ENGINEERING PROJECT MANAGEMENT: THE IPQMS METHOD AND CASE HISTORIES

By

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PREFACE AND ACKNOWLEDGMENTS

This book is based on the results of an intensive study of programs and projects in nine countries by an international, multidisciplinary team. The purpose of the study was to determine the reasons for budget overruns and other costly mistakes, and then to recommend solutions. Particular attention was devoted to private and public works projects which are basic to the needs of both developing and developed countries: infrastructure-related projects.

The most critical problem area in every case was related to the fragmented approach to planning, design, and management of implementation. Thus, the integrated planning and quality management system (IPQMS) was developed, tested, refined, and implemented. The international team designed and tested a new curriculum for education and training of project managers. The cornerstone of the curriculum is a series of case histories researched and published in the IPQMS framework. IPQMS case histories represent autopsies or postmortems, providing useful lessons for all new programs and projects, and troubleshooting projects in progress.

Experience with the IPQMS since its development clearly demonstrates its versatility and strength in providing the necessary leadership and control of the various tasks in the entire project cycle. IPQMS case histories provide a scientific basis for preparing guidelines and checklists for programs and projects in both government and industry. These guidelines and checklists prevent waste, fraud, and mismanagement — thereby ensuring total quality and cost effectiveness. For example, it is estimated that use of the IPQMS system and lessons from past projects such as the Trans-Alaska Pipeline System will result in annual savings of at least 10 percent or approximately $60 billion in the construction industry alone (1996 estimates).

The authors have used the IPQMS methodology to study the problems responsible for waste, fraud, and mismanagement in the federal government. In addition, they have recently completed IPQMS postmortems of programs and projects in the context of public health and safety: (1) the operation of the Trans-Alaska Pipeline System, (2) the Environmental Protection Agency (EPA) Superfund Programs 1 to 3, and (3) the Hanford Nuclear Reservation. These postmortems emphasize the need for accountability and quality in both industry and government.

Chapter 1 presents an overview of the deteriorating condition of our physical infrastructure, covering transportation, water supply systems, wastewater treatment plants, and public school buildings. It also covers the environment, with special attention to hazardous waste contamination and related public health problems. The need for infrastructure renewal is discussed in the context of construction industry issues. These issues, especially teamwork and accountability, must be resolved before rebuilding America. Otherwise, the on-going fragmentation of the construction industry will make the task cost prohibitive.

Chapter 2 introduces the Integrated Planning and Quality Management System (IPQMS), a new methodology to ensure teamwork, accountability, cost effectiveness, and quality. It was developed, tested, and refined based on analyses of postmortems of over 30 programs and projects in nine countries by an international team of scholars and practitioners. There is a special focus on feasibility studies, which are vital to every phase and task of the IPQMS. The feasibility studies serve as the basis for guidelines and checklists to ensure fail-safe implementation.

Chapter 3 discusses the IPQMS and case materials. Definitions of case studies and case histories are presented. IPQMS case histories represent autopsies or postmortems of past programs and projects, and are therefore in-depth analyses of why projects failed. They are a record of events and issues that actually were faced by managers during the planning, design, and implementation of the projects. Thus, the case histories are much more comprehensive than conventional case studies. The lessons learned from the postmortems are invaluable for organizing project teams and providing quality management. The need to teach teamwork and ensure accountability is emphasized. The chapter concludes with a discussion of how to use IPQMS case histories in both the classroom and in practice.

Chapter 4 presents general guidelines and questions for researchers and writers of case histories of projects in all sectors. The questions also serve as a checklist for project quality control, evaluation, and troubleshooting. The questions can be readily adapted to a specific sector such as public works (see Appendix B). They also provide a resource for student assignments in education and training programs.

Chapters 5 to 8 are postmortems (case histories) of the Trans-Alaska Pipeline System (construction and operations), the Washington State Five Nuclear Power Plants, and EPA Superfund Programs 1, 2, and 3. These postmortems are analyzed to provide specific examples of the many problems encountered and lessons learned. The analyses clearly show the relationship between fragmentation or lack of teamwork and the problems. The lessons learned in every case emphasize the need for teamwork and accountability. Each case consumed over 1000 hours of research and analyses as a basis for the first draft.

Chapter 9 summarizes postmortems of the spacecraft Challenger disaster and the Hanford Nuclear Reservation. The Challenger postmortem emphasizes the need for engineering and scientific decisions to be upheld by management. Hanford represents a disaster to the environment from nuclear weaponry research and development.

Chapter 10 illustrates the applications of the lessons learned from the case histories in rebuilding our infrastructure and cleaning up the environment. This proposed 10-year program would cost $35 billion annually, with the money coming from the more than $65 billion in Corporate Welfare. The program would be a federal–state government partnership. It would be planned, designed, and implemented in the IPQMS framework to ensure accountability, cost effectiveness, and quality. This will be accomplished by IPQMS training programs in each of the 50 states for designers, managers, and contractors.

Appendix A presents abstracts of business case studies, engineering case studies, and IPQMS case histories.

Appendix B contains a sample IPQMS checklist for public works projects. It demonstrates the importance of feasibility studies to provide baseline data for guidelines and checklists for all projects in all sectors.

Appendix C contains the names and professional positions of the international, multidisciplinary team from 1975 to 1983. It also includes contributors from 1984 to 1997.

This book was motivated by many of the authors' friends and colleagues. In particular, the authors thank Dr. John Hawkins, Dean, International Studies and Overseas Programs, University of California Los Angeles, and Dr. Daniel F. Jackson, Professor Emeritus and environmentalist. Dr. Hawkins wrote the foreword, emphasizing the needs to teach teamwork and to develop data banks of IPQMS case histories. Dr. Jackson provided constant encouragement and many suggestions on the entire manuscript. The senior author has valued his colleagueship and friendship for over 30 years. Dr. Jackson envisioned the significance of the IPQMS seminars for training senior government managers.

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Special thanks also go to the Government Accountability Project (GAP) and the Alaska Forum for Environmental Responsibility (AFER). Louis Clark, Executive Director of GAP, and Mike Riley, Executive Director for AFER, have been especially cooperative in providing reference materials on the environmental and public health problems from the Trans-Alaska Pipeline System.

Louis J. Goodman, P.E.
Rufino S. Ignacio

FOREWORD

The utilization of effective tools for project management has been a long sought after goal for engineers and project managers alike. The history of numerous large-scale programs and projects throughout Asia, the Pacific, and the United States reveals the enormous costs and failures brought on when a fragmented approach is used to plan, design, and implement projects in different sectors. Professors Goodman and Ignacio have provided in this volume, a unique and proven planning methodology illustrated in the context of actual projects in a variety of sectors. The Integrated Planning and Quality Management System (IPQMS), developed and refined by the authors over a twenty-year period, represents a breakthrough in providing the policy-maker and practitioner with a valuable tool to guide the development of projects and programs in almost any sector.

The value of this volume is that it illustrates the application of the IPQMS in the context of actual case histories. The use of the case history approach makes this study valuable for scholars and students in the field of higher education, and by practitioners in the actual process of developing and/or running a project. The first four chapters provide a valuable introduction to the concept of the IPQMS; including the four phases of (1) planning, appraisal, and design; (2) selection, approval, and implementation; (3) operation, control, and handover; and (4) evaluation and refinement.

There is a section on the use of the IPQMS in developing case histories and building the concept into the curriculum of both management and engineering courses. This section is particularly important because it discusses in an analytical manner the IPQMS prototype curriculum and the significant differences between case histories and case studies. And, there is a section providing the reader with clear and concise guidelines on how to develop and write a case history. This latter section will be particularly useful for faculty and students at the university level, not only in management and engineering but other fields as well.

However, it is the section on case histories that really brings the IPQMS to life. Here the authors provide several case histories on projects ranging from the Trans-Alaska Pipeline System to the Washington State Five Nuclear Power Plants fiasco and major disasters such as the spacecraft Challenger tragedy. By applying the IPQMS to these and other actual projects the authors are able to demonstrate what went right and what went wrong, and, most importantly, what lessons were learned from each case. Their goal is a laudable one: to provide a practical tool so that future projects can be completed in a competent and accountable way.

In fact, it is this emphasis on accountability that distinguishes this study from so many others that attempt to focus on project management issues. Too often in major projects accountability is diluted and when things go wrong the buck gets passed. Goodman and Ignacio show how to design and implement a project so that lines of authority are clear and the feasibility of the project is demonstrated from the outset. Then they go on to show how the material presented in the book can be used for more effective training and education of engineers, managers, and other professionals.

It is patently clear that the future of work and development, not just in the United States but worldwide, will require partnerships and teamwork on a scale not known before. The previous economic models of contention and strife, buck-passing and non-transparency, of conflict between labor and management, between professionals and the work force, will no longer sustain us. A new culture of cooperation will have to be constructed and at the core of this culture will be mechanisms like the IPQMS that provide guidelines for producers in all sectors.

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Dedication

To Phyllis and Marlene with our love for their encouragement and patience.

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1 A Case for Infrastructure Renewal with Accountability

1.1 INTRODUCTION

The main purpose of this book is to introduce the IPQMS (Integrated Planning and Quality Management System) and related case histories that represent autopsies or postmortems of projects. Experience shows that lessons learned from past costly mistakes and disasters are invaluable in achieving quality projects on time and on budget.[1,2] This is the first book to show how to prepare guidelines and checklists for new programs or projects. The 20-year study demonstrated that the IPQMS can be adapted to programs and projects in different sectors. It can also be adapted to the growing trend for design-construction projects. The use of this system will be applied to rebuilding America's infrastructure (Chapter 10).

The economic and social well-being of a nation are directly related to the quality of its infrastructure and environment. The demise of past civilizations — Egyptian, Roman, Inca, and others — accelerated when they stopped maintaining and improving their public works. Unfortunately, the U.S. is now guilty of ignoring the inadequacy of its infrastructure. Indeed, this is happening despite the efforts of the Rebuild America Coalition, which was established in 1987.[3]

1.2 OUR DETERIORATING INFRASTRUCTURE

America is at a crossroads in its battle to maintain economic strength and quality of life. Both are jeopardized by the nation's apathy toward repairing and expanding our existing national infrastructure, and cleaning up the environment. Infrastructure covers highways, bridges, airports, water supply systems, wastewater treatment plants, solid waste disposal facilities, and public schools. It includes the need to provide clean air and water, and control disease. Thus, it is a basic need to sustain and further economic and social growth in all nations.

It is estimated that 60 percent of the nation's highways need work, ranging from repaving to major structural rehabilitation. According to the Federal Highway Administration[4], ±35 percent of the 575,000 highway bridges in the U.S. are structurally deficient or functionally obsolete. Some cities have water-main leaks that lose up to 30 percent of their water supply every day. Such widespread decline threatens to disable entire systems made unstable by delayed maintenance and stop-gap repairs. Conservatively, the loss of man hours and fuel because of detours and traffic congestion costs both industry and the public sector over $30 billion each year, and the cost is increasing.[3]

In addition, nearly 31 percent of America's public schools were built before World War II. Thus, about a third of the country's 42 million schoolchildren are trying to prepare for adult life in schools that lack proper heat, ventilation, and bathroom facilities.

Directly related to public health is the on-going pollution of our nation's lakes, rivers, streams, and bays. This is compounded by outbreaks of bacteria in municipal drinking water supply systems, such as the one that made 400,000 people sick in Milwaukee in 1993.[3]

Though much progress has been made since the Clean Water Act of 1972, the task requires constant attention. Much remains to be done. A profile of U.S. water resources includes the following:[3]

- More than 3.5 million miles of rivers and streams
- 62,000 square miles of lakes, ponds, and reservoirs
- 5,300 miles of Great Lakes shoreline
- 37,000 square miles of estuaries

As of 1992, states reported the following:

- 8 percent of rivers, 43 percent of lakes, and 13 percent of estuaries were contaminated with toxic chemicals
- Of the assessed rivers, 38 percent are polluted to the point where they fail to meet designated uses
- 44 percent of lakes, ponds, and reservoirs fail to meet designated uses
- 97 percent of the Great Lakes shoreline miles fail to meet designated uses

In addition to the foregoing, there is the problem of hazardous waste which impacts public health in all 50 states. The number of toxic waste sites has increased despite the efforts of the Environmental Protection Agency's Superfund Program. Public health problems were found to be worse with the official exposure of the nuclear weaponry research in 1992 — thousands of contaminated sites in 13 states.[5,6] The nuclear weaponry resulted from secret bomb factories and represents a total collapse of ethics and accountability in our government and the defense contractors.

The foregoing infrastructure and related environmental problems are compounded by the serious problems in the U.S. construction industry. Our construction industry is one of the nation's largest single industries, and, unfortunately, it is also the most fragmented and least progressive.

Without continuous investment in infrastructure, a modern economy fails to grow. Our economic competitors are keenly aware of this. *All* of the major industrialized countries invest a higher percentage of gross domestic product in public works than the U.S. (Japan leads all of the G-7 countries. In 1992, its infrastructure investment was roughly triple that of the U.S. It also leads in productivity growth, about triple the rate of our country.) Rhetoric about laying the foundation for a better America rings hollow when we are last on the list of countries investing in their own economic future.

Infrastructure requires continuous attention. Federal, state, and local governments, under pressure to cut budgets, often delay maintenance and repair. This, of course, is not economical at all, but the most expensive form of underinvestment. Instead of leaving behind more than we found, our legacy to our children will be to break the unspoken promise of a better life, to pass on the debts we didn't pay and a diminished quality of life. It's not too late to make good on that promise, but as a nation we must act now. The necessary action must ensure optimization of dwindling resources to provide infrastructure rebuilding that is cost effective and high quality. This will require accountability! This will require the use of an integrated planning and quality management system such as the IPQMS.

1.3 STATUS OF THE ENVIRONMENT

Before the 1970s, few people worried about hazardous waste as long as they were not affected by the harmful by-products. The first national concerns on the dangers to life resulting from contamination of the environment were highlighted with the passage of the National Environmental Policy Act (NEPA) in 1969. NEPA created the Environmental Protection Agency (EPA) in 1970 with a mandate to safeguard the nation's environment. Section 102 of NEPA outlined the specific requirements that any proposed action, such as new programs or projects, would have to meet in terms delineating the environmental impact and providing for public comment.

