. The archaeological discovery was obviously important to the people from Turkey, and to the world at large; it also represents one of the unforeseen and unforeseeable risks that can arise on any construction project of this size. In cases like these, it is essential to have the kind of steady relationship between the project owner and the contracting consortium that will enable them to work through difficult problems like these.

In this case, methods of handling risks such as the discovery of important archaeological sites are not included in the FIDIC *Silver Book*. EPC contracts are usually applied to power plants and chemical plants. All megaprojects have considerable risks, but those risks should be in a range that is manageable by experienced contractors. It is a good question whether the people who planned the Bosphorus Crossing railroad tunnel project knew whether the EPC contract covered uncertainties like the existence of important cultural heritage sites on project grounds.

Reconsidering the Basics of Executing Megaprojects

Management Technologies Required for Megaprojects

As mentioned at the beginning of this chapter, it is expected that many megaprojects will be implemented in Asia over the next half century. It can also be expected that when one builds in areas that have supported cultures for thousands of years, a greater ratio of difficulties will arise concerning the social effects of the megaproject, making the proper execution of the project more difficult and costly. This phenomenon is why a complete knowledge of the techniques related to project management will be essential for carrying out megaprojects in these areas. In the case of the Bosphorus Crossing railroad tunnel project, difficulties arising from the social effects of the project, however unanticipated, became difficult to manage by the contractor's consortium alone.

To minimize the effects that develop from these kinds of problems, the project must be well planned in advance and must include a process that will evaluate the risks related to the social effects of the project. To accomplish this goal, project planners and especially the civil engineers who implement megaprojects will have to have a deep knowledge of social science and regional cultural activities. This role should be integrated into the job descriptions of those engineers and into the definition and meaning of civil engineering in general to make sure that techniques for approaching and solving these matters are present. It will also be necessary to reconsider the meaning of infrastructure development in terms of social effects of this kind.

Considering the Main Objective of Civil Engineering

Civil engineering is one complete set of technologies and disciplines that can be used for building the structures that serve the public welfare in a country. It can consist of various kinds of technologies, such as soil mechanics, hydrodynamics, river and coastal engineering, steel and concrete structures, disaster prevention engineering, and traffic engineering. When you ask a civil engineer the definition of civil engineering, he or she may give you answers like that above, and many people in the civil engineering field today will agree with that answer. However, this understanding of civil engineering is just one part of the overall definition of civil engineering. Civil engineering must be understood to be more like the tree in Fig. 15-10, with branches that intersect with other disciplines.

The above-mentioned technologies are connected to a trunk, and the trunk is deeply rooted in the social sciences field. The understanding of this relationship can be applied to many other fields of engineering, but in the case of civil engineering it becomes much more important because civil engineering is directly related to the general welfare of society. Judging from this sort of consideration, it is clear that infrastructure development must be done with not only strict engineering in mind but also with the social sciences in mind as well. At this time, it is difficult to say whether or not civil engineering as a modern discipline is equipped with the concept of combining civil engineering with social science considerations.

Social Activities and Supporting Systems

As mentioned above, infrastructure is something that enhances both the public welfare and positive development of a country. An additional definition of the term *welfare* should be that it satisfies the public requirements for physical, economic, cultural, and environmental benefits. Based on this understanding, we have tried to describe the basic concept of infrastructure (as shown in Fig. 15-11) in a three-dimensional way (as shown in Fig. 15-12).

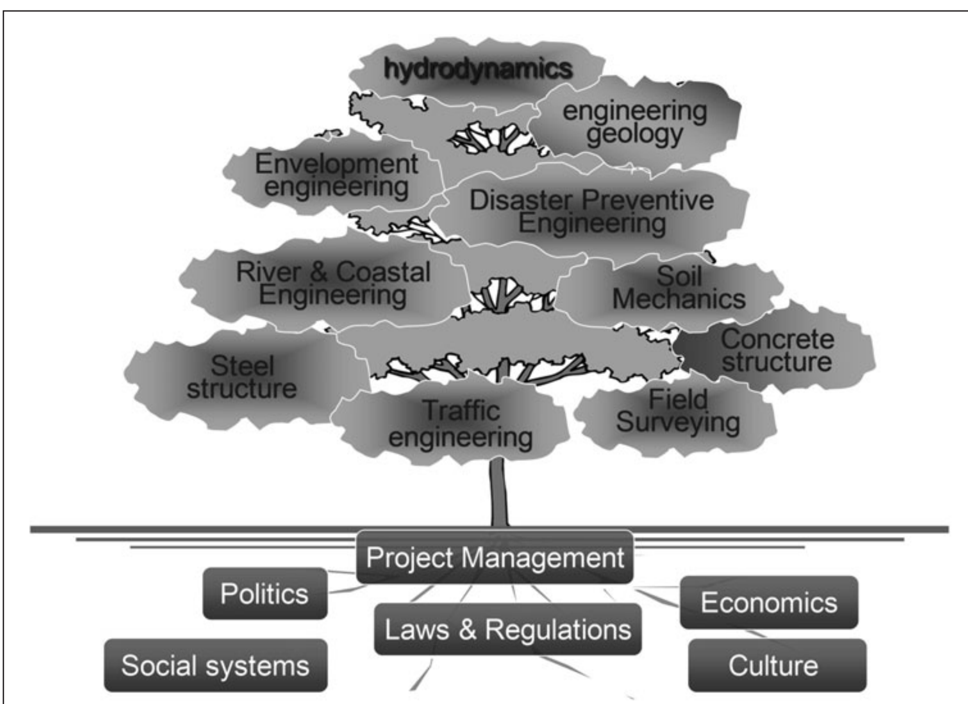

Fig. 15-10. Real shape of civil engineering

Society moves with general forces, such as economic activities, political activities, cultural activities, and the activities of living things, as well as natural activities. These activities are constantly interacting with each other in a base system that we call a "social supporting base." This base consists of two different basic systems, one of which is an artificial supporting system and the other is a natural supporting system. Furthermore, the artificial supporting system consists of social systems that may be called "soft infrastructure." The civil facilities may be called "hard infrastructure."

Nonartificial or natural support systems, on the other hand, can be described as "natural infrastructures." Our concept states that a society is supported by the social supporting base and its base is supported by three different kinds of infrastructures.

Fig. 15-13 shows the real relationships and concepts of infrastructure that civil engineers need to understand. Moreover, civil engineers need to understand that these three kinds of infrastructure should not be planned, built, and operated

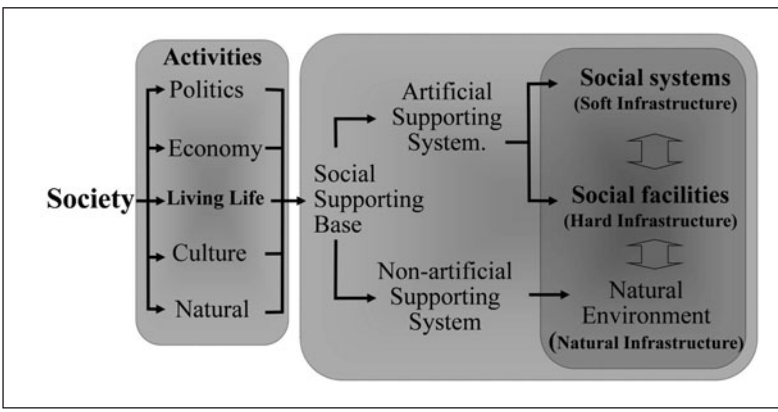

Fig. 15-11. Society supported by social activities

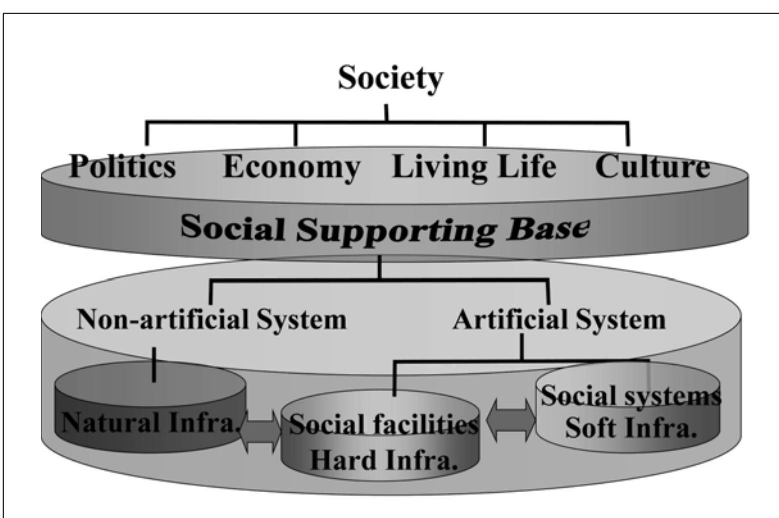

Fig. 15-12. Social supporting base supports society

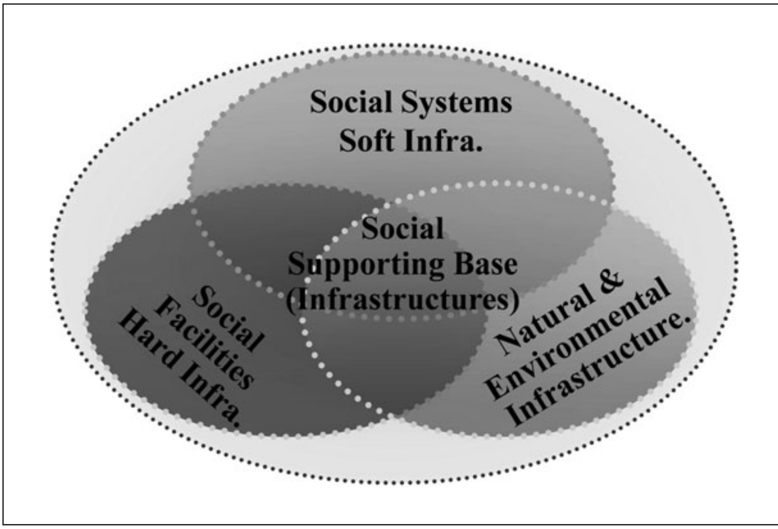

Fig. 15-13. Real shape of infrastructure

independently. They must be handled with the idea that they are interconnected. For example, when you build a school, you need to consider the natural environment, along with other social systems, such as education systems, security systems, and medical care systems.

We think that this understanding of civil engineering and infrastructure development will be required for all future planning in the execution of megaprojects, especially in developing countries, where indigenous or local cultures may not accept advanced technological changes as rapidly as do developed nations.

New Ideas Regarding Construction Management in Asia

Establishment of International Construction Management Forum in Asia

As noted above, the Bosphorus Crossing railroad tunnel is being managed and evaluated under the Overseas Development Assistance (ODA) scheme. ODA is the main scheme for implementation of infrastructure projects in the developing countries in Asia.

If you ask somebody about their understanding of ODA, most people say that ODA means development assistance from developed countries to developing countries. That may be partially correct, but one needs to think again about the relationships between the two parties. ODA is not just development assistance from developed countries to developing countries but also development assistance from developing countries to developed countries.

Developed countries like Japan are facing a problem in education and human development in civil engineering and the construction industry. This problem is occurring mostly because infrastructure development is no longer the main concern of development in developed countries any more.

However, developing countries do not have broad fields of training and education. The overall problem is not only limited to that issue. We must also address how to challenge the spirit and motivation of a younger generation in their understanding of infrastructure development. At this point, their responses to infrastructure improvement can use a boost. To remedy this situation, Dr. Kusayanagi takes his laboratory students to developing countries like Cambodia, Indonesia, Mongolia, Nepal, and Vietnam every year so that they can see the real shape of infrastructure development in developing countries. When they are there, they also have a chance to discuss infrastructure issues with students and people in these countries. This method of education and human development is quite effective and is creating positive results. The activities implemented by this author have been effective in raising the awareness of the importance of social issues in engineering and construction management education activities in Asia.

Construction and project management efficiency in infrastructure development projects in the developing countries in Asia is low, and contract administration is still an undeveloped area. There is a lack of people with the appropriate knowledge and skills in construction practices, project management, and contract administration. As a result, the majority of the projects are not being completed on time or within budget. Additionally, only a few universities in Asia offer complete courses on construction and project management.

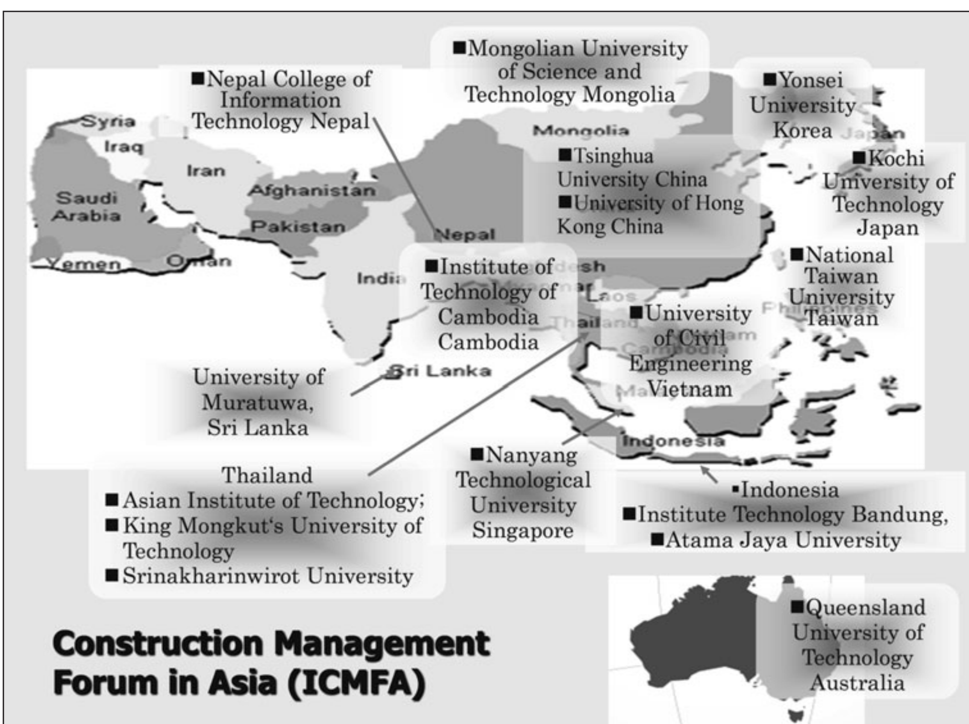

Fig. 15-14. Member organizations of the ICMFA

To address this issue, a group of faculty members from the schools shown in Fig. 15-14 and led by us have established a forum named the International Construction Management Forum in Asia (ICMFA) to promote education, research, training, and professional development in the fields of construction and project management in Asia. The ICMFA was formally inaugurated on November 20, 2008, in Taiwan.

Activities under the ICMFA

The ICMFA has the main objective of developing appropriate education and training programs in the fields of construction and project management, thereby enhancing the capacity of universities and other institutions for developing a comprehensive curriculum in the fields of construction and project management, as well as other fields. To meet this objective, ICMFA has formed a core group of faculty members and construction professionals who have relevant experience in the fields of concern. The ICMFA is organizing seminar and training opportunities to be held in member countries in cooperation with member organizations and donor agencies. The ICMFA, now at the first stage of its operation, has focused on enhancing the education of member organizations and other interested organizations from its member countries in the area of contract administration for construction projects and is also developing appropriate education and training curricula on construction and project management that will be introduced both in universities and in the construction industry.

As a part of this agenda, we have led a team among the ICMFA members that is dedicated to enhancing the educational capacity of both the construction industries and universities concerning the discipline of contract administration for international construction projects in Cambodia, Mongolia, Nepal, Sri Lanka, and Vietnam.

In addition, ICMFA has been assisting the Cambodia Institute of Technology and the Mongolian University of Science and Technology so that they can deliver appropriate construction and project management education programs. To accomplish this, the ICMFA has been sending member faculties and researchers to these universities to institute and deliver extensive courses on construction and project management. Similarly, ICMFA is cooperating with the National University of Civil Engineering in Vietnam to enable their faculty to deliver a regular course on contract administration for international construction projects in Vietnam.

The ICMFA is working closely with the Japan International Cooperation Agency (JICA) to enhance the education on contract administration for the clients of countries in Asia that receive aid from JICA. In recognition of this, JICA has invited some members of ICMFA to be resource people conducting training on contract administration for international construction projects in Asia.

Prospects

The ICMFA has realized that their way of building increased educational opportunities has been working well. The member organizations in the countries receiving aid in Asia are encouraging the ICMFA and cooperating with them in continuing to offer enhanced educational opportunities in the construction management fields. JICA has also realized that the ICMFA's methods are one of the most effective ways to enhance efficiency in project delivery in countries that receive their aid. ICMFA will continue to engage in enhancing educational and research activities and will continue to share their experiences and expertise among the member organizations and industries as well.

Summary

It is expected that many megaprojects will be carried out in Asia in this decade. The people who are implementing megaprojects are required to manage problems and to overcome various difficulties coming out of not only pure technical areas but also emerging from issues related to social matters.

The problem is how to develop the appropriate project management systems and human resources required to address these questions. It is an unavoidable responsibility for the managers and engineers in charge of megaprojects to be able to operate effectively in field activities where mutual mistrust among stakeholders exists. At the same time, it is desirable to reduce the resources needed to manage such mistrust as much as possible. We are not saying that managers need to try to move into a relationship where mutual trust exists exclusively. But we believe that creating trust by respecting the professional abilities among the stakeholders is the basic foundation for proper project execution, especially in the case of the implementation of a project as complicated as a megaproject. We believe that it is a challenge that civil engineers in Asia must meet.

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CHAPTER 16

Megaprojects in Australia

Antonino de Fina

In Australia, megaprojects fall essentially into two categories, the provision of community infrastructure projects and private infrastructure projects predominantly related to minerals and energy.

The community infrastructure projects have been developed as public–private partnerships (PPPs) by which state and territorial governments have avoided the capital costs by extending to private developers or investors a concession that allows the investor to levy consumer charges for use or supply (tollways, supply premiums, or royalties) for specified periods of time, with the project becoming the property of the state at the conclusion of the concession period.

Many of these projects are conceived and specified in general terms by the state, and tenderers rely on the information provided, for instance, projected vehicular usage numbers for tollways, as the basis for the project.

In some recent developments, the projections offered by the state to support the projects have been grossly exaggerated and, as a consequence, projected incomes have fallen far short of those required to support both the project and the private investor. In some cases, the consortium of corporate entities purposely created for the PPP has been forced into bankruptcy.

As a result of the PPP projects being conceived and promoted by the government, they are unavoidably subject to political influence and the distortion of political reasoning. The following case studies are examples of recent or current Australian megaprojects and gigaprojects that have shown instances of political interference or malfeasance (in the case of some PPPs), as well as success or failure, in purely private projects.

Boodarie Iron Briquette Project, Port Hedland, Western Australia

The Boodarie Iron Project was constructed by BHP Billiton, Australia's largest minerals and mining corporation, at a site approximately 20 km (12.4 mi) south of the town of Port Hedland in northern Western Australia.

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LESSONS LEARNED

1. With growing populations and community expectations, political parties of all descriptions are making decisions on infrastructure projects and the way they are financed and delivered, effectively having regard only to advancing their political fortunes.
2. Proper and adequate engineering, both as to feasibility and process, becomes secondary when it should be part of the initiating step or steps.
3. Informed and carefully considered engineering should not be prostituted to satisfy the demands or whims of political masters.
4. Ethical obligations of an engineer to act in the benefit of the wider community should not stifle or impede the engineers' ability to independently assess and openly comment on the value or appropriateness of an engineering project.

The plant took more than three years to construct at a capital cost in excess of approximately US$2 billion and was based on what was described as FINMET technology to convert iron ore fines into iron briquettes. In this process, the iron ore was exposed to heat, hydrogen, and carbon monoxide gases to remove oxygen. This process transformed the iron ore (with 67% iron content) into metallic granules with more than 90% iron content. The granules were then compressed into briquettes about the size and shape of a cake of soap for export, primarily to the Asia Pacific region.

As a result of persistent plant commissioning difficulties, large cost overruns, and significant operational issues, the book value of the Boodarie Iron plant was written down in the period 1998 to 2000. This loss included the announcement in May 2000 of a total write-off of the remaining carrying value of the plant. The final write-off for closure of the Boodarie Iron plant was approximately US$266 million.

In May 2004, an explosion occurred at Boodarie Iron in the Train 4 area of the plant, which had been shut down for scheduled maintenance. The incident resulted in the death of one employee and serious injuries to two others. At the time of the incident, the Boodarie Iron workforce comprised about 490 employees and a similar number of contractors.

Production at Boodarie Iron was suspended immediately after the incident, and BHP Billiton assembled a team of global experts to begin investigations into its cause. The state mining engineer (a government authority concerned with mining safety standards) also ordered BHP Billiton to commission a team of independent experts to investigate and report on the incident under Section 45b of the Western Australian Mines Safety and Inspection Act.

In September 2004, the Section 45 team presented a preliminary report to the state mining engineer indicating that the accident was caused by a series of dust explosions, at least one of which was initiated and accelerated by hydrogen formed during the cleaning process. This finding was reiterated in the final Section 45 report that was delivered to the state mining engineer on November 30, 2004.

On November 11, 2004, BHP Billiton announced that it would place the Boodarie Iron plant on care and maintenance while it determined the long-term future of the operation. This determination would be based on a full analysis of the safety and economic issues in relation to partnering with another organization in the resumption of operations and either selling the facility for conversion to another use or closure. All employees were retained for a further three months to facilitate the transition to care and maintenance.

The ultimate determination of closure, in August 2005, was decided on environmental and safety issues, particularly dust management, since some six major dust management events occurred, commencing in 2001 and occurring over the next three years.

The total failure of the Boodarie Iron project adversely affected the profitability of BHP Billiton, which did not seek to recover its losses by claims against the designers or constructors.

Murrin-Murrin (Anaconda) Nickel–Cobalt Project, Western Australia

A joint venture between Anaconda Nickel Limited and Glencore International AG established a project to produce nickel and cobalt at Murrin-Murrin in Western Australia. Murrin-Murrin is the site of the world's fifth largest nickel mine, with more than 120 million tons of ore to be mined over a 30-year period. It was also to be the world's third largest cobalt mine. Target production was to be 45,000 tons of nickel and 3,000 tons of cobalt. Additional reserves of ore in the Goldfields and Pilbara (mining regions adjacent to Murrin-Murrin) were estimated to hold accessible ore reserves of more than 100 million tons.

This joint venture project engaged what it considered a strong project team, with Fluor Daniel as project engineers and Sherritt International as process engineers. The plant process adopted was under license from Sherritt Inc., which had operated commercially proven systems at Mao Bay in Cuba and Fort Saskatchewan in Canada, respectively operating since 1955 and 1959.

Ore was mined by open cut and conveyed to the projection plant. Projected output was to be approximately 44,000 tons per annum, but by 2006 the project produced approximately 31,000 tons per annum, far less than the target production rate. In 2011, production was approximately 33,000–37,000 tons per annum.

The joint venture modified the plant to achieve greater production by installing larger capacity preheaters and a third calcite mill, upgrading neutralization circuits, modifying sulfide circuit equipment, and upgrading the acid plant.

A dispute arose between Fluor Daniel and the joint venture over production output. The dispute was referred to arbitration, and the joint venture was ultimately successful and was granted a favorable award of several hundred million dollars.

Airport Link, Brisbane, Queensland

On June 2, 2008, a consortium with the name BrisConnections was awarded a contract by the Queensland government to construct and operate a toll road from the central business district of Brisbane (the capital of Queensland) to the Brisbane Airport. The estimated cost was more than approximately US$3 billion. The project was a PPP concept development with a 30-year concession life.

From the time BrisConnections entered into the contract, the Airport Link project has been mired in controversy. Macquarie Group charged US$110 million in fees for the financial engineering, which used the equity from private investors to raise the necessary financing and planned to pay investor distributions from capital, an arrangement that resembles a Ponzi scheme and has been ridiculed as a "dead parrot model" after a famous Monty Python comedy sketch. The project quickly became a public relations nightmare when Queensland Premier Anna Bligh enjoyed a free holiday at the Sydney mansion of Thiess director Ros Kelly just before the contract was awarded. (Thiess was one of the major members of the successful consortium.) Former Labour ministers were paid a "success fee," believed to be about A$500,000, by BrisConnections after the consortium won the tender.

BrisConnections was listed as a unit trust on the Australian Securities Exchange (ASX) via a A$1.2 billion initial public offering (IPO) of installment receipts (or stapled securities) on July 31, 2008. This offering was the largest IPO in Australia in 2008 and the most disastrous. The value of initial A$1 installments fell by 60% on the first day of trading, and by late November had collapsed to 0.1 Australian cents, the lowest possible price on the ASX. The dramatic price slide was largely caused by the leverage risk associated with stapled securities. Among the institutional investors was the Queensland Investment Corporation, the state-owned corporation that invests the superannuation (retirement) funds for Queensland's public servants, which invested A$25 million.

The negative market sentiment was caused by the traffic forecasts contained within the product disclosure statement lodged by BrisConnections. The study previously released by the government showed traffic forecasts in 2012 of 95,000 vehicles per day (vpd), rising to 120,000 vpd by 2026. The product disclosure statement prepared by consultants provides a forecast of 193,000 vpd in 2012, rising to 291,000 vpd by 2026.

During the early period of the BrisConnections listing, most of the securities were owned by institutional investors; however, as the price collapsed, many of these institutions divested their now worthless stock, including Macquarie Group. Most of these shares were taken up by retail investors who were unaware that two further A$1 installments on the stapled securities were owed and who faced financial ruin as a result. BrisConnections has threatened to sue these investors to raise the capital necessary to continue the project, while reducing dividends by 99%. There are no further installments owing, which means there are no further obligations on shareholders attached to the units.

While promoting BrisConnections at their media event in April 2009, the premier of Queensland denied any responsibility for the fate of the "Mum and Dad" investors, saying, "It is not the role of the Queensland Government to underwrite private investment decisions made by people who were seeking to make a profit investing in the stock market." At that time, the Australian Securities and Investments Commission (ASIC) belatedly sought to act on behalf of investors and to seek an independent report of BrisConnection's finances.

BrisConnections was almost closed down in April 2009 after the private company of one investor requisitioned a general meeting of members of the managing company. However, on the date of the meeting, the proxies attached to the shares of the private investor company were exercised to vote against the resolutions, the originating objecting company having earlier sold the proxy rights for A$4.5 million to Thiess-John Holland (a subsidiary of Leighton Holdings and the contractor for the Airport Link project). Therefore, the special resolution fell short of the required 75% vote to pass, and BrisConnections was allowed to continue operating under its current form.

In May 2009, 70% (278 million) of the outstanding shares defaulted on the second A$1 installment payment. Some shareholders transferred their shares off market to false identities, such as Humphrey B Bear (a children's television character), to avoid payment. An auction of shares in default failed to attract a bidder. In June 2009, BrisConnections commenced legal action to recover the unpaid monies. With BrisConnections launching legal claims against defaulting investors, a controversial businessman postured as a champion of small investors. The controversy featured prominently in Brisbane newspapers. The name "BrisConnections" was played upon as a "con," and the project and ensuing farce were dubbed by the media as "BrisCon." In October 2009, BrisConnections notified ASX that it would stop pursuing defaulting investors.

By early December 2009, the share price of the second A$1 installments had collapsed to 0.1 Australian cents. With little other interest in the toxic stock at this time, the chief executive officer of BrisConnections paid A$10 for 5,000 shares. Two other directors of BrisConnections also purchased share parcels of a similar size, helping to raise the share price to 0.5 Australian cents by mid-December 2009; however, the share price had again collapsed to 0.1 Australian cents by year's end.

In addition to the financial woes, the construction of the Airport Link experienced significant construction problems.

Construction of the Airport Link commenced in November 2008. In August 2008, the main earthmoving contractor, TF Group, went into receivership, owing subcontractors as much as A$2.8 million. A group of these subcontractors threatened to blockade the project until their outstanding debts were paid.

On June 17, 2009, the consortium requested that the coordinator-general, a position in the Australian Department of State Development, Infrastructure, and Planning with wide-ranging authority to plan, deliver, and coordinate large-scale projects, evaluate a proposed change to the Airport Link project under section 35C of the State Development and Public Works Organisation Act 1971. Because of the discovery during the first half of 2009 of less than favorable ground conditions in the vicinity of the Kedron ramps, BrisConnections proposed the establishment of a new worksite on vacant land at Rose Street, Wooloowin, between Kent and Park Roads, to facilitate improved construction access to the mainline tunnels. A shaft 15 m (49 ft) in diameter and 42 m (137 ft) deep would be constructed to launch two of the project's "roadheader" excavation machines. It is anticipated that the worksite would be in use for up to 29 months, including backfilling and rehabilitation. This project was completed in mid-2012.

Public Transportation Ticketing System (Myki), Victoria

Public transportation smart card ticketing systems are used in many cities around the world, such as New York, Hong Kong, London, Paris, Delhi, and Seattle, with great success. The Victorian government decided late in 2002 to adopt a smart card ticketing system suitable for use on trains, trams, and buses and established an entity titled the Transport Ticketing Authority in June 2003.

Tenders were requested for what was called the “New Ticketing Solution,” and the tender specification was released in July 2004.

Rather than adopt a successful system from other non-Australian cities, the Victorian government decided that an entirely new system would be built and awarded the contract to a consortium of U.S. and European companies for approximately A$494 million to be completed and operative by 2007.

To date, the cost is now approximately A$1.35 billion, and the system continues to be plagued with faults in operation and application. The system, known as Myki, became partially operational in 2010 and gradually expanded in the following years as the old Metcard system was phased out.

Controversies over the tendering process abounded. For example, a staff member of the Transport Ticketing Authority (TTA) left a flash drive in a room with representatives of one of the bidders. The TTA claims that this was an accident and that there was no secret information on the flash drive. Then, the company hired by the TTA early in the process to give it technical advice was found to be part of the winning consortium. In late December 2007, it was revealed that investigators in the auditor-general’s office had uncovered serious probity concerns in the awarding of the contract to the consortium of Keane (Keane Inc. is a unit of NTT Data Corporation, a U.S. information technology firm) and Kamco (Keane Australia’s collection and payment company), although these concerns were not included in the auditor’s report to Parliament as they were said to be unsupported by the evidence.

There have been widespread reports of damage to Myki equipment; up to 60% of the machines have been targeted by vandals. Damage to display screens on fare payment devices and card-vending machines have been caused by heavy objects used to smash them, often rendering the displays unusable.

Financial penalties have been imposed upon the contractor, but cost escalations have been approved and paid. Both the Victorian government and the contractor appear to have reserved their positions in respect to disputes until after the project is complete and fully operational in December 2012.

Lane Cove Tunnel, Sydney, New South Wales

The Lane Cove Tunnel, as shown in Fig. 16-1, is a A$1.1 billion, 3.6-km (2.2-mi) twin tunnel tollway in Sydney, connecting the M2 Motorway at North Ryde with the Gore Hill Freeway at Artarmon. It forms part of Sydney Metroad 2 and the 110-km (68-mi) Sydney Orbital Network. Connector Motorways is the owner and manager of the Lane Cove Tunnel and Falcon Street Gateway and will operate the tunnel until 2037.

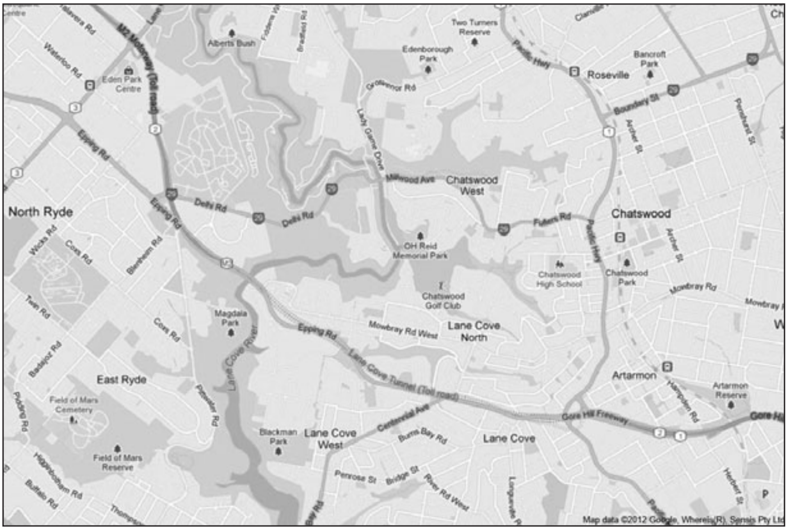

Fig. 16-1. Lane Cove Tunnel

Source: Google Maps.

Before the opening of the tunnel, motorists had to drive along Epping Road through the suburb of Lane Cove, for the few kilometers between the two freeway sections. Studies by the tunnel operator show that the Lane Cove tunnel cuts travel times by up to 17 min.

With the completion of the surface road changes in March 2008, the existing Epping Road has 24-hour bus lanes to reduce travel times for east- and west-bound bus services, a new bus interchange, a shared cyclist and pedestrian path, and other measures to improve public transportation and local traffic in the corridor. Surface road changes to improve public transportation and local traffic were carried out to guide traffic toward using the new tolled tunnel instead of the untolled surface road.

This "failed infrastructure project" has been a disaster for the company, leading to it entering receivership in January 2010 after a string of losses.

A joint venture between builders, Thiess-John Holland was awarded the A$1.1 billion contract by Connector Motorways to design and construct the tunnel.

In the early hours of November 2, 2005, the roof area of a ventilation tunnel for the project collapsed. The roof collapse caused the road above the area to subside and damaged a three-story building; 47 people had to be evacuated from the building. The collapse caused a 10-m by 10-m (32-ft by 32-ft) crater to appear near the Pacific Highway's southbound exit ramp in Lane Cove. Emergency crews pumped 1,000 m^3 (3,289 ft^3) of concrete into the hole to try to stop the rest of the housing block from collapsing into it. An investigation by Workcover NSW found that the collapse was caused by geological conditions at the site, the large span width of the tunnel, and the inadequacy of roof support. The investigation also found that the proximity of the excavations to the surface resulted in the property damage to the housing block.

The tunnel was opened March 25, 2007, by four workers, representing the 9,000 men and women who had worked on the Lane Cove Tunnel, the Falcon Street Gateway, and the widened Gore Hill Freeway Project. The tunnel opened with a one-month toll-free period.

The Labour government was accused of interfering in the tunnel project to increase its reelection chances in the March 2007 election. The tunnel's expected late 2006 opening was pushed back to "January or February," closer to the poll date. This time frame was missed, and the opening was announced to be March 25, the day after the election.

In December 2006, it was announced that surface road changes would be delayed by five months, deferring them until after the state and federal elections. The delay, which was likely to cut into tunnel revenues, was agreed to by the operators at a cost to taxpayers of A$25 million.

The *Sydney Morning Herald* described the payment as a "bribe" and a "political rort." According to a *Herald* editorial, "The use of public funds to compensate Connector Motorways for delays to road changes around the tunnel is ... as cynical a piece of political jobbery as Sydney has seen in many a long year."

Gorgon Gas Expansion, Barrow Island, Western Australia

In April 2009, the Environmental Protection Authority (EPA) approved Chevron's multibillion dollar Gorgon liquefied natural gas (LNG) project expansion on Barrow Island, Western Australia (WA), despite highlighting serious environmental concerns.

The EPA stated, in granting approval, that "given the very high environmental and unique conservation values of Barrow Island, which are reflected in its status as a class A Nature Reserve, it is the view of the EPA that, as a matter of principle, industry should not be located on a nature reserve and specifically not on Barrow Island" (EPA 2009).

However, the EPA concluded that the expanded proposal could go ahead provided that "stringent conditions" were imposed.

The EPA also concluded, "Conditions would be needed to deal with increased potential impacts on one of the most significant flatback turtle rookeries in WA. The primary objection of that condition being achievement of an 'unaltered light horizon', compared with the current natural conditions, from the perspectives of both egg-laying female flatback turtles and hatchlings" (EPA 2009).

Chevron said that it welcomed the recommendation and said that the revised and expanded Chevron-operated Gorgon project could meet environmental standards. The revised and expanded proposal added a third, 5 million ton per annum, LNG train to the original two-train proposal already approved for Barrow Island. Chevron Australia's managing director said that the EPA's decision was an important step in the regulatory process for the project, which is forecast to create up to 6,000 jobs.

In 2007, the WA government approved construction of a gas processing plant on Barrow Island. Chevron later applied to expand the proposal to 16.5 million tons a year in response to rising industry cost pressures.

It is important to introduce some background information at this point. Chevron, in partnership with Shell and Mobil, plans to develop the Greater Gorgon gas fields, located between 130 km and 200 km (81 mi and 124 mi) off the northwest coast of WA. The EPA regarded possible effects of dredging and marine infrastructure construction on the high-value coral of the Lowendal Shelf as an important issue.

Western Australia, as Australia's number one petroleum producer, relies heavily on gas fields industries in the North West Shelf (NWS) for both its domestic supply and export revenue. Although WA already relies heavily on the NWS for its gas needs through gas produced from the North West Shelf Venture (NWSV), a number of further gas developments in the region have been planned for the resource-rich area, such as Woodside Petroleum's Pluto Gas Project, Chevron's Gorgon and Wheatstone developments, and Apache Energy's Reindeer and Julimar fields. These additional projects will strive to meet the ever-increasing demand of the state.

Demand for domestic gas in WA is predicted to increase by 1,125 terajoules per day (TJ/d) by 2014, a DomGas Alliance report has said. The average rate of increase in gas consumption in the state since 1984 has been recorded at 8.5% per year. The NWSV project, after almost 25 years of pipeline gas production, remains Australia's largest natural resource development. Nor is there any sign of gas production slowing; only 11 trillion ft^3 of the NWSV's vast 33 trillion ft^3 total gas reserves have been produced to date.

The NWSV supplies gas for WA's domestic market, providing approximately 65% of the state's total production. It also supplies gas for export sourced from its offshore gas fields. Since delivering its first LNG cargoes to Japan in 1989, the A$25 billion NWSV project now ships more than 200 cargoes a year to countries such as China, Japan, and South Korea.

NWSV natural gas, LNG, liquid petroleum gas, and condensate are processed at the Woodside-operated onshore Karratha gas plant, located 1,260 km (783 mi) north of Perth. The plant has now produced more than 1,000 cargoes of condensate. Last year, the NWSV celebrated the completion of its A$2.6 billion NWS Phase V LNG expansion project. The expansion included a fifth LNG processing train—capable of producing up to 4.4 million tons per annum—a jetty extension and second LNG loading berth, two additional power generation units, a third fractionation unit, a new fuel gas compressor, an acid gas removal unit, and a third boil-off gas compressor.

North West Shelf Venture (NWSV)—North Rankin, Western Australia

When commissioned in 1984, North Rankin A was the largest gas production platform in the world, capable of producing 1,815 million cubic feet of gas per day (10^6 ft^3/d) and up to 47,400 barrels per day (7,537 m^3/d) of condensate. Subsequent modifications have increased this capacity by 50%.

In 2008, the NWSV announced the North Rankin redevelopment project, which will provide additional compression to unlock low-pressure reserves from the North Rankin and Perseus gas and condensate fields. The platform will be connected by a 100-m (328-ft) bridge to the existing North Rankin A platform. Known as the NR2 Project, it will also include necessary tie-ins and refurbishment of North Rankin A. Upon completion, both platforms will be operated as a single integrated facility.

North West Shelf Venture (NWSV)—Angel Gas Field, Western Australia

The NWSV's Angel platform became operational in October 2008, producing gas for processing at the venture's Karratha gas plant. The A$1.6 billion development involved the installation of a new platform and associated infrastructure, including a 50-km (31-mi) subsea pipeline tied back to the existing North Rankin A platform. The Angel platform is powered and remotely controlled from the North Rankin A platform via a subsea cable.

Located approximately 120 km (74.5 mi) northwest of Karratha, the Angel platform stands in about 80 m (262 ft) of water and is supplied by three subsea production wells. With a production capacity of 800 10^6 ft^3 of raw gas and up to 50 trillion ft/d of condensate, hydrocarbons from the Angel platform will be processed through the NWSV's integrated system.

Gorgon and Wheatstone Developments, Western Australia

The Gorgon LNG Development is a joint venture among Chevron, Shell, and ExxonMobil and is located approximately 130 km (80.8 mi) off the northwest coast of Western Australia.

The development involves the installation of a subsea gathering system and pipelines from the Gorgon and Jansz fields to Barrow Island. A 300 TJ/d gas processing facility, located on the central east coast of Barrow Island, will then process the gas, and carbon dioxide will be removed and reinjected into deep saline reservoirs beneath the island. The LNG will then be shipped to international markets while the compressed domestic gas will be delivered to the Western Australian mainland via subsea pipeline.

In September 2008, the joint venture extended the front-end engineering and design contract to a joint venture made up of KBR, JGC Corporation, Clough Projects Australia, and Hatch Associates Group to incorporate a third 5-million-ton-per-annum LNG train to be developed in conjunction with the first two trains.

Chevron has also announced plans to develop an LNG project, based on its Wheatstone natural gas discovery, located 145 km (90 mi) offshore in the Carnarvon Basin. The facility will be located on the Pilbara Coast and will have an initial capacity of at least two 5-million-ton-per-annum LNG production trains, with expansion capacity for an additional three production trains. The development will also include a 250 million ft^3/d domestic gas plant that will form part of the development and a 220-km (136-mi) pipeline.

At the time of approval, the Gorgon gas project in northwest Australia was described by environmental group WWF (World Wildlife Fund) Australia as the thin end of the wedge for oil and gas development in the region.

Paul Gamblin, WWF's WA program leader, said that the A$50 billion LNG project's official confirmation by project partners Chevron, ExxonMobil, and Shell would act as a green light to massive development in northwest WA. "Today's announcement on Gorgon marks the start of a new era of massive oil and gas development in northwest Australia, much to the detriment of the region," he said in a press release (WWF Australia 2009).

WWF cited the recent oil spill in the state's waters as one example of excessive development and called for more restrictions on energy projects (WWF Australia 2009):

> Northwest Australia is fast becoming a "pin-cushion" of oil and gas wells, yet there is negligible protection for its tropical wildlife, islands and coral reefs. The recent oil spill is just one example of the risks associated with development in our oceans.
>
> Multinational companies have managed to bluff Australian governments into allowing them access to the most sensitive and fragile places. As Australians begin to learn of the majestic tropical wonders and threatened wildlife of northwest WA, this must change.

WWF Australia is particularly concerned that the Grade A nature reserve of Barrow Island, described by the WWF as "Australia's own Galapagos," would be the site for the project's processing plant.

However the joint venture partners point to its economic benefits, which include the creating of 10,000 jobs during construction and 3,000 ongoing positions. They also tout the project's benefits as an environmental test with the expected use of geosequestration, the pumping underground of carbon emissions from the gas development.

Royal Children's Hospital, Melbourne, Victoria

In May 2005, the Victorian government committed A$37.9 million of the 2005–2006 budget to fast-track master planning and upgrade existing facilities before the redevelopment of the Royal Children's Hospital (RCH). The new RCH was to include 340 beds, modern wards, and specialized medical equipment. The planning process was to determine the future of the existing RCH buildings.

The master plan was completed in September 2005, and a final business case (business plan in the United States) was submitted to the government in November 2005. In November 2007, the government announced that

- The Children's Health Partnership (CHP) would design, build, finance, and maintain the hospital for 25 years and provide a range of extra facilities to benefit patients, their families, and hospital staff; and
- The new hospital was scheduled to open in December 2011.

The Department of Human Services (DHS) has the lead role in overseeing delivery of the new RCH project on behalf of the state.

The project is subject to review under the government's Gateway Review Process. To date, the project has been subjected to a strategic assessment (Gate 1) in early 2005, and the business case was reviewed (Gate 2) in October 2005. The project provides facilities for the provision of services in accordance with the RCH service plan and business case. In addition, it provides facilities for the Murdoch Children's Research Institute and the University of Melbourne's Department of Paediatrics. The RCH business case (Victorian Auditor-General 2009) describes the size and scope of the project as

- Encompassing approximately 96,000 m^2 (314,961 ft^2) in gross floor area, an increase of 9.4% over the existing area of 87,200 m^2 (286,089 ft^2);
- Providing an increase of 25% in gross departmental area for clinical and clinical support;
- Transferring services currently provided offsite into the new facility, such as parent accommodations, mental health inpatient beds, ambulatory mental health services, the Neonatal Emergency Transport Service, and the Centre for Adolescent Health; and
- Including more than 20,000 m^2 (65,617 ft^2) in space for the Murdoch Children's Research Institute and the University of Melbourne's Department of Paediatrics.

The new hospital is being delivered as a PPP in accordance with the government of Victoria's Partnerships Victoria policy, which was first released in June 2000.

The Partnerships Victoria procurement model used for the RCH involves a partnership between a private-sector consortium, responsible for designing, building, financing, and maintaining a facility, with the public sector maintaining responsibility for provision of clinical services within the new hospital. This arrangement accords with the current governmental policy that core public services should be provided directly by the public sector.

A project agreement was executed on November 20, 2007, between the minister for health on behalf of the state of Victoria and the Children's Health Partnership (project company) requiring the project company to

- Finance, design, and construct the new facility in two stages as follows:
- Stage one—Construct all elements of the hospital and fully move the hospital functions to the new facility by December 2011; and
- Stage two—Demolish existing buildings that are not to be retained and undertake further work on Murdoch Children's Research Institute space, commercial precinct construction, and reinstatement of the existing site for handing back to the state in 2014.
- Provide ongoing delivery of general services, help desk, building management, utilities and medical gas management, waste, security, parking facilities, grounds and gardens maintenance, and pest control for a period of 25 years, from the completion of the facility in December 2011 to December 2036. The project company has in turn entered into a range of contractual relationships with the following consortium partners to deliver elements of the project:
  - Equity provider—Babcock & Brown International Pty Ltd. was the original project sponsor and underwrote the equity requirement for CHP before a

change in control was approved by the minister for health in 2008 to sell this stake to the satellite fund called Babcock & Brown Public Partnerships, which is listed on the London Stock Exchange.

– Financiers—CHP has arranged for the involvement of a number of financiers to raise funds to pay for the construction of the hospital and other associated costs. A majority of the funding for the project has been raised from the issuance of bonds into the capital market. The raised proceeds have been placed in a deposit account managed by the security trustee (Bank of New York Mellon) until funds are required for the project.
– Builder—Bovis Lend Lease Pty Ltd. was engaged to design, construct, and commission the new facility and to demolish and remediate that part of the existing site that will be reinstated as parkland.
– Facilities management contract—Spotless P&F Pty Ltd. was engaged to provide a range of facility management related services over the operating phase of the project.

In November 2005, the government agreed that the new RCH project should proceed on the basis outlined in the final business case and approved the project to be delivered under a Partnerships Victoria model, subject to private-sector bids satisfying value for money criteria.

The government committed funding for the project on the basis that A$90 million were to be provided by RCH to reduce the net cost to government of the project, broken down as follows:

- A$50 million from the RCH, on the basis of a qualified commitment given by the RCH board to raise the funds, with any shortfall to be possibly underwritten by other fundraising by the Royal Children's Hospital Foundation (RCHF);
- A$30 million from RCH financed by a loan from Treasury Corporation Victoria (secured against future RCH parking lot revenues), as agreed by the RCH board; and
- A$10 million from RCH asset sales, after the commissioning of the new hospital, as agreed by the RCH board.

When approving the final business case for the project, the government was advised that A$30 million of this contribution from RCH was expected in 2009–2010, with the remaining A$60 million expected in 2010–2011.

In November 2007, other government advice said that the cost of delivering the A$1 billion RCH project through the private sector was cheaper than if it were to be done by the Victorian government alone.

The Public Sector Comparator (PSC) for the project estimated the net present cost of the project to be A$1.016 billion. The net present cost of the Children's Health Partnership consortium's winning bid was A$946 million at financial close in December 2007, representing a saving of around 6.9% when compared against the PSC.

With Stage 1 completed in October 2011, the state will make quarterly services payments (QSPs) over the 25-year operating phase of the contract. The QSPs are expected to cover the capital cost of construction and services to be delivered by the private sector over the term of the agreement. The state's financial commitment over the 25-year period is A$4.125 billion in nominal dollar terms, or A$1.12 billion in net present value terms, as of June 2012.

The 2007–2008 RCH annual report (RCH 2008) states that the financial arrangement will be reviewed before the completion of the project to determine whether the lease will be recognized as a finance lease or operating lease by the RCH. In terms of the expected contribution of A$90 million to government from RCH toward the cost of the project, the DHS and the Department of Treasury and Finance agreed in April 2008 that a commitment to CHP's winning bid to secure donations of A$25 million to RCH could be used by RCH to partly satisfy its funding obligation.

Issues have subsequently emerged about the timing and certainty of receipt of the A$35 million because of the downturn in global financial markets and the enforceability of the commitment.

Summary

Driven by the continuing need to provide infrastructure or community services, the reticence or financial inability of state and federal governments in Australia to support such projects will likely see a continuation of the use of PPPs in Australia, despite major failures in economic and practical terms of some projects.

Some necessary or desirable projects are now being developed as franchises given by a government to an operator for income-generating facilities, such as tollways, bridges, or penal institutions to avoid pitfalls experienced in past PPPs.

In some instances, governments are guaranteeing income streams and are thus in an effective partnership with the developers.

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CHAPTER 17

Delivery of UK Megaprojects within a European Context

Steve Rowsell and John Mason

The delivery of publicly funded megaprojects in Europe is heavily influenced by the European regulatory framework, which in the area of procurement has been particularly focused on removing trade barriers across Europe, and in the United Kingdom by government policy. As a result of these new regulations and policies, there have been considerable changes to procurement and commercial practices in the United Kingdom over the period of the mid-1990s to 2012. These changes, when combined with lessons learned from recent megaprojects, new forms of delivery (such as the private finance initiative (PFI) and early contractor involvement), and new forms of contract, mean that the landscape within which megaprojects are delivered in the United Kingdom has become very different from the period before the mid-1990s. This change, in turn, has required the development of new organizational models and ways of working, with a greater emphasis on partnering and the achievement of shared goals.

Regulatory Framework and Government Policy

Regulatory Framework

The establishment of the European Economic Community (EEC) has led to the removal of trade barriers across Europe. The procurement of all works and services above specified thresholds by public-sector authorities is regulated by European Community Directives, which in the United Kingdom (excluding Scotland) are translated into national law through the Public Contracts Regulations 2006 and the Utilities Contracts Regulations 2006. The threshold for works contracts is around £3.5 million, so any projects above this value have to be advertised in the *Official Journal of the European Union,* and the competition is open to any company across

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LESSONS LEARNED

1. With the formation of the European Economic Community (EEC), the regulatory framework for the execution of megaprojects has changed in the United Kingdom.
2. Important UK policies have also changed over the past decade, focusing on delivery of the best value for money procurement rather than lowest cost for completion of a megaproject.
3. As a result of regulatory and policy changes, the megaproject procurement and delivery practices have changed substantially in the past decade.
4. Accepted "best practices" within the construction industry have also changed as another result of the regulatory and policy changes noted above.
5. Within megaprojects, the first changes flowing from the regulatory and policy changes affect the organization and structure of the project management, resulting in integration of the delivery organization.
6. Alternative contracting approaches and delivery methodologies are being adopted by clients, changing traditional risk allocation models within the United Kingdom.
7. There has been an increasing use of private finance initiative (PFI) arrangements similar to the public–private partnerships (PPPs) evolving in other parts of the globe.
8. The current economic climate and the overall shortage of funds have resulted in additional scrutiny from the government to increase its confidence that megaprojects can be successfully executed on time and within budget.

Europe that can demonstrate that they have technical capacity and financial strength to deliver the requirements of the contract. The main areas covered by the regulations are advertising, selection, award criteria, and notification of the outcome, but they do not cover contractual matters.

Contracting authorities are permitted to set rules to restrict the number of companies selected to tender for the contract to keep the tender process manageable. The overarching principles of the procurement directives and regulations are that contracting authorities ensure transparency in the procurement procedures, that they treat suppliers equally, and that they do not discriminate in their procedures.

The need for fairness and transparency in public-sector procurement practices is clearly beneficial in helping to ensure that proper competition is achieved and that suppliers are willing and keen to tender for work. In the United Kingdom, the level playing field arising from compliance with the regulations has led to many European contractors bidding for work and establishing UK divisions of their companies.

From the point of view of clients, it has become important that regulations are strictly complied with, particularly with regard to the need for transparency of criteria and weightings used to determine contract awards. The risk of failing to comply with the regulations is that contract award decisions can be challenged and those decisions set aside where a contracting authority has been found not to have met its obligations. The consequence of a legal challenge to a procurement procedure can result in delays of up to a year or more while the matter is taken through the courts. Delays will be longer if the contracting authority is found to have breached its duty and is required to recommence the procurement procedure.

Policy Framework

Public-sector clients in the United Kingdom are required to demonstrate best value for money in the way they procure and deliver works and services using taxpayers' money. They are also required to adhere to relevant government policies. In the past, there has been a wide range of strategies and methods used by different authorities, including those across the 150 highway authorities responsible for the English road network. There was little understanding of what effect the different approaches had on the achievement of best value. As a result, the government has introduced control processes into investment decisions, funding allocations, and project delivery strategies to ensure that spending authorities demonstrate adequate capability and robust delivery plans to achieve successful outcomes.

To support the promotion of best practice and the delivery of best value, the government established the Office of Government Commerce (OGC) in 2001 to oversee procurement policy and standards across central government departments. The OGC is an independent department within Her Majesty's Treasury (HMT), and this structure provides an increasing link between the allocation of budgets to government departments and their capability to achieve value for money from the allocated funds. An independent audit of the value for money achieved by central government departments is provided by the National Audit Office, which reports to the Parliamentary Public Accounts Committee. The Audit Commission delivers a similar role in local government.

Changes to Procurement in the Early 21st Century

Looking back to the 1980s, major government departments retained in-house design teams, and clients were fully responsible for the design of major projects. This arrangement had significant disadvantages, including the cost of retaining design teams during the lengthy planning processes and the risk of abortive expenditure on projects because of changes in government administrations every five years or less, and the revised spending priorities that followed. Some schemes stayed in the planning pipeline for 20 years or more and incurred substantial preparation costs as a result of reviews, delays, and redesigns. It was decided to introduce greater resource flexibility and achieve better value for money by privatizing the public-sector design teams and introducing compulsory competitive tendering.

This approach introduced private-sector expertise into the design of major projects, but design responsibility remained with the employer (project owner). Major projects were designed and planned under the control and direction of the employer, and the supply chain members were only involved after projects were fully designed and the construction contracts were put out to the market. In addition, there was little involvement of the organization that would be responsible for maintaining the asset after it was built under the scope of a separate contract. It was common for the contractor appointed to construct the project to have only a few weeks, or less on occasions (normally around the end of the financial year, when key dates had to be achieved), to mobilize their resources and to start work on site. The result was that there was little consideration to buildability and maintainability in the design of the solution that formed the basis of the construction contract, and problems inevitably occurred during construction and later in the operation of the asset.

The most common form of contract used in the United Kingdom on major projects at this time was the Institution of Civil Engineers *Conditions of Contract,* 5th Edition (ICE5 1986), which was reimbursed on the basis of bills of quantities, with most risks retained by the employer. Contracts were awarded on the basis of the lowest tender price, and this method led to the development of a "bid low–claim high" culture across the industry. The result was a confrontational approach to contracting, with contractors seeking to take advantage of the risks carried by the employer to manipulate additional entitlement to payment and to recover monies not allowed for in their low tender prices. By the early 1990s, the conditions had been created whereby the National Audit Office identified that cost overruns on major projects were averaging 40% (with some projects having cost overruns more than 100% above the tender price). The majority of projects were delivered late, and final accounts on contracts were typically taking three years or more to settle. There were extensive claims on many contracts, which resulted in formal dispute proceedings and incurred high legal costs to resolve. With the uncertainty created by 40% of their expenditure being subject to the outcome of negotiations about claims and of dispute proceedings, there was a growing recognition among owners that something needed to be done to find a more satisfactory and reliable way of contracting with the supply chain.

In 1994, the government commissioned Michael Latham to review the problems in the construction industry, and in July he produced his influential report "Constructing the Team." This report sought to reform the industry by creating a new approach based on teamwork and by clients adopting best practice principles in their procurement methods. It also set a target for the use of the recently developed new engineering contract (NEC) on major projects taken forward by the public sector. Government clients were also being encouraged to consider design–build (DB) contracts as an alternative to the traditional approach of separate contracts covering the design and the construction of major projects. Clients were not comfortable with the NEC at this time, and a range of new custom contracts were produced, which generally sought to transfer most risks to the contractor. The problem remained, however, that planning approval to major projects was required, and this approval involved the development of extensive detailed design to satisfy the needs of public inquiries. Contractors were appointed only after planning approval was obtained, and many constraints were introduced without contractor input, which resulted in poor buildability. Nevertheless, the new approach did offer more scope for innovation by the supply chain and did allow more time for the contractor to plan its construction activities and to mobilize its resources.

The move to DB and the development of early partnering initiatives in response to Latham (1994) did start to reform the industry, but problems remained. Firstly, employers in the public sector still considered that they had an obligation to award contracts on the basis of lowest price. Secondly, the use of DB contracts that passed all risk across to the contractor meant that tenderers were required to complete detailed designs and assess all risks during tender periods. This arrangement meant that it became expensive for contractors to tender for major projects and to win the contract, they faced difficult decisions about their exposure to the level of risk they would face in delivering the contract. Initially, when there were a large number of contracts being placed, high tender prices were received, which adequately covered potential risk costs, but were not necessarily good value to the clients if the risks did not occur. After the change in government in 1997, however, there was a major review of public expenditure, and the amount of money spent on construction reduced dramatically. This decline in the number of projects coming to the market meant that contractors were keen to win work and tender prices were reduced to secure contracts despite the high level of risk exposure. As a result, in the late 1990s DB contracts began to experience significant quality problems as contractors, without the same opportunities to resort to contractual claims, attempted to save costs by cutting corners.

By 1998, the government was not happy with the pace of reform in the construction industry after Latham (1994), and they appointed John Egan to undertake a further review. His report, "Rethinking Construction" (Egan 1998), reinforced the earlier messages, set out a clear strategy for an integrated approach to delivery, and established challenging targets for measuring improvement. The government's response led to the establishment of the Office of Government Commerce (OGC) in 2001 to oversee procurement across central government and to the production of the "Achieving Excellence" guidance notes for the procurement of construction projects.

Industry Change in the United Kingdom and Other Drivers for Change

The Achieving Excellence initiative has resulted in a substantial change in procurement and project delivery practices used in the United Kingdom on major projects. Good progress has been achieved in applying the best practice principles to many major new projects although they have not been fully embraced by all clients and evidence of the old approach is still to be seen. Reviews undertaken by the National Audit Office in 2001 and 2005 have set out the improvements that have been achieved and are supportive of the new initiatives. In addition to the guidance produced by the OGC, there have been other supporting documents produced by HMT, including "Transforming Government Procurement" and "Infrastructure Procurement—Delivering Long-Term Value." These documents have helped to demonstrate the strong leadership being given by government and have helped the industry by giving confidence to the supply chain that they should respond to the initiatives and put in place the systems and the culture needed to deliver in line with the Achieving Excellence principles.

Alongside the drive for reform in the construction industry, the development of the PFI in the mid-1990s to support the delivery of major infrastructure projects has also had a significant effect, which is described later in this chapter.

Best Practice Principles for Megaproject Delivery, Including Lessons Learned

In addition to the regulatory and policy framework described above, the current delivery models in the United Kingdom are being driven by lessons learned and best practice principles on recent megaprojects.

Although every major project is unique, with a different sponsor and stakeholder environment and with different objectives and external influences, in reviewing lessons learned from UK megaprojects over the past 15 years, a number of key issues and themes have been identified that are pertinent to how delivery organizations should be structured and how they should operate to deliver client objectives. The following pointers are not meant to be exhaustive or exclusive, and clients will be influenced by the prevailing circumstances, but the issues raised should resonate well with those who have been engaged with megaprojects in the past, wherever they have been located.

Sponsor Requirements and Change Control

The requirements of the project sponsors, however they are communicated, are directly linked to the output cost of the megaproject and should be established and, where possible, frozen at an early stage of the project. A robust sponsor level change control process should also be put in place to manage subsequent changes in the sponsors' requirements, so as to fully assess their implications before the changes are adopted and to minimize the potentially disruptive effect of the changes on ongoing project delivery.