Unfortunately, in the past, no provisions were made for dumping of hazardous wastes. This severe problem was compounded by two facts: (1) the U.S. military is the nation's largest polluter and its activities have been covered up by its classified (secret) status, and (2) engineers and scientists found that the EPA-accepted method of containing most waste materials in the 1970s was flawed. Despite special linings and barriers to prevent the waste from seeping, leaks occurred after a few years of "containment". These leaks seeped into the water supplies of communities and wildlife habitats.

The nation was shocked in the 1970s when the story of Love Canal in upstate New York hit the media. Dumping started in the 1920s and accelerated after Hooker Chemical Company purchased the property in the 1940s. Engineers at the Hooker Chemical Company plant in California advised their superiors that the company was creating a serious public health problem by violating pollution limits and dumping toxic wastes. The Love Canal tragedy erupted a few years later when construction of a new school broke the clay seals that had held the chemicals inside. The highly toxic chemicals seeped through the soil toward the school and hundreds of homes surrounding the canal. Over 400 different chemicals were eventually identified, with some known to cause birth defects and cancer. Love Canal was found to be the "tip of the iceberg" — one of thousands of hazardous waste sites across the country.

From an environmental standpoint, Love Canal was not an isolated event. By 1978 the public had already witnessed dozens of environmental and public health disasters: a fire on the surface of the Cuyahoga River in Ohio, an enormous oil spill in Santa Barbara, the Kepone poisoning of the wells of Hopewell, Virginia, the inadvertent mixture of cancer-causing fire retardant with cattle feed in Michigan, the 17,000* containers of hazardous chemicals found in the "Valley of the Drums" near Louisville, the release

* This figure was found to be closer to 100,000 drums which had been dumped illegally at a farm and left to rot. The hazardous waste contents contaminated the soil and a local creek.

of a dioxin cloud over Seveso, Italy, and a massive cluster of birth defects among infants in a Woburn, Massachusetts neighborhood.

There are many forms of hazardous wastes, produced by industries such as manufacturers of chemicals, paints, petroleum products, and electrical equipment. In addition, the U.S. military and its contractors are major producers of toxic waste from nuclear weaponry research and development. In fact, all military installations have contaminated the environment with no regard for public health and safety.

The federal government has identified approximately 450 substances as hazardous to public health and the environment. For example, dioxin is one of the most toxic substances known. It covers a class of 75 chlorine-related compounds which are waste by-products from the manufacturing of chemicals and paper products. These toxic materials have been dumped in landfills and waterways, ending up in drinking water supply systems and food systems, including fish. Other chemicals that threaten health and the environment include polychlorinated biphenyls (PCBs). PCBs have been used to make paint, plastics, adhesives, and printing ink. They can cause cancer, birth defects, and skin diseases. Mercury is another industrial waste by-product that is poisonous — and yet has found its way into the food system from waterways.

In addition to the foregoing, there are many problems resulting from nuclear waste, including power plants and nuclear weaponry research and development. The latter is a "time bomb" because of the secret status of the research during the Cold War era, 1947–1992. There are untold thousands of sites on military bases and installations where tens of billions of gallons of toxic and radioactive wastes have been dumped into porous soil.

The discovery of Love Canal and scores of other dangerous chemical waste sites ignited fear and outrage across the country in the late 1970s. Galvanized into action — largely to remove immediate threats in communities such as Love Canal, New York — Congress in 1980 enacted the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), which quickly became known as Superfund. The law provided $1.6 billion in cleanup funds and gave the EPA authority to force parties responsible for the contamination to conduct the cleanups or repay the federal government for its cleanup costs.

Superfund's implementation has attracted almost continual criticism since its inception. In its first years, congressional investigations into allegations of mismanagement and political manipulation of the program led to the resignation of EPA's administrator and the incarceration of the Superfund program's top official. In addition, the EPA Superfund was placed on the government's list of high-risk programs in 1992.[7] Seventeen federal programs were so rated because of their vulnerability to waste, fraud, abuse, and mismanagement. Meanwhile, the number of highly toxic sites had grown to over 1300 in 1994, after spending over $14 billion. The EPA Superfund Programs 1, 2, and 3 (1980-1995) are discussed as an IPQMS postmortem in Chapter 8.

In addition to the industrial dumping of hazardous wastes into the environment for many years, we now find that there are thousands of sites at military bases and installations contaminated by nuclear wastes from the Cold War era (1947–1992) research and development of nuclear bombs and weaponry.[5,6]

Evidence of the on-going contamination is presented in the next section on the bomb factories. Additional evidence is documented in the IPQMS postmortems of the operation of the Trans-Alaska Pipeline System (Chapter 6), the EPA Superfund Programs 1 to 3 (Chapter 8), and the Hanford Nuclear Reservation (Chapter 9).

1.4 NUCLEAR WASTE CONTAMINATION

The age of nuclear energy, now over 50 years old, has given the world a great source of energy for both good and evil. On the one hand, it has helped to provide the electric power that does so much to make our lives more productive and enjoyable. On the other hand, it has terrorized us with the awful weapons it has created and the damages to public health and the environment.

Ranking high among its most frightening aspects are the waste materials that result from the production of nuclear energy and nuclear weaponry. Nuclear wastes loom as a danger to life and the environment because they are radioactive, emitting a radiation that can be deadly. Adding to their dangers is the fact that many require up to an astonishing 10,000 years before their radiation dwindles to the point where they are no longer able to harm.

The production of nuclear power and nuclear weaponry generates radioactive waste products, otherwise known as radwastes. If not properly stored, these wastes render our soil, air, and water supply vulnerable to radioactive contamination. The only secure means of disposal is shielding. Nuclear waste needs to be stored far beyond human reach, where it can decay for the hundreds, even thousands, of years necessary for it to become harmless.

Unfortunately, a serious problem of radioactive contamination of both the workplace and the environment emerged in the late 1980s. This was the exposure of the "Cold War era" secret testing of human reaction to exposure to radiation and the poisoning of millions of people working in or living near nuclear weapons facilities. It began in 1947 and was kept secret for over 40 years. Meanwhile, nuclear waste disposal was taking place at 117 weapons factories, 16 principal and over 100 secondary, in 13 states. Contract management initially was the responsibility of the Atomic Energy Commission (AEC), one of the predecessors to the Department of Energy (DOE). DOE now has the responsibility for the huge task of cleaning up these sites.[8]

The bomb factories highlight the absolute disregard for public health, worker safety, human dignity, and the environment. Indeed, they represent a total collapse of ethics and accountability in our government and the defense contractors as evidenced by their ignoring the professional engineers, scientists, and managers who were trying to "blow the whistle".[9] The media first made a large-scale exposure of the nuclear weaponry research and development at the 16 major sites in late 1988. Whistleblowers were beginning to expose the innumerable health, safety, security, and other violations at all the bomb factory sites in 1986. Plant workers, their families, and their communities have been knowingly exposed to unacceptable levels of radioactive emissions and wastes since 1947. However, it took the Chernobyl nuclear plant disaster of 1986 in Russia to trigger U.S. media to listen to the whistleblowers.

The bomb factories represent an unfortunate symbol of collusion between the military and defense contractors that President Eisenhower warned the nation about in his farewell speech, January 1961. He was deeply concerned about the secret power of a military-industrial complex, one that would result in excessive deception, corruption, and fraud. Unfortunately, his advice was not followed, and the collusion between the federal government and big business, especially defense contractors and the oil industry, resulted in complete disregard for laws and regulations designed to protect public health and safety and the environment. The whistleblowers, or ethical resisters, are a relatively new group who are concerned about the lack of accountability in government and industry today.

The whistleblowers have been harassed, both mentally and sexually, by their superiors. They have also been rebuked by the federal government, including the Nuclear Regulatory Commission and members of Congress. They now have an ally in the Government Accountability Project (GAP), a nonprofit, public interest organization based in Washington, D.C.[9,10] GAP provides legal and advocacy assistance to concerned citizens who witness dangerous, illegal or environmentally unsound practices in their workplaces and communities and choose to "blow the whistle". Since its founding in 1977, GAP has helped hundreds of public and private employees and grass-roots organizations expose threats to public health and safety and the environment.

The nuclear weaponry sites have contaminated billions of gallons of water and millions of tons of soil with wastes from the bomb building plants. Estimated costs of cleanup range from $250 to $300 billion over the next 20 to 30 years.[6,11] Goodman and Ignacio show how a new methodology they developed with an international team, the Integrated Planning and Quality Management System (IPQMS), can be used to clean up these sites efficiently. The IPQMS, when properly introduced and implemented, results in accountability, cost effectiveness, and quality.

The postmortem shows that waste, fraud, and mismanagement in the cleanup of the Hanford Nuclear Reservation site are rampant. Over $7.5 billion were spent between 1991 and 1996, with $2.5 billion lost because of *no accountability*. Meanwhile, the nuclear contamination continues to move into the groundwater which flows into the Columbia River. Yet, the whistle-blowers continue to be ignored by Westinghouse Hanford and the DOE.[12]

1.5 CONTAMINATION OF MILITARY BASES

In addition to the bomb factory sites, there are over 9700 military installations and former defense properties in all 50 states. In 1988, the Department of Defense (DoD) began to examine ways to achieve savings by realigning and closing military bases that were costly to operate and no longer needed to meet changing requirements. In December of that year, the Commission on Base Realignment and Closure (BRAC 88) recommended that 86 military installations be closed and 59 others be partially closed, expanded, or reduced by the relocation of military units.[13]

Because the commission was concerned primarily with ensuring that military requirements be met, such factors as the environmental impact of closing bases received less emphasis in its deliberations. The commission concluded, for instance, that it did not need to consider the cost of cleaning up hazardous wastes because, under current law, the government would have to clean up the properties in any event. Consequently, in considering which bases to close, the commission had only preliminary estimates of the extent and nature of environmental contamination.

Until legislation governing the handling and disposal of hazardous waste took effect during the past decade, requirements for managing the disposal of waste on military bases were not nearly as stringent as they are today. Consequently, environmental contamination is widespread, in some cases constituting a significant potential threat to public health and safety.

On the bases scheduled for BRAC 88 closings, a wide variety of sources of pollution exists: landfills, fuel and paint dumps, buried munitions, PCB transformers, asbestos, radon, groundwater contamination, and underground storage tanks that have developed leaks. Cleaning up buried munitions and groundwater contamination are among the most difficult, time consuming, and costly of these problems. Among the BRAC 88 bases, DoD had identified seven with buried munitions and at least 10 instances of groundwater contamination. The latter may also exist at numerous additional sites — for example, landfills and underground storage tanks — but final determinations have not yet been made. Other types of cleanup, such as removing PCB transformers, can be relatively simple and require only a short time to complete.[13]

The Congressional Budget Office (CBO) estimated there might be over 20,000 contaminated sites on the 9700 military installations in 1994. Again, it is emphasized that these sites are in addition to the Cold War era nuclear weaponry research and development sites, such as the Hanford Nuclear Reservation. A small number of these sites have been placed on the EPA Superfund National Priority List (NPL).

1.6 CONSTRUCTION INDUSTRY ISSUES

The construction industry is the nation's second largest industry (behind health care) and also the most fragmented and among the least progressive. In recent years it has been required to build facilities that are more and more complex, utilizing methods that are largely unchanged. At the same time, there has been a steady erosion in quality and productivity of the industry. This negative impact on the cost of every office building, water supply system, waste disposal system, or power plant that is built affects the price that must be charged for the services provided by those facilities.

One major reason that construction is comparatively inefficient is in its fragmentation and consequent lack of teamwork. It is a $600+ billion a year activity (1995) involving close to one million contractors, over 70 national contractor associations,* more than 10,000 local and national labor organizations, and over 6 million people, including professionals and skilled and semiskilled workers. Despite the capabilities of the larger and more progressive contractors, and despite the sophistication of many clients for construction, too much of the industry remains mired in the past. Construction effectiveness starts with the owners, and they, along with governmental regulators of the construction industry, are part of the restraint. An adversarial relationship often exists, breeding suspicion and lack of cooperation among key participants.

In parallel with decreasing construction efficiency, construction's share of gross national product** has been declining. Historically, it has run about 10 percent of GNP, but since 1975 that share has dropped several percent. Currently, it is about 8 percent of GNP. Keys to upgrading the industry are cooperation and communication between and among the principal parties — owners, planners, designers, and contractors. There is a great need for organized knowledge and exchange of information. Meaningful research must involve realistic data gathered from current practice. In contrast to most areas of engineering, it is difficult to model projects in a laboratory. Data are scattered among thousands of projects, involving a multitude of owners, contractors, and other parties.

Construction has long been recognized as a fertile field for research and significant academic and practical contributions. Only recently, however, has adequate attention been given to the needs for funds to support continuing studies in the field. The Business Roundtable completed a multi-million dollar study in 1982 which identified many research needs.[14] The President's Private Sector Survey on Cost Control (Grace Commission) identified waste and mismanagement in public works projects as part of its comprehensive study of the federal government in 1982 and 1983.[15] The East-West Center conducted autopsies on 30 projects in nine countries from 1977 to 1982 to

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* The largest is the Associated General Contractors of America (AGC), with 32,500 member firms and 102 chapters nationwide.

** Gross National Product (GNP) is the sum of the country's total output of goods and services. GNP used here is based on current dollars. GNP in 1995 was ±$7.35 trillion.

better understand why projects fail (run over schedule or budget, *or* collapse), and how to improve productivity and quality.[1]

The conclusions drawn from the various studies of the construction industry, including autopsies or postmortems of projects, clearly demonstrate a common problem — fragmentation. Thus, the need for integrating planning, design, construction, and management has been reinforced. This will require teamwork, exchange of information, and establishing a data base to provide insights and lessons from past mistakes. Teamwork must include the principal parties involved in the industry: owner, design professional, and contractor.

1.7 TWO MAJOR PROGRAMS ADDRESSING THE ISSUES

1.7.1 The Construction Industry Institute (CII)

The Business Roundtable study resulted in the creation of a national forum called the Construction Industry Institute (CII). The CII was established at the University of Texas in Austin in 1983. It is supported by large industrial firms and construction companies, including design-build firms.

The CII is an innovative concept for research and development in construction. It is intended to provide a resource to help bring together the fragmented industry in areas of common problems and needs. It allows owners, designers, contractors, universities, and other organizations involved in construction to cooperate in areas of common concerns and interests.[16] The initial objectives of the institute were:

- To develop into a principal national forum for issues related to the cost effectiveness of the construction industry.
- To bring together experienced management, technical personnel, and their companies who share a broad view of the construction industry, and are willing to participate and pool their expertise to improve it.
- To identify important issues which impact the cost effectiveness of the construction industry, support and direct research, prepare and

offer recommendations, and define the measurable results expected from implementation.

- To disseminate both credible information of value and state-of-the-art knowledge to the construction industry through appropriate vehicles of communication and education.
- To establish and maintain appropriate liaison with other organizations active on construction industry issues of mutual interest.

Sustaining membership in the CII is open to companies in the U.S. that have a significant involvement in the U.S. construction industry as a construction user, constructor, or engineer. Sustaining membership in the CII requires an annual membership fee of $36,000 plus a commitment to support the activities of the CII through participation in the Board of Advisors and the Advisory Committees. The membership objective is to have no less than 40 percent representation by either the construction users or the contractors/engineers group. There were approximately 100 members in 1996.

The CII has made much progess in construction productivity in large projects involving the charter members. Unfortunately, there has been little or no impact on the majority of construction projects in the U.S. The CII has made significant contributions to education and practice through an extensive series of research reports and video tapes in areas of contracts, implementation, materials, management, partnering, and quality of management. Again, the audience has been limited to primarily the charter members, who represent a small percentage of the overall industry.

1.7.2 The American Society of Civil Engineers (ASCE)

The American Society of Civil Engineers (ASCE) convened a series of meetings with leaders of the design and construction industry in 1983–1985 to discuss efforts to achieve quality in the constructed project. The principal recommendation was that ASCE should develop and publish "a comprehensive and authoritative guide on quality in design and construction that would clearly define roles and responsibilities of the participants in the process." ASCE recruited approximately 40 authors and 70 reviewers to produce Volume 1 of a manual titled *Quality in the Constructed Project: A Guide for Owners, Designers and Constructors*.[17]

The manual encourages teamwork among the principal parties of owner, design professional, and constructor. Unfortunately, there is lack of an integrative force in the manual to ensure the necessary teamwork is achieved. Another major gap is lack of attention to the importance of feasibility studies to the design and construction phases. Thus, the barriers in design and construction that account for fragmentation still exist.

In 1987, members of ASCE tackled the question "What will the probable state of civil engineering be in the 21st century?" ASCE concluded that "meeting the challenges of the civil engineering profession in the 21st century will require imaginative and creative research, some of it in totally new fields." The members recommended a "coordinated national research strategy...," which at the time was nonexistent, and requested that ASCE "...develop and execute a program of basic and applied studies, and demonstration projects."

In May 1988, the ASCE Task Committee on Implementation of a Civil Engineering Research Foundation (CERF) reported on its activities to the ASCE Board of Direction, which included the establishment of the corporate entity now known as CERF and the Committee's recommendations leading to the start-up of the Foundation in 1989.

The mission of CERF is to unify the civil engineering profession through research and innovation. It received basic support from ASCE, with major support from cooperating organizations through a partnership effort in joint research projects. Collaboration to date has been significant with federal departments and agencies. For example, the U.S. Environmental Protection Agency (EPA) is now collaborating with CERF to evaluate a broad range of new environmental technologies for pollution avoidance and remediation/restoration.

Another example is the Highway Innovative Technology Evaluation Center (HITEC). HITEC was established in 1993 in conjunction with the Federal Highway Administration to help move highway innovation into practice more quickly.

These joint efforts are intended to evaluate new technologies and then move them into practice. However, CERF does not address issues of accountability, cost effectiveness, and quality.

In summary, the overall picture of the status of the nation's infrastructure and environment is not good. Many circumstances have converged to create current infrastructure problems. The most serious are:

- The high cost of construction because of fragmentation of the industry, which results in lack of teamwork and accountability.
- Shifting responsibilities: the Reagan administration shifted infrastructure maintenance and repair from federal to state budgets. In many cases, state and local treasuries were unable to foot the bill. In addition, the Highway and Airport Trust Funds are broke.[18]
- Deferred maintenance: elected officials, faced with the choice of erecting new structures or systems, or repairing old ones, tend to leave the repairs to their successors. So do their successors, leaving bigger and bigger problems.
- Funding allocations: owing to the way federal funds have been distributed, many states and municipalities have found it cheaper to "build new" than "fix old." Highway funds, for example, are made available for construction, not earmarked for repairs.
- Increased loadings: structures built to take specific loads now must take much more, with trucks having doubled and even tripled in weight.
- Timing: the numerous public works projects of 40 to 50 years ago are "coming due," revealing any mistakes embedded in their construction (such as the bridges and overpasses in the California earthquakes of 1971, 1989, and 1993).

Rebuild America, a broad-based coalition of organizations concerned with adequate infrastructure investment, was established in 1987.[3] It lobbies for the release of federal trust funds for needed transportation and public building improvements, including school buildings. Unfortunately, they do not understand that all the Federal Trust Funds are broke. Rebuild America includes city, county, state, and national officials, as well as other public leaders whose job it is to maintain, inspect, and plan for the building and rebuilding of our public facilities. These professionals are supported by engineers, builders, financiers, contractors, and architects concerned about the dire national consequences of substandard infrastructure.

The rise and fall of a civilization ultimately is linked to its ability to feed and shelter its people and to defend itself. These capabilities depend on the vitality of its infrastructure — the underlying, nearly imperceptible foundation of a society's wealth and quality of life. A civilization that stops investing in its infrastructure takes the first steps toward decline. As the infrastructure decays, society slowly becomes paralyzed by its inability to transport people and food, provide clean air and water, control disease, and conduct commerce.

In the last century, the U.S. invested heavily in its infrastructure — from canals to fiber optic systems, from fresh water to interstate highways and rapid mass transit systems. But this infrastructure now is deteriorating due to excessive demand, misuse, and neglect. The fragility of these systems and the staggering losses their failure will incur was graphically illustrated by the Chicago flood in April 1992, Hurricane Andrew in August 1992, and a minor telephone outage in New York in September 1991 that shut down three major airports. Several studies indicate that the current decline in U.S. productivity and its increasing deficit are partly the result of a deteriorating, inadequate infrastructure.[19]

The Rebuild America Coalition requires assistance to awaken Congress and the White House to the vital need for their actions. The National Science Foundation (NSF) will sharpen the focus on this urgency by establishing a national Institute for Civil Infrastructure Systems (ICIS) in late 1997.[20] Unfortunately, neither the Rebuild America Coalition nor the NSF initiative addresses the construction industry issues. The IPQMS, when properly introduced and implemented, would result in the necessary teamwork essential for success.

1.8 THE NEED TO TEACH TEAMWORK

To be successful, rebuilding America's infrastructure and cleaning up the environment must be undertaken on a team basis. Of equal importance, this task must include provision for accountability. Experience with over 20 years studying budget overruns and other costly mistakes in both public and private projects points to common problems of fragmentation in planning, design, and implementation. To illustrate these problems, consider the following cases:

- The Trans-Alaska Pipeline System (TAPS) Part One (1968–1977)
  Budget overrun from $900 million to $8+ billion.
  Constant design changes during construction.

$1.5 billion lost to waste, fraud, and mismanagement.
Basic problems related to lack of adequate feasibility studies.

- TAPS Part Two: Operation (1978–1996)
  Constant violation of federal and state laws regarding worker health and safety and polluting the environment.
  Sexual and mental harassment of whistleblowers by management.
  The largest oil spill in U.S. history, compounded by lack of a viable response system.
- State of Washington Five Nuclear Power Plants (1968–1992)
  Original estimate of $5.7 billion ballooned to over $24 billion in 1984, and growing.
  State defaulted on $2.25 billion in municipal bonds in 1982 due to waste, fraud, and mismanagement.
  Two power plants canceled in 1982 and two were "shelved" after construction was more than 65 percent completed.
  Escalation of construction costs in one state causing an economic depression in neighboring states.
- Washington, D.C. Metro System (1968–1995)
  Original estimates of $1 billion exceeded $7+ billion in 1995 with only 81 miles and 70 stations completed out of a projected 102 miles and 83 stations; another $2.6+ billion needed.
  Large budget overruns caused by inadequate planning regarding the effect of tunneling on adjacent structures and resulting litigation.
  Lack of competence in the management of design and construction.
- Environmental Protection Agency's Superfund Programs 1, 2, and 3 (1980–1995)
  Only 90 toxic waste sites cleaned up after 14 years and $14+ billion expended (projections estimated 300+ sites would be completed).
  Lack of integration of planning, design, and implementation.
  No attempt made to establish a data base after Program No. 1 in 1985.
  The U.S. General Accounting Office (GAO) reports on waste, fraud, and mismanagement ignored by Congress and the White House.
  Lack of continuity in leadership of the EPA — use of political

appointees.
Nobody in the entire federal government is accountable — this violates the Constitution regarding the spending of public money.

- Spacecraft Challenger Disaster (January 28, 1986)
  Explosion 73.213 seconds into launch, killing six astronauts and one school teacher.
  O-Ring pressure seals in the right solid rocket motor failed, permitting the escape of highly pressurized rocket fuel.
  The recommended escape system for such an emergency had been rejected in 1972 as too costly ($300 million).
  Repeated warnings by engineers of O-ring problems (charring and erosion) since 1979 ignored by Morton Thiokol and National Aeronautics and Space Administration (NASA) managers.
- Hanford Nuclear Reservation, Richland, WA (1950–1996)
  Management operating the facility for over 40 years without regard for environmental, health, or safety requirements.
  Department of Energy (DOE) and its predecessor agencies knowingly exposed tens of thousands of bomb-plant workers to conditions that resulted in injury, health problems, and death. In addition, most of these workers and neighboring communities have been exposed to harmful levels of radioactivity.
  High-level nuclear wastes dumped onto the desert floor and into the Columbia River.
  No oversight by federal agencies or members of Congress. Indeed, contractors such as Westinghouse Hanford and its predecessor, Rockwell International, are reimbursed by the DOE for legal expenses fighting the whistleblowers.
  Deliberate and illegal destruction of documents showing waste storage problems, leaks, and other dangerous conditions.
  Waste, fraud, and mismanagement rampant in clean up of contaminated sites. Over $7 billion spent since 1991, with $2+ billion lost to waste and fraud.
  Whistleblowers ignored by management and the U.S. government in all of the above.

The foregoing problems can be avoided by using the integrated planning and quality management system (IPQMS). Chapter 2 introduces the IPQMS.

The authors propose a 10-year program in Chapter 10 to rebuild the infrastructure and clean up the environment. The program would be a federal–state government partnership costing $35 billion a year. It would be planned, designed, and implemented in the IPQMS framework to ensure accountability, cost effectiveness, and quality. The money would come from the $65+ billion in Corporate Welfare.

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2 The Integrated Planning and Quality Management System (IPQMS)

2.1 BRIEF OVERVIEW

Studies of costly overruns and failures of over 30 projects in nine countries by an international team of senior scholars and practitioners clearly pointed to the need for a new approach to project planning and management.[1] In every case, the study team found common denominators in the reasons for the many problems encountered. The most critical problem areas were directly related to the fragmented approach to project planning and management. The basic problem is that different groups are normally involved with:

- Project identification and formulation
- Feasibility analysis and appraisal
- Design, including preparation of drawings, specifications, and establishing personnel needs
- Traditional project management, which includes activation, implementation, supervision, and control through completion

The study team found there was no coordination between and among these groups in every project, which results in fragmentation. The roots for this critical problem of fragmentation are found in education and training programs.

The outstanding conclusion from these studies emphasized the need for more effective coordination *and* control of the various tasks throughout the project cycle. The project cycle is not a new concept. It has been used by the World Bank and other international funding agencies for a number of years as a basis for their lending programs. There is general agreement that each project passes through a cycle which, with some variations, is common to all.[2] However, as the international team determined, the principal need was to focus on the *integrated* project cycle. Thus, the project team developed the IPQMS* as its conceptual framework for the new curriculum because of

* The IPQMS is a further development of the original integrated project planning and management cycle (IPPMC).

the need to systematically integrate the many tasks and procedures to ensure better control and productivity.

The IPQMS is a conceptual tool for observing and analyzing the process of projects in all sectors (Figure 2.1). This integrated matrix has been developed to clarify the major phases and tasks that constitute the project, from planning through implementation, evaluation, and refinement, with the central function of policy making providing focus and direction throughout. The IPQMS may be divided into four phases:

- Planning, appraisal, and design
- Selection, approval, and activation
- Operation, control, and handover
- Evaluation and refinement

Specific tasks may be further identified within these four phases, as illustrated in Figure 2.1.

Figure 2.1 illustrates the relationship among the phases of the project cycle, the tasks within each phase, and the overall dependence on central policy issues. It must be emphasized that the project cycle is an ideal model; not every project will conform exactly to it. However, as mentioned earlier, each project does pass through a cycle consisting of a sequence of phases, and the last phase should produce new project ideas and approaches. Thus, the project cycle is self-renewing, as shown in Figure 2.1. Continual feedback and dependency do exist among the tasks, however. Each task is dependent upon and influenced by the others.

There is a two-way flow of information between those responsible for policy and those responsible for managing each of the project tasks. This feedback to policy makers and management's response is an important part of the integrated project cycle. Decisions on project implementation, although in the hands of the manager on a day-to-day basis, are closely linked to the policy framework within which the project operates. Thus, all tasks within the four phases of the IPQMS are tied together by policies emanating from the various authorities concerned with the project.[3]

The IPQMS framework emphasizes the interdependent and cyclical nature of projects. However, because each task within the four phases of the cycle is distinct and must be examined as an individual entity, proceeding in an orderly time sequence, the cycle must also reflect this linear progression.