Governance

Complex capital works programs require clear governance arrangements and strong leadership. The client's interactions with and obligations to the project sponsors are important to project success and should be clearly defined and managed.

Organization

The client's role and the size of the client's team over the life of the project should be established during the early developmental phases of the megaproject. This establishment should include the level of control that the client will want, or need, to exercise, recognizing the need to avoid duplication of effort and unnecessary layers of supervision.

Client staff should be selected on the basis of those best suited to fulfilling client functions during the appropriate stage of the project and roles and responsibilities within the project defined accurately and at an early stage. This suitability is particularly important where a client wishes to adopt an integrated or colocated client program management or delivery team.

Communication and reporting within the megaproject should be structured, open, and frequent to facilitate any integration, but they are equally important, if not more so, where a conventional delivery model is adopted.

The megaproject culture should be established from the outset, e.g., partnering and collaboration. Where partnering or team integration is adopted, it should not be viewed as a soft option because these options require a significant amount of work to make sure that they work effectively. However, if the team is set up correctly, they can greatly enhance the ability of the megaproject to meet its targets in a positive, collaborative environment.

Resources

The successful delivery of a megaproject and the effectiveness of integration have as much to do with the individuals working on a megaproject as the companies that stand behind them. Continuity of senior personnel should therefore be a project objective, particularly when one is assigning or appointing client staff or procuring program managers or delivery partners.

The multiyear nature of megaprojects also provides the opportunity to establish a framework for succession planning, continuous improvement, and training. Where such a framework is set up, it should align with national and regional government initiatives and should be established at an early stage in the life of the megaproject to make sure that the potential benefits can be fully derived.

Delivery Strategy

Clear project objectives should be established from the outset of the megaproject, with implementation and execution strategies developed to support these objectives. Alignment of objectives and organizations is then one of the most important strategies to be addressed in the subsequent delivery of a megaproject. This alignment should start with all the key stakeholders and needs to continue throughout the project, with contractual terms and conditions carefully aligned with the delivery models adopted.

The project procurement strategy should form part of the project delivery strategy, should match client goals, and should contain an outline and flexible packaging strategy that addresses emerging project and market trends and requirements.

Early contractor involvement in the development of megaproject designs can reduce risk and enhance constructability, with cost and schedule benefits. Significant benefits can also be derived from engineering the new or enhanced infrastructure as an operational system, not as a discrete delivery project within, or through which, operational arrangements are retrofitted.

Interface management is a crucial part of delivery and needs to be managed at the most appropriate level. This level is not always at the main works contractor level as, by way of example, enabling or advanced works can provide a good opportunity for de-risking the main contract(s) by the early removal of complex interactions.

Engineering and Design

Engineering requirements and scope within the megaproject should be defined early and accurately, and change should be aggressively managed throughout the life of the project, with the scope of any enhancement works clearly defined against an understanding of existing asset conditions. It is also likely that the more remote the client is from this process of requirement definition and change control, the greater the risk there will be for scope creep and budget escalation.

Where possible, cost containment should be practiced from the outset and a budget philosophy should be adopted, with consideration given to design freezes at the appropriate stages of design evolution. Unproven technical innovation should also be avoided as far as possible, with use of "proven in service" technology maximized to meet megaproject objectives.

Design interactions, such as those between the client and a contractor at the design stage, can introduce inefficiencies and ambiguity, with negative effects on cost and schedule. This complication is a major consideration in the adoption of a DB approach.

Assurance, Approval, and Audit Processes

The assurance, approval, and audit processes can take a considerable amount of time and effort and can significantly affect the ability of a client to deliver a megaproject on time and under budget. This effect should not be underestimated in the preparation of delivery budgets and schedules. A number of approaches should be considered to mitigate this effect:

- Engineering should be integrated with delivery for the design and approval program to be driven to meet cost and schedule objectives, as well as to meet scope and quality criteria.
- Progressive design assurance should be tailored to fit delivery requirements because it can generate significant levels of bureaucracy if not set up and managed correctly.
- The goals for any independent technical certifier should be aligned with those of the megaproject to avoid the potential for protracted and costly delays in approval.
- A contractor's ability to manage the design and approval process should be reviewed at the tender stage before responsibilities are transferred through a DB contract.

- Sponsor-level audit processes, though important, can add a significant cost and schedule burden to a megaproject and need to be optimized and managed effectively.

Project Controls

Good project controls are vital to successful delivery and need to be robust and transparent. Lessons learned suggest that

- A construction schedule should be prepared early in the life of the megaproject with realistic and achievable schedule milestones and delivery dates. Any updates made to the schedule need to be visible throughout its development.
- Project control systems, including the project schedule and, where adopted, earned value analysis, should be robust, with periodic sponsor gateway reviews to monitor progress.
- Risk identification, assignment, and mitigation are a key to the success of megaprojects, with risks assigned to those parties best placed to manage, control, or reduce them.
- Contingency is an important aspect of cost management and should only be allocated to individual project managers in a limited and controlled manner.

Stakeholders and Third Parties

Stakeholders, as defined in Chapter 1, should be engaged in an open manner to achieve their buy-in to any areas of scope, access, and schedule over which they have management control or input. In particular, the eventual operator or end user is a key stakeholder whose input should be sought at an early stage and who should sign off on the project's definition as acceptable.

Utility company works can also have a significant bearing on the ability of a megaproject to achieve its objectives. With major capital works commitments of their own, significant benefits can be achieved through a coordinated approach to such things as training, supply chain, and logistics, as well as the use of integrated design teams for project-related works.

Implementation

Safety must always be the megaproject's highest priority throughout and must be managed accordingly. A proactive and positive safety culture should be built into the megaproject from its inception.

Access to carry out delivery can have a huge bearing on project schedule and should be managed proactively and incorporated into execution planning at an early stage. This need is particularly the case with safety critical, operationally constrained infrastructure, such as railways.

Industrial relations strategy should be addressed at a project, rather than at a contract, level because good industrial relations and training programs will ensure an adequate supply of skilled workers and will lessen the likelihood of labor-related disputes.

Organizational Considerations

One of the first stages in delivering a megaproject is to establish the shape of the client's delivery organization.

Client Delivery Models

Megaprojects are large undertakings of multiyear duration that are complex to define, especially at the outset, and complex to manage. Clients often need to coordinate the oversight of multiple aspects of the megaproject to achieve their goals through the collective management of a number of design and construction projects. In doing so, they will need to adopt a unified, projectwide approach to communication, coordination, and control to manage identified risks and to have adequate contractual rights to discharge these responsibilities.

Clients do not always have the full capacity or expertise needed to deliver a megaproject and often need to supplement their core staff with externally procured resources. There are a number of ways that UK clients have achieved this supplementation over the past 10 to 15 years.

Client Delivery Team

With this model, a client delivery team is built on existing client resources and developed through external staff hires and transfers. This model works best in mature organizations, where there is a pool of suitable and available resources in the marketplace. The structure provides great efficiency because the delivery functions are incorporated within one client group, with a common management structure and culture and common objectives and operational systems. There is less potential for overlapping roles and the duplication of effort.

The single-client delivery organization reduces the risk of a lack of coordination and the integration risk of bringing in a third party to augment the expertise within the client team. However, given the scope of the role and the complexity of the delivery requirements for a megaproject, it can take considerable time to establish the team, recruiting suitably qualified staff, building the resources into a single team with a common culture and introducing management systems to support the delivery effort. This effort can be made more challenging by countervailing cultural issues in the local employment market.

With this form of delivery, the client carries the overall risk and accountability for delivery but has the maximum level of control over decision making and the highest degree of flexibility to change the delivery structure as the megaproject progresses. The expectation is that even with a single-point client delivery team, external recruitment of additional resources would be needed because it is unlikely that the requisite and appropriate resources would already exist within the client structure. In addition, even if preexisting standards and processes exist within the client's organization, a major task would be required to refine and make them megaproject-specific.

The alternative to forming a new client organization is to refine a preexisting mature organization, should such an organization already exist. The opportunities for this process are extremely rare.

Integrated Delivery Team

With this model, an integrated team is established, where the delivery organization becomes a blend of staff from the client's existing team, from additional client hires, and from an externally procured program manager or delivery partner, at both management and staff level. This integrated client delivery team does not normally implement the work themselves but rather establishes the framework within which the megaproject is delivered and procures and manages the supply chain undertaking design and construction.

Under these circumstances, the program manager or delivery partner(s) would be given incentives to work very much as an extension of the client's own staff and would be expected to work collaboratively with the client's team in an integrated manner, where the best expertise from both organizations can be pooled together.

This integrated team must work within the confines of prudent contractual bounds but must be willing and flexible enough to accomplish the shared objectives, successful completion of the megaproject within budget, on time, and with the scope of work necessary to satisfy the desired outcomes.

Where this approach is adopted, it works most effectively when the client or program management teams are integrated from the start into one delivery team with clearly defined roles and responsibilities, forums for resolving issues, and common goals for the outcome of the megaproject.

With this particular model, the client normally augments its team with an experienced project director, experienced program management professionals from a specialist company, and other selected professionals from other disciplines who combine with some of the client's staff who have the correct skills or knowledge base to contribute to the integrated delivery team.

An important factor in adopting any integrated approach is the clear establishment of roles and responsibilities within the team. Some roles need to remain with the client, some naturally fall to outside companies, and others can be a combination of both, depending on resource suitability and availability.

Given the high level of integration, shared accountability, common objectives, and teaming are strong driving factors that underpin the culture of the organization. However, through a clear delineation of roles and responsibilities, it is also possible for risks to be allocated to the party best suited to address them.

This team functions as the client's representative and has overall responsibility for delivering the megaproject. This team puts together the plan and then executes it by bringing on various execution agents, including designers, planners, suppliers, and contractors, to complete the myriad tasks associated with delivering the desired outcomes.

The integrated approach to megaproject delivery provides the client with a significantly enhanced ability to access a broad range of technical, delivery, and project management resources, resources that are unlikely to exist within the client's own organization. With this ability comes the opportunity to scale resources to meet the fluctuating demands of the megaproject and to supply the resources needed within the timescales and for the durations required.

The ability to leverage in third-party skills and to use them in the areas where they can most effectively be applied provides the opportunity for best practices to be generated and retained within the delivery organization. Great care does, however, need to be taken to ensure that the contractual relationship between the client and the program manager aligns with the client's objectives and does not undermine them. A significant amount of effort is required to integrate the client and delivery partner teams and to make sure that they are culturally aligned and focused on objectives.

Contractual Delegation

This model involves the client effectively subcontracting the responsibility for megaproject delivery to a dedicated external organization. This is the model commonly adopted for PFI design–build–finance–operate (DBFO) contracts in the United Kingdom.

Total delegation and risk transfer involves most management and delivery functions being assigned to a separate program manager or delivery partner. This model works best on megaprojects where requirements, risks, and stakeholder interactions are well defined and ongoing client control is not required. The tendering period required for this type of arrangement is normally significant.

With this model, it is usually more difficult to ensure that all commitments, obligations and stakeholder requirements are delivered, and it can be difficult and expensive to accommodate changed requirements. However, with this delivery model, a substantial amount of schedule, quality, and cost risk for project delivery may be transferred to a third party, who will provide a single point of accountability for the delivery of the megaproject to the client.

The amount of risk that can actually be transferred depends on many factors, including the complexity of the megaproject, market conditions, and external dependencies, but it is unlikely that any third party would accept anything approaching a full transfer of the risks of a megaproject because of the complex stakeholder environment within which they are delivered.

Under this model, client costs and overhead can be minimized to those core activities that the client must perform for governance, legal, planning, financial and commercial, land acquisition, public relations, scope definition, and output cost management reasons.

Although the option is potentially attractive in providing a greater level of certainty in output cost, this certainty is likely to come at a high cost. The relationship between the client and its appointed partner must be well defined, and the level of detail required to transfer risk effectively to a third party can require a significant lead time. This lead time is needed to establish the necessary commercial and contractual framework and to define client requirements to a level that minimizes subsequent changes because this model makes it harder, more expensive, and more disruptive to introduce change over the life of the megaproject.

The transfer of risk also brings with it a significant loss of control and flexibility over how the megaproject is delivered, and the client must define clearly the outputs and objectives that he or she is seeking when appointing the third-party delivery agent.

The engagement of a single-point delivery partner can, however, facilitate the introduction of management, technical, and delivery resources into the megaproject, within a common culture and with an established system of controls and processes for project management, design, procurement, and delivery.

New Approaches to Procurement (Including PFI and ECI Contracts)

New Procurement Approach, Key Principles

The background to the development of new approaches to procurement and the key drivers for change were mentioned earlier. The key principles on which the new approach to project procurement has been based are

- Packaging of work to minimize interface risks;
- Early creation of integrated delivery teams based on partnering principles;
- Development of long-term relationships;
- Fair allocation of risk;
- Selection of suppliers based on best value incentives for best value delivery;
- Robust performance measurement and management; and
- Achievement of continuous improvement targets.

Although some parts of the industry and some clients were slow to respond to the drivers for change, major UK construction clients, including the Highways Agency, the Environment Agency, and the Defence Estates, initiated major change programs to their approaches to the procurement and delivery of major projects. There was a much stronger focus on the supply chain, and clients sought to understand how they could achieve better value. Previously clients in the public sector had taken a cautious approach to the size of contracts to avoid the risk of supplier failure. It was also normal to seek to maximize competition by having as many tenderers as possible. The result of this approach was generally a high number of low-value contracts and high bidding costs for the industry. The new approach has led to a smaller number of higher-value contracts and fewer but better suppliers. Some of the new procurement initiatives are described below.

Private Finance Initiative Development

The PFI concept was developed in the early 1990s at the time that the Second Severn Crossing was being taken through the planning stages for delivery as a toll concession contract. This development led to consideration about whether the approach might also be used for nonestuarial crossing highway projects, and legislation was put in place in 1991, the New Roads and Street Works Act, to allow the construction of tolled highways. The first such road to be taken forward in this way was the Birmingham Northern Relief Road, which had already been taken through statutory planning stages under the Highways Act in 1989. A 50-year concession contract covering the design, planning, construction, maintenance, and operation of the road, fully funded by the private sector, was put in place. The project was renamed the M6 Toll Road, and it was taken through a further public inquiry in 1994–1995; the 27-mi-long (43.45 km) road finally opened to traffic in 2003.

This project was the first time the design, construction, and maintenance over the whole life of an infrastructure asset had been brought together under a single contract. This success in turn led to consideration being given as to whether a similar whole-life approach might be used for nontolled infrastructure assets, which resulted in the design–build–finance–operate–maintain (DBFO or DBFM) approach being introduced.

The main benefits of this approach were that the use of private finance allowed projects to be brought forward earlier; it allowed optimal whole-life solutions to be developed; there was greater scope for innovation in the construction and maintenance of the asset; and it allowed the skills and knowledge of the constructor and the maintainer to be involved from the outset of the project planning. A series of DBFO contracts was awarded for the construction of highway improvement projects, together with the maintenance of an adjoining area of existing road network over a 30-year period.

The initial DBFO roads contracts were reimbursed by the government on the basis of shadow tolls for the volume of traffic using the new section of highway over the life of the contract. A threshold was built into the payment mechanism linked to the theoretical capacity of the road above which no additional shadow tolls would be paid. It was recognized that this method of payment did not incentivize the contractor to take account of the level of service to road users, and this problem was addressed by moving the payment mechanism to one based on the availability of the asset. This approach was further developed, and later DBFO contracts incorporated payment mechanisms based on a combination of traffic volume and the average speed of traffic, together with a measurement of safety performance.

The M25 DBFO

The most recent DBFO highway contract awarded is the M25 widening contract, which, with a contract value of around £6 billion, is also the largest private-finance contract to date in the United Kingdom. This contract has developed the payment mechanism, to be focused as far as possible on customer service, with payments linked to journey time reliability and safety. The contract includes the widening of the dual three-lane sections of the M25 orbital around London to dual four-lane standards and also includes the maintenance of the motorway over a 30-year period. The widening is being planned in two main phases. The tenderers for the contract are required to price the first phase, and the price of the second will be determined in due course from a pricing process that uses information from the actual costs of construction of the first phase. The contract includes provision for reviewing any unforeseen step changes that occur over the life of the contract that have a significant effect on service delivery and cost. The costs of the tendering process were minimized by the use of a funding competition after the selection of the preferred bidder.

PFI Results

Reviews of the benefits of the PFI approach have indicated that up to 15% better value has been obtained compared to traditional procurement methods using public-sector funding. This improvement has been largely through the transfer of risk to the supply chain for the construction and maintenance of the asset over the whole life period of the asset. The approach has also achieved better integration of the design, construction, and operational phases and has provided greater opportunity for innovation. The level of risk transfer has brought with it a greater focus on due diligence in understanding risks and requirements and ensuring that solutions are fit for their purpose and deliver the best value.

Early Contractor Involvement

The use of early contractor involvement (ECI) principles is becoming widespread in the delivery of major infrastructure projects in the United Kingdom, although the principles are applied in different ways by different clients. The approach was introduced to achieve input from the supply chain members at an early stage to allow greater scope for innovation and to achieve better planning of the buildability of the works and better understanding and management of the risks. ECI contracts were split into three phases covering the design, the public inquiry, and the construction stages. For the first two phases, the contractor provides an integrated team, including the designer, paid on an incentivized time-charge basis. Progression to the construction stage would be subject to the team delivering an affordable solution within the client's budget and also to a satisfactory outcome of the public inquiry.

ECI was first introduced as an early form of DB, with the contractor appointing the designer and managing the design process. Clients who adopted this approach found benefits in the more effective management and control of the design process by contractors. The ECI approach has also been implemented where the employer has chosen to retain design responsibility either up to a specified point in the development of the project or throughout the planning and construction phases. In the latter case, the approach has been called optimized contractor involvement (OCI), and this type of involvement involves the contractor working alongside the employer's designer before the completion of the detailed design to review buildability and to undertake final value engineering reviews. The OCI process is supported by the use of value engineering clauses that allow any savings to be shared between the parties.

A key aspect of the ECI approach is how to determine the successful tenderer in the procurement process when the final design of the works has not been fully developed and cannot be reliably priced. This aspect is discussed below.

Risk Allocation in ECI Contracts

ECI contracts developed in the highway sector in the United Kingdom have been based on the NEC form of contract, which provides a fair and sensible allocation of risk between the parties. The intention is to allocate risks to the party best able to assess and to manage them. It is not considered good value to allocate risks to the contractor that cannot be fully evaluated and, therefore, cannot be reliably priced. If the contractor is guessing at the potential consequence, then he or she will either underprice the risk (particularly if price is the primary factor in determining the award of the contract), with the adverse consequences of that commercial pressure, or he or she will overprice the risk, which will provide the client with certainty of price but will not offer good value.

In the ECI approach, the contract is awarded before risks have been fully assessed and quantified. Indeed, it is one of the key benefits of ECI to have the contractor as part of the team who are evaluating risks and identifying options for either avoiding risks or for mitigating the effect of the risks. The approach has been adopted to produce initial risk schedules as part of the tender documentation and to seek tenderer proposals as to how risks will be evaluated and mitigated.

During the first phase of the ECI contract, the risk schedule is developed and mitigation proposals and risk allocations are developed and agreed on between the parties on the basis of the best value solutions. The use of target cost contracts means that payment is made on the basis of actual costs necessarily incurred in delivering the works and incentives are incorporated to minimize overall costs.

The consequence of allocating risks is that the estimated price of a contractor's risk is included in the target price for the contract, and if the contractor can manage the cost of the risk within the estimated price, then he or she takes a share of the cost savings. The estimated price of an employer's risk is excluded from the target price, and if the risk occurs, then the target price is adjusted accordingly and the costs of the risk are paid to the contractor. This approach means that all parties are incentivized to manage risks as efficiently as possible.

Rewards in ECI Contracts

The aim of the ECI approach is to achieve a collaborative and partnership approach between the parties supported by common objectives and incentives for all parties aligned with the achievement of those objectives. The target cost approach provides the main incentive mechanism for delivering the contract within budget. This method has been found to work well, provided that the initial target is fair and reasonable for the cost of delivering the contract.

It is important that contracts are not awarded solely on the basis of lowest price and that the adequacy of tenderer prices is evaluated as part of the tender assessment process. Further incentives can also be used in the NEC contract to help support successful project outcomes. These incentives can include value-engineering clauses that provide the contractor with a greater incentive to develop better value solutions and also the use of key performance incentives, with financial incentives for good performance in areas such as health, safety, and environmental sustainability.

For clients with longer term programs of major projects then, a key incentive for the supply chain is to perform well to allow them to be considered for the delivery of further projects in the program. The client may enable this incentive by awarding contracts covering a package of projects where progression to the next project is linked to satisfactory performance, or the client may use separate contracts for each project but takes account of past performance in the selection of firms to tender for the contract. Good performance by the contractor and their supply chain is always incentivized where the client is willing to acknowledge and recognize it in a way that enhances the reputation of the companies involved in successful delivery.

Benefits of ECI

The use of the ECI approach has delivered the following benefits:

- More scope for innovation by using the skills of the supply chain earlier;
- Schemes delivered more quickly and provided greater certainty of time;
- Improved buildability;
- Better resource planning and more effective use of resources;
- Better understanding of cost and where wastage occurs;
- Better H&S planning and performance;
- Improved evaluation and management of risks;
- Better cost estimating and certainty of price; and
- Fewer disputes and earlier settlement of final accounts.

The use of ECI principles has also led to the development of alternative delivery structures to meet the needs of different clients. For example, in the rail sector on a complex project subject to extensive undertakings and assurances, the client has retained design responsibility but has developed an OCI approach whereby the contractor works alongside the designer before the finalization of the detailed design and is incentivized to identify improvements from value engineering and buildability reviews.

The NEC Form of Contract

The NEC used on ECI contracts was first developed in the mid-1990s and is now in its third form; NEC3 was published in 2006. Its use for public-sector clients has been endorsed by the Office of Government Commerce, and it is now used widely across the public sector in the United Kingdom. The NEC supports collaborative working and partnerships between the parties. It is a flexible contract that provides six main payment options, ranging from lump sum to cost reimbursement, which allows the employer to select the appropriate option based on the circumstances of the project.

The contract requires the parties to give early warning to the other parties of any issues or events that may affect time, cost, or performance. The parties are then required to jointly consider how best to mitigate the effect of any such matters, and the project manager determines whether there is any entitlement due to the contractor as a consequence. Any such entitlement is known as a compensation event, which, in the case of target cost contracts, has the effect of increasing the target price. The target price is supported by a pain–gain incentive mechanism, which provides the contractor with a share of any savings and also exposes them to the risk of sharing any cost overruns. It is common to use a 50–50 split to provide an equitable share of risk and opportunity.

The successful use of the NEC contract depends on the robust management of the contract and the handing of compensation events and related programming matters in a timely manner. This management requires sufficient experienced resources to be available to all parties for the management of the contract, and where this is achieved it can be expected to deliver successful outcomes with a prompt conclusion of all contractual matters.

The increasing use of the NEC form of contract in the United Kingdom since 2000 has made a significant contribution to the changed and improved culture in the construction industry. There has been a considerable move toward partnering and collaboration, and the number of contracts suffering the damaging consequences of confrontational relationships has been substantially reduced.

Supplier Selection and Engagement

Lowest price was used as the sole criterion to award public-sector contracts until the late 1990s. At that time, in parallel with the government initiatives to improve the performance of the construction industry, HMT put out guidance that public-sector construction clients should not simply focus on lowest price as the basis for the award of contracts but should consider the most economically advantageous offer that was provided for in the European Procurement Directives. This consideration led to the development of quality–price procedures by clients and provided a strong signal that public-sector clients were committed to moving away from the adversarial relationships that had plagued the industry. The use of lowest price tendering had the following problems:

- Quality of product was put at risk;
- Quality of service was put at risk;
- Cost and time overruns were rampant;
- It was likely to lead to claims and formal disputes with high legal costs;
- It does not encourage innovation;
- Supply chain sustainability was threatened; and
- The approach is not attractive to the best-quality suppliers.

The introduction of the ECI initiative also required a new approach to the criteria used for the award of contracts because the contractor was being appointed before the project was fully designed and could not be priced on a reliable basis. The approach adopted was to look at the quality of the company, their processes and systems, and the capability of the proposed team and individuals to deliver successful outcomes. The tender process required tenderers to set out their approach to delivering the project and to identifying and managing risks. This process was supported by commercial information that could be used to develop a target price on a consistent basis across the tenderers.

Current Themes in the Delivery of Major Projects

Collaboration and Efficiency

A strong focus on efficiency in public-sector procurement in the United Kingdom was introduced in the 2004 government's public spending review, which included efficiency targets for government departments that were known as the Gershon efficiency targets. Initial target of 2% year on year efficiencies were set, which were increased in the 2008 spending review to 5%, and the current economic position is expected to require more. These targets will require public-sector clients to find better ways of engaging with their supply chains to deliver better value solutions and will also require greater collaboration between clients to reduce wastage and achieve smarter ways of working together and procuring requirements.

Supply Chain Management

As part of the drive of achieving better value, the importance of the role of the supply chain needs to be recognized and understood. Clients often tend to focus on their first-tier suppliers without fully understanding the lower tiers of the supply chain and without recognizing the role they can play in achieving better value solutions.

In the United Kingdom, most public-sector clients spend more than 90% of their budgets through the supply chain. Main contractors typically subcontract 50% to 80% of the contract value to subcontractors and suppliers in the lower levels of the supply chain. It is vital, therefore, for clients to understand and engage with the whole of their supply chain to ensure that requirements and objectives are understood and that any barriers to best value delivery are removed.

In the delivery of contracts, it is important that key subcontractors and suppliers are brought into integrated teams and partnering arrangements. In the United Kingdom, leading clients have established supplier communities to allow working methods and procedures to be reviewed and improved; the benefits are then shared by all. There are also various smart purchasing initiatives underway, with clients collaborating to get better value where they have common requirements in category expenditure.

Governance and Demonstrable Good Value

There is high importance given to clients' robust governance arrangements and their ability to demonstrate best value in the expenditure of funds. Clients are required to demonstrate, as part of client capability and project delivery reviews, that they have the necessary skills, have robust procedures, and that they have learned lessons from other projects to move forward through the various project delivery phases. These requirements cover:

- Defined procedures;
- Assurance and change control processes;
- Framework of delegations;
- Project gateway reviews;
- Performance measurement and reporting;
- Benchmarking; and
- Audit—internal and external.

The project gateway reviews used in the United Kingdom have been developed by the OGC and are applied to all high-risk or complex projects at the following stages:

- Stage 0—Strategic assessment;
- Stage 1—Business justification;
- Stage 2—Delivery strategy;
- Stage 3—Investment decision;
- Stage 4—Readiness for service; and
- Stage 5—Operations review and benefits realization.

Fair Payment Practice

The OGC produced a guide to fair payment practices in June 2007, which makes the case for change in UK construction payment practices and follows on from a series of government initiatives in the 1990s, most notably Latham (1994), which led to the Construction Act of 1996, and the Late Payment of Commercial Debts (Interest) Act of 1998.

The OGC guide describes fair payment as payment in which the contractual terms relating to the discharge of payment obligations and the payment process are fair and adhered to, and it recommends principles and practices to be adopted in the UK public sector.

OGC highlights the fact that poor payment practices in the UK construction industry give rise to substantial additional financing and transaction costs, and they emphasize the notion that certainty over how much and when a payment is made builds up trust between supply team members and underpins collaborative working to achieve value for money projects for clients.

The stated aim of the improvements recommended by OGC is to provide greater certainty on payment to everyone in the supply chain and to optimize payment periods to minimize financing charges. Based on their analyses, OGC contends that public-sector clients could expect to save up to 2.5% on construction costs from the introduction of better payment practices.

OGC estimates that widespread adoption of these principles and fair payment practices set out in their guide would save the public sector some £200 million, rising to more than £750 million as the processes become embedded and confidence in the system increases. In the current economic climate, it is also anticipated that the adoption of fair payment practices should help to reduce the risk of supplier failure because of cash flow problems. OGC's proposals include

- The adoption of a fair payment charter, which should be agreed to and signed by the client and the main supply chain members working on a project or a framework of projects;
- Targeting payment of the supply chain (to level 3) within 30 days;
- Shorter payment periods, greater use of milestone payments, and the inclusion of past performance on payment as a key prequalifying criterion for contractors; and
- The introduction of project bank accounts where they are "practical and cost effective."

Responsible Procurement

The role of procurement and project delivery in supporting wider sustainability policies and objectives is becoming increasingly recognized, and public-sector clients in the United Kingdom are now required to address the following themes in their procedures and contracts:

- Encouraging a diverse supply base;
- Promoting fair employment practices;
- Promoting workforce welfare;
- Meeting strategic labor needs and training opportunities;
- Identifying and promoting community benefits;
- Ethical sourcing practices; and
- Promoting greater environmental sustainability.

Summary

It could have been anticipated, given the current difficult economic climate, that there would be few infrastructure megaprojects taken forward in the United Kingdom in the foreseeable future. Investment in infrastructure projects continues, however, to be politically attractive as a way of stimulating and supporting economic recovery. There are plans for a range of major investments in the UK transport and energy sectors in particular, which will require world-class program and project delivery skills to achieve successful outcomes on these megaprojects.

In view of the economic climate and the overall shortage of funds, it will be increasingly important that lessons learned from previous projects and best practice delivery principles are incorporated into the delivery models of future projects. Public-sector clients are coming under greater scrutiny from government and their advisors to demonstrate that delivery plans are robust and have been subjected to an appropriate level of evaluation and review by independent experts to give them confidence that clients can and will deliver successful outcomes within available budgets. The expectation is, therefore, that recent initiatives based on integrated delivery teams and collaborative working methods described in this chapter will continue to be developed and implemented.

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CHAPTER 18

Strategic Considerations in North American Megaprojects

Albert Bates Jr.

Creative minds have fashioned many different project delivery systems for megaprojects constructed in North America. "Project delivery system" means the manner in which an owner contracts for the engineering, procurement, and construction services.[1] This chapter focuses on project delivery systems on multibillion-dollar, privately funded projects and uses as the central example the construction of coal-fired power generating facilities.

In the context of privately funded megaprojects, a variety of methods have been used to contract for engineering, procurement, and construction services. Three common types of project delivery systems are:

- The general contractor (GC) model;
- The EPC, or turnkey, model; and
- A hybrid approach, such as multiple prime contractors.

There are many variants to these general delivery methods. For simplicity, this chapter focuses on the strategic concepts applicable to each of these delivery models. Each contracting strategy presents certain advantages and disadvantages, particularly with respect to financial risk, project management responsibilities, and cost management and control.

This chapter initially describes three common types of project delivery systems and then generally discusses the advantages and disadvantages of each. The chapter

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1 In the United States, there are restrictions on public contracting methodologies in many jurisdictions under applicable federal or state laws. Some of these laws require public or quasipublic owners to competitively bid multiple prime construction packages (typically including equipment and material procurement by each prime contractor) but expressly authorize the negotiation of professional services contracts (including engineering contracts). The complexities of these federal or state public procurement laws or regulations are beyond the scope of this chapter.

LESSONS LEARNED

1. Selection of the appropriate project delivery system is a critical strategic consideration for a successful megaproject, particularly in North America.
2. Every delivery system has advantages and disadvantages; it is important to match the delivery system to the specific conditions of the megaproject to be executed.
3. Project duration (from design through commercial operation), total project cost, owner's project management capabilities, and owner's risk profile are typically the driving factors in selecting a delivery system for the megaproject.
4. The traditional general contractor model provides the best opportunity to minimize total project cost but places greater risks on the owner and places a premium on the owner's ability to manage project design, procurement, and execution.
5. The engineering, procurement, and construction (EPC), or turnkey, model provides the owner with a lesser risk profile than the traditional general contractor delivery system and is well suited for fast-track projects. However, since the EPC contractor accepts significant risks, it can be the most expensive of the project delivery systems. Also, fewer contractors are willing to contract on a turnkey basis, given the breadth of work required of the EPC contractor on a megaproject.
6. The hybrid multiprime delivery system provides the most flexibility to the owner, but it is the most complex delivery system to manage from the owner's perspective.
7. Economic downturns lead to EPC consortiums being more common.
8. The allocation of risk under an EPC consortium delivery system is complex because risks must be allocated both between the owner and the EPC consortium, among the members of the EPC consortium, and between the members of the EPC consortium and their respective supply chains.
9. The strategic importance of the dispute resolution provisions are magnified on megaprojects. Carefully prepared dispute avoidance and resolution provisions can save significant time and money during the project, and "boilerplate" or inconsistent provisions across contracts can result in the unnecessary waste of millions of dollars at the conclusion of the project.

next focuses on EPC consortiums, a widely used method of contracting for megaprojects in North America, and discusses the primary challenges facing consortium partners, the allocation of risk between the owner and the EPC consortium, and the allocation of risk inter se (between or among themselves) between the participants in the EPC consortium.

Overview of the General Types of Project Delivery Systems

Regardless of the project delivery model used, there are usually certain preliminary tasks performed by the owner or its engineer before project execution. These tasks include but are not limited to conceptual design, equipment sizing, operating criteria, initial schedule development, cost estimating, permitting and other necessary corporate and regulatory approvals, project control and management plan, labor availability study, and creating an owner oversight and staffing plan.[2] In addition, given the long lead times associated with major equipment procurement, owners often begin procurement of major equipment, such as the boiler work and the turbine island, before final selection of the project delivery system. Although this work complicates the contract negotiation and execution process, it often occurs because of the economics attendant on in-service requirements on megaprojects.

The selection of the project delivery system builds upon the initial project scoping. The project delivery system addresses project execution, and in particular detailed design, procurement, construction, and start-up, commissioning, and training, based upon the owner's requirements as defined during the initial project definition stages.

For many owners, project cost is a principal factor in selecting a project delivery system. However, megaprojects have a long useful life, and initial capital outlays, including the costs of the owner's project management team, are only a part of the equation. The owner should evaluate not only the initial capital costs but also the operating and maintenance costs of the facility, as well as its safety, reliability, durability, and other longer term costs associated with the design and technology selection criteria for the project.

The Traditional Approach: The General Contractor Model

Under the traditional general contractor model (GC model), the owner retains a general contractor to construct the project in accordance with the plans and specifications supplied by the owner. The owner and/or its project engineer prepares detailed engineering drawings and specifications, procures the major equipment, and provides the construction milestone dates and engineering and equipment delivery dates for use by the general contractor in developing the integrated project schedule. The GC model traditionally involves a project design, then bid, then build approach, but more frequently uses a "fast-track" basis in which procurement of major equipment and some civil construction proceeds before the final project design is completed. Rather than self-perform contract administration responsibilities, owners may employ a construction manager (CM) to control and manage the

2 The role of the project engineer varies depending upon the contracting methodology. The scope of work of the owner's engineer may be limited to some or all of these preliminary tasks, or, on the other extreme, may have design and construction administration responsibility for the entire project. Between the two extremes, the owner's engineer may be assigned procurement responsibility, cost and schedule management and control, construction oversight or construction management functions, or any combination of these and similar tasks.

design, procurement, construction, and commissioning process on its behalf. In this model, owners typically seek cost certainty through a lump sum, target price, or guaranteed maximum price contract, recognizing the potential for design maturation and further scope definition through contingency allocations and the potential for the sharing of "savings" with the general contractor. Though the general contractor model typically strives for a reasonable degree of cost certainty through some variant of lump-sum contract pricing, the timeliness and completeness of the design, the timely and complete performance by the major equipment suppliers, and effective change management by the owner significantly affect the project costs. As the old adage goes, "E and P come before C." In other words, unless engineering and procurement are performed in accordance with the owner's contractual obligations, the project will suffer, and the owner will likely face contractor claims for additional time and money.

The EPC or "Turnkey" Model

In the EPC model, the owner typically retains an engineer to develop the design criteria, in-service date requirements, performance targets, and other operational criteria for the project. The owner then contracts with a single entity, often a consortium, to provide all aspects of detailed engineering, procurement, scheduling, and construction of the project. EPC contracts traditionally contain performance guarantees, whereby the EPC contractor warrants the operational and performance criteria of the project. Significant liquidated damage payments are usually tied to interim and final design, procurement, and construction milestones, the most significant of which are "first fire" or other provisional operation, mechanical completion, and final completion. Significant agreed contract adjustments may also be tied to failing to meet operational or performance criteria. The EPC model typically involves a "fast-track" project, in which major equipment procurement and civil construction precedes final design completion. The EPC contract is typically a fixed price, target price, guaranteed maximum price contract or some other variant of a lump-sum contracting methodology, often laden with incentives for the EPC contractor. It is not uncommon for major portions of an EPC contract to be performed on a cost-reimbursable or "open book" basis, typically with a target price for a defined scope based on installed units or other objective criteria. This method is particularly common when the owner has a tight schedule with a drop-dead in-service date, and the owner's requirements are either not fully developed or may change during the course of detailed design. In these circumstances, a more collaborative approach, including cost reimbursable elements and a team approach to project definition, may best serve the needs of the owner.

Hybrid Approach—Multiple Prime Contractors

Under a multiple prime contractor approach, the owner enters into multiple prime contracts for the major scopes of the project. For example, on a coal-fired power generation project, the owner frequently enters into a prime contract for the design, supply, and construction of the boiler and air quality control system (AQCS) on an EPC basis. With respect to the remaining scope of work, including the turbine island, civil, and balance of plant (BOP) engineering, a sophisticated owner may retain procurement and detailed engineering responsibility, including responsibility to procure the major equipment for the turbine, civil, and BOP engineering but hire multiple prime contractors for installation by defined work scope, such as civil, piping, electrical, and structural steel engineering. Another multiple-prime method is for the owner to enter into two EPC contracts, one EPC contract for the supply of the boiler and AQCS, and one EPC contract for turbine, civil, and BOP engineering. Under this approach, overall construction schedule responsibility must be assigned to one of the EPC constructors. A variant of this approach is an EPC wrap for the turbine, civil, and BOP engineering, an approach in which the owner retains procurement and detailed engineering responsibility for the turbine, civil, and BOP engineering but contracts with a single constructor to install all work not included in the boiler EPC contract, assigns all rights and responsibilities under its equipment procurement contracts to the constructor, and obligates the constructor to integrate the schedule for its work with that of the boiler EPC constructor and manage project schedule and coordination to achieve the required interim and final construction milestones. There are also various other multiple-prime contracting structures; the common thread is the owner's retention of responsibility to manage multiple major prime contractors. Rather than self-perform contract administration responsibilities, owners in a multiple-prime contracting structure may employ a CM to control and manage the design, procurement, construction, and commissioning process on behalf of the owner.

Advantages and Disadvantages of Various Project Delivery Systems

Traditional Approach: The General Contractor Model

The GC model maximizes the owner's control over the project, including the project schedule and cost. However, the GC model requires the longest lead time; presents significant financial risks; has the potential for significant disputes among the owner, project engineer, equipment suppliers, and general contractor; and requires a strong and sophisticated project management and project controls team. In addition, because of the sheer size of the projects and limitations on bonding capacity, few general contractors are in a position to bid on megaprojects, which can lead to a lack of competition and a higher contract price in robust economic times.

Advantages

The two biggest advantages of the GC model are that it provides the best opportunity for the lowest overall project cost, and early scope definition is less critical than in other project delivery methods. With respect to cost, each element of supply is negotiated between the owner and the supplier, so that the owner has the opportunity to achieve cost savings over budget with the buyout of each scope. In addition, since the construction contract is not traditionally let until the design is complete and major equipment contracts have been placed, design maturation and refinement typically have less cost effect under the GC model than under other project delivery systems. In other words, the major equipment procurement affects the detailed engineering, from undergrounds through foundations to piping and electrical supply. Under a design, then bid, then build GC model, the issued for construction (IFC) drawings typically form the basis of the general contractor's bid, and the IFC drawings should be reflective of all information available to the engineer at the time that the drawings are issued. Since the design maturation process should precede the issuance of IFC drawings, the owner has a bit more flexibility on the timing of scope definition.

The owner typically retains the general contractor on a fixed price, target price, guaranteed maximum price contract, or some other variant of a lump-sum contracting methodology but retains responsibility vis-à-vis the general contractor for late, incomplete, or otherwise deficient design information, as well as delays in delivery of major equipment. Consequently, aggressive management of the engineering, procurement, scheduling, and change management functions is at a premium, since any costs incurred by the general contractor as a result of deficiencies in the performance of the owner or its agents are charged to the owner's account. The owner typically retains the ability to pursue claims against the engineer, major equipment vendors, and others with whom it contracts directly for losses arising from their deficiencies, actions, inactions, and other contractual breaches.

The GC model also offers the owner the greatest degree of control over the design and equipment technology selection, as well as the overall project schedule. The GC model allows the owner to directly control each stage of the engineering, procurement, construction, quality control, commissioning, and start-up to ensure that the owner gets precisely the plant it wants. Unlike the EPC model, the GC model provides the owner with the ability to individually select the engineer, its preferred technology, all major equipment vendors, and the general contractor and its subcontractors. It also allows enhanced usage of local specialty contractors and subcontractors in situations where that may be an important consideration. Though the owner takes responsibility for overall planning and execution of the megaproject, the owner's engineer focuses on engineering and quality control, and the general contractor focuses on building the plant in strict accordance with the owner's plans and specifications.

The GC model typically allocates risk associated with construction, including labor productivity, labor availability, construction equipment availability, means and methods of construction, and construction supervision, to the general contractor and allocates risks associated with engineering and procurement to the owner; it is often considered an efficient allocation of risk among project participants since the GC model generally allocates risk to the party that can best control, manage, or absorb that risk.

The GC model provides a built-in check and balance dynamic between the project engineer and the general contractor, which should facilitate early identification and resolution of problems to achieve a successful and timely completion of the project. Because there is no direct relationship between the engineer and the general contractor under the GC model, there are no blurred lines of responsibility, so any issues that the engineer or general contractor faces in completing its work as a result of shortcomings outside of its control should be identified and resolved in a timely fashion (albeit with more conflict potential).

Disadvantages

The GC model places a heavy burden upon the owner to properly manage the project, and it can be a sluggish method in the face of significant delays or disruptions to the project schedule. The GC model uses a "three-legged stool" that inherently diffuses responsibility among owner, engineer, and contractor and invariably leaves residual risk in the lap of the owner. The degree to which an owner retains residual risk is dependent upon the terms of the contracts on the project. However, some degree of residual risk typically remains with the owner under the traditional approach. The owner must be diligent in coordinating the procurement and engineering function between the engineer and the general contractor in light of the lack of contractual privity and formal communication line between the two parties. This approach requires clear, well-defined points of contact and communication so that necessary information is successfully and efficiently shared between the engineer and the contractor on a real-time basis. The split in responsibility inherent under the GC model can also make resolution of scope changes and recovery schedules far more difficult, expensive, and time consuming than under an EPC model. In addition, in the absence of well-defined and managed project schedule and project control functions, the owner may be slow to recognize when a project is becoming troubled (i.e., behind schedule or over budget). Under a GC model, it is important that the owner have access to accurate progress and cost information and that project schedule and cost functions be transparent so that issues can be identified and resolved in real time, before irreparable damage to the project occurs.

The owner also assumes a substantial amount of risk for the engineering and procurement phases of the project under the GC model. Typically, any breach of duty by the engineer or equipment suppliers to the owner gives rise to a breach by the owner of its obligations to the general contractor. Deficiencies or delays by the equipment suppliers typically expose the owner to contractual responsibility to the contractor and engineer. Although the owner has control over the project, the owner also is the target of all claims of deficient performance by the engineer and the equipment suppliers. The GC model typically puts the owner in the center of all claims on the project. Owners often attempt to contractually craft ways to insulate themselves from liability for errors, omissions, deficiencies in performance, or other breaches of duty by the engineer, equipment suppliers, general contractor, or others in direct contractual privity with the owner. In general, even with careful contract drafting, it can be difficult for an owner to excise itself from contractual claims by the general contractor for breaches of contract related to deficiencies in performance by the engineer or equipment suppliers under a GC model. In addition to risk shifting and risk allocation considerations, the disputes provision, including when the joining of parties, or joinder, is appropriate, should be uniformly established in all major contracts with the owner under the GC model.

By its nature, the GC model has the potential for significant claims against the owner if the project is not properly managed. This approach often leads to greater conflict on the project as the engineer, the equipment suppliers, and the general contractor blame one another if the project falls behind schedule or over budget, which forces the owner to expend time and resources managing claims and/or the arbitration process. The owner may be exposed to multiple dispute resolution proceedings involving the engineer, major suppliers, and the general contractor. The potential for claim proliferation after the project has been completed is compounded by joinder problems and common exculpatory and damages limiting provisions typically found in the contract with the engineer and major equipment vendors. The ability to join the engineer or major equipment suppliers into contractual disputes with the general contractor is dependent upon the joinder and consolidation provisions of the contract documents. Likewise, the general contractor's ability to join the owner into disputes with its subcontracts is also dependent upon the joinder and consolidation provisions of the contract documents. All parties would be well served to carefully review and consider the ramifications of the joinder and consolidation provisions, if any, of the contract documents. This issue can be minimized to some degree through careful contract drafting, with particular attention to uniformity among the contract documents. However, performance guarantees, targets, and warranties can be particularly problematic using the GC model.

Alternatively, with respect to claims by the owner, the GC model can lead to significant causation issues if the owner assessed liquidated damages for late completion or if the plant as constructed does not achieve performance criteria. This issue can be minimized to some degree through careful contract drafting, with particular attention to uniformity among the contract documents. However, performance guarantees, targets, and warranties can be particularly problematic using the GC model.

For example, if the plant as designed was to achieve a minimum of 850 MW, but the plant as constructed only achieves 800 MW, the owner will incur significant losses over the operating life of the plant and may violate certain covenants that it has with the purchasers of power from the project. Inevitably, the general contractor will allege that it built the plant in accordance with the plans and specifications. The turbine supplier will blame some combination of the boiler supplier, controls supplier, other equipment supplier, engineer, general contractor, or owner. The same holds true for the boiler supplier. The engineer will likewise disavow responsibility, and the owner will be left in a quagmire attempting to enforce performance criteria or alternatively recoup long-term operational losses incurred as a result of an underperforming plant, often in the face of limitation of liability provisions in the respective contracts and potentially significant causation issues. If the owner takes control of the project through a traditional GC model, the owner inherently is left to manage and control deficiencies in performance and to arbitrate with a number of diffuse parties, each of whom disavows responsibility for the deficiency in performance.

Several other points should not be overlooked. Regardless of how well crafted the contracts may be, the owner inherently retains some residual risk. Furthermore, by its nature, the GC model has the potential for gaps in the scope of supply. Finally, the owner must have a sufficiently large and sophisticated staff to manage the overall project or must retain an experienced construction management team externally. The level of design, procurement, cost, schedule, quality, change, and project management required with the GC model greatly exceeds that required by the owner under an EPC model. If the owner only completes one or two major capital projects every 10 years, it is unlikely to possess the in-house systems necessary to properly manage cost, schedule, quality, and changes, or to track costs and schedule to budget or baseline. This type of owner will be required to acquire these resources, either through direct hiring or through outsourcing those critical functions to one or more experienced vendors. The owner's staffing plan needs to be carefully considered in determining the appropriate delivery system for the project.

EPC, or Turnkey, Model

If the owner is risk- and conflict-averse, lacks a large and sophisticated project management staff, and desires a reasonable degree of price certainty at an early stage of the project, the EPC, or turnkey, model generally provides a lower risk profile than the traditional approach, although the cost of the project may reflect a risk premium to the EPC contractor.

Advantages

The EPC or turnkey model offers the owner the ultimate in one-stop shopping. Under this approach, the owner has to communicate with only one entity for the entire project, and the need for the owner to inject itself into the day-to-day management of the project is minimized. The project oversight and management functions, particularly as they relate to project cost, schedule, and scope management, remain of critical importance to the owner's overall successful execution of the project. The owner must prudently manage the project, from selecting the appropriate project delivery system through design, procurement, construction, commissioning, and commercial operation. The owner must ensure that appropriate cost, schedule, and project management control systems and project reporting are in place from the outset of the project. Although the EPC contractor manages the day-to-day implementation of the design, procurement, and construction activities, the owner must have appropriate systems in place to aggressively monitor contractor progress and project cost and make prudent decisions based upon the real-time information developed during construction. The owner typically owes such a duty to its shareholders, and in the case of regulated utilities, to the ratepayers and/or governmental oversight authorities. The EPC contractor takes an active role in the design of the project, the selection of the major equipment, and the integration of the design and procurement schedule into the project construction schedule. The EPC contractor is responsible for all aspects of the performance of the work. Risk management for the owner becomes easier because the risk for satisfactory and timely project completion is assigned to the EPC contractor. Financial risk is shifted to the EPC contractor through a lump or guaranteed maximum price, substantial liquidated damages for schedule delays or deficiencies in project performance, and financial security instruments, such as payment, performance, and warranty bonds, letters of credit, or parental guarantees (a guarantee by a parent company of its subsidiary's performance under contract). Obviously, the careful selection of the appropriate EPC contractor and development of a strong working relationship with the EPC contractor is important in minimizing financial, schedule, and performance risks on the project.

The increased and centralized power vested in the EPC contractor should lead to a more efficient, flexible, and adaptable process. A visual comparison of the basic process associated with the EPC or turnkey model versus the basic process associated with the traditional approach of design–bid–build (DBB) is shown in Figs. 18-1 and 18-2.

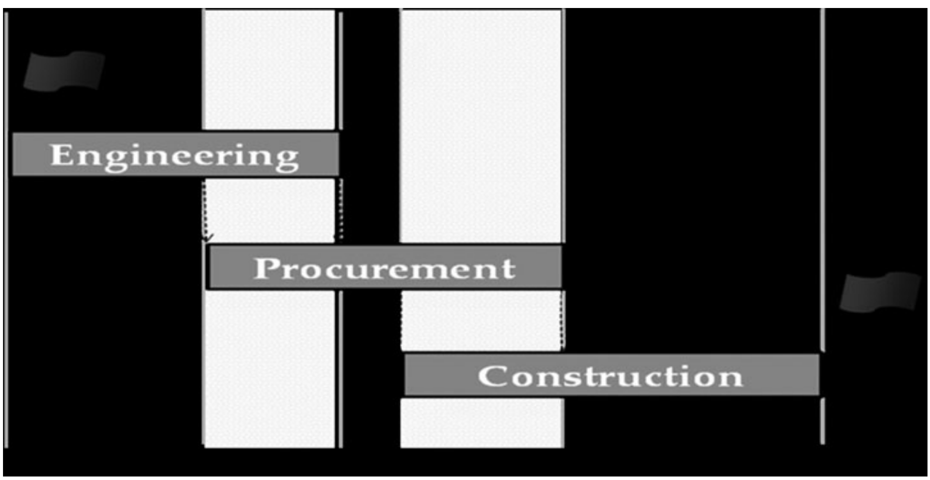

Fig. 18-1. EPC model: fast-track schedule with a single source of supply

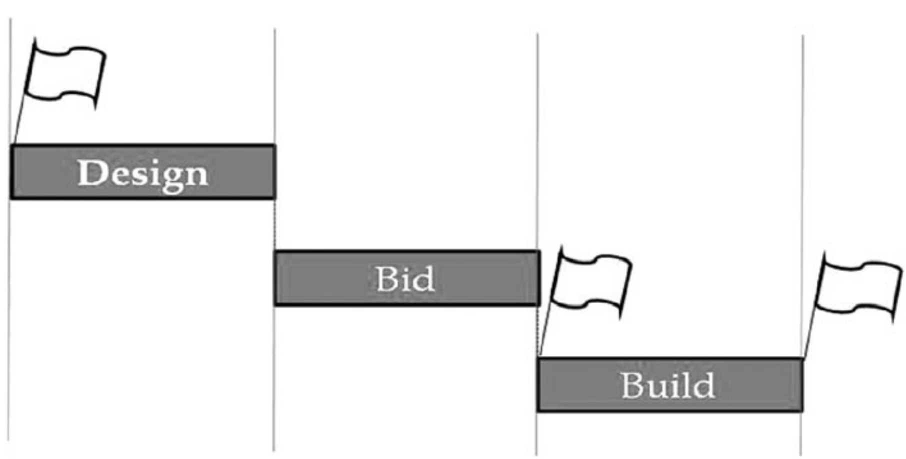

Fig. 18-2. Traditional approach: design, bid, build with multiple sources of supply

The constructability and performance risk for the project is transferred to the EPC contractor through the integration of the design, procurement, and construction responsibilities under the EPC contract. If structured properly, the EPC approach typically increases the probability of meeting project milestone dates and decreases the probability of significant claims between the owner and the EPC contractor. It is of critical importance under the EPC approach to ensure that the type and level of liquidated damages are sufficient to address schedule or performance deficiency issues. Otherwise, the potential exists for the EPC contractor to perform a cost–benefit analysis and determine that the cost of acceleration or curing performance deficiencies outweighs the liquidated damages to be assessed. Consequently, the liquidated damage provisions, as well as the termination, limitation of liability, and indemnification provisions, must be carefully reviewed as part of the project risk matrix.

As is discussed more fully later, the EPC model typically insulates the owner from many types of construction claims, but it may lead to increased conflict among the members of the EPC consortium. The ability to place the project on a "fast track" is considerably easier under this method, and total project duration can typically be reduced. This approach also affords the owner increased ease and flexibility in obtaining project financing because lenders appreciate the increased cost certainty and the increased likelihood of timely project completion. The potential for claims against the owner is reduced under the EPC or turnkey model because of the reduction in adversarial relationships with the owner and the placement of sole source responsibility for the project on the EPC contractor. Limited residual risks are typically retained by the owner under the EPC approach, such as scope changes, force majeure, weather delays, unknown or undisclosed site conditions, start-up and commissioning delays, and similar risks.

Disadvantages

The disadvantages of the EPC model stem from the fact that all of the owner's eggs are in one basket. The owner relies on the ability of the EPC contractor to perform as promised. Some owners are also reluctant to use an EPC approach because the owner has less control over the selection of the engineer, contractor, and major equipment suppliers. The project must achieve performance criteria and milestone dates, but the owner typically cedes control over the selection of engineer, constructor, and major equipment to the EPC contractor.

Another disadvantage to an owner is that there are likely to be fewer bidders willing to bid on the project, given the size, scope, and responsibility to be undertaken by the EPC contractor. The sheer project contract value and the requirement for bonds, guarantees, and other financial security instruments further limits the field of competitive bidders. The number of EPC contractors willing to bid on megaprojects has significantly decreased during the global economic downturn that began in 2008. Fewer and fewer project participants have been able to meet the bonding, security, or other financial requirements during this global downturn, and the downturn has led to more owners opting for the hybrid model, which uses one or more EPC contracts as well as direct contracts with the owner for defined scopes of work. The cost of the project includes a risk premium to the EPC contractor. The contract value of the EPC contract typically exceeds the sum of the costs that the owner could obtain individually for the engineering, procurement, and construction scopes because of the assumption of greater risk by the single EPC contractor.

Another potential disadvantage is the difficulty that an owner has in obtaining full, complete, and accurate information as to schedule and cost from the EPC contractor. EPC contractors often contend that certain categories of information are proprietary and cannot be disclosed to the owner. Owners also may have a more difficult task in accurately measuring the status of the project when much of the information is in the control of the EPC contractor, and the contractor lacks the incentive to be proactively involved with the owner in identifying and correcting issues as they arise. EPC contractors often prefer to shield an owner from disputes within its team or other issues that may affect the project until it is too late to proactively address the issue with minimal disruption to the project schedule. In addition, liquidated damages may not provide a full remedy to an owner when a megaproject, that by its nature is a notorious and high-profile undertaking, is late, significantly over budget, or fails to perform as guaranteed. Furthermore, the effect on the project can be almost catastrophic if the EPC contractor fails to perform and is terminated for default or goes bankrupt because responsibility for the entire project was vested with the EPC contractor.

Hybrid Approach—Multiple Prime Contractors

In an attempt to reduce risk and lower overall project cost, owners have crafted hybrid approaches tailored to their specific project goals, risk profile, and project management capabilities. The hybrid approach is typically considered more costly than the GC model but less costly than an EPC approach because the owner assumes more risk in managing multiple construction packages. Unique advantages and disadvantages flow from the use of a hybrid approach, in addition to the advantages and disadvantages that are associated with each of the component methods used in a hybrid approach. Some of these advantages and disadvantages are outlined here in relation to the example of a power generating project in which the owner uses an EPC model for the boiler and air quality control system (AQCS) work but implements a traditional approach for the turbine, civil, and BOP work.

Advantages

A hybrid approach can offer a sophisticated owner flexibility when it can identify certain critical portions of a project for early procurement or design. The hybrid approach has also been used during the current global downturn to increase the number of potential bidders that are technically and financially capable of satisfactorily completing the project. Using the coal-fired power plant example, the longest lead and schedule critical equipment supply is the boiler. In this scenario, a hybrid approach allows the owner to procure the boiler scope of supply under an early direct contract with the equipment supplier, while moving forward with the turbine, civil, and BOP on another basis.

The hybrid approach typically involves one or more scopes of supply on an EPC basis, allowing the owner to attempt to shift portions of the risk to the EPC contractor. The owner may directly procure the boiler and AQCS from a major equipment supplier and then assign that contract to an EPC contractor that has been retained to complete the turbine, civil, and BOP scopes of work. I have also seen projects in which the owner retains an EPC contractor for the boiler and AQCS scopes of work, and a second EPC contractor for the turbine, civil, and BOP scopes. Major equipment suppliers are more likely to be direct bidders on EPC packages than under a traditional EPC model.

The hybrid approach should give the owner access to timely and accurate information regarding project cost, schedule, and progress. Furthermore, it allows the owner to reduce overall project cost and pay less of a risk premium than in the EPC model, affords greater control over the project schedule, and enhances the ability to cost-effectively manage changes and schedule effects that may occur during the design, procurement, or construction processes. It also allows the owner more involvement in selecting critical design and operational elements than would be available under an EPC model.

The hybrid approach offers a great deal of flexibility but requires a strong project management staff by the owner and careful allocation and coordination of overall project cost, control, and schedule management functions.

Disadvantages

Given that it is a more complex project delivery method, a hybrid approach results in some disadvantages as well. The definition of the scope of work included within each bid package is critical. The bid packages must ensure that all scope is included in one and only one of the bid packages. There is a potential for scope gaps between packages. Schedule, sequence, and access issues also become more critical. For example, it is more likely that there will be schedule integration and coordination issues between the boiler and AQCS work on one side, and the turbine, civil, and BOP work on the other. These issues must be carefully and appropriately managed by the owner.

Cost and project management and controls also become more complicated and difficult in a hybrid approach. The owner must either retain contractor coordination and schedule management responsibility, or it must clearly assign that responsibility to one of the EPC contractors. Although a fully integrated level 3 project schedule can minimize site accessibility issues, there is an inherent potential conflict to assigning schedule and coordination responsibility to one of the EPC contractors. For example, if the EPC contractor for the boiler has overall responsibility for coordination of work and schedule prioritization, the natural inclination is to protect one's turf and prioritize the boiler task over the conflicting turbine or civil task. Similarly, if a limited supply of skilled laborers, such as pipefitters, welders, or ironworkers, is available in the local labor market, allocation of labor should be determined based upon the criticality of the work, rather than on self-preservation considerations. Consequently, the owner often retains a degree of control over schedule and coordination issues under the hybrid approach.

A hybrid approach has a tendency to involve a more complex dispute resolution process than the EPC model. The owner may have to deal with claims from multiple parties since it has contractual privity with a number of entities. For example, if the EPC contractor for the boiler and AQCS work falls behind schedule and goes into a recovery plan, then the turbine, civil, and BOP work may be affected by site congestion, labor productivity issues, labor shortages, or schedule effects. Given that the EPC contractor would not have a direct contractual relationship to the turbine, civil, or BOP constructors, the owner would be the central focus of the dispute resolution proceedings, and the owner may face joinder and consolidation issues in attempting to resolve claims among multiple parties in one arbitration. In a tight market for skilled craft labor, such as ironworkers, pipefitters, or welders, the decision to work overtime on the boiler work may force the constructor for the turbine or civil work to work overtime as well to attract high-quality craft labor. In essence, the boiler contractor may be competing with the turbine constructor for the same pool of skilled labor; if the boiler contractor is working 50 to 60 hours per week, and the turbine contractor is working 40 to 45 hours per week, craft labor, particularly travelers, are more likely to want to work for the boiler contractor than the turbine constructor. Rather than compete for high-quality workers on the same project from the same scarce labor pool, the work scheduled is often normalized on a project basis.