The IPQMS is intended to be a flexible model for analysis and observation. The bond between the myriad activities it encompasses is the authority

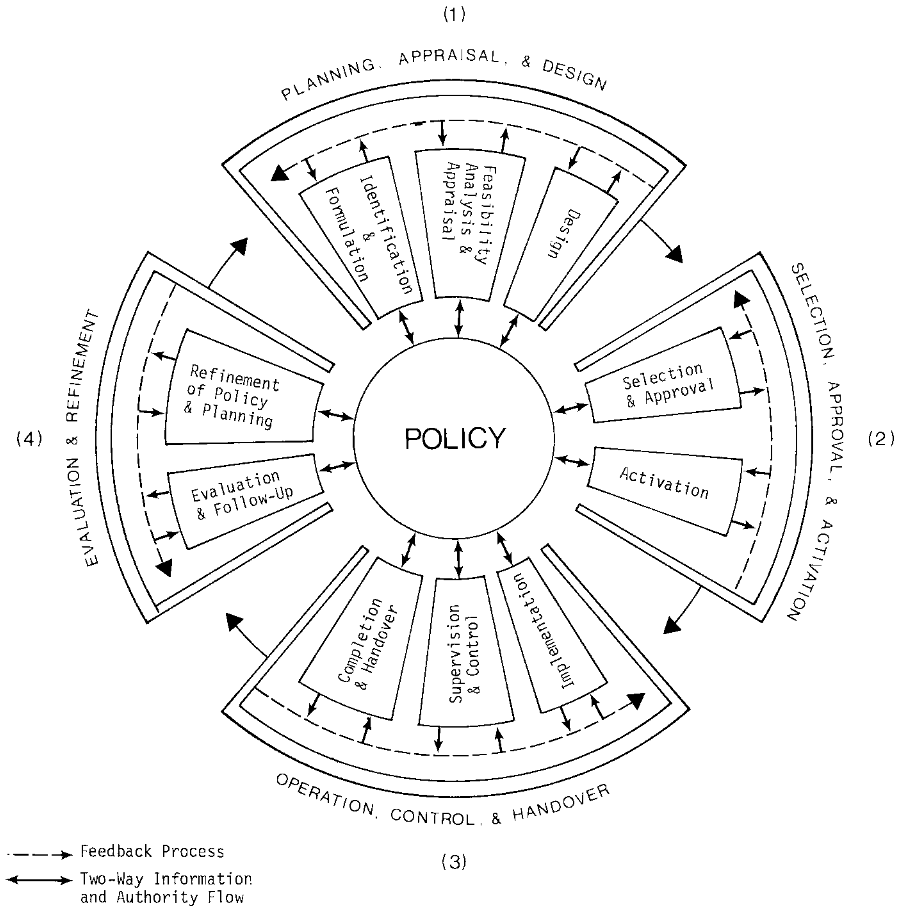

FIGURE 2.1 The four phases of the Integrated Planning and Quality Management System (IPQMS).

relationship of all of the decision makers involved, from top government policy makers down to project foremen. By analyzing these changing power relationships within the framework of the integrated project cycle, a cohesive and readily intelligible overview of the project can be provided. The IPQMS conceptual framework provides the basis for the syllabus of the prototype curriculum.

With this overview, we can proceed to examine each of the four phases and their tasks.

2.2 PHASE 1: PLANNING, APPRAISAL, AND DESIGN

The first phase of the project is planning, appraisal, and design. There are three basic tasks in this phase: (1) identification and formulation of the project, (2) feasibility analysis and appraisal, and (3) design of the project. The first joint task, *identification and formulation*, involves the actual conception or identification of a project, which may occur in several ways. The basic requirements of a country indicate the need for projects to satisfy them. The planning process often identifies a variety of project possibilities for each sector of society. For example, identification of an agricultural project may first require irrigation and transportation projects.

The major sources of projects in developing countries, however, are the government departments or ministries, including central planning agencies. Projects may be identified by political parties or government officials. In this case, the motivation to undertake a project may be political, such as an attempt to gain the support of particular constituents. In some countries, private entrepreneurs or multinational corporations will identify projects that meet the criteria established by the government.

International agencies have their own procedures for identifying projects. The identification process, then, must take into account various needs, preconditions, and policies if the project idea is to proceed to operational reality.

After a project has been identified, its parameters must be defined. This is part of the *formulation* task. The formulation of a project involves the development of a statement in broad terms which shows the objectives and expected results of the project and provides an estimate of the various resources required to achieve them.

The second set of tasks in the first phase, *feasibility analysis and appraisal*, are critical ones which involve two distinct operations. A prerequisite for this set of tasks is the development of preliminary designs for the project. These early designs must be detailed enough so that cost estimates and decisions on various aspects of the project can be made.

Feasibility analysis is the process of determining if the project can be implemented. *Appraisal* is the evaluation of the ability of the project to succeed. Projects will proceed to the feasibility stage only if decision makers find them desirable.

While feasibility analysis and appraisal are being conducted, several critical decisions need to be made. These decisions will determine, first, if the project is capable of achieving its objective within the limits imposed by the decision makers and, second, whether it will proceed. Preliminary estimates of the resources required, and basic decisions about size, location, technology, and administrative needs, must be made.

Feasibility and appraisal should be approached systematically and deliberately. Time spent in researching the feasibility of a project is usually time well spent. Moreover, the findings at this point in the project will be useful during other phases of the project, particularly phase 3.

Determining the feasibility of the project depends on the accuracy of the information received. Even though the final detailed design of the project can be undertaken only after approval has been given, the preliminary designs form the basis of future decisions. Most developing countries have to contend with a shortage of both design and research-development capabilities. The result may be a lack of attention to critical aspects of the project. When decisions have been made on the overall project concept, its dimensions and parameters, it is then possible to determine its feasibility in the terms required by the policy makers and funding agencies.

Some projects may require a pilot study as part of the feasibility process. Pilot studies provide data that enable more meaningful decisions to be made about larger projects. The appraisal process may require a comparative study to determine the merits of one project over another. Although the project identified may be feasible to implement, a comparative study determines whether the resources will be best used in the project or in some other form.

Many governments and international agencies have developed rigid procedures to be followed when their funds are required. While the actual details vary from project to project and from organization to organization, the trend in recent years has been toward more sophisticated and more systematic project-related studies. For example, to receive a recommendation from the United Nations Development Program (UNDP) for industrial projects, prospective borrowers must undertake market analyses that include national trends in production, foreign trade, consumption, and consumer prices, together with details about output type and use, cost of production, and estimated sales. Other agencies have added new dimensions to their studies, such as the impact on the social and cultural life of the community and the environmental and ecological impact of the project.

Numerous components of the project must be dealt with in the feasibility report. Studies can relate to the feasibility of the technical, economic, commercial, financial, administrative/managerial, and organizational aspects. Additional political, social, environmental, and cultural factors that affect the project may also be included. Of great importance here is the need to make an inventory of the present environment in order to assess and manage the impact of the project on change in any of the environmental baseline factors, such as groundwater contamination and/or air pollution. Various technical alternatives must also be studied to ensure that the suggested approach fulfills project requirements.

Economic studies examine the overall sector into which the project falls and consider how the project fits into this sector and the regional planning framework. Related to economic feasibility studies are commercial studies, which may be necessary to determine the competitiveness of the proposed project. These studies examine the market demand for the output of the project, consider the costs of production, and look at all aspects of the project to determine if it is viable.

Financial studies determine how much capital is required to complete the project. These studies focus on whether the project can sustain its financial obligations, have adequate working capital, and generate enough funds to ensure adequate cash flow to keep the project operational.

Administrative/managerial studies determine the adequacy of personnel to control and direct the project. Studies in this area are not always undertaken, even though all projects would benefit from them. Their objective is to determine whether a project that is economically, financially, and commercially sound can be properly implemented by available managerial and administrative procedures. Many regions and countries suffer from a lack of management and administrative capacity to direct projects. Related to this problem is a lack of ability to ensure that a project can be administered effectively by an appropriate agency or organization. Because administration of a project differs from normal departmental procedures, a careful assessment of the operational methods of existing units is necessary to ensure that a project's unique features can be catered to. Even though a project may be conceived and sponsored by an existing department, the department itself may not be the appropriate body to administer it. This is especially true when the involvement of a large group of outside personnel and agencies is necessary, since existing departmental procedures are often unable to provide the required flexibility.

Once the feasibility studies have been completed, a meaningful appraisal of the project is possible. Policy and decision makers and lending institutions may carry out the appraisal. They satisfy themselves that the project meets the conditions that enable it to proceed. Their concern is to determine whether or not the project is the best means of reaching the objectives they have set. In addition to viewing the project itself, they may consider alternative means of reaching the objective.

Potential lending institutions may undertake their appraisal with a healthy skepticism toward all phases of the project. They attempt to determine if the project is intrinsically sound and if all the circumstances that surround it are favorable.

The last task within this phase of the integrated project cycle is *design*. As mentioned earlier, preliminary design criteria must be established before project feasibility and appraisal begin. Once it has been determined that the project will continue, the design proceeds. Design is a critical function. It establishes the basic programs, allocates responsibilities, determines activities and resources, and sets down in operational form the areas of priority and functions to be carried out. All inputs relating to projects, including personnel, skills, technical requirements, and so on, must be determined at this point. Environmental factors, social criteria, and procedures must be assessed and included.

The design task also includes the preparation of blueprints and specifications for construction, facilities, and equipment. Operating plans and work schedules are prepared and brought together in a formal implementation plan; contingency plans may also be prepared. Designers must bring together the views of policy and decision makers and technical experts in such a way that the design reflects the inputs of all persons contributing to the project.

2.3 PHASE 2: SELECTION, APPROVAL, AND ACTIVATION

This phase of the project has two major tasks: (1) selection and approval and (2) activation. *Selection* takes place after the project has been accepted by policy makers and funding organizations as meeting the feasibility criteria. At this point, the design function, including the formal implementation plan, has been completed. The project has been well defined, with key elements and inputs clearly identified. The selection of one project over another is made on the basis of several criteria. Policy makers consider the feasibility of the project and the priority of the project area. If a project fulfills a major need or contributes to national or sector goals and is politically desirable, it may be selected over a competing project that is not politically important. Funding agencies, however, have a variety of techniques for determining whether resources will be allocated to a particular project. These techniques may range from cost-benefit to other complex forms of analysis. Overall, however, the policy makers and the funding agency must conclude that the project itself has a priority claim for the resources it requires. Therefore, the selection process is normally competitive.

Project selection requires negotiations to obtain formal *approval* from national authorities, funding agencies, and other contributors. This requires the finalization of funding proposals, agreements, and contract documents, including tenders and other contracts and the introduction by the government or some other organization of appropriate regulations.

Activation of the program involves the coordination and allocation of resources to make the project operational. This is a complex process in which the project manager brings together a project team, which may include professionals, technicians, and resource personnel. Other contributions to the project may come from other groups, such as consultants, contractors, suppliers, and policy makers in other agencies. The outside inputs must be coordinated with the work of the project team. Responsibility and authority for executing the project must be assigned at this point. This includes the granting of authority to make decisions in areas relating to personnel, legal, financial, organizational, procurement, and administrative matters.

The activation task must ensure that planning for all phases is undertaken so that delays in vital inputs do not occur. Organizational and administrative procedures, together with feedback and responses to policy makers' decisions, will have an important bearing on implementation. Concern for detail and proper planning during activation can save a great deal of time and resources during later phases of the project. At this point, the actual work of the project is about to begin.

2.4 PHASE 3: OPERATION, CONTROL, AND HANDOVER

Looking at the development project from the outside, the uninitiated observer might mistake this most visible phase for the entire project. As has been indicated, phase 3 in fact makes up only a small part of the integrated project cycle. This phase has three sets of tasks: (1) implementation, (2) supervision, and (3) completion and handover.

Implementation involves the allocation of tasks to groups within the project organization. It is based on procedures set down during the two earlier phases. At this point, a final review of the project design and timetable is undertaken, and any necessary changes or adjustments are included. Decisions about the procurement of equipment, resources, and manpower also need to be made. Schedules and time frames need to be established, and efficient feedback, communication, and other management information systems must be set up. The responsibility for implementation rests with the project manager. This person must work with policy makers, authorities, and organizations related to the project, as well as with the policy makers controlling it. His task is a complex one, requiring him to steer the project through many obstacles.

The second set of tasks in phase 3 is *supervision and control*. Appropriate procedures must be activated to provide feedback to both the policy makers and the project manager. Control procedures must identify and isolate problem areas; because of the limited time span of a project, fast action is necessary if costly delays are to be avoided. At this point, specific management tools, such as the critical path method (CPM), program review and evaluation techniques (PERT), and other forms of network analysis are particularly useful. These control and supervision techniques break down a project into detailed activities and establish the interrelationships between and among them. This allows the project manager to organize the project into manageable components, to coordinate all activities, and to set a time-sequence schedule for project implementation. Although using such techniques means taking more time prior to implementation, it is time well spent. Not only will these techniques give the project internal coherence, they will also save implementation time by isolating any problems to the appropriate project component.

In addition to providing internal control, those funding the project maintain an independent monitoring and control system. The project manager must therefore meet control criteria established by either the government or another controlling agency, or perhaps by the funding institution. This may involve using specified procedures, such as international competitive bidding, for supply contracts. Formal procedures are established by many international organizations for the procurement and control of resources.

Whatever supervision and control techniques are used, they must take into account the changing patterns that occur during the life of the project. These may include changes in policy making and political organizations, difficulties with procurement, and poor performance by project team members and contractors. In many cases, the overall project design will need to be reviewed. Many technicians are involved in the supervision and control processes, and adequate information flow in all directions — from the project manager and from those within his organization with special responsibilities — is essential if these procedures are to be effective. As part of supervision and control, any problems relating to environmental factors must also be identified and appropriate action taken.

Control procedures are useful only if action is taken to correct any deviation. It should also be noted that both personnel and input patterns change as the project proceeds through its four phases. As work on some tasks is completed, other personnel, experts, and contractors move in to begin new tasks. Personnel must adjust to their new environment, and procedures need to be reviewed and updated to meet the changing situation.

Project *completion* prepares the project for phasing out and *handover* to another form of administration. These are the third set of tasks in this phase. Project completion consists of scaling down and dismantling the project organization. It also involves the transfer of project personnel to other areas of operation. Assets and other facilities, including equipment and technology, may not be required by the operational project. Provisions for their transfer must be made, since it is not always possible to have an automatic transition from the development to the operational stage.

Completion may take place over a considerable period. As various parts of a project are completed, however, they may be taken over by a new organization, and handover may therefore be accomplished piecemeal. It is essential that development resource linkages between scaled-down projects and projects in the elementary stages of implementation be planned systematically to ensure optimal use of limited resources, particularly in broad development programs. The new project, when operational, will have an effect on other aspects within the sector. As the project becomes operational, the new controlling organization must have the skills, personnel, and technical backup required. Key personnel working in the development stage will often transfer over to the new controlling organization.

In cases where technical, financial, political, or other factors prevent projects from being completed according to the original terms, handover and termination procedures may have to be implemented at an earlier stage. This may involve considerable loss as far as the project is concerned. In this situation, the objective should be to liquidate the project in a way that will obtain the most benefit.

As a project nears completion, special reporting systems should be set up so that full information on the project is available. Completion reports should be prepared for various authorities, including funding organizations and policy makers.