The EPC Consortium

Given the sheer size of a megaproject and the effects of the recent global economic downturn, EPC consortiums have become a common, if not the most common, method of contracting for megaprojects in North America. Under an EPC consortium arrangement, the owner contracts with a consortium on an EPC basis, and the consortium participants internally allocate responsibility for development and execution of the project among themselves. The consortium participants are generally jointly and severally liable to the owner, with allocation of responsibility for schedule, costs, and performance for consortium partners addressed in the consortium agreements. A typical collection of participants forming an EPC consortium includes one or more major equipment suppliers, engineers, and constructors.[3]

The EPC consortium allows for each of the consortium partners to pool their resources and knowledge in an effort to effectively complete the EPC project, but it requires a heightened level of communication and coordination within the EPC consortium. This method contemplates a single line of communication between a

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3 Major equipment suppliers are also sometimes referred to as original equipment manufacturers, or OEMs. These are the suppliers of the major equipment for the project, such as the boiler, the turbine island, or the AQCS system. These major scopes of supply account for the majority of nonlabor costs on a megaproject.

designated representative of the EPC consortium and the owner and a separate and distinct internal line of communication between the designated representative of the EPC consortium and the designated representative of each participating member of the EPC consortium.

Primary Challenges of EPC Consortiums

There are a number of challenges associated with an EPC consortium, each of which must be identified and addressed to achieve a successful project. Three of the primary challenges facing EPC consortiums are differences in culture among consortium participants, differences in experience and approach to a project, and allocation of risk inter se among consortium participants. Each of these primary challenges is discussed below.

Cultural Differences among Consortium Participants

EPC consortiums for North American megaprojects are seldom composed of partners that are all based in North America or that all come from common law countries. The presence of these fundamental cultural differences within an EPC consortium can present increased difficulty with communication and in achieving consensus and agreement regarding the development and execution of the project. Aside from the potential communication and/or language barrier, varying business practices and approaches stemming from each partner's culture can present significant obstacles if not dealt with directly and affirmatively.

For example, design and major equipment for the boiler may come from Japan, whereas pipe and structural steel for the boiler scope come from China or Eastern Europe. The design and major equipment for the AQCS may come from France, the design and major equipment for the turbine island scope of supply may come from Germany, the design for the civil and BOP scopes may come from the United States, and structural steel, miscellaneous metals, and other supplies may come from China or other regions. The project execution, project management, and project scheduling and controls team may come from the United States, along with the constructor. Under this scenario, the consortium must clearly define the scope of supply of the participants and must ensure that each participant understands the unique nature of constructing an EPC project in North America.

The North American market has many unique features that must be clearly understood and anticipated if a project is to be successful. Labor unions and the price of labor, for example, may be significantly different in the United States and Canada than it is in Japan, China, Latin America, or other parts of the world. Consortium participants that typically work in parts of the world with low labor costs do not face the same demand for labor efficiency that is present in the United States.

Many of the coal-fired power projects that have been built in the United States and Canada over the past 10 years have experienced enormous overruns in labor hours and labor costs, often to recover schedule that was lost as a result of late or incomplete engineering or late, incomplete, or out of sequence equipment supply, leading to a shorter duration for construction. Constructors added crews and worked overtime, often on an extended basis, and also added second or third shifts, leading to significantly higher labor costs than originally anticipated. In addition, because the number of craft laborers required significantly increased (doubling or more in some cases), travelers were required on most of these projects, further adding to the cost of labor and stressing the capacity and quality of the labor pool. EPC contractors that were not intimately familiar with these and other features of the North American market may have experienced significant losses. The participants in the EPC consortium must understand the nature of the local market, while also recognizing the inherent cultural differences between participants in the EPC consortium. Failure to recognize and address these cultural differences at the outset of the EPC consortium discussions can be fatal to the financial success of the consortium.

Difference in Experience and Approach

EPC consortiums for North American megaprojects often include a collection of participants that have had significant successes on EPC projects and have developed certain approaches and methods that have proved to be "the right way to do it" through their respective experiences. This blending of knowledge and experience is one of the benefits of the EPC consortium, but it also presents practical difficulties in executing the project because there is not a singular entity guiding the project, as would be the case under a traditional EPC approach. The consortium partners must identify and discuss their respective experiences and approaches at an early stage and put communication mechanisms and processes in place so that the EPC consortium can decide which approaches are best suited for the successful completion of the particular EPC project. The EPC consortium must designate a project representative who shall have the singular responsibility of interacting with the owner on behalf of the EPC consortium. Selecting a qualified and experienced project representative to interact with the owner and effectively communicate to the EPC consortium is critical to the success of the project.

Another example is the approach to project controls, project scheduling, and cost management. Different organizations may have different approaches to project controls, scheduling, and cost reporting. In addition to the tracking that is performed at the participant level, the EPC consortium must have a unified approach to project controls, scheduling, and cost management. This approach requires a team that is employed by the EPC consortium to monitor and report on behalf of the consortium. Independence from the individual participants is highly desirable, and transparency with the owner and the EPC participants yields the highest likelihood for a successful project.

Allocation of Risk among Consortium Participants

Perhaps the most important challenge faced by an EPC consortium in effectively completing a North American megaproject with minimal disputes is the clear allocation of responsibility and risk among the consortium participants. Identification and acceptance of defined risks by each of the consortium participants at the outset of the project is crucial. The EPC consortium must work diligently at the outset of the project to identity and address all foreseeable risk contingencies. Specific issues regarding allocation of risk on projects using an EPC consortium are addressed below.

Allocation of Risk on Projects Involving EPC Consortiums

Two different types of risk allocation must be addressed when using an EPC consortium on a North American megaproject. First, although one of the primary benefits to an owner in using an EPC consortium is reduction of risk, there are still certain limited elements of risk that an owner is likely to have to retain. Second, the risk that is assigned to the EPC consortium must be allocated among the consortium partners.

Step 1—Allocation of Risk between Owner and EPC Consortium

Typically, the responsibilities and risks retained by an owner under an EPC consortium approach include the initial considerations and preconditions necessary for the project to proceed, such as site access, initial permits, variances, or other preliminary regulatory matters, and the development and maintenance of certain functions that will be necessary to operate the facility, including performance criteria. The EPC consortium typically takes the responsibility and risk for the successful, efficient, and timely delivery of the project to the owner, for meeting all applicable performance guarantees or criteria, and for compliance with applicable laws, orders, and regulations.

Owner Risks

The following is a list and description of items for which the owner often retains responsibility and risk under the EPC consortium approach:

- Securing project financing;
- Obtaining the necessary environmental, construction, and other permits;
- Selecting the site for the project, along with the logistics related to accessing the site, the management of any hazardous materials on the site, and the condition and assessment of the subsurface and soil conditions of the site;
- Arranging for fuel supply and/or power take-off interconnection to the facility;
- Providing trained or trainable operations and maintenance staff to the facility;
- Arranging for site waste removal and ancillary supplies, such as water and sanitary; and
- Providing performance criteria and evaluation to the EPC consortium.[4]

Owner's Implied Obligations during Construction

In addition to the responsibilities and risks retained by the owner under an EPC consortium approach, certain implied obligations may be imposed upon an owner under the federal or state or provincial laws of the United States or Canada. These implied obligations include the following:

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4 The owner also typically retains specific responsibilities relating to performance testing, start-up, and commissioning of the project, and the consortium warrants all or certain defined aspects of the project for a defined period of time after mechanical completion and/or final completion.

- The duty to disclose material information to prospective bidders;
- The duty to provide accurate performance specifications and to provide performance criteria that are achievable;
- The duty to provide accurate site information;
- The duty to obtain necessary regulatory approvals, permits, and easements;
- The duty to provide access to the worksite; and
- Duties relating to owner-furnished products, materials, or equipment.

Consortium Risks

The following is a list and description of items for which the EPC consortium typically assumes responsibility and risk under the EPC consortium method:

- Safety—Committing to complete the project with no significant incidents or injuries;
- Price—Committing to complete the project at a price set by the owner, including risks relating to labor productivity and labor availability;
- Schedule—Committing to complete the project by a date certain set by the owner;
- Performance guarantees—Committing to provide a facility that functions within the specifications and performance criteria set by the owner;
- Environmental compliance—Committing to provide a facility that operates in compliance with environmental rules and regulations required by the government and set by the owner; and
- Start-up and commissioning—Committing to perform tasks and testing necessary to bring the facility into its operational mode.

Step 2—Allocation of Risk within the EPC Consortium

The responsibilities and risks assumed by the EPC consortium must be allocated between the consortium partners who are in the best position to effectively manage each element of responsibility and risk. It is crucial that this division of responsibility and risk be as clearly, specifically, precisely, and realistically defined as possible because the practical allocation and application of this responsibility and risk during the project can be significantly more difficult in application than any theoretical allocation.

Original Equipment Manufacturer and Project Engineer Risks

Of the responsibilities and risks assumed by the EPC consortium, there are certain risks that are traditionally associated with the original equipment manufacturer (OEM) and/or project engineer participant(s) of the EPC consortium. The following is a list and description of items for which the OEM and/or project engineer typically assumes responsibility and risk under the EPC consortium approach:

- Safety—Supplying sound equipment and engineering that will allow for the safe installation of equipment and construction of the facility;
- Price—Completing the engineering and procurement for the project at the price set by the owner;
- Engineering—Supplying timely and accurate engineering to the constructor;
- Procurement—Supplying the process equipment in a timely fashion, fully assembled and without defects, and supplied in the sequence specified in the contract documents;

- Schedule—Developing the engineering schedule as well as supplying engineering and procurement deliverables in accordance with an overall project schedule;
- Commissioning—Supplying technical supervision of commissioning activities after mechanical completion is achieved; and
- Performance guarantees—Supplying the required engineering and procurement so that the project as constructed achieves the specifications and performance criteria set by the owner.

Constructor Risks

Of the responsibilities and risks assumed by the EPC consortium, there are certain risks that are traditionally associated with the constructor participants of the EPC consortium. The following is a list and description of items for which the constructor typically assumes responsibility and risk under the EPC consortium approach:

- Site safety—Ensuring that the labor force is using construction practices and procedures that minimize the potential for incidents and injuries and comply with OSHA regulations;
- Price—Completing the construction of the project at the price set by the owner, including pricing for risks relating to labor productivity and labor and equipment availability;
- Management of subsurface conditions—Constructing the project without disruption or delay caused by subsurface conditions that were identified and disclosed by the owner;
- Schedule—Managing and implementing an overall project schedule to achieve mechanical completion, based on compliance by the OEM and/or project engineer with schedule and deliverable obligations;
- Site QA–QC—Ensuring that the construction of the plant and installation of equipment complies with the specifications provided by the OEM and/or project engineer and satisfies the warranty obligations of the EPC consortium; and
- Craft support of commissioning—Providing and managing the craft labor necessary to support the start-up and commissioning of the facility.

Risk Management during Performance

The EPC consortium approach is used on North American megaprojects in an attempt to manage and minimize the enormous risks associated with multiyear, multibillion-dollar projects. It bears repeating that although there are certain areas of risk that are expressly allocated between the participants of the EPC consortium, failure to identify, allocate, and manage project risk can be devastating to the overall project, causing severe to catastrophic financial implications to the EPC consortium participants.

In the absence of sound project controls, project scheduling, and project cost reporting, cost overruns or schedule performance delays will most likely manifest themselves during the construction phase of a megaproject. From an overall risk management perspective, the EPC consortium must effectively control and manage the engineering and procurement, as to timeliness, completion, accuracy, quality, and sequence, so that any delays or disruptions in the engineering or procurement processes are promptly identified and solved without affecting construction. Unless properly managed and mitigated, delays to engineering and procurement interfere with, compress, and/or delay the construction phase of the project. Although the cost consequences of deficiencies in engineering or procurement may not be incurred until the construction phase, the costs incurred during the construction phase are inherently dependent upon timely and complete engineering and procurement. Early recognition and mitigation of engineering and procurement deficiencies can minimize their adverse effects on the construction phase of the project.

Another key to risk management during the performance of a megaproject is to resolve individual disputes on the project as they arise, regardless of whether those disputes are between the owner and the EPC consortium or among the participants in the EPC consortium. Letters are often written on construction projects, identifying disputes, putting a party on notice, or otherwise "preserving" a position on an issue. Rather than attempting to resolve the issue at that point, project participants, including the owner, often simply have letters written and rights reserved until the project is nearing completion, or until consideration is given to assessing liquidated damages for failing to achieve an interim milestone, or, in a worst-case scenario, until termination is considered. By that point, the losses have grown, the claims have morphed, positions have polarized, and amicable resolution of the underlying dispute(s) becomes a remote possibility. Proactive leadership between the owner and EPC contractor, and among the EPC consortium participants, is imperative if the project is to be successful. If left unresolved, small, manageable disputes tend to destroy cooperative working relationships among project participants, multiply, and give rise to major claims with significant cost and schedule effects. Often, communication issues are at the root of these problems. The personality, background, culture, or perspective of the designated representatives clash, impeding the ability of their respective organizations to communicate with one another to resolve a discrete and manageable issue. If that pattern develops, it can become difficult to control unless it is addressed promptly by strong management action.[5]

Summary

In closing, the dispute resolution provisions of the construction contract are often treated as the bastard stepchild during the negotiation of the contract documents. The commercial teams negotiate the commercial terms, and the technical teams negotiate the technical terms. As the legal team becomes involved, the bulk of the

5 For these and other reasons, the use of project neutrals, dispute resolution boards, partnering sessions, and other binding or nonbinding "real-time" dispute resolution processes has been successfully implemented on megaprojects. Though extensive discussion of these techniques is beyond the scope of this chapter, these methods have a great deal of utility on megaprojects and can be effective is minimizing disputes and their attendant effects on the project if the major project participants (whether between owner and EPC consortium or among EPC consortium participants) agree to and fully support the process.

attention is focused on indemnification, limitation of liability and consequential damage provisions, changes, liquidated damages, insurance requirements, security instruments, and key definitions. The commercial team does not want to think about the disputes that will inevitably arise. The technical team is concerned with fully defining the scope of supply and performance criteria, not with dispute resolution. Unfortunately, the legal team often takes the last EPC form that was negotiated and "cuts and pastes" that "disputes" provision into the new contract documents and negotiates based upon the last form or some predefined corporate policy on arbitration or mediation, without regard to the unique features of this project and their effect on the nature of the disputes that may arise.

As discussed intermittently elsewhere within this chapter and in Chapter 12, the dispute resolution provision is of critical importance in the North American megaproject. Arbitration, often preceded by mandatory negotiation and/or mediation, is the dominant dispute resolution mechanism for North American megaprojects.[6] The issues that must be considered and addressed include consolidation and joinder of related disputes; the appropriate arbitral institution and arbitral rules; the location of the arbitration; the language of the arbitration; the arbitral law; the number of arbitrators and their manner of selection; the law governing applicable legal privileges, retention, and exchange of relevant project data (and reasonable limits upon information exchange or "discovery," particularly as it relates to electronic data); recoverability of attorneys and expert fees and expenses; arbitrator compensation and arbitration association fees by the substantially prevailing party; and a host of other issues.

Chapter 8 of this book addresses these issues in greater detail, and that discussion will not be replicated here. Nevertheless, given the importance of the dispute resolution on megaprojects, failure to aggressively and specifically negotiate meaningful dispute resolution provisions in the contract documents that are appropriate for the particular project, based upon the project, the project delivery process, and the parties, will lead to the waste of potentially millions of dollars by the parties at the conclusion of the project. Advance planning for the efficient resolution of disputes saves everyone involved significant time and money at the conclusion of the project.

6 As previously stated, discussion of nonbinding dispute resolution techniques that may be used during the course of the project, such as dispute resolution boards, partnering, project neutrals, executive level meetings, and similar mechanisms, is beyond the purview of this chapter. However, parties are also encouraged to explore these techniques to obtain real-time resolution of disputes that arise during the course of the project to alleviate or at least minimize the incidence of large claims during or immediately after project completion.

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CHAPTER 19

The Ultimate Gigaproject: Nuclear Power Plant Construction

Charles W. Whitney, Annalisa M. Bloodworth, and Antony L. Sanacory

The power generation industry is poised to make substantial investments in the ultimate power gigaprojects—new nuclear capacity.[1] Construction of a single nuclear reactor facility costs billions of dollars, spans the jurisdiction of a multitude of federal and state regulatory agencies, and involves years of planning, numerous public hearings, and years of construction. History teaches that each phase of permitting, licensing, planning, and construction contains risks that can be fatal to a nuclear project. Mobilizing for an endeavor of this magnitude requires not only incredible skill on the part of the owner and the project management team, but also an awareness by each member of the project team of the diverse and numerous needs and interests of the parties to the project, from the governing agencies to the public as a whole. To understand the construction of new nuclear plants—and to be a valuable member of a nuclear power plant construction team—you must understand more than just the role you or your company plays in the project.

This chapter serves to help you understand the incredibly complex and interconnected issues that arise during the development of a new nuclear-powered electric generation facility. To take an already complex endeavor and make it harder, there are more "lessons learned" from previous problem projects in the United States than there is precedent for completion of nuclear facilities on time and under budget. Historically, most nuclear projects built in the United States were plagued with public relations issues and serious construction and permitting delays. Those projects that were completed and became operational did so well over budget (in some instances, final costs of construction were more than 10 times the original budget). Several projects that were attempted in the United States in the 1970s and 1980s

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1 "New nuclear" is used within this chapter to delineate the current push to add new nuclear power plants to the U.S. fleet of base-load power generation facilities from the original nuclear power generation plants in service before 2010.

LESSONS LEARNED

1. Almost 20% of the electricity generated in the United States comes from nuclear power plants.
2. Of the possible alternatives to fossil fuels—wind, solar, tidal, biomass, and nuclear—only nuclear can provide enough electricity to meet the United States' base-load needs.
3. The owners of the next wave of new nuclear power generation megaprojects must learn from the mistakes made a generation ago during the last round of construction of nuclear power megaprojects.
4. The Nuclear Regulatory Commission (NRC) established permitting processes in 1989 for the construction of nuclear power generation that are designed to remove uncertainty and risk by front-loading the permitting and approvals before significant construction occurs. Permitting is now done in three steps: (1) design certification process; (2) early site permitting; and (3) combined construction and operating licensing.
5. In scaling megaprojects, bigger is not necessarily better. Project size and schedule should match demand need and the utility company's financial resources and experience.
6. Any nuclear gigaproject being constructed after 2000 must be evaluated in the context of the regulatory regime that will govern the facility and the electricity it generates.
7. Project owners must know, understand, and be involved in site selection, community relations, the design of its facility, the permitting of its facility, the composition and experience of the workforce that is constructing its facility, the construction schedule, and all quality management programs (on and off site).
8. During the construction of nuclear power megaprojects, quality control and assurance are mandatory.
9. Any utility seeking to successfully complete a megaproject must seek, secure, and maintain public support at all levels—from elected and appointed officials at the federal, state, and local level to individual community members.
10. Even with recent events in Japan reminding the industry worldwide of the need to put safety first, the next wave of nuclear construction must be afforded the opportunity to prove itself as a viable source to meet the U.S. need for clean, affordable base-load power.

were canceled altogether, with considerable debate about how much of the sunk costs should have been and, in fact, were borne by consumers upon termination. Lingering doubts remained as to the safety and environmental impact of nuclear power after the Three Mile Island accident in 1979 in the northeast United States and the Chernobyl disaster in 1986 in Ukraine. So, in addition to enormous technical and financial obstacles that new nuclear power faces, nuclear power also has a history to overcome.

Still, there is a substantial need for new base-load generation capacity in the United States. Wind, biomass, and solar power have received considerable attention as alternative, renewable sources of electric power, but the primary sources for base-load power in the United States are, and until technology changes will continue to be, coal and nuclear power. Senator Lamar Alexander stated in June 2010 on the floor of the U.S. Senate (Alexander 2010):

> [Biomass] cannot be the solution for our clean energy needs because of the problem of scale. We would have to continually forest an area one-and-a-half times the size of the Great Smoky Mountains National Park to replace the electricity created by two standard coal plants or one standard nuclear reactor ... New Jersey wants to close down a nuclear reactor and replace it with an off-shore wind farm. It will have to build 50-story wind turbines along its entire 125-mile coast, and it will still need a nuclear plant or a natural gas plant or coal plant or some other plant to provide electricity when the wind doesn't blow, which is most of the time ... Meanwhile, France, which has gone to 80 percent nuclear power ... has so much cheap electricity that [it] is making $3 billion a year exporting its electricity, mostly from nuclear power, to other countries.

Biomass, wind, and solar power are valid supplements, but they cannot provide the base-load power needed to run this country.

Notwithstanding the troubled history of past nuclear generation megaprojects, interest in nuclear has increased considerably in the past few years. Almost 20% of the nation's current electrical generation supply comes from nuclear power plants. Although plants are extremely expensive to construct, nuclear power remains substantially more cost-efficient to operate than most other types of facilities. Moreover, though tempered by the March 2011 nuclear disaster at the Fukushima Daiichi facility in Japan, after decades of safe nuclear operations in the United States, public concerns surrounding the safety of nuclear are significantly less than was the case in years past. In recognition of this record and the strong condition of existing nuclear facilities, current projections from the U.S. Energy Information Administration actually assume the renewal of all existing nuclear plant licenses past the existing presumed 60-year life expectancy of a nuclear plant (U.S. EIA 2010).

Trends in public policy disfavor the construction of additional fossil fuel powered facilities because of the environmental issues associated with carbon emissions and the potential volatility in the cost of fossil fuels. Of the possible alternatives to fossil fuels—wind, solar, tidal, biomass, and nuclear power—only nuclear power can provide enough electricity to meet America's base-load needs. In his 2011 State of the Union Address (Obama 2011), President Obama urged the nation to support clean energy as a growth industry:

> Now, clean energy breakthroughs will only translate into clean energy jobs if businesses know there will be a market for what they're selling. So tonight,

> I challenge you to join me in setting a new goal: By 2035, 80 percent of America's electricity will come from clean energy sources.
>
> Some folks want wind and solar. Others want nuclear, clean coal and natural gas. To meet this goal, we will need them all—and I urge Democrats and Republicans to work together to make it happen.

Consistent with the federal government's support of new nuclear power, the power generation industry is poised to make a substantial investment in nuclear from 2010 to 2030. According to information provided by the Nuclear Regulatory Commission (NRC) (Fig. 19-1), the NRC received applications for the construction of 8 new reactors in 2007, 16 reactors in 2008, and 2 reactors in 2009 (NRC 2011a). The NRC expects to receive applications for the construction of an additional 8 new reactors in 2012. These investments may be delayed somewhat as governments, regulators, and the public process the events at Fukushima Daiichi, but they will still come.

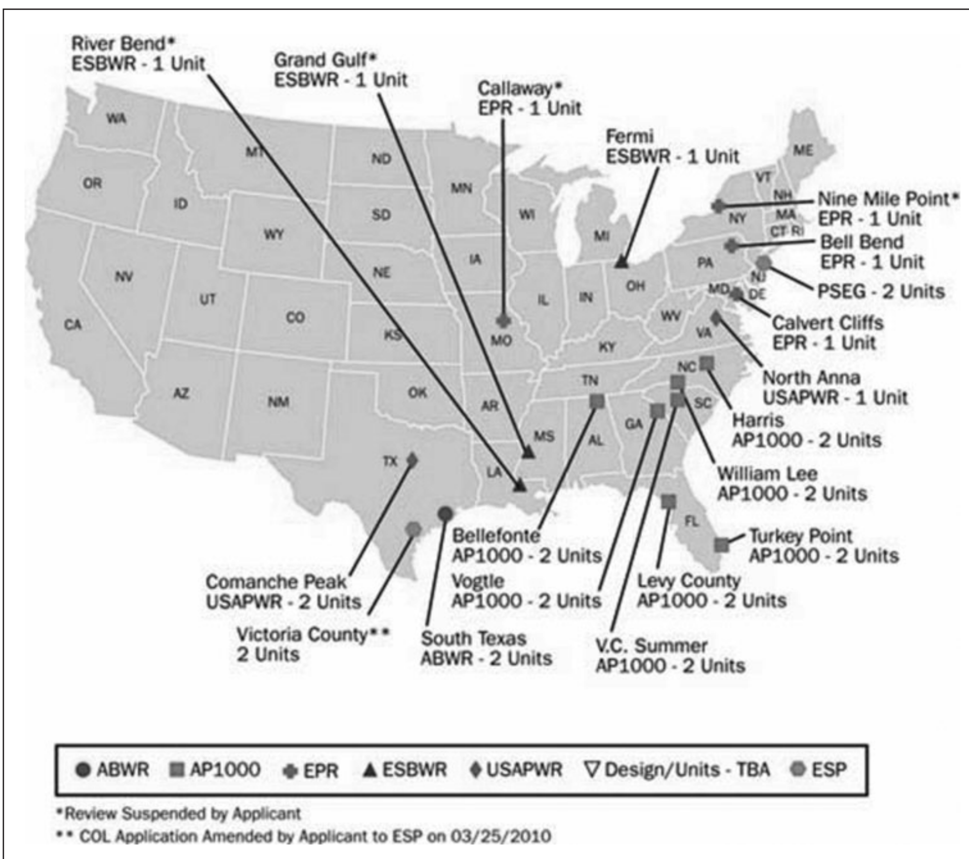

Fig. 19-1. NRC's projected new nuclear power reactor locations

Source: NRC (2012).

The construction of any new power plant, let alone a nuclear power plant, comes with substantial risk. This risk can and must be managed. The size of the investment (easily several billion dollars) and the duration of planning and construction (approaching a decade) by themselves stack the odds against an on-time and under-budget new nuclear project. The challenge for those of us who desire to be successful owners or helpful partners in the process of building these new facilities is to make sure that as many of the difficult issues that might arise over the lengthy planning and construction process are thought through and mitigated as much as possible in advance.

Electricity Policy in the United States: A Primer

Any new nuclear project must be evaluated in the context of the regulatory regime that will govern the facility and the electricity it generates. Understanding these regulatory policies and processes will ensure that decisions can be made wisely and, if necessary, justified at a later stage of the process. Regulations may govern when, if, and how new power will be generated.

One of the keys to understanding the regulatory regime is to first understand the major actors in the U.S. electricity market and their respective roles in the delivery of electricity to consumers. The actors in the electricity market have been grouped into five basic categories, as follows:

1. Investor-owned utilities—These are privately owned, state regulated utility companies that, at least historically, owned everything from the generation facilities to the transmission and distribution grids, all the way to the power meter on the exterior of the customer's home or business. Most electricity generation and distribution in the United Sates still is provided by investor-owned utilities.
2. Federally owned utilities—These utilities usually generate and transmit electricity but rarely sell to end-users.
3. Publicly owned utilities and rural cooperatives—These utilities usually serve smaller populations, often in rural areas. Sometimes these utilities are vertically integrated, but more often they purchase their electricity from other sources and distribute it to the communities they serve.
4. Merchant generators (also referred to as wholesale generators, unregulated producers, or independent power producers)—These are investor-owned companies that typically own just generation facilities. These entities generate electricity and are permitted to transmit their electricity on utility-owned transmission lines, so that they can sell their electricity "wholesale" to utilities that then deliver the electricity to the end-user. Merchant generators are described as "unregulated" because the market on which they are permitted to trade—the wholesale market—is not subject to a regulatory rate-setting process (which is described in detail below).
5. Power marketers and brokers—These are the intermediaries that facilitate electricity trading on the wholesale market between generators and distributors.

With rare exception, state public utility commissions do not regulate electric cooperatives, municipally owned utilities, public power agencies, or merchant generators. The overwhelming majority of new nuclear construction is expected to be done by "regulated" investor-owned utilities and, to a lesser degree, merchant generators.

For investor-owned utilities, new generation must be established as necessary and in the interest of the public. A regulated utility's investment in new generation will become the subject of public rate hearings to determine whether the utility will be permitted to recoup the costs of (and earn a profit on) its investment. Thus, the utility will not know until *after* the plant is constructed—at the conclusion of the rate hearings—the exact amount of construction and finance costs that the regulated utility will be permitted to recover in its rate structure (increasingly, utilities are being permitted to recover some portion of their costs during construction, but this arrangement is not guaranteed).

Electricity is a unique commodity in several respects. First, by its nature, electricity cannot be stored easily or efficiently. Thus, electricity must be generated in "real time" based on the demand of the customers of the particular region that is being served. This is no simple task. Customers are not required to preorder their electricity. Making the task more difficult is the fact that demand fluctuates based on a number of factors, including the state of the economy, changes in the weather, the time of day, the season of the year, and several other possible factors. If there is a mismatch between supply and demand, generators must respond by either increasing or decreasing production, not an easy task given the costs and logistics of starting up and shutting down power plants throughout a region.

Second, electricity is often generated at great distances from the end-user, which means that it must be transmitted across a network of cables so that it can be made available to the consumer. The construction of these lines is done with an eye toward uncertain future demand, and the efficiency at which these lines can transmit power is influenced by the amount that is being transmitted at any given moment.

Third, just about every aspect of the U.S. economy and way of life is affected significantly by the availability of electricity. The system must be cost-effective for the consumer and sufficiently robust so as not to have interruptions in service.

One commentator (Brennan 2005) has observed the following:

> This makes the reliability of the electricity system a "public good" that an unregulated market is unlikely to provide adequately. As the August 14, 2003, Northeast blackout reminded us, our economy and society grind to a halt absent electricity to provide light, refrigeration, heating and cooling, communications, transportation, and the energy to power our factories, businesses, and homes.

In addition to being of vital national importance, it has been observed that the electricity market does not act like a competitive free market. The high cost of entry into the market, the fact that some markets are relatively small, the need for stability in the provision of electricity, and economies of scale have all been cited as examples of why electricity is a "natural monopoly." Thus, for roughly a century in the United

States, the state has acted as a proxy for the competitive market by regulating the way utilities could generate and sell electricity. Commentators in the industry (Lesser and Giacchino 2007) have observed

> Policymakers determined early on that the operation of natural gas and electricity markets could not be left to the vagaries of the free market place; these industries were "too important" to be allowed to operate unfettered. In regulating industries affected with the public interest, the courts had to consider constitutional limitations, specifically, the "Due Process" clause of the Fourteenth Amendment of the U.S. Constitution, which limits the degree to which government can meddle in the affairs of private firms. To get around this limitation, industries so deemed were (and still are) defined as *public utilities:* private, for-profit firms whose operations were strictly controlled so as not to jeopardize the public interest.