The actual handover of the project's operation involves finalization of contracts, termination of loan facilities, and so on. It also includes the transfer of the project's activity and resources to the new administration. This is a critical task. While the development of the project can be viewed initially as a creative task, once the project is completed, it must be viewed as a long-term operational program.

2.5 PHASE 4: EVALUATION AND REFINEMENT

The final phase of the project is the evaluation and refinement of policy and planning factors. The first task is *evaluation and follow-up*. While it is possible to evaluate project results immediately, actual benefits — both anticipated and unanticipated — together with their side effects, may not become apparent until the project has been operating for some time. Evaluation thus needs to cover several time periods. Evaluation normally includes a retrospective examination of the project in attaining its intended goals within both the timetable and the budget. However, experience clearly demonstrates that it is necessary to consider evaluation as an ongoing process integrated with each phase of IPQMS. For example, evaluation procedures must be designed to analyze and propose solutions to problems that may arise during the tasks of activation, implementation, supervision, and control. Ongoing evaluation, which includes retrospective evaluation, should result in a careful documentation of experiences which can provide both insights and lessons for improving project planning and project management in the near future.

Evaluation of a project can take several forms. These include evaluation by those responsible for implementation and by others with an interest in the project, including funding organizations and contractors. Those who are funding the project will undertake a thorough investigation of its financial aspects, including an effectiveness study of goal attainment. The agency responsible for the project will determine whether its goals have been attained and whether the expected impact on a sector or on national development will be achieved. The studies should consider, in addition to the project's impact on the target group, its influence on the political, social, cultural, and environmental factors relating to the project. An exhaustive evaluation of each phase, to determine its contribution to the project in terms of the budget, timetable, and other factors, is most desirable. In most cases, however, the project is evaluated as a whole, with little effort made to analyze each phase or each task separately.

International agencies, such as the World Bank and the United Nations, have their own procedures for evaluating projects. These may be useful to policy makers, since they provide the opportunity for comparative analysis with similar projects.

Related to, and often arising from, the evaluation of a project is the need for follow-up. Follow-up activities may vary from determining how unmet needs can be satisfied to action on project tasks not properly fulfilled. The piggyback or follow-up projects mentioned earlier may come into play at this point. For a project to achieve its full objective, smaller or related projects may need to be implemented almost immediately. There is then a clear need to relate follow-up action closely to project evaluation. Follow-up action is one aspect of the project manager's role which may involve considerably more commitment than he or she initially envisages. If follow-up action makes the difference between the project's being fully or only partially operational, it is wise to undertake these activities as quickly as possible. Aspects arising from the follow-up procedures may be useful in the future. If the project is successful, guidelines can be set down for the project to be repeated in another setting.

The second and last task is *refinement* of policy and planning. Policy makers and managers will need to refine their procedures in the light of each completed project. Experiences and lessons learned should be the basis on which planning and policy tasks are reviewed. As the essential controlling force, policy procedures must be continually updated to meet future challenges. Planning must also be able to meet new demands and situations. Refinement of these procedures is an important contribution that the project can make to future development programs.

The IPQMS is a flexible model for all phases of projects from conception to completion. The force unifying all of the phases and tasks is the power and authority vested in various policy makers, ranging from top government and political decision makers to those in charge of one aspect of the project. The project managers, the staff, and outside contributors such as consultants or contractors are bound by and exist within the framework of policy decisions. Analysis of these changing relationships through the IPQMS model can provide a comprehensive overview of a development project. It is also useful for policy makers in providing guidelines for addressing policy issues as a basis for more viable policy formulation and related decision making.

It is significant that the IPQMS conceptual framework was developed as the basis of a new and dynamic approach to planning and management because of past experience with the problems of poor planning and management, resulting in the waste of enormous human and capital resources in projects from all sectors. The viability and effectiveness of this system in designing and implementing new curriculum materials for educating and training project planners and project managers have been established. In addition, the IPQMS has been shown to provide an effective conceptual framework in four sorely neglected areas: (1) encouraging long overdue *teamwork* among planners, designers, contractors, and owners of projects;

(2) satisfying the need for accurate information flows between and among these groups to ensure safe, cost-effective projects; (3) creation of data bases in each sector through carefully documented case histories of projects; and (4) the most difficult task of all — application of lessons learned from the case histories to refinement of policies and planning to improve productivity and quality of new projects.

Thus, the IPQMS methodology, when properly introduced and implemented, ensures *accountability*, *cost effectiveness*, and *quality* in all programs and projects. The IPQMS can be used for projects and programs in all sectors.

Subsequent applications of the IPQMS by the authors to the Trans-Alaska Pipeline System (Chapter 5) and the Washington State Nuclear Power Plants (Chapter 7) demonstrated the need for more attention to the feasibility studies.

2.6 FEASIBILITY STUDIES

As the IPQMS figure shows (Figure 2.1), planning emanates from a policy to identify and formulate programs and projects for specific needs or objectives. In most cases, the project must satisfy economic and social needs. Of course, in the military, the project must satisfy a defense need. In all cases, experience shows projects follow a similar process from inception to completion, and the most important task in the planning phase is the determination of the feasibility of implementation. Thus, feasibility studies and analyses or appraisal form the critical juncture in the IPQMS. Unfortunately, policies usually do not stress the importance of planning to the future success (or failure) of projects.

Feasibility studies require a preliminary design which is developed from the formulation task. Formulation defines the parameters of the project and estimates of the various resources required to achieve the objectives. This makes it possible to develop one or more preliminary designs to conduct a comprehensive feasibility analysis.

A complete feasibility analysis of a project must cover six important study areas: (1) technical, including manpower and technological requirements; (2) economic justification, such as the cost and benefits; (3) administrative and managerial, including external linkages and internal organization; (4) environmental, including present baseline data and impact on those data; (5) social and political, including demographic data and social needs; and (6) financial for funding needs/sources. Each of these six studies should be conducted in the context of five interrelated questions:

- Is the proposed project responsive to urgent present or anticipated social and economic needs?
- Will the project as planned adequately serve or fulfill the intended purposes without detriment to the environment?
- Will the benefits of the project to both society and the economy be justified by the costs?
- Should various technical alternatives be studied to optimize or maximize cost effectiveness of the project without sacrificing the quality or function of the project?
- Do the feasibility studies provide sufficient baseline criteria and measures to establish a checklist for subsequent project implementation, control, and evaluation?

Well-prepared feasibility studies and analyses examine and question every aspect of the preliminary design within the context of the actual project environment. They determine whether a project can be satisfactorily carried out with the financial, technical, human, material, and organizational resources available. Thus, together with design, feasibility and appraisal function as the interface between conception and reality. They link the planning set of project tasks — identification, formulation, and preliminary design — with the action-oriented set of tasks — selection and approval, activation, implementation, handover, and evaluation.

In providing this link, feasibility and appraisal serve several other crucial functions. First, by examining project goals and by questioning all assumptions, they provide a framework to reformulate the preliminary design into the most appropriate design. Second, feasibility and appraisal help guide the implementation of the project. Not only do they point out potential trouble spots, they also discuss the use of possible contingency plans. Finally, a complete feasibility study includes criteria and baseline measures to evaluate the project, providing the framework both to monitor the project during implementation and to evaluate its overall success and completion. Thus, guidelines and checklists can be prepared to ensure both cost effectiveness and quality. In fact, the significance of feasibility studies is setting up guidelines and checklists for subsequent tasks in the IPQMS!

In the field of project management, the bulk of literature on feasibility and appraisal deals almost exclusively with economic analysis (including market studies, which are not always applicable) and technical studies, with particular emphasis on engineering criteria. In practice, however, feasibility analysis and appraisal incorporate a much wider range of factors than these, including such areas as management and personnel considerations, environmental impact, and sociopolitical repercussions, together with their often complex and overlapping relationships.

In summary, poor project planning results in many problems, especially in design and implementation. In particular, lack of adequate attention to the feasibility studies has been found to be directly responsible for costly budget overruns and structural collapses. Classic examples of the impact of poor planning on costly project results are found in the IPQMS case history chapters of the Trans-Alaska Pipeline System (Chapter 5) and the Washington State Nuclear Power Plants (Chapter 7).

The six types of feasibility studies are summarized in matrix form in Table 2.1. The sequence in which these studies are conducted may vary from project to project, with the exception of the technical studies, which are needed to provide vital information for the economic, environmental, and social studies.

The factors to be considered in each study are drawn from agriculture, industrial, public works, and social sectors. Within the matrix, the general terms of each feasibility study are translated into specific interrelated questions the study must ask and answer. Key questions are included in the tabulation.

TABLE 2.1
Feasibility Study Checklist

Technical	
A. Site Data Geology and soil conditions Drainage characteristics Climate conditions Water supply Power and transportation	Is there an adequate choice of available technologies for alternative design purposes considering physical layout, engineering design, and availablility of raw materials?
B. Choice of available technologies Equipment and machinery Manufacturing process Spare parts	Do the alternative designs meet relevant building codes?
C. Design Layout Engineering requirements Construction materials	What are the costs of constructing and operating project facilities (and services), including machinery, equipment, and spare parts as appropriate?
D. Manpower Professional Technician Labor	What are the manpower requirements, from professional to labor, and are they locally available?

Economic	
A. Demand Domestic Export	Is the project responsive to an urgent present of anticipated economic and social need?
B. Supply Domestic Import	Will the project's planned economic outputs adequately serve the intended purpose?
C. Marketing program	
D. Employment impact	Will the services proposed to be perfromed through the project and the benefits produced by the project justify its cost?
E. Raw material needs Domestic Import	
F. Cost-benefits	

TABLE 2.1 (CONTINUED)

Administrative/Managerial	
A. Internal organization Structure Authority Lines of communication Flexibility	Will the internal organization proposed to implement the project be comprehensive enough to provide the necessary leadership and unified control?
B. External linkages Government support Government regulations Funding (appropriations)	Who will have complete responsibility and accountability for successful completion of the project?
C. Personnel Needs/capabilities Position descriptions Local vs. foreign Policies	Are there adequate personnel with the necessary skills for implementation of all project activities?
D. Management Management of project Control techniques Scheduling	Are internal lines of cummunication established and lines of authority clearly defined?
Environmental	
A. Physical/chemical Water Land Air Noise	Is the environment suitable for the success of the project?
B. Ecological Species and population Habitats and communities Ecosystems	What will be the project's impact on the environment, considering both short-term and long-term effects on water supply systems, wildlife, plants, soil erosion, and quality of air?
C. Esthetic Land, air, and water Biota Man-made objects Overall composition	
D. Social Individual well-being Social interactions Community well-being	

TABLE 2.1 (CONTINUED)

Social/Political	
A. Social impact Culture and life-style Demography	What is the project's likely social impact?
B. Political impact Equity Social justice Political organization	What is the project's likely polictical impact?
C. Community resistance	What social factors in the project environment will hinder or aid the project in achieving its goals?
D. Institutional resistance Legal constraints Stability of political support	What polictical factors in the project environment will hinder or aid the project in achieving its goals?
Financial	
A. Project design and implementation	What are the magnitudes of the capital and operating costs?
B. Cash flow studies, profitability External Domestic	What are the sources of funds and draw-down schedules, and are they sufficient to cover costs of activitites and implementation?
C. Source of funding	What is the projected cash flow of the project? To what extent is necessary borrowing scheduled to meet running deficits at activation?
D. Adequacy of funds	Is there an adequate accounting system to regularly provide balance sheets, cash flow statements, debt servicing schedules, and other financial reports? What are the provisions for project completion investment and other means of recovery investment and operating costs?

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3. Goodman, Louis J., et al. Summary Report: Planning Conference for Training of Trainers Seminar on Use of IPQMS in Public Works Projects. Honolulu: East-West Center, Centerwide Programs, 1982.
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3 The IPQMS and Case Histories

The East-West Center initiated an intensive international team study in 1975 to develop a new approach to project management education and training. The mandate to the team was to produce a new generation of managers who would have the analytical skills to ensure cost effectiveness and total quality in all projects in both public and private sectors. A primary objective of the strategy was to design a curriculum that would view planning, design, implementation, and evaluation as integral parts of the total process.

3.1 IPQMS PROTOTYPE CURRICULUM

In September 1976, the project team convened at the East-West Center to present and discuss curriculum development progress reports. It was agreed that the concept of a *prototype curriculum* was necessary — a curriculum that could be adapted to both training and educational programs. It was further agreed that the curriculum would include policy issues related to development projects. A timetable of nine months was established to complete the following materials:

- A syllabus and course outline for a 15- or 16-week curriculum that could be adapted to both academic courses and training programs.
- Identification of selected readings on each task of the integrated project cycle.
- A portfolio of five or six case studies of development projects to be researched and written in the context of the integrated project cycle.
- An annotated bibliography.
- A teacher's guide on the use of these case studies.

The project team reached a consensus on the prototype curriculum in June 1977 at its next meeting at the East-West Center.[1] At that time, it was agreed to implement the curriculum for testing and refinement during the 1977–1978 academic year, provided that the East-West Center could package all the materials into a 16-week (six hours per day, five days per week) curriculum and deliver it to the participating institutions by September 1977. It was also agreed to develop the curriculum and supporting materials within the IPQMS framework. A final request called for additional case studies of projects from four sectors: agriculture, public works, industry, and social services.

The highlights of the many project team activities from 1977 to 1983 are summarized below:

- A major research grant proposal for support to research and write 30 case histories was submitted to the Exxon Education Foundation in 1977.
- A comparative evaluation of initial implementation of the prototype curriculum was held at the East-West Center in 1978.
- Thirty case histories of development projects in nine countries were completed and published between 1979 and 1982. Twenty-two cases were published by Pergamon Press and eight cases by the East-West Center.
- A basic textbook was published by Pergamon Press in 1980 to replace the selected readings in the prototype curriculum.
- A planning conference on management training for public works projects was convened in 1982. Participants included key persons from industry, government, and academe.
- A seminar for trainers of public works project managers from eight countries was held in 1983.

The syllabus for the prototype curriculum designed in the IPQMS conceptual framework reflects the results of the initial testing in 1977–1978 (Tables 3.1, 3.2, and 3.3), as well as further refinement resulting from a Training of Trainers Seminar in 1983.[2,3] The initial selected readings to be used with the curriculum resulted from an intensive global literature search in 1976–1977. One thousand pages were finally identified, representing 25 book chapters and/or journal articles from 23 publishers throughout the world. The selected readings were related to the various phases and tasks in the IPQMS. Twenty copies of these readings were reproduced and packaged in 1977 for initial testing purposes. Selected references for these readings are shown for each phase of the IPQMS.[4-7] In addition, Goodman and Love packaged a case book containing drafts of five cases researched and written in the IPQMS conceptual framework.[8]

TABLE 3.1
Courses in Project Management in Different Countries*

Country	Academic Course	Training Course
New Zealand	X	X
Malaysia		X
U.S.	X	
Philippines	X	X
Indonesia	X	X
Taiwan	X	
Iran		X

*Courses offered at the institutions represented by the workshop participants.

TABLE 3.2
Comparison of Training Courses Offered

	New Zealand	Malaysia	Philippines	Indonesia
Agency	University	Government planning	University	University
Duration	12 weeks	8 weeks	7 weeks (2 weeks in plant)	32 weeks
No. of participants	18	24	39 (15 in plant)	45

TABLE 3.3
Comparison of Academic Courses Offered

	New Zealand	U.S.	Philippines
Name of university	Massey Univ.	Univ. of Arizona	Univ. of the Philippines De La Salle University
Type of university	Public	Public	Public/private
program/college	MBA	MPA/Ph.D	MPA/ME/MBA

3.2 USE OF CASES IN EDUCATION

The evaluation of the initial implementation of the curriculum[2] concluded that the most important component is a series of IPQMS case histories covering projects from agricultural, industrial, public works, and social sectors. It was also concluded that the case histories must come from a representative cross section of socioeconomic settings.

Case study research has been used throughout the world for over 120 years in teaching law and medicine. It has also been successfully used for about 70 years in teaching business administration. The use of engineering cases is reported to have originated at Stanford University in 1964.[9] More recently, schools of public affairs and administration have become interested in developing cases for use in strengthening both administration and program management capabilities in developing countries.[10]

The East-West Center (EWC) project team decided to conduct a global search of the literature in an attempt to locate case studies that had a focus on the different phases/tasks in the integrated project cycle. This decision was based on the use of five cases packaged by Goodman and Love for the testing of the curriculum in 1977–1978.[8] The team and EWC graduate students at the University of Hawaii reviewed over 1000 abstracts of cases from the Harvard Graduate School of Business Administration, the Philippine Case Clearing House, and the American Society for Engineering Education (ASEE).

The results were negative. Thus, it was decided to initiate the necessary research and writing of cases in the conceptual framework of the integrated project cycle. It was further decided that these cases should be called case histories since they would be based on autopsies or postmortems of programs and projects. Only in this way could the facts as to why projects failed or succeeded be determined. This type of research is extremely time consuming and could only be carried out with a significant grant from the Exxon Education Foundation.

The guidelines for researching and writing the case histories are covered in Chapter 4.

3.2.1 Business Case Studies

The Harvard University Business School reports the first business case study was written in the early 1920s. Since then, over 7000 case studies have been produced. They normally focus on a principle, an issue, or the value of a particular approach in making a decision.

Business school cases utilize studies of actual business situations and decisions faced by real corporations, large and small. They may involve a toy redesign problem to improve marketing or an assembly-line problem. In today's economy, a large corporation may be faced with a decision to either expand its portfolio or downsize. Harvard Business School does provide a publication describing how to prepare case studies for both the instructor and the student.[11]

3.2.2 Engineering Case Studies

The American Society for Engineering Education maintained an Engineering Case Library (ECL) until the late 1980s.[12] The ECL cases normally deal with specific problem situations or issues, such as a sinking floor (settlement problem) or magnetic fusion. The cases began to include the impact of policy matters in the mid-1980s. They are useful in the classroom for courses in design and production processes. The ASEE engineering cases are now housed at Rose-Hulman Institute of Technology, Terre Haute, Indiana. There were approximately 285 cases as of 1995. The ECL is now jointly administered by ASEE and the Rose-Hulman Institute of Technology.

Another example of engineering cases can now be found at the Massachusetts Institute of Technology (MIT). Dr. John Miller of the Department of Civil and Environmental Engineering has initiated a series of case studies of infrastructure projects in the U.S., Canada, and Hong Kong.[13] As a point of interest, he includes both questions and task exercises at the end of each case. His cases represent a combination of case studies and case problems.*

According to ASEE, the University of Michigan is developing case studies for every course in chemical engineering.[14] This is a joint effort by both faculty and graduate students.

The majority of business and engineering cases are used in the classroom to help students develop some real-world skills. Of course, the ideal situation in academia occurs when instructors have students work on teams in solving case problems. This means the instructors must develop their own cases unless there are data banks of comprehensive cases available.

3.2.3 IPQMS Case Histories

These cases are based on autopsies or postmortems of projects. Each case examines and analyzes the entire spectrum of a particular project, from inception through completion, showing how the interrelationships (or lack thereof) among policy makers, planners, designers, implementers, and managers contributed to the success (or failure) of the project. Special emphasis is placed on the feasibility studies in the planning phase to cover all aspects:

* Case problems normally involve a team approach to research the problem over a specific time period.

economic, technical, financial, administrative/managerial, environmental, and social/political.

The cases are a record of events and issues that actually have been faced by managers: events interwoven with facts, opinions, prejudices, and data upon which the manager's decisions depended. They contain the experience and influence of government officials, consultants, international assistance officials, designers, contractors (especially in public works projects), and project managers so that others can learn from these successes and mistakes. The projects presented vary in country, sector, form of management, and funding. The lessons learned have been used in rebuilding the island of Kauai after Hurricane Iniki in 1992.

3.3 SIGNIFICANT DIFFERENCES BETWEEN CASE STUDIES AND IPQMS CASE HISTORIES

The foregoing definitions for case studies and IPQMS case histories are better understood in examining abstracts of cases obtained from the American Society for Engineering Education, the Harvard Business School,[10] and the writers' inventory of case histories. Harvard reports that nearly 100 hours may be required to write a business case. Writing an IPQMS case requires a minimum of 1000 hours (the case of the Trans-Alaskan Pipeline System [TAPS], Chapter 5, required 1500 hours). Indeed, one IPQMS case history will yield ten or more case studies (one for each task).

Abstracts of business/engineering case studies and IPQMS case histories are presented in Appendix A. They vividly illustrate the differences.

3.4 THE NEED FOR CASES BASED ON POSTMORTEMS

There is agreement among many educators, project planners, designers, contractors, and managers regarding the need to provide unified control of all projects in all sectors in order to ensure both quality and cost effectiveness.[15] This eminently qualified group endorsed the principles of the IPQMS conceptual framework for education and training of project planners and managers — the professionals responsible for different aspects of projects from inception through completion. They further agreed on the need for data banks of case histories of public works projects to provide the necessary scientific and engineering data to strengthen project planning and management capabilities. This situation is true of all sectors, but it is especially crucial in hazardous waste disposal systems because of its direct impact on public health.[16]

As noted earlier, this book places heavy emphasis on project feasibility, project evaluation, and the use of IPQMS cases. Regarding the last factor, there is urgent need for case histories of public works projects, especially in areas of hazardous waste disposal and water supply systems. This need is reinforced in the postmortem of EPA Superfund Programs 1 to 3 (Chapter 8).

Thus, it is clear that learning lessons from the past can be invaluable in planning new programs to ensure accountability, cost effectiveness, and quality. The applications of in-depth analyses of past operations, programs, and organizations are beneficial in all sectors and fields. Generals George Patton and Douglas MacArthur were highly successful in World War II because they analyzed the winning strategies employed by General Hannibal of ancient Carthage and other generals in the past. The medical profession has made outstanding progress in finding cures for many diseases because it initiated case research based on autopsies over 120 years ago, maintaining an updated data bank available to physicians worldwide.[17]

A worthwhile book on the history of project failure is found in Petroski's *Design Paradigms*.[18] The book provides insight into the design process and the role of failure in design. It contains a history of many examples of design failures, including the reasons for the failures.

The IPQMS framework allows the examination of a broad range of factors that contribute to a project's success or failure. Each case examines and analyzes the entire spectrum of a particular project, from inception through completion, showing how the interrelationships (or lack thereof) among policy makers, planners, designers, implementers, and managers contributed to the success (or failure) of the project. The variety and range of projects documented by the cases further ensure that where one case focuses on technical factors or managerial policy, for example, other cases will complement it with an emphasis in other areas.

The foregoing illustrates the need and potential for educating and training a more effective project manager. This effort requires a curriculum and supporting materials that focus on unified control of all projects. The IPQMS and related cases represent such an approach.

Thirty IPQMS cases have been researched and published as of this writing. Each case is analogous to an autopsy or postmortem of a project in a similar framework, which is essential to establishing a data base in a given field, such as public works.[17] The guidelines for researching and writing the cases are presented in Chapter 4. The authors have completed research on eight additional postmortems of infrastructure-related projects, and include six in this book (Chapters 5 to 9). Senior scholars and practitioners from industry and academe recommend the use of this type of case, both as a reference and textbook material in architecture, civil engineering, and construction. Twenty-two cases of the initial 30 have been published by Pergamon Press.[19-22]

3.5 THE NEED TO TEACH TEAMWORK

Experience with troubleshooting a wide variety of problem areas in public works projects by the senior author clearly pointed to the need for teamwork among the principal parties: the owner, design professional, and contractor. This lesson was learned over 30 years ago. Unfortunately, the same problems persist today in both private and public sectors. The best way to solve this need is to begin educating and training new generations of professionals in the benefits of teamwork. Working together toward common goals will result in accountability, cost effectiveness, and quality. A significant fringe benefit is the minimization of litigation, which has been on the increase in public works projects for the past 20 years.

The IPQMS was developed to ensure teamwork from the principal parties. Using IPQMS case histories calls upon students to think actively and constructively about a real situation.* It requires dealing with contemporaries, communicating ideas, and developing individual decision making and judgment. Often this process must take place in a situation surrounded by conflicting ideas. The case method places an important role on the instructor. The instructor will assign a case for discussion, provoke interest and thinking, guide discussions where necessary, and perhaps bring together in summary form the threads of students' arguments. Each case is in fact a new learning situation and new opportunity for students to express their ideas. Throughout the case discussion students must be encouraged to communicate their views, support their views against disagreements from others, or accept the merits of the others' reasoning.

A careful step-by-step analysis of case facts is an essential prelude to discussion of the case, and students should appraise the specific situations and consider the choices of action available on the various issues. Analysis of case facts should be encouraged by continually focusing upon case details,

* The terms "students" and "participants" are normally used to denote education and training, respectively. The process is identical in teaching the use of cases.

the interrelations of case details and their implications for management action. Instructors should be careful to distinguish between objective facts and a student's evaluation of the facts, as sometimes opinions or comments recorded in a case may be taken as facts and not as a statement of opinion. The instructor must encourage contributors to differentiate between fact and opinion.

In some instances, the instructor will have to focus the attention of the class on points that should be discussed. This may occur when the class becomes so concerned with one aspect of the case that they neglect other issues that should be considered. When this happens, issues should be reviewed with caution, and there may be need to provide a set of criteria for the students. Cases are, in effect, the tools that encourage purposeful thought, and both individual and group creativity. They provide the raw materials from which decisions are made, interaction and intercommunications are established, and ideas are presented, challenged and defended.

At all times, the instructor must keep in mind the case histories provide a direct and intimate view of the role and activities of the project manager. They also focus on the many techniques, relationships, and other factors that contribute to the success or failure of particular projects. For education and training purposes, they provide a realistic context for analyzing the management of projects. As a reference, they provide both scholars and practitioners with useful insights in (1) planning and managing new projects, and (2) troubleshooting on-going projects.

3.5.1 Using the Team Method

Experience with the IPQMS in both education and practice demonstrates the usefulness of selecting topics from each of the four phases for class or team discussions and homework assignments. The instructor will divide the class into effective team groups of three or four students to understand the benefits of a team approach by all parties working towards a common goal. Effective team division ensures that students from different backgrounds and disciplines will work together and define common grounds to resolve issues.

At the very start, the instructor and the teams should emphasize the following guidelines to achieve results:

- Clarification of the team's purpose and the role of each member
- Smooth communication and interaction among members
- Unrestrained expression of, and access to, ideas of team members

- Acceptance and recognition of contending opinions within the group
- Trusting, but not fraternal, relationships within the group

The instructor will act as a coach/advisor to the teams, and if necessary as facilitator in case of breakdowns in discussions. He or she will try to remove barriers and enhance constructive interaction among team members and across teams.

A team leader is selected for each team either by the instructor or the team members. The team leader will actually role play in class the project manager in the field. The team leader:

- Prepares the schedules and short agenda for the team meetings
- Makes sure that notes are taken on the proceedings
- Leads discussion, elicits and referees ideas and other issues on the subject
- Delegates assignments and follow up progress
- Makes sure that reports are prepared and presented to team members
- Devises feedback mechanism for further discussion of report with the members and other teams

For successful team output and before further discussion of the specifics of the case histories, the members of the team(s) should express their commitment to the group's mission and goals, objectives and procedures. They will participate actively in the problem identification and solution processes. They should feel free, absolutely uninhibited, to recommend ideas and alternatives. Most important, team members should carry out the delegated assignments from the team leader.

3.5.2 Exercises for Students/Participants

In phase 1, both class discussion and homework assignments could focus on the cost effectiveness of geotechnical investigations, especially for senior-level and graduate students in civil and environmental engineering and architecture. Failure to provide adequate funds and time for a thorough site study for a project such as TAPS (Chapter 5) results in costly construction delays. Additional questions are readily available in Chapter 4. Different teams could summarize the costly consequences of inadequate site studies for several different projects (library research) and then compare with TAPS (Chapter 5). All universities have a variety of reference books dealing with this subject matter, including reports by the State of Alaska and the U.S. Department of the Interior on TAPS specifically. Other source material on this topic can be found in the references and bibliography.

The instructor can provoke further team discussion in phase 1 by comparing the results of the above assignments with the feasibility studies (Chapter 2) and Appendix B in the text. Other aspects of phase 1 can be handled in a similar manner with respect to worker productivity, materials procurement, and communication problems in isolated locations such as in the arctic environment. Of course, the most important discussion topic in phase 1 should focus on the need to select a project manager (or management team) at the outset for overall responsibility and accountability (see Appendix B). For both civil and environmental engineering students, additional discussion and homework topics should include the innumerable environmental impact studies resulting from opposition of environmentalists and the creation of the Environmental Protection Agency.