The regulation of the energy market falls under the jurisdiction of both the federal and state governments. In general terms, excluding municipal utilities and cooperatives, new generation and sales to end-users are regulated by state public utility commissions (PUCs). Transmission of electricity along the interconnected power grids is regulated by the Federal Energy Regulatory Commission (FERC). FERC and the state PUCs typically define their missions in terms of safeguarding fair and reasonable pricing, safety, reliability, efficiency, and the broader public interest, including environmental sustainability. Just how to accomplish fair rates and safe and reliable sources of energy has been the source of much debate for generations, and even to this day some of the best minds disagree as to the proper blend of regulation and open competition for energy. We do not attempt to resolve these debates but instead hope to help the reader understand the issues so that wise decisions in planning and construction can be made.

Regulated vs. Unregulated Power Markets

In the United States, there are essentially two "markets" for electricity: (1) sale by the utility to the end consumer (often referred to as the "regulated market") and (2) sale by private merchant generators to the retailers as part of an unregulated market. The regulated market is typically occupied by investor-owned utility companies.[2] The investor-owned utilities are described as "vertically integrated" because, traditionally, they have owned the power generation facilities, transmission lines used to transmit electricity over great distances, and the distribution resources necessary to actually deliver the electricity into the homes and businesses of the end-users. Regulated utilities are subject to a considerable degree of regulation to make sure

2 As noted previously, with rare exception, state PUCs do not regulate electric cooperatives, municipally owned utilities, public power agencies, or exempt wholesale generators (also referred to as merchant generators or independent power producers).

that electricity is provided reliably and at a fair price to all of the customers in the utility's geography.

In the 1990s (and to a lesser extent, as early as the 1970s), the perception that introducing competition to the electricity markets would serve the public interest resulted in efforts to deregulate the industry. Indeed, commentators have observed that massive cost overruns related to the construction of nuclear facilities in the 1970s and 1980s (cost overruns that were passed on to the customers, borne by the utilities, or absorbed by taxpayers) were a contributing factor to the deregulation of the electricity wholesale market. Both state and federal policies were implemented to increase access to the transmission grid and to permit the sale of electricity in a wholesale market. This freedom allows nonutility power generators to generate electricity (presumably at less cost than the utility), transmit the electricity to where it is needed, and sell it "wholesale" to the entities that provide the electricity to the end-user. In many states, some degree of competition also has been permitted in the sale to end-users. However, long-distance transmission and the infrastructure used for local distribution are likely to remain regulated monopolies.

The wholesale marketplace exists to facilitate trades among generators, retailers, and other intermediaries for short-term delivery of electricity and for delivery of electricity in future time periods. Electricity sold into the wholesale marketplace may be sold to a partial requirements customer or a full requirements customer. A *partial requirements customer* is a customer that is purchasing only a portion of its electricity needs from any one source. Typically, the contract between the wholesale generator and the partial requirements customer specifies the *maximum* amount of electricity that can be called from a particular facility or source.

In contrast to the partial requirements customer, the *full requirements customer* is a customer that purchases all of its electricity needs from a single wholesale generator according to the Edison Electric Institute (EEI 2011). Reliability concerns demand that, for both types of customers, there be more than one generating facility backing any obligation to deliver electricity. In some situations, a partial requirements customer may have the flexibility to have only a single generating facility backing the obligations of the wholesale generator.

The retail market—as opposed to the wholesale market—refers to the market for the sale of electricity to a residential or commercial customer. Whether residential or commercial, these customers are end-users that do not resell the electricity that they purchase. In some jurisdictions, commercial retail customers may have a one-time or other limited opportunity to select their electricity provider. However, almost all residential retail customers are simply told where their electricity will come from. As discussed, the utility's monopoly position in the retail marketplace is countered by public utility commissions (in the case of investor-owned public utilities) or by ownership interests (in the case of municipally owned electric systems and cooperatives).

Nuclear power and coal are typically used to meet a region's base-load demand (the minimum continuous demand for electricity).[3] This situation occurs because

3 At current natural gas prices, combined cycle, natural gas fired facilities are often and increasingly a part of the base-load supply picture.

almost without exception, once built, nuclear and coal plants operate at a much lower cost than other types of facilities. Of course, nuclear and coal facilities are also much more expensive to construct. Additionally, nuclear and coal power serve base-load rather than intermediate or peak demand because they are "inflexible" to being started up and shut down over short time periods. Indeed, coal and nuclear facilities generally take much longer (many hours, if not days) to reach their peak electricity output. As a result, peaks or spikes in customer power demand are better handled by smaller and more responsive types of power plants called peaking power plants, typically powered with gas turbines. Fig. 19-2 shows a comparison of the construction and operational costs for nuclear, coal, and gas plants (Landis 2007).

In some parts of the world, renewable base-load sources (e.g., hydroelectric, geothermal, biogas, biomass, or solar power) are used to meet base-load need. However, technologies do not exist today to generate sufficient electricity from these renewable sources to meet U.S. base-load demand.

In some ways, the economic models for regulated and unregulated power generators are alike. The massive investment in any new generation project needs to be recouped, whether by set rates, from full cost recovery from members or citizens, or through the wholesale market. In other ways, the revenue model is quite different. Once built, coal and nuclear projects operate much more cost-efficiently than other types of facilities.[4] At face value, this cheap power would seem to present an excel-

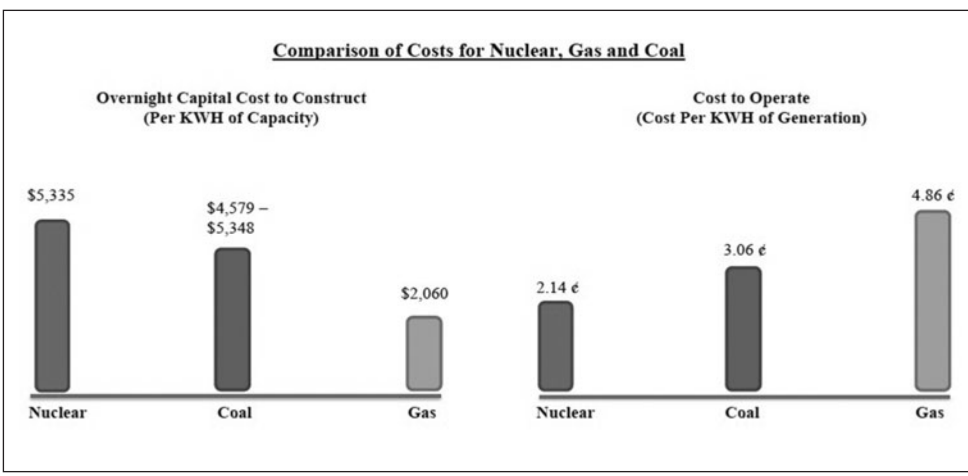

Fig. 19-2. Comparison of costs for nuclear, coal, and gas facilities

Note: This figure assumes that coal and gas plants are constructed with carbon capture and sequestration (CCS). Construction cost is taken from U.S. Energy Information Administration (2010). Operational costs are taken from a Ventex report, as cited in http://energy.aol.com/2012/04/03/summer-nuclear-unit-already-behind-as-it-gets-federal-green-ligh/.

4 We acknowledge that the traditional economies underlying coal-produced electricity are being challenged by an onslaught of new environmental regulations.

lent opportunity to produce "low" and sell "high" when prices peak in the wholesale market. However, nuclear and coal plants can't come online quickly enough to respond to short-term peaks in pricing. Thus, for nuclear power to make commercial sense for wholesale generators, long-term contracts for the purchase of electricity would likely need to be in place. Of the roughly 28 reactors that are planned and in the NRC's licensing queue, the World Nuclear Association has categorized 20 of the reactors as being built for investor-owned utilities, 6 as being built for merchant generators, and 2 as being built for a federal utility (the Tennessee Valley Authority has submitted an application for two new reactors in Scottsboro, in Jackson County, Alabama) (World Nuclear Association 2012).

Regulations Governing Whether and How New Generation Capacity Can Be Built

Meeting a Region's Need and a Certificate of Public Convenience and Necessity

Utilities engage in a planning process often referred to as integrated resource planning (IRP) to determine the appropriate blend of base-load and peaking electricity capacity that they will need to effectively and efficiently meet a region's demand. There are many factors that could affect how a utility will meet a region's need with new generation capacity, including the following:

- There are multiple possible sources of electricity to meet a region's fluctuating demand (e.g., nuclear, coal, hydro, natural gas, solar, wind, and biomass power). The facilities that use these different fuels involve different time frames and costs to construct.
- Certain types of facilities (e.g., nuclear and coal) are "inflexible" to frequent start-ups and shutdowns and operate more efficiently when run more or less continuously.
- Energy demand fluctuates seasonally, during extreme weather conditions, and depending on the hour of the day. Peaking generators (usually powered by natural gas) can be started up quickly to meet peak demand.
- Often, when there is increased demand for electricity (i.e., during cold weather), there is simultaneously increased demand for the fuels that are used to produce electricity during peak consumption (e.g., natural gas).
- All of the fuels that can be used to generate electricity have different costs and, equally important, have differing propensities for lesser or greater cost fluctuations. This situation means that the per unit cost to generate electricity can vary substantially depending on factors that are unknown when the plant is being built.

The purpose of the IRP process is to achieve the most efficient and reliable mix of generation resources.

A utility's planning efforts typically are put to the test when it presents its plan to construct a new facility to its regulating body. This test occurs because, before a regulated utility is permitted to construct a new facility, it must obtain a license (usually called a certificate of public convenience and necessity, or "CPCN"). The licensing process typically requires the utility to explain in detail the long-range electricity needs of the area being served and why the particular proposed facility would best meet the electricity needs of a region's customers.

A utility may be required to submit its long-term IRP as part of the CPCN process. But even if there is no requirement to submit the IRP, the utility has to explain as part of the CPCN why the proposed facility is consistent with the traditional goals of electricity planning (e.g., reliability, efficiency, and environmental protection) and why the facility is superior to other types of fuels or generation facilities to meet the particular region's particular electricity needs. As discussed in further detail below, the "prudence" of the utility's decision to construct the new facility is revisited in public hearings where the rates that the utility will be permitted to charge are determined.

U.S. Nuclear Regulatory Commission

For obvious reasons, the safe construction and operation of a nuclear power plant (as opposed to other types of facilities) presents nuanced and nuclear-specific complexities and, therefore, falls under an additional layer of regulation. In defining its mission, the NRC states (NRC 2007b), "It is the NRC's job to protect people and the environment from radiation hazards through regulation of the various commercial and institutional uses of nuclear material." The NRC has adopted a rigorous licensing process regarding the location, design, and construction of a nuclear power plant. It is important to note that, unlike the state utility commissions that identify cost-efficiency as a primary goal of their regulatory process, the NRC's mission relates to safety (that said, the new permit and licensing procedures adopted by the NRC certainly are at least mindful of cost).

Until recently, the three core subject matter areas of NRC—(1) site selection, (2) design, and (3) approval for operation as constructed—were handled separately. Each new nuclear plant was effectively custom-built and designed without any significant standardization. The design (and therefore the certification of the design) would be revised and finalized as the plant was being built. As a result, the NRC can and did order design changes that introduced additional delays and required completed work to be redone. This type of certification process was the source of problems in that it was slow (causing delays and adding to the finance costs). In addition to the issues with design and certification, the operating license procedures proved problematic. The old NRC permitting process is illustrated in Fig. 19-3. Because operating license hearings were public and took place after completion of construction, anyone opposing or disputing issuance of a license could significantly delay the plant's scheduled operation date (again, the source of considerable additional financing costs) by opposing issuance of the operating license.

The objective of the NRC's new permitting process is to remove much of the uncertainty of past nuclear construction projects by front-loading the permitting process before the NRC.[5] Permitting is done in three steps: (1) design certification process; (2) early site permitting; and (3) combined construction and operating licensing. The new permitting process combines licensing procedures that previously were treated separately and, more importantly, provides sufficient opportunity for public comment at the beginning of the permitting process, as opposed to after construction. Under this new process, all licensing and permitting is effectively complete before ground is broken, whereas under the previous permitting structure licensing proceedings, only a construction license would trigger preconstruction, and operating license hearings (with the opportunity for public comment) occurred after construction. Delays in issuing operating licenses proved enormously costly the last time the industry was heavily investing in new nuclear capacity. The intended benefits of the new permitting and licensing procedure are illustrated in Fig. 19-4.

The first step in permitting—design certification—takes a considerable degree of uncertainty out of permitting and plant design. Design certification means that generic reactors go through an approval process with the NRC irrespective of a particular site. According to the NRC website (www.nrc.gov), there currently are four certified reactor designs:

- Advanced Boiling Water Reactor design by GE Nuclear Energy (May 1997);
- System 80+ design by Westinghouse (formerly ABB-Combustion Engineering) (May 1997);
- AP600 design by Westinghouse (December 1999); and
- AP1000 design by Westinghouse (January 2006).

During the second step of the NRC's new early permitting—early site permitting—the NRC considers issues specific to the proposed site, either concurrently with or independent of an application for construction and operating licensing. Site safety issues, environmental protection issues, and emergency planning are evaluated independent of the review of a specific nuclear plant design. All stakeholders, including the public, are permitted to participate in this phase of permitting.

The third step of the NRC's new early permitting—combined construction and operating licensing (COL)—is perhaps the most dramatic change to the previous permitting process. Issues such as the applicant's qualifications, specific design safety, environmental impacts, operational programs, site safety, and verification of construction with the NRC's inspections, tests, analyses, and acceptance criteria (ITAAC) are addressed preconstruction. Thus, COL results in approval of a sufficiently detailed plant design and issuance of construction and operation licenses before the plant is even built. Again, all stakeholders, including the public, are permitted to participate in this phase of permitting.

The combined effect of the new permitting process is detailed design preconstruction, complete and expeditious permitting preconstruction, a significantly

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5 The materials discussing the NRC's new permitting process are taken, in part, from an article written by two of the authors of this chapter (Whitney and Sanacory 2010).

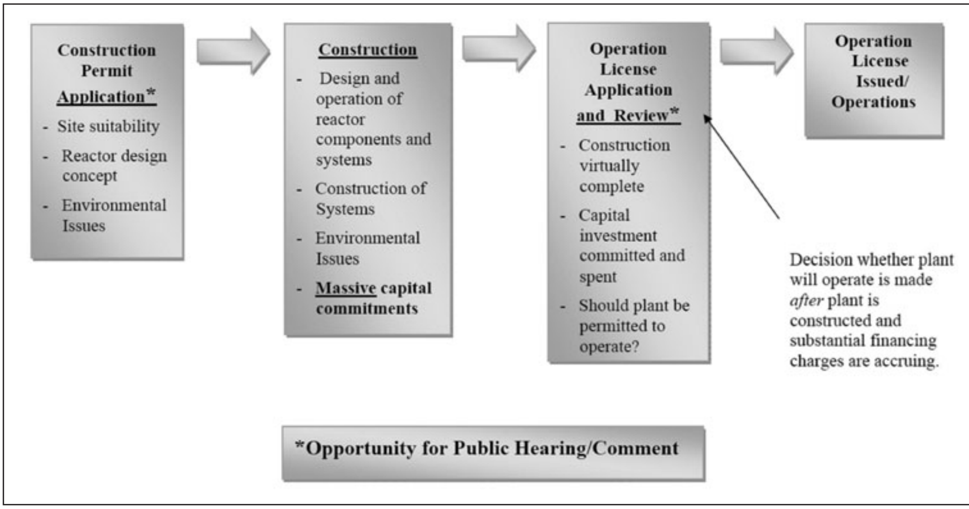

Fig. 19-3. NRC's old permitting process

Source: Carr (2011), reproduced with permission.

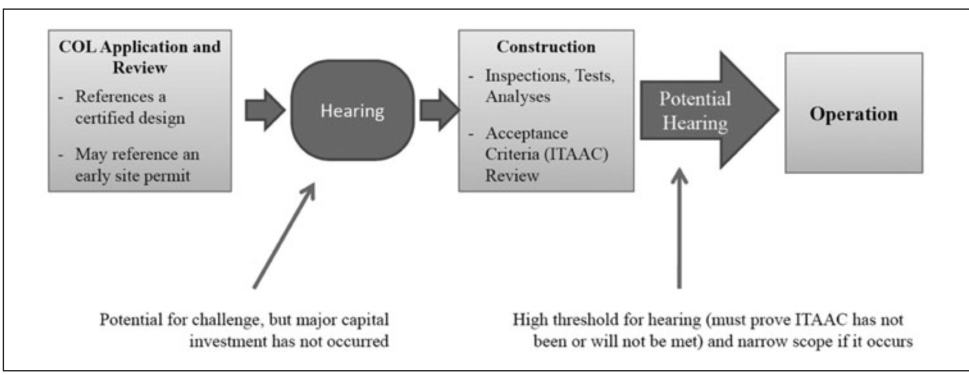

Fig. 19-4. Intended benefits of new permitting and licensing procedures

Source: Carr (2011), reproduced with permission.

higher degree of certainty that permission to operate will be obtained, and a considerable reduction in finance costs. Of course, adequate safety measures are preserved; postconstruction ITAAC verification is performed and, if appropriate, a hearing may be held on ITAAC compliance.

Rate Making, Building a Power Plant under a 20–20 Hindsight Microscope

A power generation company's ability to recoup its enormous investments in any power generation facility is based on the amount of electricity that it is able to sell and the rates it is able to charge for that electricity. For regulated utilities, the trade-off for having to operate under a substantial degree of regulation is often referred to as the "regulatory compact": In exchange for having imposed on it the absolute, nondelegable legal obligation to plan, design, construct, and operate its system to meet all present and projected customer load in its franchised service territory and sell electricity at set prices, a utility enjoys regional monopolies and prices set so that it can recover its prudently incurred costs of providing service plus a reasonable rate of return on those costs. Critics of this approach observe that periods of relatively high inflation or volatility in fuel costs do not allow the utilities to recover a "fair rate."

In most states, the state PUC sets the rates that the utility may charge to its consumers. In other words, the entities that are charged with ensuring that the public receives an abundant and continuous supply of electricity at a fair price set the prices and additional charges that a utility may pass on to the end-user.

Generally, the rates that consumers pay are set as part of rate change proceedings (often referred to as "rate cases"), where the PUC acts similarly to a court of law, follows formal procedures, and allows the utility and other interested parties (including the public) to present evidence and argument as to the appropriate rate that a utility should be permitted to recover through the rates it charges its users. Utilities typically are required to provide notice of rate change applications. In some states, this notice means notifying customers that an application has been made. Rate cases can be time consuming and expensive, without any guarantee that the PUC will grant a rate increase.

In determining the rates that a utility is permitted to charge, the law requires the PUC to hold the utilities to a standard of prudence. Thus, utilities typically are permitted to recover the capital costs that it reasonably or prudently incurred (most states also require that the costs or investments be actually used and useful), plus a reasonable profit; operating costs, such as fuel, operating and maintenance taxes, and interest payments, typically are recovered on a dollar-for-dollar basis. Nuclear plants are far more expensive to build than coal or gas plants but have lower fuel costs. The economics of all three vary according to the prices of the fuel and, increasingly, the prices of carbon emissions. When coal prices are high, gas plants become more cost-effective, and vice versa. When both fuels are costly—which also drives up the wholesale price of electricity—nuclear power can undercut coal and gas plants.

One of the tensions surrounding the rate-making process, relative to the utility's ability to recoup costs and earn an "allowed rate of return," is that there is not complete agreement by all participants to a rate case (which might include interest groups that opposed the construction of the plant in the first place) as to what should be included in the utility's rate base. For example, if a utility constructs a new facility based on demand forecasts that anticipated greater demand growth than actually occurred and the new facility turns out to be excess capacity, the utility may face criticism and opposition during the rate case that the new facility is not "used and useful" or that the utility did not prudently incur the costs of the new facility, thus raising the possibility that the utility may not recover fully its costs incurred in serving the public and its shareholders may not earn a return on their monies invested.

For many years, it was common practice to include in the rate base an allowance for "overhead" construction costs. Such an allowance included the costs of incorporation; legal, engineering, and administrative services; and interest insurance and taxes during construction. However, there is considerable disagreement regarding cost recovery treatment of new construction works that are in progress but not yet in service. Historically, plants were funded by the utility itself or by the issuance of bonds or stock. Construction works-in-progress (CWIP) charges were excluded from utility rates based on the notion that a partially completed plant is not "used and useful," that is, it is not generating any power for ratepayers.

Problems began in the late 1960s because the costs to build new generating plants soared (and again in the 1970s because of double-digit inflation and interest rates). Construction delays, especially those dealing with nuclear plants, greatly lengthened the time needed to finish construction. As a result, in some instances, the financial burden of these cost overruns became more than many utilities could manage. In other instances, the rate increases that took effect when costly plants finally went into service were met with a considerable degree of public dissatisfaction (sometimes referred to as "rate shock").

To address these problems, state and federal regulators began allowing all or part of CWIP to be included in the rate base (and thus to allow rates charged to customers to reflect CWIP). Some state regulators adopted multiyear phase-ins of construction costs to lessen rate shock. By the late 1970s, a majority of the states allowed CWIP in the rate base. Actual practices vary considerably, however, as to the amount of CWIP that may be included and the conditions for its inclusion.

Nuclear Rate-Making Cases

Rate-making cases for nuclear power plants are likely to be met with a high degree of public interest and involvement. In other words, the viability of a new nuclear project can be threatened at the earliest phase of the rate-making process. Utilities seek rate increases to recover the costs of building these plants, and critics of nuclear energy come forward to challenge the prudence of any new nuclear project. These critics question whether the utility has adequately justified a large increase in capacity and argue that it is imprudent to undertake such an enormous project laden with risks. They point to the projects of the past as evidence that nuclear power should not be revived. They argue that alternative fuel sources are a more prudent choice.

Utilities trying to construct new nuclear plants, on the other hand, note the perceived benefits of nuclear power:

- the need for additional base-load power, the risk of not taking steps now to meet growing demand and replacement of existing base-load facilities set for retirement;
- cheaper operations costs;
- the policy objectives of cleaner air; and
- all of the federal policies designed to facilitate and encourage new nuclear energy.

Even true skeptics of nuclear power have noted that it is considered at least competitive with, if not less costly than, clean coal.

The "prudence" of new nuclear energy is usually decided "after the fact" in the form of a rate case before the state PUC when construction is completed. At least one commentator has observed that the decision of a utility to go forward with the construction of new capacity is "rarely blatantly imprudent when viewed in light of the knowledge and alternatives reasonably available to the utility's management at the time of the decision.... The conditions forecast by experts in the 1970s suggest that the utilities' decisions to build new plants during that period were reasonable and prudent at the time they were made" (Pierce 1984).

There is some precedent that, even if the new facility produces excess capacity, construction of the plant based on information available at the time was nonetheless prudent. For example, in 1967 in *Duquesne Light Co. v. Barasch*, Pennsylvania's PUC found that Duquesne did not act imprudently by initiating the construction of more nuclear generating capacity and found instead that intervening events that resulted in less than forecasted demand (such as an OPEC oil embargo, the incident at Three Mile Island, and inflation) caused actual demand to be less than forecasted. The Pennsylvania PUC approved rate increases notwithstanding the fact that the electricity generated from the plant was excess capacity when the plant was first placed in service.

However, there are also many instances where the PUC disallowed inclusion of nuclear costs into a utility's rate base. In the 1970s and 1980s, state PUCs disallowed recovery of almost $10 billion of nuclear costs caused by construction imprudence and the fact that certain completed projects delivered excess capacity.

It is not entirely certain how CWIP will be treated in the context of new nuclear rate cases, though we are beginning to get a glimpse. With the Tennessee Valley Authority's decision to delay work at its Bellefonte site, Georgia Power, a subsidiary of Southern Company, is responsible for Vogtle Units No. 3 and 4, which will be the first new nuclear construction in the United States in roughly three decades. In issuing a CPCN, the Georgia Public Service Commission found on June 17, 2010, that the recovery of CWIP in Georgia Power's rate base would be in the public interest. In its order, the commission noted that allowance of CWIP would reduce the cost of the plant by approximately US$300 million and would preserve Georgia Power's credit rating (thereby avoiding an increase in Georgia Power's credit costs, which ultimately would be passed on to ratepayers). The commission also noted that allowance of CWIP would avoid the unpleasant consequence of "rate shock" once the plants are placed into service.[6]

Obtaining rate increases for CWIP-related costs for new nuclear plants may be more complicated in other states, where the laws may be different. For example, the construction of a proposed reactor in Callaway County, Missouri, is subject to a 1976 Missouri voter-approved measure that prohibits the inclusion of CWIP costs in a utility's rate base. In late 2010, Governor Nixon of Missouri began working with the Missouri legislature and members of an energy consortium to revamp the measure (Blank 2012). Predictably, there is opposition to any such efforts, and it is unclear how these efforts will turn out or how the plant will be financed if they are unsuccessful.

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6 This finding was a preliminary ruling, and the commission invited further comment at subsequent rate cases.

Lessons from Nuclear Energy's History

Shoreham, Zimmer, and Midland—these are names that many in the utility industry would rather forget. The birth and premature demise of these nuclear projects, among many other failed nuclear builds, helps to explain why this country stopped building nuclear electricity generation projects for decades. The stories of these nuclear projects are summarized and repeated here not to discourage current industry leaders but, instead, to allow lessons from these projects to be carried to the future. In looking at how and why these projects failed, we find some obvious and some not-so-obvious best practices and pitfalls to avoid. Although several of these lessons are specific to nuclear power, much of what we learned at Shoreham, Zimmer, and Midland can and should be applied to any utility generation megaproject or gigaproject.

A number of ailments have been blamed for the troubles that plagued nuclear construction in the 1970s and 1980s. As previously mentioned, plants were effectively custom-built and -constructed and designed "as you go," meaning that design was being performed at the same time that construction activities were being undertaken. These facts, coupled with the fact that the licensing procedures used by the NRC occurred during and after construction, created a perfect storm of lengthy and costly delays and a need for rework that is rarely seen in other types of large construction projects. As a result, the prices for the nuclear plants that were completed ballooned, and many projects were canceled altogether, with the costs of these overruns and unfinished plants eventually borne in a significant manner by the end consumer. The stories of Shoreham, Zimmer, and Midland illustrate problems and missteps that can be fatal to new nuclear.

Shoreham Nuclear Power Plant

Of all of the nuclear projects *Forbes* magazine once coined part of "the largest managerial disaster in business history" (Cook 1985), none is more infamous than the Shoreham nuclear power plant in East Shoreham, New York. Plans to construct the facility were first announced by the Long Island Lighting Company (LILCO) in April 1965. LILCO's original plan was to build a 500-MW plant, and in May 1968, LILCO filed an application with the NRC's predecessor, the Atomic Energy Commission, to begin constructing the plant. That same year, LILCO decided to enlarge the plant's planned output from 500 MW to 820 MW. This decision caused another year of planning and a delay in filing Shoreham's construction permit to May 1969. The decision to increase the plant's output came with a considerable increase in the cost estimate to construct the plant, from US$70 million to US$270 million (as expressed then, without adjustment to current dollars). At the same time that LILCO announced its expansion in size of the Shoreham nuclear power plant, LILCO also announced plans to build two more reactors in Jamestown and Lloyd Harbor, New York. Construction on Shoreham actually began in 1973 (the year LILCO had originally planned for the plant to be in commercial operation). A year later, the number of new nuclear plants on order reached its highest number in this nation's history.

In what was perhaps an early omen of things to come for the industry, on March 22, 1975, a plant worker at the Tennessee Valley Authority's Browns Ferry nuclear power plant used a candle to search for an air leak. The candle caused a temporary cable seal to catch fire, and the fire spread through the wall and caused significant damage to the station's control cabling. That same year, 13 nuclear projects were canceled. In all, more than 100 nuclear projects in the 1970s and 1980s were canceled.

Notwithstanding these events, construction on the Shoreham plant continued. By the end of the 1970s, the cost estimate to construct the Shoreham nuclear power plant had risen to US$2 billion (as expressed then, without adjustment to current dollars). Despite the cost overruns, it was announced that the plant would begin commercial operation in 1980.

Construction of the Shoreham plant was still not complete in 1979 when a malfunction in the cooling system caused a partial meltdown in one of the reactor cores at the Three Mile Island nuclear power plant located near Harrisburg, Pennsylvania. The Three Mile Island accident prompted the NRC to require operators of nuclear power plants to establish community evacuation plans in cooperation with state and local governments. It also prompted a massive protest against nuclear power at the Shoreham facility.

On June 3, 1979, 15,000 protesters gathered to rally against completion and commercial operation of the Shoreham nuclear power plant. At least 600 of those protesters were arrested.

In 1981, the NRC declared Shoreham safe for operation. Commercial operation of the plant was not possible, however, because local authorities would not sign off on the community evacuation plan. Years passed as LILCO worked to gain community approval of its evacuation plan. In February 1983, the Suffolk County legislature voted that the county could not be safely evacuated in the event of a nuclear accident at Shoreham. At the same time, the then governor of New York, Mario Cuomo, ordered state officials not to approve any LILCO-sponsored evacuation plan. By 1985, there was still no agreed-upon evacuation plan, but the plant received permission from the federal government to conduct low-power 5% tests of the facility. In September of that same year, Hurricane Gloria hit Long Island, and LILCO was unable to restore power to the island for weeks. The public lost even more faith in LILCO as an organization.

The fighting over Shoreham continued for years, while a fully functional nuclear plant stood idle. In December 1988, a federal jury found LILCO guilty of repeatedly lying to state officials about the plant's progress to obtain rate increases to help finance the project. In February 1989, a hamstrung LILCO announced a deal wherein LILCO would abandon the Shoreham nuclear power plant forever by selling it for $1 to the Long Island Power Authority, which would then be charged with decommissioning the plant. The sale was completed in 1992. LILCO stockholders were saddled with a heavy hit, and a surcharge of 3% was added to Long Island ratepayers' electric bills for 30 years to help pay off the Shoreham debt. By the time it was decommissioned in 1994, the price tag for the plant that never ran reached US$6 billion (as expressed then, without adjustment to current dollars).