The final designs and environmental impact studies logically continue into phase 2, serving as a basis for selection and approval. Specific discussion topics and assignments could initially focus on how Congress entered the picture, passing the Trans-Alaska Pipeline Authorization Act of 1973. What were the features of the Act and its impact, if any, on activation and implementation? Additional major assignments should include the many factors involved to activate a project of this complexity, ranging from scheduling of manpower and equipment needs to developing a preliminary control system such as CPM or PERT. Discussion of the construction cycle in the arctic environment and what studies were made prior to activation of the project would constitute another interesting assignment. This could involve additional library research to obtain past experience with projects constructed in the arctic.

In phase 3, the impact of a cumbersome project organizational structure (Chapter 5) on overall management will require critical discussions on relationships between and among the owners, designers, contractors, and construction managers. The marked decline in productivity should be thoroughly discussed in the context of the outstanding needs for (1) teamwork among the principal groups involved in this project (or any other project), and (2) selecting a project manager or management team with over-all responsibility and accountability. Additional discussion topics and questions can be taken from Chapters 7, 8, and 9.

Evaluation and refinement (phase 4) are just as alien to students and many practitioners as the concept of IPQMS case histories. Thus, the instructor must both provoke team interest and thinking along with providing close guidance. An extremely useful assignment is to elaborate on a detailed checklist of questions and guidelines adapted from Appendix B for TAPS. Remember evaluation of a project is concerned with both socioeconomic needs and performance of each task in the IPQMS (see Chapter 4). The latter should be the focus of teams with students in architecture and engineering. A comprehensive assignment would have the teams evaluating each task in phases 1 to 3. Then, demonstrate how their evaluation could be used to improve policies, planning, design, and implementation of new projects. Another assignment for the teams would be to apply the IPQMS framework to costly problems in past projects, including structural collapses. These projects might include:

1. The Washington, D.C. Metropolitan Area Transit System (METRO) with costly overruns of budget compounded by litigation as a result of damage to adjacent properties.

2. The Washington State Public Power Supply System (WPPSS) design and construction of five nuclear power plants, with two plants abandoned (and two shelved) in varying stages of construction in the early 1980s and over $24 billion wasted, default of State municipal bonds ($2.25 billion), and on-going litigations (Chapter 7).

3. The tragic collapse of two atrium walkways in the Kansas City Hyatt Regency Hotel in 1981, killing 114 persons and injuring nearly 200 others.

4. The Spacecraft Challenger disaster in 1986, killing one school teacher and six astronauts. Of special interest here would be the management-engineer relationship: why Morton-Thiokol and NASA managers rejected the pleas of the design engineers to abort the lift-off (Chapter 9).

5. The Hanford Nuclear Reservation, Richland, Washington (1943–1996). Hanford was the nation's premier bomb factory in the country, and also the most contaminated. It is one of 16 principal sites in 13 states that have contaminated billions of gallons of water and millions of tons of soil with wastes from the bomb building

plants. Estimated costs of cleanup range from $200 to $300 billion over the next 20 to 30 years (see Chapter 9).

6. The Hartford-Connecticut Civic Center Roof collapse of 1978. The space frame was designed with the aid of a computer model (CAD). The roof, which covered two and a half acres of an arena, collapsed hours after thousands of fans had left.

Assignments include researching all the factors causing the problems and then, through team presentations in class, preparing a list of these problems, showing how many are common. Additional team assignments can be readily obtained from the training seminar outline in Chapter 10. Course research papers in the IPQMS framework are required by participants working in teams of three or four to illustrate the importance of teamwork.

3.5.3 In Practice

Many of the preceding examples of discussion and assignment topics will also be of interest to the practitioner. Of particular importance to the consulting engineers, architects, managers, environmentalists, and contractors, the lessons learned from past mistakes should be of primary concern (Chapters 5 to 9). Thus, the planning, design, implementation, and management of new projects should be more effective if the lessons are heeded.

In addition, practitioners should develop comprehensive checklists and guidelines for each new project to provide the necessary control systems to turn out safe and cost-effective projects. Practitioners must encourage the project owners to invest in thorough planning (phase 1) to satisfy the above objectives. In particular, the design professional (architect-engineer) should stress the importance of selecting the project manager who will be both responsible and accountable for proper implementation (see Appendix B). Another necessary step is to document each project to develop badly needed data bases of IPQMS case histories in public works project areas as well as other project areas. Ideally, teamwork with universities and consulting firms (and public agencies such as EPA) could be formed to permit graduate students to research and write these case histories for graduate credit (special projects course or thesis).

Experience with the use of IPQMS histories as a reference source in practice confirms their value in producing quality projects on schedule and within budget. They illustrate the importance of judgment in potentially controversial matters, thus avoiding litigation.

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4 Guidelines for Researching and Writing IPQMS Case Histories

Chapter 3 shows conclusively that the cornerstone of the IPQMS methodology is a data base of case histories that provide useful lessons to improve the process of planning, design, implementation, and management of projects in all sectors. The international study team concluded that the research and writing must be conducted similar to autopsies or postmortems to fully understand why projects fail and how to prevent similar failures for new projects. Thus, it was decided to use the integrated project cycle as the basis for the conduct of the postmortems.

The project team also agreed that the case histories must be an integral part of the curriculum for the education and training of project managers. Thus, the cases are used to provide realistic contexts in studying the special difficulties inherent in sound project management needs. To accomplish this purpose, the cases must be written in a prescribed format with detailed guidelines to ensure all factual data relevant to each case are obtained. This can only be accomplished by researching and writing the cases in the framework of the IPQMS.

In summary, autopsies or postmortems of projects can furnish invaluable lessons to improve planning, design, implementation, and management for new projects. To be effective, the postmortems must be conducted in a consistent and systematic manner. The integrated project cycle provides an ideal framework for the investigative procedures and analyses. Experience demonstrates it also promotes teamwork and holistic control which will ensure accountability, cost effectiveness, and quality in all sectors.

4.1 GENERAL OUTLINE OF THE CASES

The form of the case histories should generally follow the framework of the IPQMS and should be organized in the following manner:

Chapter 1 Project background
Chapter 2 Planning, appraisal, and design

Chapter 3 Selection, appraisal, and activation
Chapter 4 Operation, control, and handover
Chapter 5 Evaluation and refinement
Chapter 6 Conclusion

4.1.1 Suggested Discussion Questions

Although the case writers should generally follow the sequence of chapters, they may not be able to adhere exactly to the sequence of tasks within each chapter. The tasks may run together, or be out of sequence, or possibly be omitted in one of the phases. Thus, the writers should exercise imagination and flexibility in organizing a project's activities and interactions.

Moreover, since each project is a new situation set in a new environment, it requires the writers to highlight the factors significant to their particular case. Thus, the writers must emphasize or de-emphasize phases according to the individual requirements of their case history. This means that some chapters of a case history will be more detailed than others. Above all, the case writers must focus on the special lessons to be learned from their project, describing fully the different sets of issues, problems, interrelationships, and tasks.

The IPQMS is thus a focal point — not a rigid framework — from which writers can elucidate the many variables and interrelationships that make their case an excellent learning device.

4.2 GUIDELINES FOR CHECKLIST OF QUESTIONS IN THE IPQMS

The 260± questions represent the composite experience of 18 senior scholars and practitioners involved with policies, planning, design, implementation, management, and evaluation of large numbers of projects in their home countries.

Thus, the checklist of questions serves a variety of purposes in addition to providing a comparable framework for researching and writing case histories. First, it gives the reader an appreciation of the number and complexity of the factors and issues affecting project management. Second, the questions are useful in the analysis of other projects for either evaluation purposes or for troubleshooting purposes. Third, they are extremely useful for the instructor in planning and guiding student assignments for term papers, group reports, and class discussions. Fourth, questions in the final phase of the IPQMS are useful for both policy makers and planners in refining policies and plans for new projects. The questions are systematically arranged according to the IPQMS.

4.3 CHECKLIST OF QUESTIONS IN THE IPQMS

4.3.1 Phase 1: Planning, Appraisal, and Design

4.3.1.1 Identification and Formulation

1. Was the project identified in the course of the national (or state/county) or corporate development planning process?
   a. If so, what was the policy-making characteristic or corporate culture of this process?
   b. If not, how did it come about? Is the project just a reaction to a short-term opportunity but with a future potential for growth?
2. Can the national (or state/county) planning process ensure that policies and programs for economic or social development at that level are translated into or integrated with counterpart plans at regional and local levels? Similarly, can the corporate planning process ensure that the project can eventually be integrated with the other units of the organization?
3. Did the original project idea relate to problems identified in the national, sectoral, or regional plan? In the overall corporate context, did the original project idea relate to problems pertaining or obtaining in the various units?
4. What were the major environmental factors — political, economic, social, cultural, technical, or others that led to the project?
5. What was the primary source of the project idea?
6. Who were the individuals or groups that first proposed the project? What were their background interests on the project?
7. Did other organizations or companies, allied or competitive, become involved in defining the project?
8. What was the role of external donors or international funding agencies and business finance institutions in project identification? Were foreign subsidiaries of the corporation involved in project identification?

9. Who, other than the first proposers, supported the project idea? Who opposed it? Who were ambivalent toward the project?

10. Were other groups or individuals involved in the preparation, such as clients, users, beneficiaries, political supporters or opponents, resource suppliers, potential project implementors, competitors, and other parties?

11. How and by whom was the initial idea justified in order to be included in the country/state/county or corporate investment program?
    a. Should it be in the program at this stage? If so, why?
    b. If it should not be, why not?

12. Were the prefeasibility studies done?

13. How clearly and explicitly were the purposes and goals of the project stated or defined?
    a. Were the major potential problems also identified at this time?
    b. Were the time constraints, and budget limitations and quality of outputs taken into consideration?

14. Was there a general commitment to the goals of the project by all of the constituencies in its design?
    a. Whose political, administrative, technical, and financial support could initially be counted upon?
    b. What resource did these supporters have?
    c. What conflicts arose and how were they settled? What were the compromises made?

4.3.1.2 Feasibility Analysis and Appraisal

1. How extensive was the preliminary design?
    a. Who prepared it? What is the background information on the company or group that prepared the preliminary design?
    b. How reliable were the assumptions and supporting documents?

2. Was a formal feasibility analysis conducted?

3. Who conducted it?
    a. Was it a national organization, an international assistance agency, a consulting team, or a combination of all of these? Or is it

within the project development group of the corporate or regional headquarters?
   b. What were the key qualifications of the key persons involved?

4. How comprehensive and detailed were:
   a. The technical feasibility studies (project location and layout, subsurface conditions and problem areas, technology needs, availability of construction and raw materials, provision for environmental impact requirements, availability and training of technical personnel, and other areas of concern)?
   b. The financial feasibility analyses (investment analysis, projected capital needs at various stages)?
   c. The economic feasibility analyses (regional/corporate economic benefits, cost-benefit studies of alternative designs, effect on employment and cultural diversity in the project area)?
   d. The market and commercial/industrial feasibility of the corporate project, or as appropriate for a public sector project?
   e. The administrative, organizational, and managerial studies?
   f. The environmental baseline studies?
   g. If need be, the environmental impact studies (estimated impact and mitigation involved in the project)?
   h. The social and political impact studies?

5. Did the studies reveal any weaknesses in the project that might affect future operations?
   a. If so, what were these weaknesses?
   b. How were these weaknesses addressed?
   c. Any provisions to prevent such weaknesses from recurring?

6. What appraisal criteria were used?
   a. Who had authority for the appraisal?
   b. Were the appraisers trained?

7. What procedures were used during the appraisal process?
   a. How many stages did it go through?
   b. How extensive and intensive were they?

8. Did the appraisers and reviewers make an on-site inspection?

9. Were there any reservations about the overall ability of the project to succeed?

a. If so, what were these reservations? Who made these reservations?
b. Were there any problems that other appraisers foresaw that were not included in the final appraisal?
c. If so, what were the problems and why were they not included?

10. How were uncertainties and gaps in the reliable estimates or projections affecting project appraisal dealt with?

4.3.1.3 Design

1. What were the major sources of data or information used in designing the principal components of the project? How about the semi-major components?

2. How well did the project design reflect the initial and most important objectives and targets of the project idea?

3. How clearly and explicitly were the purposes and goals of the project defined and stated?
   a. Were the immediate goals distinguished from longer-range goals?
   b. Were project objectives related to broader development studies?

4. Did the proposal include measurable targets for attaining objectives and specifications for the project's outputs?

5. Did the source of the project's identification influence how it was prepared and designed? If so, how?

6. What attempts were made to identify the potential project manager(s) and to involve him or her in reviewing both project plans and design?

7. Were the project's activities, functions, tasks, and components clearly identified and analyzed?

8. How many and what kind of design alternatives were considered and analyzed?
   a. How were these alternatives evaluated and chosen?
   b. Were relevant building and other codes satisfied?
   c. Were relevant environmental impact assessments and studies, including mitigation, made for each alternative?

9. Were preconditions or prerequisites of success considered during the design task? Were potential problems or bottlenecks to successful implementation identified?
10. Were potential social and cultural impacts of the project taken into consideration in its design?
    a. Were adverse effects identified?
    b. If so, how was the design modified?
11. Did the project design indicate an adequate mechanism for internal and external communication requirements?
12. Were links and relationships with complementary or competing projects examined?
13. In how much detail were plans, budgets, specifications, job descriptions, and work schedules prepared?
14. Were alternative organizational arrangements for project execution and operation considered? Were plans made for expanding the administrative and technical capacity of the potential project implementation unit?
15. Did the project organization maintain a balance, appropriate to the project task, between technical, administrative, and managerial persons and functions?
16. Were the different elements of the project design integrated into a coherent whole?
    a. Was there any one person or group responsible for this integration?
    b. If so, what were their qualifications?
17. Was a post-evaluation plan prepared, and were arrangements made for collecting baseline data for the various tasks?
    a. If so, what method was selected for the evaluation?
    b. Did it include checks on project goals, costs, quality, and schedule?
    c. Do the baseline data reflect *all* the feasibility studies as covered in Chapter 2?
    d. Are they sufficient to prepare a checklist for project implementation and control?