William H. Zimmer Nuclear Power Station

Today, the William H. Zimmer power station in Moscow, Ohio, is a coal-fired power plant, but that was not always its destiny. In 1969, Cincinnati Gas and Electric Company, Dayton Power and Light Company, and Columbus and Southern Ohio Electric Company announced their plans to build a new boiling water reactor nuclear power plant at a cost of US$240 million (as expressed then, without adjustment to current dollars). By 1984, the plant was still not complete and its cost had risen to US$1.4 billion (as expressed then, without adjustment to current dollars), with an anticipated completion date in 1986.

From the time the plant was conceived to 1984, the accidents at Browns Ferry nuclear plant and, more importantly, Three Mile Island occurred, and plans for more than 100 U.S. nuclear plants were canceled. Just as importantly, the 7% per year economic growth that Ohio was enjoying in 1969 had disappeared. As the criticism mounted, the owners of what was to be the William H. Zimmer nuclear power station announced their plans to convert the project to a coal-fired power plant. The decision to convert the plant from nuclear to coal was made when construction of the plant was 97% complete. Still, the price tag to complete the outstanding 3% of construction was estimated at more than US$3 billion (as expressed then, without adjustment to current dollars).

Unlike at Shoreham, where the final holdup was approval of the plant's community evacuation plan, the completion of Zimmer was bogged down in a plague of allegations concerning failed quality assurance programs and mismanagement. One consulting firm hired by the public utility commission of Ohio attributed US$1.3 billion of the US$1.7 billion of construction costs that existed at the time that the conversion decision was announced to mismanagement. The NRC received at least 300 allegations about the plant's construction and record keeping. Some had merit; some did not. In response to the flood of allegations, the commission held hearings and ordered studies to review the quality of construction, the quality of hardware, and management controls at the Zimmer nuclear power station. Originally, the studies were designed to identify construction defects that needed to be addressed before the plant could be completed and go into commercial operation. With the decision to convert the plant to coal, these studies provide a historical road map of pitfalls to avoid in the future. The lessons of Zimmer are discussed below.

Midland Nuclear Power Station

Consumers Energy first announced plans for the Midland nuclear power station in Midland, Michigan, in 1967. Seventeen years later, US$4 billion had been invested, and the project was still just 85% complete. On July 16, 1984, Consumers Energy canceled its nuclear megaproject. At the time the project was canceled, a report commissioned by Michigan's then attorney general concluded that it would cost US$24.3 billion more to complete the plant than to scrap it (over the life of the plant, as expressed then, without adjustment to current dollars). The cost overruns at Midland were largely attributable to construction problems, including sinking and cracking of some buildings on the site. A technical writer and researcher for the neighboring Dow Chemical Co. by the name of Mary Sinclair famously led the charge in identifying and exposing safety concerns surrounding construction of the plant and site soil stability. Midland was eventually converted into the largest natural-gas-fired electrical and steam cogeneration plant in the world. The process of converting the facility from nuclear to natural gas cost US$500 million and took five years.

Lessons Learned

A combination of low worker productivity, design changes, and new regulatory requirements has been blamed for what happened at Shoreham. Without question, these factors did affect the plant's construction cost and time line. If LILCO had stuck with its original plan to build a 500-MW plant, the difference in cost and timing might have led to a much different outcome for the Shoreham nuclear power plant. In scaling megaprojects, bigger is not necessarily better. Project size and schedule should match demand need and the utility company's financial resources and experience. Still, despite the challenges it faced with workers, design, regulations, and cost overruns, at the end of the day Shoreham was a safe and complete nuclear power plant ready to go into commercial operation. Indeed, Shoreham's near twin, Unit One at the Millstone nuclear power plant in Waterford, Connecticut, successfully generated electricity for decades, from 1970 to 1995.

Shoreham is perhaps the greatest example of how the erosion of public support can be fatal to a project, even a safely and soundly completed project. It was not low worker productivity (though important to manage and guard against) or regulatory and design changes that caused Shoreham to be shut down. Shoreham was shut down because LILCO could not get its evacuation plan approved, and LILCO could not get its evacuation plan approved because its surrounding community of ratepayers didn't believe that LILCO was telling the truth anymore. This attitude left the door open for aggressive challenges by antinuclear activists. There was nothing substantively wrong with the Shoreham evacuation plan. Indeed, in September 1988, the Federal Emergency Management Association concluded that the plan would ensure public safety in the event of an accident.

What happened at Shoreham teaches us that a utility seeking to successfully complete any kind of megaproject must retain credibility—with its governing boards and/or members, the agencies that regulate it, and its ratepayers. The utility's communications regarding project costs and schedule (initially and as they may change) must be consistent and forthright. In addition, a utility seeking to successfully complete a megaproject must seek, secure, and maintain public support at all levels—from elected and appointed officials at the federal, state, and local level to individual community members.

To maintain public backing, in addition to being in control of its megaproject construction site, schedule, and budget, while engaged in the megaproject build cycle, a utility must be particularly responsive to customer needs (particularly in time of storms or other disasters) and vigilant about safety across its system. An accident or failure to deliver reliable utility service that occurs during construction of a megaproject, even if wholly unrelated to the megaproject, can destroy public confidence. Shoreham also teaches us that a utility should not bite off more than it can chew, either by scaling a megaproject at a size that exceeds demand or company resources (in human or financial capital) or by attempting to pursue multiple megaprojects at once (for all but a few of the nation's most sophisticated utility providers, only one megaproject should be pursued at any one time).

As was the case at Shoreham, Zimmer was handicapped by a continual stream of new and changing regulations with which the Zimmer project was forced to comply. Though the implementation of the NRC's new three-step permitting process is only now being tested at Vogtle Units No. 3 and 4 and in other nuclear megaprojects currently under construction, the NRC's new process is a direct attempt to mitigate the "moving target" problem encountered at Zimmer. To date, it seems to be working.

Beyond the need for clear and stable regulations, the story of the Zimmer nuclear power station teaches us the importance of both ensuring the quality of the construction of the plant and having a strict quality assurance program to document that quality. The only effective way to establish the quality of construction is to have thorough and organized documentation through a quality control program. The independent third party retained by the NRC in 1983 to review project management for the Zimmer nuclear power station found the following causes for quality issues at the plant:

- Lack of prior nuclear experience;
- Inadequately sized and experienced staff;
- Failure to dedicate key managers and professional staff to the project;
- Failure to supervise responsibilities delegated to subcontractors or others;
- Failure to hold commitment to quality equal with commitment to cost and schedule; and
- Lack of a comprehensive set of documented project management procedures.

Regardless of whether or not the independent third party's conclusions were correct, any utility executive undertaking the construction of a new nuclear facility or other megaproject would be wise to carefully consider how it will address each of the factors identified as causes for quality failure in the Zimmer review. This analysis should be undertaken well before the megaproject breaks ground and should be revisited continually throughout the project. Particularly with nuclear plants, finding and retaining employees with significant nuclear experience will be challenging in light of the generational gap (almost 30 years) since this country was last heavily invested in nuclear construction. For owners, if a dedicated staff member with nuclear experience will not be available, then your organization must seek and retain wise counsel in the form of a consultant with such experience. New nuclear construction owners and construction management must build their teams consciously and keep them on the project over the long haul. Once teams are established, construction workers and construction management teams must create and document a quality management program and then demand compliance with that program.

Compliance with quality management programs must be reviewed as consistently and in as great detail as the budget and project schedule.

Like at Zimmer, the central lesson of Midland is the need to ensure quality construction. Despite allegations that the plant would sink into the soil, the site selected for construction of the Midland nuclear power station was adequate, but the soil was not properly compacted or prepared. Once buildings started to sink and show cracks, the tide against Midland could not be stopped.

In 2007, Kenneth J. Aupperle and Charles W. Hess gathered data on 100 nuclear projects attempted or completed in the United States from 1965 to 1990. The authors focused on a critical analysis of eight nuclear projects (four failed nuclear projects and four completed). Aupperle and Hess attempted to identify the root causes and any common characteristics of failure in nuclear megaprojects. The authors analyzed the three failed projects discussed in detail here, plus the failed Marble Hill nuclear power station in Indiana. After completing their analysis, Aupperle and Hess identified the following root causes of failure (Aupperle and Hess 2007):

1. Insufficient leadership and ownership by the utility;
2. Unclear or changing definition of project expectations, roles, and responsibilities;
3. Insufficient project integration;
4. Inadequate resources dedicated to planning and project management;
5. A mind-set of passing on risks that cannot be passed on;
6. Lack of a nuclear mentality at the management and workforce levels;
7. Lack of commitment to quality;
8. Failure to keep an adequate quality assurance program and detailed records in place;
9. Owner pressure on contractor to engage in bad practices; and
10. Inadequate training.

Regulators and industry groups have worked to respond to many of the lessons of the past, creating intended cures in the form of NRC's three-step permitting process, government backed loan guarantees to help control the cost of credit to build new nuclear facilities, and industry groups, such as the Institute of Nuclear Power Operations (INPO) and NuStart, which are discussed in greater detail below. As important as these steps have been, the lessons of the past also emphasize the need for strong and vigilant management control in any future nuclear project build, and no regulation or program can replace the importance of owner involvement.

Owner Insight and Involvement in Every Aspect of Quality Control and Quality Assurance

In response to the problems that plagued nuclear construction projects in the 1970s and 1980s, Congress, through an amendment to the NRC's 1982 and 1983 fiscal budgets, directed the NRC to conduct a study to understand the quality issues that the industry encountered and to derive a set of best practices and lessons learned.

The results of this study were published in 1984 in a 564-page report to Congress called NUREG-1055, "Improving Quality and the Assurance of Quality in the Design and Construction of Nuclear Power Plants" (NRC 1984).

The study concluded that the root cause for major quality-related problems was the failure or inability of some utility management to effectively implement a management system that ensured adequate control over all aspects of the project. These management shortcomings arose in part from inexperience on the part of some project teams in the construction of nuclear power plants. NRC's past licensing and inspection practices did not adequately screen construction permit applicants for overall capability to manage or provide effective management oversight over the construction project.

The study went on to identify two corollary findings:

1. Previous nuclear design and construction experience of the collective project team (defined as the architect–engineer (A–E), nuclear steam supply system manufacturer, construction manager (CM), constructor, and owner) is essential, and inexperience of some members of the project team must be offset and compensated for by experience of other members of the team. Each member of the project team should assume a project role consistent with its previous nuclear experience and not overstep its capabilities; and
2. The NRC has not adequately assessed the factors of management capability and previous nuclear experience in its preconstruction permit reviews and inspections. The substantial changes the NRC has required of some licensees' projects to bring them up to minimum standards are evidence that some utilities that were not adequately prepared to undertake a nuclear construction project were granted construction permits.

Additionally, the NRC recommended in NUREG-1055 a number of improvements for the industry and the NRC programs. For industry, the NUREG-1055 recommended a comprehensive commitment to excellence, a quality assurance program to be used as a management tool (not a substitution for owner management of quality issues), and a comprehensive third-party audit program. For the NRC programs, the study recommended a thorough review of an applicant's capabilities to construct nuclear plants, an emphasis on inspectors resident at the construction site, as well as a focus on using quality information as a tool for managing the project.

The NRC noted that application of lessons learned would decrease the probability of major quality issues that were encountered in the 1970s and 1980s. However, the NRC also warned that quality issues might recur, including the following circumstances:

- A first-time utility with a staff or A–E, CM, or constructor who has inadequate nuclear design and construction experience;
- A large growth in the number of nuclear plants being constructed that (again) overwhelms the industry's and NRC's capabilities;

- A long delay before nuclear plant construction activities start again, resulting in a dearth of experience in the industry; and
- Regulatory actions at federal and state levels that undercut quality.

The warnings contained in NUREG-1055 were reemphasized in 2007 when the NRC issued Information Notice 2007-04 in response to the increased industry interest in new nuclear construction. Specifically, the NRC noted that "several of the conditions identified in NUREG-1055 under which major quality problems might recur currently exist in the United States. This fact emphasizes the importance of understanding the causal factors associated with historical construction problems in order to chart a future course for assuring quality in new nuclear power plant construction" (NRC 2007a).

INPO was formed by the nuclear power industry in 1979 after the incident at Three Mile Island and in response to recommendations made in a report to President Jimmy Carter. INPO's mission is "to promote the highest levels of safety and reliability—to promote excellence—in the operation of commercial nuclear power plants." In NUREG-1055, the NRC noted that "significant improvements can come only from the industry. We view the industry's Institute of Nuclear Power Operations as a positive step in that direction" (NRC 1984).

Since NUREG-1055 was presented to Congress, INPO has published its "Principles for Excellence in Nuclear Project Construction," which discusses principles that are critical to the success of new nuclear construction and are good practices in any major power generation project, particularly in light of a prudence review during the rate-setting process. INPO's standards focus heavily on a culture of excellence and devotion to high quality from the top of the organization down. The standards (INPO 2010) include detailed requirements for policies and plans that address each of the "lessons learned" from past problem nuclear projects, including

- Key managers who have relevant nuclear experience;
- Complete and correct design;
- Well-qualified personnel and trade;
- Strong first-line supervision ensuring quality as the work is installed (as opposed to relying on inspections after the work is installed);
- An accurate, well-developed, realistic, and communicated schedule;
- Awareness of all project personnel of the particular requirements for nuclear construction; and
- Adherence to the design documents and an advance and well-planned turnover process.

Contract Pricing

On any major construction project, the contract documents among the owner and the various parties to the projects go a long way in allocating the various risks inherent in the project. Ideally, the contract documents allocate each particular risk to the party or parties best able to manage it.

Most of the last generation of nuclear projects were priced on a time and material (T&M) basis and were constructed "design as you go." The simultaneous design and construction made it impossible to fix construction costs. As the NRC noted in NUREG-1055 (1984), "Without substantially more complete designs before construction is begun and stabilization of technical requirements, fixed-price contracting does not appear to be justified for most aspects of nuclear power plant construction." T&M contracts contain cost reimbursable aspects that put the risk of scope creep, delay, and increased costs in materials largely on the owner. "Design as you go" invited delays when projects were already underway but the constructor was waiting on design information (sometimes driven by regulatory change) while attempting to sequence work and construct plant components on site.

In contrast to T&M contracting, "fixed-price" or "lump-sum" contracting shifts most, if not all, risk of cost increases to the major contractors, who take on responsibility for engineering, procurement, and constructing (thus, the term *EPC contracting*). EPC contracting puts a greater portion of project control (and risk) with the constructor. This arrangement means a better understanding of actual project costs by the owner. It also means that the EPC contractor will have a greater financial incentive for finishing the project on time and under budget.

For the next round of nuclear construction, owners and contractors will be relying on a hybrid of EPC and T&M contracting principles. For well-defined portions of the scope work, fixed pricing will be applied. Where there are contingencies, risk of schedule effects, or other aspects of the project where scope of work or timing is not well-defined, owners will continue to bear the risk of cost increases, highlighting again the importance of certainty in the NRC's approval process.

Staying on Schedule

The adage "time is money" has perhaps never been proven to be more true than by the nuclear energy industry in the 1970s and 1980s. Anywhere from one-third to as much as one-half of the cost of the last generation of nuclear power plant projects was direct cost of finance during construction. The cruel and relentless effects of time and financing costs wore on as design, construction, and permitting delays mounted. One of the key challenges for the nuclear industry in this next wave of new nuclear construction will be to implement new approaches to maintaining a schedule.

The NRC's new guidelines are a major effort toward maintaining schedule. The perceived benefits of the new permitting process were that uncertainties would be removed, any issues with design that needed to be corrected or improved would be known further in advance, and public discourse over a proposed project would occur before massive capital investments were made, avoiding lengthy disputes while interest on a multibillion-dollar project was accruing. The lynchpin to the new process is that reactor designs are precertified and the plant design is almost complete when the application is filed.

Complete and accurate design is important to maintaining schedule for a number of reasons, not the least of which is minimizing potential disputes between the party responsible for design and the constructor. One issue that often accompanies a slip in schedule is an increase in the issuance of design clarification by the contractor in the form of requests for information (RFIs). Some have argued, particularly in the context of litigation, that, to avoid responsibility for construction delays, contractors will increasingly issue RFIs, seeking more detailed design or design changes that may not be necessary and, ultimately, change orders, to avoid responsibility for slippage in the schedule. What can ensue is an erosion of trust between major parties on the project and even a costly dispute to resolve whether the contractor abused the RFI process or properly issued the RFIs. One way to mitigate the risk of such an occurrence is to have complete and accurate design and for the design team to have an organized, proactive, and well-defined method for responding to RFIs.

As we approach the four-year anniversary of the first COL applications that were filed under the new procedures, reviews are mixed (Domenici and Meserve 2010). For example, the Bipartisan Policy Center (BPC), a nonprofit organization established in 2007 by Howard Baker, Tom Daschle, Bob Dole, and George Mitchell, interviewed NRC staff, former NRC commissioners, reactor vendors, COL applicants, nuclear energy firms, and representatives of environmental and other organizations to review the NRC's new licensing process. Of note, the BPC observed that the "current Design Certification (DC) process has proven cumbersome, in large part because of the parallel submission of COL applications referencing a design then undergoing review for certification.... The simultaneous processing of DC and COL applications has created some uncertainty arising from the interplay between the two processes" (Domenici and Meserve 2010). Design certification in this method is supposed to be complete before COL application. The Bipartisan Policy Center also noted that "some vendors have complained that issues that were believed to have been resolved were subject to reopening as different reviewers became involved."

Notwithstanding these observations by the Bipartisan Policy Center in their study, the process seems to be delivering on much of what was hoped for. First and perhaps most significant is that the design issues are being worked out before construction. Thus, even if the process is working more slowly or in a more cumbersome manner than hoped for, the financing costs are not accruing at the rate of past projects because the major investments on the projects awaiting COLs have yet to be made. Moreover, as the Bipartisan Policy Center observed, "The overall aim should be to reduce the licensing burden *without affecting the quality, scope or thoroughness of the review*" [emphasis added] (Domenici and Meserve 2010).

In addition to advance design, the industry has attempted to provide scheduling relief to nuclear projects by revolutionizing the way the plants are constructed. Specifically, the industry is attempting to implement strategies to perform more work off site through modular construction, where quality control can be more easily monitored and work conditions are better and more convenient and where interference caused by multiple contractors attempting to perform work simultaneously at the same location can be mitigated. Through modular construction, plant components such as heating, ventilation, and air conditioning (HVAC) or electric services are built off site, then "snapped together" on site. As noted below in reference to the Sanmen project in China, which is using the AP1000 Westinghouse reactor type, modular construction techniques are being credited for enabling the recovery of six months of scheduling delays.

Workforce Availability

As noted before, the wise owner of a new nuclear generation megaproject finds and retains a workforce with significant nuclear experience. There is a need for nuclear experienced workers at all levels, from those engineering, supervising, and managing the construction for the owner and the EPC contractor to the skilled crafts people—including welders, pipefitters, masons, carpenters, millwrights, sheet metal workers, electricians, ironworkers, and heavy equipment operators and insulators—constructing the facility. Moreover, a lot of employees with this kind of experience are needed; the National Commission on Energy Policy estimates that it takes 14,360 work-years per gigawatt installed to construct a new nuclear generation facility.

As important as a workforce with nuclear experience is to a project, finding this workforce can be difficult. Across the nuclear generation industry, the average employee is 48 years old. After Three Mile Island and Chernobyl, with no new nuclear construction projects underway, the industry stopped hiring and the federal government stopped supporting most of its university-level nuclear science and engineering education programs. Consequently, as this employee group ages, the industry is heading for a retirement cliff with the replacement workforce not yet in line. This issue has significant effects for construction and operation of these facilities. The effect of this retirement wave, with 38% of nuclear utility employees reaching their retirement eligibility between 2009 and 2014, is already being felt.

In 2004, the International Atomic Energy Agency (IAEA) issued a report entitled "The Nuclear Power Industry's Aging Workforce: Transfer of Knowledge to the Next Generation." In its report, the IAEA focused on the need to develop programs to retain current workers, enhance educational programs to prepare students for nuclear power plant careers, enhance programs to attract students into nuclear careers, and preserve organizational knowledge for transfer to others. Though the report focused principally on the challenges of finding and retaining an experienced workforce to operate fully constructed nuclear power plants, many of the IAEA's recommendations apply equally well to the challenges of finding and retaining an experienced workforce to construct a new nuclear power plant. In her August 31, 2010, testimony before the Blue Ribbon Commission on America's Nuclear Future, Subcommittee on Reactor and Fuel Cycle Technology, the Nuclear Energy Institute's senior director urged legislators to renew and expand existing tax incentives for nuclear workforce training and to create a tax credit for the expense of training workers.

The challenge for those constructing a new nuclear project is that to date, many of the existing programs designed to target and train the next generation of nuclear workers are focused on operators, not builders. Given the issue of workforce availability, the owner seeking to build a new nuclear generation facility must pay special attention to its nuclear experienced employees and its ability to retain these employees for the life of the construction project. Moreover, the owner must ask its EPC contractor some tough questions regarding how many of the EPC contractor's employees assigned to the owner's project site will have nuclear experience, and at what level.

Nuclear Today

Without minimizing past challenges in constructing new nuclear generation and accidents like Three Mile Island, Chernobyl, and now Fukushima Daiichi, it has not been all bad news for the nuclear industry. The United States is the largest producer of nuclear power in the world. Exactly 104 reactors safely and cleanly generate 20% of the nation's electricity. Moreover, the industry has created and promises a number of improvements that are intended to mitigate several of the problems that were encountered the last time the industry made a massive investment in nuclear energy.

There is no doubting that it is in the interest of the United States to have a reliable and adequate source of base-load power. As U.S. Senator Lamar Alexander stated in June 2010, Americans use a lot of electricity, and we use it productively (Alexander 2010):

> We use 25 percent of all the energy in the world to produce about 25 percent of all the money in the world ... five percent of the people in the world. We ought to keep that high standard of living. We need to remember we are not a desert island. Someday, solar, wind and the Earth may be an important supplement to our energy needs, but for today, we are not going to power the United States on electricity produced by a windmill, a controlled bonfire and a few solar panels.

Though recent economic challenges and some gains in efficiency have caused the United States' year-to-year demand for electricity to stabilize, the aging and retirement of existing base-load power generation facilities and long-term forecasts for increased energy demand mean that there is still a need for utilities to step up to construct the next generation of this country's base-load power generators.

Concerns over carbon emissions and the resulting regulatory regimes requiring ever-cleaner coal facilities have effectively put new coal megaproject construction on hold. In 2010, Black Hills Corporation's WyGen III coal facility went online in northeastern Wyoming and Kansas City Power & Light Co.'s Iatan 2 coal facility finished in-service testing, but construction did not begin on a single new coal-fired power plant. In 2009, no new coal-fired power plant construction broke ground, utilities and power generators dropped previously announced plans to build 38 coal plants, and 48 coal plants were announced for retirement. One notable exception to the trend described here is Sunflower Electric Power Corporation's proposed 895-MW coal-fired power plant to be built near Holcomb, Kansas. The facility's air permit was approved December 16, 2010, but suits brought by environmental groups remain ongoing.

Coal-fired plants generate almost half of the electricity we use in this country. The average age of the U.S. coal fleet is 43 years, with more than half of the plants currently in operation built before 1967. On January 7, 2011, ICF International released its Integrated Energy Outlook for the fourth quarter of 2010 and projected that almost one-fifth of the U.S. coal fleet could retire over the next 10 years in response to new air, waste, and water regulations.

Although regulators may be forced to give the coal power generation industry some relief before these dire predictions are realized, you cannot retire existing or stop building new coal facilities without replacing the lost reliable base-load power. Until the regulatory attack on coal-fired generating facilities subsides, the options for new base-load electricity generators left on the table are to use natural-gas-fired facilities for base-load power (viable only for as long as natural gas prices remain low) and to build more nuclear plants. As of 2011, the United States was the world's largest producer of nuclear power.

Nuclear Projects outside the United States

At least 58 new nuclear reactors are now being built in 15 countries around the world (20 in China alone). Recently completed and current nuclear megaprojects in Finland, Taiwan, China, and Japan demonstrate the feasibility of new nuclear plants. These projects also demonstrate the need to carry the lessons we learned from the last round of nuclear construction forward.

Construction of Finland's Olkiluoto 1600-MW nuclear power plant began in 2005 and continues today. Completion is currently expected by the end of 2012. However, like the nuclear projects of the 1970s and 1980s in the United States, the Olkiluoto project was commenced before detailed design documents were finalized, making it difficult to draw conclusions as to how counterpart projects in the United States, with a more complete design at groundbreaking, will perform. In addition to redesign issues, regulators stopped work at the Olkiluoto site on at least two separate occasions because of quality issues with the concrete. Regulators also stopped work on the reactor's cooling system after discovering issues with pipe welding (both deviations from design and failure to follow procedures). In all, delays, redesign, and rework have put the plan roughly four years behind schedule, and the budget for the project has grown from US$4 billion to US$7.2 billion.

As in Finland, the construction of Units No. 1 and 2 at Taiwan's Lungmen nuclear power plant has run into budget and scheduling issues. Construction began in 1997 with the two-unit project originally estimated to cost US$5.9 billion and to come online in 2009 and 2010. Political disputes and high material costs stopped construction in 2000. Construction was later restarted and is ongoing, but the project cost has risen to US$8.1 billion. The units are expected to be operational in 2012, following post-Fukushima safety evaluations by the government and international organizations.

Four of the AP1000 Westinghouse type units—the same units being constructed at Georgia Power Company's Vogtle site—are currently under construction in China.

The first of these units to go commercial will be Sanmen Unit No. 1. Authorization to proceed on Sanmen Unit No. 1 was given on December 31, 2007; the first concrete was poured on March 31, 2009; and the plant is on target to be fully operational by 2013.

Right behind Sanmen Unit No. 1 is Haiyang Unit No. 1. Authorization to proceed on Haiyang Unit No. 1 was given on December 31, 2007; the first concrete was poured on September 27, 2009; and the plant is on target to be fully operational by 2014. Construction for Sanmen Unit No. 1 at one point fell six months behind schedule. However, the fact that Westinghouse's design is modular—construction of certain components is done off site and then "snapped together" on site—has been credited for enabling the construction team to recover the lost time. The five-year construction schedule for China's Sanmen Unit No. 1 and the six-year construction schedule for China's Haiyang Unit No. 1 are megaproject success stories. Not surprisingly, in January 2011, Chinese authorities and Westinghouse signed a two-year extension of their cooperation agreement for continued deployment of the AP1000 reactors in China.

The initial construction of Units No. 6 and No. 7 of Japan's Kashiwazaki-Kariwa nuclear power plant is another megaproject success story. Both of these units use General Electric's advanced boiling water reactor design and took five years to construct, 1991 to 1996 for Unit No. 6 and 1992 to 1997 for Unit No. 7. The temporary suspension of operation of these units was the result of the July 2007 earthquake that struck the site and was not related to initial construction.

A Gigaproject Emerges: Vogtle Plant Units No. 3 and 4

In the United States, the NRC has received combined license applications for 18 sites, each for one to two units, and has issued early site permits for Exelon Generation's Clinton site, System Energy Resources Inc.'s Grand Gulf site, Dominion's North Anna site, and Southern Company's Vogtle site. Regardless of what size this next wave reaches, the test of the NRC's new three-step process is well under way at Vogtle. The Vogtle project represents the country's first new nuclear construction in 30 years.

Mindful of skeptics and the need to approach new nuclear construction with caution and care, the nuclear industry in the United States has worked together to overcome problems of past nuclear projects and prove the efficacy of NRC's new three-step process. NuStart Energy is a consortium for new nuclear energy development. Members of the consortium include DTE Energy, Duke Energy, EDF, Entergy Corporation, Exelon Corporation, FPL Group, Progress Energy, SCANA, Southern Company, and the Tennessee Valley Authority. GE Energy and Westinghouse Electric Company also participate in the consortium. Acting through NuStart, the consortium members set out to obtain a combined license under the NRC's new process and to complete the design engineering for the consortium's selected reactor technologies.

By forming this consortium to share certain non-site-specific design and licensing costs, these utilities and vendors recognized the importance of demonstrating that new nuclear plants can work and that success in one nuclear project can lead to success for other nuclear projects. Westinghouse's AP1000 is one of NuStart's selected technologies. With respect to NuStart's design engineering goals, on January 2006, the NRC approved the final design certification for Westinghouse's AP1000. The certification is valid for 15 years from approval. With respect to its goal to obtain a combined license, NuStart has backed Vogtle as its first site. The combined license for Vogtle was awarded in early 2012, and the units are expected to come online in 2016 (Unit No. 3) and 2017 (Unit No. 4). The lessons learned at Vogtle will be shared with other NuStart consortium members, who will collectively benefit from the design certification already awarded to Westinghouse's AP1000 technology.

Fukushima Daiichi

On March 11, 2011, a 9.0 magnitude undersea earthquake occurred off the northeastern coast of Japan. The earthquake was the fifth largest earthquake in the world since 1900 and caused a tsunami (a wall of water between 30 and 40 ft tall) that swept across the coast of Japan and six miles inland, destroying almost everything in its path. All told, more than 300,000 buildings and 4,000 roads were destroyed by the tsunami.

Situated directly in the path of the devastating tidal wave was the Fukushima Daiichi nuclear power station. Fukushima has six reactors, all put into service in the 1970s, five of the reactors built with the Mark I containment structure (Unit 6 is of the Mark II design). When the earthquake occurred, Fukushima Unit 4 was defueled and in maintenance and units 5 and 6 were in cold shutdown for planned maintenance. Units 1, 2, and 3 were operating but shut down automatically after the earthquake, leaving the reactor core to be cooled by emergency generators. The tsunami reached Fukushima roughly an hour after the earthquake, bringing with it a wall of water that flooded the plant and disabled the emergency generators that were powering the reactor cooling systems. Without power to cool reactors, engineers vented radioactive steam to release pressure, leading to as many as four explosions (Kitamura and Shiraki 2011). Despite being shut down, fuel rods for Units 5 and 6 that were being stored in pools began to overheat as water levels in the pools began to drop. The cleanup and decommissioning of Fukushima is expected to take several years.

No fatalities and no significant radiological health effects have been attributed to the Fukushima Daiichi nuclear power plant accident. Still, the ultimate effect that the accident will have on nuclear regulatory regimes in the United States and in other countries is not yet fully known. According to a May 2, 2011, report by Navigant, the Fukushima events have elevated safety concerns in certain countries where new nuclear construction is planned or currently underway, but substantial nuclear construction is continuing largely as planned (Navigant 2011). With substantial new nuclear construction underway and modern designs that are considered to be far safer than the older Mark I design, the industry has the opportunity to demonstrate success and improvement over the last round of construction. However, existing facilities, particularly those with the Mark I containment structure (albeit a design, particularly for Mark I containment structures operating in the United States, that has been modified substantially over the years and declared safe by the NRC), already are facing challenges to their continued operation. For example, Entergy and the state of Vermont currently are litigating over whether the state of Vermont can shut down the Vermont Yankee power station (based on the Mark I design), notwithstanding the fact that the NRC has granted that facility an extension to its operating license.

A likely effect of Fukushima that may be felt in the United States relates to the storage of spent fuel. Despite being described as "spent," spent fuel rods that are no longer able to maintain a nuclear reaction sufficient for commercial power generation remain highly radioactive and give off considerable amounts of decay heat that must continuously be dissipated. All nuclear power plants in the United States store spent fuel in pools made with thick walls of concrete and steel and in 40 ft of water to both cool the spent fuel rods and shield the radiation. After roughly five to ten years of "cooling," spent fuel is then transferred to "dry cask" storage.[7] The NRC has indicated that spent fuel storage in the United States remains safe; however, in light of the events at Fukushima, the method and manner of storing spent fuel will receive increased attention, and changes in regulations relating to spent fuel storage may follow.

In July 2011, the NRC issued *Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Incident* (2011b). In this report, the Near-Term Task Force, charged with conducting a systematic and methodical review of NRC processes and regulations to determine whether the agency should improve its regulatory system and make recommendations for agency policy direction in light of the Fukushima accident, reported (NRC 2011b):

> The [NRC's] current regulatory approach, and more importantly, the resultant plant capabilities allow the Task Force to conclude that a sequence of events like the Fukushima accident is unlikely to occur in the United States and some appropriate mitigation measures have been implemented, reducing the likelihood of core damage and radiological releases. Therefore, continued operation and continued licensing activities do not pose an imminent risk to public health and safety.

On March 12, 2012, the NRC issued the first regulatory requirements for nuclear plants in the United States that were spawned by the lessons learned at Fukushima. Implementation of these new requirements is to be completed within two refueling outages or by December 31, 2016, whichever comes first. The new safety requirements include (NRC 2012):

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7 More information on spent fuel storage is available at http://www.nrc.gov/waste/spent-fuel-storage/faqs.html.

- Mitigation strategies to respond to extreme natural events resulting in the loss of power at plants;
- Ensuring reliable hardened containment vents; and
- Enhancing spent fuel pool instrumentation.

These steps, along with other measures being taken, such as reevaluation of seismic and flooding hazards, will ensure that the nuclear industry has a strong and safe future as the next wave of nuclear power plant construction continues.

Summary

The need for new base-load power cannot be ignored. Even with recent events in Japan reminding the industry worldwide of the need to put safety first, the signs point to the need to give the new wave of nuclear construction the opportunity to prove itself as a viable source to meet the U.S. need for clean, affordable base-load power. The challenge for those of us who want to be successful owners and partners as we embark on this massive investment in meeting our country's future electricity (and environmental) needs will be to take history's lessons seriously and to use skill and sound judgment as we embark on these megaprojects.

A number of the problems that the industry faced in the 1970s and 1980s have been addressed. Still, there is no crystal ball that can accurately predict the outcome of the coming round of nuclear power plant construction. As we have seen from past examples, all kinds of problems can arise during the construction of any major project, but particularly so in the case of nuclear power plants.

Regardless of how insulated an owner may be from increases in project cost under its EPC contract structure, for this generation of new nuclear power plant construction, the owner cannot simply arrange for project financing and consider its work done. Any owner building a new nuclear megaproject or gigaproject must recognize the need for owner involvement at every level. The project owner must know, understand, and be involved in site selection, community relations, the design of its facility, the permitting of its facility, the composition and experience of the workforce that is constructing its facility, the construction schedule, and all quality management programs (on and off site). High-level understanding and involvement are not enough; the owner's involvement must be detailed and should go so far as having a real and significant presence in vendor facilities as they construct the various components of the facility. Once in place, the project owner should be monitoring and auditing compliance with all of the programs established for construction of the project. This compliance is particularly important in the areas of quality management and schedule.

At the same time that the nuclear industry touts dramatic improvements in project budgeting and scheduling, skeptics demand proof that nuclear power's ailments have been cured. The technology underpinning this generation of nuclear generating megaprojects continues to evolve and is new. The regulations governing new nuclear construction are also new. The labor force for construction of these projects is new. It's been decades since the last nuclear plants in this country were built. These challenges are real, but they can be overcome.

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Crumm's 25 years with Foster Wheeler Corporation culminated in his position as President and CEO of Foster Wheeler's North American and Asian power boiler equipment business units, which supply solid fuel power boilers, package boilers, and heat recovery steam generators to customers worldwide. His position carried the additional management responsibilities for a multimillion-dollar North American power plant maintenance and construction group, global procurement of all material and services for the entire Global Power Group, and the operation of pressure part manufacturing facilities in China, Poland, Spain, and Finland. He can be reached at cjctwo@gmail.com.

Cláudio Dall'Acqua has more than 30 years of experience as a civil engineer and has extensive experience as a general contractor in the construction industry and engineering special services. He has built many diverse type of construction plants for Brazilian and multinational companies, governments, real estate contracts, and others. He has participated in several dispute resolution cases and administrative boards.

Dall'Acqua has postgraduate studies in business administration and engineering for safety work in construction. He has received several awards, medals, and recognition diplomas of excellence during his professional career. Dall'Acqua is a member of the Arbitration Chamber of Instituto de Engenharia in São Paulo, Brazil, the Pan American Federation of Engineers Association, and the American Society of Civil Engineers. He can be reached at c.dallacqua@pegasus-global.com.

Antonino de Fina, O.A.M., has conducted a large number of arbitrations, both domestic (Australia) and international, involving substantial sums up to approximately US$4 billion (one case) and complex legal and factual issues, particularly in areas involving science and technology, including buildings and construction, intellectual property, shipping and transport, harbor construction, dredging, telecommunications, tunneling, major infrastructure, power and energy (including geothermal, thermal, hydro and nuclear power stations), oil, gas, and mineral concessions resources and processes, and joint ventures. Arbitrations have been conducted under institutional rules, such as ICC, SIAC and DIAC, and UNCITRAL, and ad hoc and governed variously by Common Law (Australia, New Zealand, United

Kingdom, United States, Canada [British Columbia], Singapore, Hong Kong, and India), Civil Code (France, People's Republic of China, Taiwan, Philippines, Indonesia, Italy, Korea, Switzerland, Venezuela, and Chile), and Arab state commercial codes and procedural law (Bahrain, Dubai, Oman, Qatar, Germany, and UAE), substantive and Sharia law and in languages other than English. He has also conducted mediations and been appointed as a special referee. de Fina is a member of many international arbitration associations. He writes and lectures on the subject as well. He can be reached at aa.defina@definaconsultants.com.

André Steagall Gertsenchtein is a civil engineer, graduated in 1991 by Escola Politécnica from São Paulo University—USP. He has more than two decades of a successful professional career with international experience on development of business in Brazil, such as environmental and safety vehicle technical inspection for concession services and partnership on hydroelectric power generation central dams. He was the executive leader on negotiations of power purchase agreements between many companies.

Gertsenchtein is the owner and principal of Inaplan Planning & Constructions Ltd., a general contractor company that has built more than 4,000 commercial buildings for government programs. Gertsenchtein works as chief commercial officer for SPENCO Participações S/A, a holding of SPENCO Group, a Brazilian construction company with partnerships and consortiums with big international companies such as AUTOVISION of Brazil Ltd.; MASA GmbH, Frankfurt; FINSPECTION Oy Helsinki, Finland; Acciona Group Madrid, Spain; Trevi Group Cesena, Italy; and Robopark, Ohio.

Gertsenchtein is a member of the advisory council of the Foundation for Technological Development of Engineering, and he was Vice President of the Engineering Institute of São Paulo.

William P. Henry, P.E., D.WRE, has more than 40 years of experience, both domestically and internationally, in the engineering and construction industry, primarily on water resources and environment projects. He has served as a technical contributor, project manager, corporate officer, and general manager. Henry's responsibilities have included engineering analyses and design, report preparation, plans, specs and cost estimate preparation, construction oversight, expert testimony, organization development, staffing, and quality management. He has served as President of the American Society of Civil Engineers and as Chair of the American Association of Engineering Societies. Henry initiated a program to develop an anticorruption education and training program useful to engineering and construction companies, public agencies, private owners, lenders, and colleges and universities where engineering is taught. Henry speaks regularly on the subject of addressing corruption in the engineering and construction industry. He can be reached at whenrype@wavecable.com.

John Hinchey is recognized as a national and international leader in the practice of construction law, with extensive experience in resolving significant construction disputes as a mediator and arbitrator on a number of global panels, including the JAMS Global Engineering and Construction Panel, LCIA, and the CPR Institute. For 18 years, he led the construction dispute practice at King & Spalding. Now, as a retired senior partner, he focuses his practice on international and domestic construction arbitration and dispute resolution.

Hinchey has served as Chair of, and received the highest achievement Cornerstone Award from, the world's largest organization of construction lawyers, the American Bar Association Forum on the Construction Industry. He is a Past President and Fellow of the American College of Construction Lawyers, an honorary fellow of the Canadian College of Construction Lawyers, a former Chair of the Atlanta Bar Association, Construction Law Section, and former President of the Georgia Arbitrators Forum. He has recently published the 2nd edition of the *International Construction Arbitration Handbook,* is the author of numerous published articles, and has spoken to many professional groups on construction and dispute resolution subjects. He serves on the JAMS Global Engineering and Construction Panel, the CPR Distinguished Panel of Neutrals—Construction, and the Council of Distinguished Advisors to the Straus Institute, Pepperdine University School of Law. Hinchey is also currently listed in *Chambers and Partners, Best Lawyers in America, Who's Who in American Law, Who's Who in America,* and has been recently listed as one of the top eight "Most Highly Regarded Individuals—Global" in the *International Who's Who of Construction Lawyers.* He can be reached at johnwhinchey@gmail.com.

Peter Hughes, B.S., J.D., has more than 40 years of experience on a wide range of projects both domestically and internationally, including power and petroleum, water, wastewater, federal, transportation, environmental, and retrofit and clean fuels projects. Hughes is an engineer and a lawyer and has experience at many program and project levels. He has provided the legal, risk management framework, contract negotiation, project development, process management, project and team management, and insurance management for projects and organizations.

Hughes was Vice President and Chief Counsel of CH2M Hill Constructors, Inc., where he provided the legal and risk management framework for a new CH2M Hill start-up organization as part of the start-up team. His projects included water and wastewater treatment plants in Halifax, Nova Scotia; Auckland, New Zealand; Seattle and Tacoma in Washington; Tampa, Florida; Phoenix, Arizona; and Stockton and San Diego in California; Southern California Edison contract operations for transmission lines to be sold to the state of California; U.S. Army utility privatization at Fort Campbell, Kentucky; city of San Jose and Calpine Energy offsite utility services contract for the Metcalf Energy Center; desalination projects in the United Arab Emirates; and Masdar City program management in Abu Dhabi. He can be reached at phugheslaw@gmail.com.

William Kerivan has more than 20 years of experience as senior counsel advising clients at the highest levels of government and industry in risk management, commercial resolution in demanding domestic and international environments, arbitration, claims analysis and negotiation, contract management, cost allowability determinations, defense contracting and procurement, dispute resolution, management standards of care, testimony, and litigation.

Kerivan provided commercial advice, cost and schedule analysis, contract claims management, and resolution services for the New Doha International Airport Project. This US$12.5 billion project was performed for the government of the state of Qatar. In addition, he has provided commercial consulting services for institutional, public, and private clients in the United States and abroad, including the kingdom of Bahrain; the Nippon Steel Corporation in Sakhalin Island, Russia and Moscow, Russia; the Guam International Airport; the Oman LNG facility; the Cantarell Field for Petroleos Mexicanos; and British Columbia Ministry of Transportation and Highways. He can be reached at wrk45@aol.com.

Shunji Kusayanagi, Ph.D., is a civil engineer with more than 36 years of construction experience on domestic and international projects. He is currently a professor at Kochi University of Technology in the Department of Infrastructure Systems Engineering. He is the Head of the Social System Management Master Course. Kusayanagi is a Guest Professor in the Civil Engineering Department of the Institute of Technology of Cambodia and the Civil Engineering Department of the Mongolian University of Science and Technology.

Kusayanagi is a specialist in construction management and project management, particularly in the management of international projects. He has worked on many construction projects, both domestically and internationally, including Nigeria, India, Colombia, China, Taiwan, Hong Kong, Singapore, Malaysia, Philippines, Myanmar, and Kenya. Kusayanagi is a prolific writer and has authored many books and papers. He was awarded the International Activities Contribution Prize by the Japanese Society of Civil Engineers. He can be reached at kusayanagi.shunji@kochi-tech.ac.jp.

Richard G. Little, AICP, is a Senior Fellow in the Price School of Public Policy at the University of Southern California. Little teaches, consults, conducts research, and develops policy studies aimed at informing the discussion of infrastructure issues critical to California and the nation. Before joining USC, he was Director of the Board on Infrastructure and the Constructed Environment of the National Research Council (NRC). He has conducted numerous studies dealing with life-cycle management and financing of infrastructure, project management, and hazard preparedness and mitigation and has lectured and published extensively on risk management and decision making for critical infrastructure. He has been certified by the American Institute of Certified Planners and is editor of the journal *Public Works Management and Policy*. Little was elected to the National Academy of Construction in 2008 and in 2009 was appointed to the California Public Infrastructure Advisory Commission to assist the state in implementing public–private partnerships for transportation. He holds an M.S. in Urban-Environmental Studies from Rensselaer Polytechnic Institute. He can be reached at rglittle@usc.edu.

Christyan F. Malek, M.Eng., is an Executive Director at Nomura, where he is head of the Oil Field Services Division in Europe. Malek spent almost 10 years at Deutsche Bank, where he developed the Oil Field Services Sector, which became a top-rated research franchise (ranked by investors and company management globally) that competes in a sector of 40 banks worldwide. Malek's published articles on the evolution of project execution risk and analysis of contracting strategies, along with his cutting-edge work on global capital expenditure and exploration, makes him highly regarded by both investment funds and senior executives within the energy industry. His prediction of the Middle East downturn of 2011 in a note published November 2010 titled "Middle East: Are the golden years over?" is one of several thought pieces that have not only challenged traditional mind-sets and been well timed with respect to related investment recommendations but also helped company managements with their own respective outlooks. Malek lives in London with his wife and daughter, who was born in the summer of 2011. He can be reached at christyan.malek@nomura.com.

John Mason, B.Sc., C.Eng., MICE, MIHT, MIEAust, is Aurecon's Global Leader for Program Management and Project Delivery and is Managing Director for JMPM Consulting Ltd. John is currently based in Brisbane, Australia. He has more than 20 years of senior management experience across Europe, the United States, and Australasia. Mason has held senior roles in program and executive management at Parsons Brinckerhoff; project and program management at Bechtel; and in design management at Arup. He established his own consultancy, JMPM Consulting Ltd., in 2007 and joined Aurecon in 2010. With his international background in corporate development and program management, Mason has specific skills in the area of organizational development and the delivery of complex infrastructure programs and projects. He has an understanding of the measures that need to be taken to achieve delivery objectives.

Mason has extensive experience in the planning, design, procurement, management, and supervision of major international transportation and infrastructure projects for both the public and private sectors. He has significant experience in the establishment and management of integrated program and project teams, having worked in both client and consultant roles, most recently on the proposed US$25 billion Crossrail heavy-rail program in London. In this role, Mason advised the client at an executive board and sponsor level on delivery strategy, delivery organization, and the procurement of program and project delivery partners for the implementation phase of the program. He also advised Crossrail on energy procurement, modular construction, the establishment of project bank accounts, and supply chain management.

Rajendra Niraula, Ph.D., has more than 17 years of experience in the civil engineering field and worked for and provided consulting services to government and private organizations on construction and project management, including procurement, contract administration, and project scheduling. Niraula is a recognized expert in procurement, contract management/administration, claim analysis, and project scheduling. He graduated in civil engineering from the Institute of Engineering, Tribhuvan University, Nepal, in 1994 and earned his Ph.D. in construction and project management from Kochi University of Technology, Japan, in 2006.

Niraula is the Secretary General of the International Construction Management Forum in Asia (ICMFA), established in 2008, with faculties from 12 universities in

Asia and Australia with a vision of enhancing construction and project management education in Asia. He is also the secretary of the Nepal Council of Arbitration (NEPCA) and is a guest associate professor for the Institute of Technology of Cambodia.

Robert Prieto is a senior vice president for Fluor. He focuses on the development and delivery of large, complex projects worldwide. Before joining Fluor, Prieto served as chairman of Parsons Brinckerhoff Inc. He holds a master of science in nuclear engineering from Polytechnic University of New York and a bachelor of science in nuclear engineering from New York University. He is the author of *Strategic Program Management* (published by the Construction Management Association of America), which looks at the challenges and opportunities of large capital construction programs and how the owner's role needs to evolve under a program management approach, and *Topics in Strategic Program Management,* which continues his analysis, thinking, and writing on the subject of program management in large, complex engineering and construction programs using a program management approach. He has also authored more than 375 papers and presentations.

Prieto has served on numerous national and international committees and task forces looking at infrastructure delivery, funding and resiliency, large program management, and response to major events, both natural and human-made. He is a member of the National Academy of Construction.

John J. Reilly, P.E., C.P.Eng., graduated from the University of Sydney in 1963 with honors and from the University of California with a Master of Science in 1964, both in structural engineering. He has 48 years of professional experience and is a Registered Professional Engineer in the United States and Australia. He has worked on the design of significant structures, including highways, tunnels, metro systems, airports, buildings, historic structures, industrial facilities, and vehicle manufacturing programs. He has managed megaprojects and elements of megaprojects and consults in the areas of strategy, organization, team alignment, risk management, probabilistic cost estimating, contracting, and delivery and planning. For the past 30 years, he has focused on the management of large, complex infrastructure projects, internationally and in North America, including highways, airports, tunnels, roads, and transit systems.

Reilly has been President of the American Underground Construction Association and the Chair of two International Tunneling Association Working Groups—Number 13 (Direct and Indirect Benefits of Underground Structures) and Number 20 (Urban Problems—Underground Solutions). Over the past seven years, he has written on strategies to better understand, manage, and deliver complex projects, including teaming, collaborative processes, partnering and alliancing, life-cycle benefits, risk identification and mitigation, and the link between risk and probable cost. He is the author of more than 70 papers on these topics.

Steve Rowsell, B.Sc., C.Eng., MICE, FCIHT, MCIPS, is a chartered Civil Engineer and has 35 years of experience in the delivery of major transport infrastructure projects. This work included the delivery of many major road contracts under the old ICE5 form of contract. During the 1990s, he was Highways Agency Projects Director on projects including the Second Severn Crossing, M25 Widening, M60 Manchester Orbital, M5 Avonmouth Bridge, and the A34 Newbury Bypass. Between 2000 and 2007, Rowsell was Procurement Director at the Highways Agency. While there, he developed and implemented their new procurement strategy—"Delivering Best Value Solutions and Services"—which was aimed at replacing the old confrontational relationships with contractors with new collaborative methods of working. A key part of the new strategy was the introduction of the NEC as the standard form of contract on Highways Agency's contracts. This was used alongside new methods, such as early contractor involvement, to bring better value and much greater certainty of successful outcomes.

Rowsell left the HA in March 2007 to establish a new procurement consultancy, Rowsell Wright Limited. In this new role, he acted for two years as interim Head of Procurement at Crossrail, leading the development of the procurement strategy for the new railway across London which at £15 billion is the biggest construction project in Europe. Rowsell is also now advising the High Speed 2 project, which is developing a new high-speed railway between London and the West Midlands at an estimated cost of £17 billion. He is currently Chairman of the NEC Users Group, an Executive Board Member of the Chartered Institution of Highways and Transportation, and a former member of the Office of Government Commerce Chief Executive's Advisory Group.

Antony L. Sanacory, J.D., is a partner in the Trial Group at the law firm Duane Morris LLP. His practice includes resolution of disputes related to construction and complex technology disputes (such as technology licensing disputes and patent infringement disputes), as well as other complex commercial litigation matters. Sanacory regularly represents clients in federal and state courts and before the American Arbitration Association. He has represented a number of clients (including power generators and contractors) in the energy industry.

Sanacory is a 2001 graduate of Duke University School of Law, where he was executive editor of the *Alaska Law Review*, and a graduate of the Pennsylvania State University (B.A., political science, with distinction), where he was elected to membership in Phi Beta Kappa. Sanacory studied abroad at the University of Exeter, England, and the University of Guanajuato, Mexico.

Gerald Tucker, C.P.A. inactive, has more than 40 years of experience in accounting and financial matters for regulated utilities, management audit services for utility systems, and cost damage quantification services in utility and construction projects. Projects have included roadway and bridge projects, nuclear power plants, fossil power plants, and chemical refinery projects both in the United States and internationally.

Tucker uniquely provides management expertise in all phases of the regulated utility industry, including reporting to the SEC and federal and state regulatory bodies. His experience includes development and application cost of service calculations and cost allocation for operating utilities in support of rate applications. Tucker has negotiated both power sales agreements and the per year revenue of physical facilities. He has also testified on behalf of utility and intervenor groups in more than 30 regulatory proceedings in five states.

Thomas R. Warne, P.E., is president of Tom Warne and Associates, assisting public agencies in becoming more effective and private companies in their quest to achieve higher profitability in the 21st century. Projects and engagements include large design–build efforts, strategic planning, partnering facilitation, succession management, legislative initiatives, market analysis, government relations, leadership seminars, process improvement initiatives, and client interventions.

Warne is known in the industry for his work on large, complex projects and programs. In addition, his knowledge of national policy issues, as well as state and local concerns, allows him to provide insights and advice to his clients across the country. An area of emphasis for Warne is in the resolution of issues facing state departments of transportation.

The *Tom Warne Report* is a weekly Internet newsletter that reports on the activities, projects, policies, and other relevant transportation happenings in the 50 states. Warne is the editor and provides his insights about the news and shares the nuances with his readers so that they are better informed to make critical decisions for their organizations.

Charles W. Whitney, J.D., is Senior Vice President and General Counsel of Oglethorpe Power and has served in that capacity since August 2009. Whitney's areas of focus are energy, particularly nuclear energy, regulatory, construction, and labor law. He has legal experience that spans a broad range of activities in both private practice and as chief counsel to a nuclear generating plant project. He has represented independent power producers and engineering procurement and construction (EPC) contractors in the development, construction, and operation of power projects in Georgia, New York, Pennsylvania, Ohio, Michigan, and Wisconsin.

Whitney's nuclear work has included negotiating and documenting all commercial activities, including procurement, architect and engineering services, contractor agreements, and labor agreements; construction claim litigation; licensing proceedings before the Nuclear Regulatory Commission (NRC); negotiating and documenting the resolution of warranty and contract claims against suppliers, vendors, and professional service providers; and "whistleblower" defense at the NRC and the Department of Labor. His practice has also included extensive work in labor and employment discrimination; certification, enforcement, and rate-making proceedings before state and federal regulators; and general trial work. In addition to practicing law for 20 years, Whitney has more than 10 years of experience in senior management in the electricity industry, including both the regulated and unregulated aspects of the business.

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About the Editors

Patricia D. Galloway, Ph.D., P.E., is Chief Executive Officer of Pegasus Global Holdings, Inc., an international management consulting firm. She serves as an advisor to the energy and infrastructure industries regarding corporate governance, risk management, contracting and delivery, industry best practices, program and project management, standard of care, project controls, and claims prevention on complex megaprojects worldwide. She also served as a consulting member of the U.S. National Science Board, appointed by President G. W. Bush with Senate confirmation in 2006 for a six-year term, and served as its Vice Chair from 2008 to 2010. She is a mediator, international arbitrator, and member of the Board of Directors of the American Arbitration Association, and serves as chair of its National Construction Dispute Resolution Committee.

Galloway received her bachelor's degree in civil engineering from Purdue University in 1978 with majors in both structures and construction management, a master's in business administration (M.B.A.) magna cum laude from the New York Institute of Technology in 1984, and a Ph.D. in infrastructure systems (civil) engineering from the Kochi University of Technology in Japan in 2005. With more than 32 years of experience globally, she is a Registered Professional Engineer in 14 U.S. states; Manitoba, Canada; and Australia. Galloway is a Certified Project Management Professional by the Project Management Institute and holds a Certificate of Director Education by the National Association of Corporate Directors and has served on a number of private and nonprofit boards.

She has served as an adviser to multiple owner and contractor clients, including board audit and compliance committees, and has served as a member of various risk management assessment and independent review panels. She serves on the Eastern Washington Governor's Business Advisory Council and the Discovery Science Channel's Board of Advisors. She is a member of the New York Institute of Technology Engineering Dean's Advisory Council and has also served on the Purdue University Engineering Dean's Advisory Council. Galloway has been recognized by her peers and is an elected member to the National Academy of Construction and the Pan American Academy of Engineering and holds the position of Fellow in several professional organizations. In 2004, Pat served as the first woman President of the American Society of Civil Engineers.

Galloway is a prolific writer and world-renowned speaker; she has written one book, *The 21st Century Engineer: A Proposal for Engineering Education Reform* (ASCE, Reston, VA, 2007) and the foreword to several other books. She has authored more than 120 papers, 30 peer-reviewed journal articles, and almost 200 public speaking engagements (including more than 45 keynote addresses) regarding leadership, corporate governance, ethics and professionalism, communication, risk management, dispute resolution, contract administration, program and project management, dispute resolution and arbitration, project controls, women in engineering, and other topics. She has also been featured in many international publications. She can be reached at p.galloway@pegasus-global.com.

Kris R. Nielsen, Ph.D., J.D., PMP, MRICS, M.JSCE., serves as Chairman and President of Pegasus Global Holdings, Inc. Nielsen has directed and participated on matters covering the entire project delivery process in the energy and infrastructure industries and has worked on behalf of private and public-sector clients globally. With an extensive background in engineering, construction, project management, and project controls, he has advised board audit and compliance committees, owners, engineers, and contractors relative to execution management, corporate governance, and enterprise risk management issues. He has also presented expert witness testimony in legal proceedings around the world and served as a chairman and member on dispute review boards, as well as an arbitrator and mediator on dispute matters. Nielsen also provides high-level advice to senior management and boards in the energy and financial sectors.

Nielsen received a B.S. in mechanical engineering from Princeton University, a J.D. from George Washington University Law School, and a Ph.D. in infrastructure systems (civil) engineering from Kochi University of Technology in Japan. He is a licensed attorney, a Certified Project Management Professional and a Professional Member of the Royal Institution of Chartered Surveyors and holds a Certificate of Director Education. Nielsen is a member of the American Arbitration Association, the International Centre for Dispute Resolution, the Association for International Arbitration, the Dispute Resolution Board Foundation Panel, the United Nations Commission on International Trade Law, the Caltrans Dispute Resolution Board Panel, the American Bar Association, the American Association of Engineering Services, the American Society of Civil Engineers, the American Nuclear Society, the Association for the Advancement of Cost Engineering International, and the Japan Society of Civil Engineers. He has served on a number of private and nonprofit boards.

Nielsen was recently awarded the American Society of Civil Engineers Outstanding Projects and Leaders (OPAL) Award, Construction, 2011.

Drawing upon his extensive dispute resolution experience, Nielsen also consults on claims prevention, management, and negotiation. As a global innovator in the development and application of risk management techniques, he has developed and led training and instructional programs for a variety of private, multinational, and public agency clients.

Nielsen is a prolific writer and speaker globally, having authored four books and chapters of books, more than 200 papers, 30 peer-reviewed journal articles, and almost

125 public speaking engagements (including more than 75 keynote addresses) regarding management and strategic issues, management audits (prudence, compliance, and performance); program and project risk management; arbitration, mediation, and dispute review boards; dispute resolution, and other topics. He has been featured in many international publications. He can be reached at k.nielsen@pegasus-global.com.

Jack L. Dignum, M.A., CFCC, is a Senior Vice President and the Chief Operating Officer of Pegasus Global Holdings, Inc. With extensive experience in project management and controls, project risk management, and contract disputes, Dignum is fully involved in all aspects of the firm's management consulting and services. He has held senior positions with both owner and contractor organizations in private and public environments, so he is fully knowledgeable and experienced with the roles and tasks needed to ensure successful completion of complex projects throughout the power, process, infrastructure, transportation, and building industries.

Dignum's experience includes strategic advice to senior management and boards in the energy and infrastructure industries; formal management system design and development, project control system development, implementation, and use; and organization of project management teams and structures. He has performed project prudence and performance audits, process assessments, change management, and control reviews and assessments and has consulted on critical issues and lessons learned. Dignum has led project management teams, including project management and controls formation, implementation, and results assessments and analysis of schedule, delay, and cost effects. He has developed extensive project management training programs for a variety of audiences (owners, contractors, engineers, and constructors) in private, multinational corporations as well as local, state, and federal government agencies.

His risk management experience includes the design, development, and implementation of project risk management programs for large, international EPC contractors; development of several risk management techniques, tools, and systems addressing risk identification, quantification, avoidance, and mitigation plans; risk element integration into standard project control tools; and project-specific risk profiling. He has led risk management teams in projects in North America, Australia, Europe, Asia, and South America for both owner and contractor clients ranging in value from $500,000 to more than $12 billion. Dignum has taught numerous training courses in every aspect of risk management in the construction industry.

Dignum has a B.A. in industrial psychology from the University of Oklahoma and an M.A. in public administration and gerontology from North Texas State University. He is a Certified Forensic Claims Consultant and has a Certificate of Director Education. He is a member of the Construction Management Association of America, the Association for the Advancement of Cost Engineering International, National Association of Corporate Directors, and the Project Management Institute.

Dignum has published and presented numerous technical papers and articles on construction management, engineering management, contract administration, project controls, scheduling, change management, and other topics. He can be reached at j.dignum@pegasus-global.com.

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