4.3.2 Phase 2: Selection, Approval, and Activation

4.3.2.1 Selection and Approval

1. What appraisal and selection criteria were used?
2. How many stages of review were necessary before reaching final selection and approval? Who participated in the review, selection, and approval processes?
3. Did these stages involve:
   a. Obtaining legislative and/or policy change authorization?
   b. Obtaining executive and/or corporate approval?
   c. Confirming procedures for budget operation, human resources management, and interagency and interbranch operation?
4. Did any changes occur in the project environment since the time of the feasibility study that affected project approval?
5. How long did the appraisal, selection, negotiation, and approval processes take?
6. What major factors such as political, social, technical, economic, administrative and managerial, environmental and others were considered that influenced decisions at each stage of the review?
7. How were the uncertainties and gaps in the reliable estimates of projections affecting project appraisal and selection dealt with?
8. Was the proposal in competition with or complementary to others? If so, was the project appraised and evaluated comparatively with these others?
9. Which of the following criteria were used in the selection?
   a. Linkage with national or local programs, or in the case of corporate projects, linkage with other units and products in the corporation?
   b. Accelerating the pace of economic and social progress in the area, or profitability of the corporation, or advancing the frontiers of competition against other products?
   c. Availability of manpower, natural resources, and raw materials?
   d. Priorities dictated by political pressures, corporate culture, or competitive positioning?
   e. Quality, cost, and duration?
   f. Other criteria? If so, list.

10. From what sources was the project to be funded? Internal resources? Loans from funding organizations — corporate, national, or international, and other sources?

11. Who was involved in the negotiation of loans, grants, or other forms of funding for the project?
    a. What were the major issues of negotiation?
    b. What were the positions of the negotiators?
    c. How were differences resolved?

12. Were constraints and conditions placed on the project's design or operation by the selection, approval, or funding authorities? Was the plan modified to conform to those conditions?

4.3.2.2 Activation

1. What criteria were used in choosing a project implementation unit or executing agency?

2. What variables influenced the choice of organizational structure?

3. What was the relationship between the project implementation unit and higher organizational authorities in terms of responsibilities and support?

4. Who was included in the project team?
    a. Were they relieved of their previous responsibilities temporarily or permanently?
    b. Were they included on a part-time or full-time basis?
    c. What were their qualifications?

5. What criteria were used in selecting personnel for the project team? In selecting the project manager?
    a. What recruitment methods were used?
    b. What inducements were provided?

6. Were the project leader and the project team given their job responsibilities clearly? Were they given orientation or a period of retraining?

7. What working contracts and activation documents were used? Who prepared them?

8. Were adequate information and control systems provided at the activation phase? If not, why not?

9. How was the project organized internally with regard to:
   a. Work and task division?
   b. Authority, responsibility, and supervision?
   c. Communication channels among divisions and supporting organizations?
   d. Relationships between technical, managerial, and supporting organizations?
   e. Resource procurement and allocation?
   f. Monitoring and reporting?
10. What types of systems or procedures were established for bidding and contracting?
11. What were the major sources of the following project inputs?
   a. Financial resources?
   b. Materials, supplies, equipment, and facilities?
   c. Manpower?
   d. Political/corporate support?
   e. Technology?
   f. Public participation?
12. Were detailed and realistic project operation plans formulated for:
   a. Budgeting?
   b. Recruitment and training of personnel?
   c. Data collection?
   d. Work and activity scheduling?

4.3.3 Phase 3: Operation, Control, and Handover

4.3.3.1 Implementation

1. How were work activities and project tasks scheduled?
   a. Did the project management team make use of such techniques as CPM or PERT analysis, and other advanced computer-aided techniques?
   b. What technique was used, and why was it selected?
2. Was there an adequate management information system?
3. Did it define:
   a. Information requirements?
   b. Sources of information?
   c. Systematic procedures and organizations for collecting data?

d. A coordinated design to integrate internal and external project activities?

4. Were feedback channels and feedback elements identified?
   a. Was adequate use made of these channels?
   b. Was adequate use made of the information received from these channels?

5. Were formal problem-solving or troubleshooting procedures established?

6. What arrangements were made for coordination of project activities with supporters, suppliers, clients, other corporate branches, and the public?

7. What was the leadership style of the project manager during the implementation phase? Could it be characterized as:
   a. Management by control? A management approach involving authority and responsibility to oversee and coordinate all phases in the project cycle in order to ensure that project goals are met on both budget and schedule.
   b. Management by objectives? A management approach according to which performance is monitored by comparing actual outputs with initial goals and objectives.
   c. Management by exception? A management approach that focuses on problems in scheduling and actual progress (progress of the object is the primary concern).

8. Was the project redesigned or modified to meet unanticipated problems during implementation?

4.3.3.2 Supervision and Control

1. Were formal systems or procedures created to:
   a. Procure, inspect, and inventory at optimum levels raw materials and other resources?
   b. Ensure vigorous recruitment and optimum utilization of manpower and output?
   c. Monitor budget performance and cash flows; forecast changes in funding requirements?
   d. Inspect the various activities in implementation to ensure design requirements are met?
   e. Test and adapt transferred technology?

2. What methods were used to report progress and problems to higher authorities?
3. How were remedial actions initiated and performed when monitoring and control procedures indicated problems?
4. Did conflicts occur:
   a. Between technicians from different disciplines or specializations?
   b. Between administrators and technicians?
   c. Between project managers within the parent organization?
   d. Between the project implementation unit and other organizations?
5. Were periodic job meetings held to resolve any conflicts? If so, how often?

4.3.3.3 Completion and Handover

1. Were project completion reports prepared and reviewed?
2. Was a plan prepared either for replication or for the transition of a successful experimental, pilot, or demonstration project to full-scale operation?
3. What arrangements were made for diffusion of project outputs and results?
4. Were replicable components of the project identified?
5. Were arrangements made for follow-up investment or multiphase funding?
6. Were extension or technical assistance services created to assist clients or users in adapting project outputs and results?
7. Were procedures and methods of handover to an ongoing organization well established?
   a. Were they complied with?
   b. If not, why not?
8. What kinds of arrangements were made to transfer unutilized or excess resources (human, financial, physical, and technical) from the project at completion to other projects or organizations?

9. What arrangements were made for the transfer or disposition of the capital assets of the project?
10. What arrangements were made for credit or loan repayment?
11. Would levels of outside funding change considerably upon handover to an ongoing organization?
12. Were project personnel reassigned to new duties at the project's completion?
13. Did the handover mean that new persons took over the project activities, or were the same persons transferred to a different setting within the organization?
14. What restructuring or modification was required of the receiving agency, institution, or implementing company?
15. What difficulties arose as a result of the transfer and handover:
    a. To the project team?
    b. To the receiving institutions?
    c. To the beneficiaries?
    d. To the funding agencies?

4.3.4 Phase 4: Evaluation and Refinement

4.3.4.1 Evaluation and Follow-Up

1. Was the need for the evaluation adequately perceived?
2. Were the objectives of the evaluation sufficiently clear?
3. What type of evaluation was decided upon? Was the focus to be on short-, medium-, or long-term effects/benefits of the project?
4. Were formal evaluation procedures established? Was an evaluation timetable set up?
5. What techniques were used in the evaluation (cost-benefit analysis, baseline measures, etc.)?
6. Who did the evaluation?
    a. Was it an individual or a team?

   b. If a team, was it composed of individuals independent and outside of the parent institution/holding corporation, or of individuals from within, or both?
   c. Why was this choice made?

7. What level of seniority did the evaluators have?

8. Were adequate background information and data provided for evaluation purposes?

9. Was the evaluation team provided with adequate administrative support?

10. What were the results of the evaluation?
    a. Were the intended benefits realized?
    b. If not, why not?

11. Was project efficiency measured using time schedule, budget, and performance output considerations? What were the major factors causing delay, cost overruns, and failure to meet project performance criteria?

12. Were variance analysis and other methods used to measure the difference between projected and actual results?

13. Did the evaluation consider the appropriateness of the following aspects of the project:
    a. Management information system?
    b. Level of technology?
    c. Operating design?
    d. Manpower capabilities?
    e. Organizational structures and flexibility?

14. Did the outcome of the project support the programmatic and policy goals for which the project was intended?

15. What was the overall impact of the project on the region and locality, sector, or corporation?

16. What was the prevailing attitude and reaction of the end-users at the start of the project?
    a. What was it at the end?
    b. Did they perceive the project objectives in the same way?

17. Did the evaluation identify unmet needs? Did the evaluation identify piggyback or follow-up projects?

18. Did the evaluation identify replicable components of the project?
    a. Did it identify the need for follow-up investment or multiphase funding?
    b. Did it detect unforeseen side effects of the project, whether fortunate or unfortunate?
19. Were formal evaluation reports prepared and presented?
    a. To which individuals or agencies were they given?
    b. When?
    c. How were they used?
20. Did the project teams see the reports or participate in their formulation or preparation?
    a. If so, what was the response?
    b. If not, why not?

4.3.4.2 Refinement of Policy and Planning

1. Were the results of the evaluation followed up?
    a. If so, by whom and how soon afterward?
    b. What were the results?
    c. If there was no follow-up, why not?
2. Did the evaluation results lead to the formulation of proposals for further projects? Did they lead to improvements or modifications of national, regional, or corporate policy?
3. What lessons and insights were gained from the project?
    a. Was there an analysis of the reason for deviations in implementation from the operating plan?
    b. Did the analysis reveal both long- and short-term lessons?
    c. What were they?
4. How can these lessons be applied to refine the project or future similar projects?
5. How can these lessons be applied to future policy decisions on project management?

As the foregoing list of questions demonstrates, the issues and factors affecting project planning and management are numerous and complex. To bring order out of this maze of diverse factors, the IPQMS organizes management tasks and issues into an integrated concept which views projects in their entirety from identification to follow-up and places them in a cohesive framework. This conceptual framework provides a comprehensive and balanced approach to planning and management, one that will result in total quality and cost effectiveness in all programs and projects.

4.4 SAMPLE PROPOSAL FOR CASE HISTORY

A sample of the form developed for IPQMS case proposals follows.

1. Proposed Title of Case History: ....
....

2. Author: ....
(Family) (First) (Title)

Address: ....
....
....

Present Position: ....
....

Qualifications: ....
....

Curriculum Vitae: Please attach C.V. to proposal, giving further details, particularly regarding positions held, list of publications, etc.

3. About the Case

Description of the case: Please attach a two- to four-page description of the case covering the various stages as outlined in the integrated planning and quality management system. Include in your description:

(a) The dates of the project: commencement and completion.

(b) Details of the stages of your case you consider would be especially important for teaching particular aspects of project management.

(c) The key organizational or management activities in the project which impressed you as being particularly significant.

(d) Organization Setting: Attach a one- to two-page description of the organizational setting of the case, including details of the project organization and project management personnel.

(e) Personal Involvement: State briefly any personal involvement you had in the case.

4. Source Materials

(a) Are the materials, documents, etc. needed for the case available for your use?

....

(b) What organizations have the materials?

....

....

(c) Is special permission required to use the materials? If so, please list those materials and how permission should be obtained.

....

....

....

....

5. Work Plan

(a) How long will it take you to write the first draft?

....

(b) When are you able to start writing the case?

....

(c) If your proposal is accepted, when do you expect to finalize the case?

....

Illustrations — Photos

(a) Do you propose to use illustrations (e.g., graphics, photos)?

(b) If you do, please estimate the number to be used.

Line drawings: ....

Photos (Black & White): ....

5 The Trans-Alaska Pipeline System (TAPS): Planning, Design, and Construction (1968–1977)*

5.1 BACKGROUND

Early in 1968, the Atlantic-Richfield Company (ARCO), which had been engaged in exploratory drilling on Alaska's North Slope, announced that its well had encountered a substantial flow of gas at 8500 feet (2591 meters). Further exploratory drilling confirmed that significant amounts of oil and gas were indeed present, and in a few months it became clear that reserves in the area represented the largest oil field ever discovered in the U.S. The site of the discovery, the Prudhoe Bay region on Alaska's Arctic Ocean coastline, is a remote area then accessible year round only by air and only briefly during the summer by ships. The magnitude of the field clearly made it a priority for development to the production stage, but, just as clearly, a major transportation system would have to be constructed before any oil could be sent to market.

The system ultimately chosen was a pipeline: an 800-mile (1287 kilometers) link from the arctic coast to the ice-free port of Valdez on the Gulf of Alaska. In Valdez, oil would be shipped by tankers to refineries or other pipelines on the U.S. west coast. In summary, the project would consist of three major components: the pipeline, which would cross three mountain ranges, the pump stations, and the marine terminal. The massiveness of the project was further complicated by both state and federal relationships and the Alaska construction cycle.

In Alaska, the federal influence has always been disproportionately great. Before statehood, all significant legal power in Alaska was held by the federal government. Federal employment, both military and civil, was a major source of income. When Alaska attained statehood in January 1959, the legal power

* Adapted from *The Trans-Alaska Pipeline*, a case history by George Geistauts and Vern Hauck (edited by L.J. Goodman and R.N. Love), Honolulu: East-West Center, Resource Systems Institute, 1979.

of Alaskans to control their state and their lives expanded substantially. However, the federal government still remained a major influence in Alaska, not only because it had increased its power throughout the U.S., but to a great extent because it retained title to almost all of the land in Alaska.

For the proposed pipeline, these power relationships had two implications: (1) the federal government would exert a major influence in authorizing pipeline construction and in establishing rules governing design, construction practices, and hiring; and (2) the state government would also exert authority and control over the project. Further, to the extent that state and federal interests differed, those building the pipeline would face contradictory pressures and demands. At the very least, duplication could be expected in the areas of project oversight controls and reporting requirements. Conflicts between these dual sources of authority could add to delays in construction and thus could increase management difficulties and ultimately raise costs.

In October 1968, ARCO, Humble, and British Petroleum (BP) formed the Trans-Alaska Pipeline System (TAPS) as an unincorporated joint venture. Since this organization was funded by and borrowed people from the sponsoring parent companies, the parent companies exerted control through a series of meetings and a number of committees. At this point, TAPS was more of an alliance than a tightly knit organization.

In November 1968, ARCO and Humble applied for land in Valdez for a terminal. By December, the feasibility studies were finished and the basic TAPS design concept had emerged. On February 10, 1969, ARCO, Humble, and BP formally announced their Alaska pipeline plan. Unlike some aspects of the detailed route and terminal location, which were still under study, the concept of a 48-inch (122 centimeters) diameter hot-oil pipeline approximately 800 miles long (1287 kilometers) clearly had been adopted. Initial capacity would be 500,000 barrels per day, rising to 1.2 million barrels by 1975, and finally to 2 million barrels by 1980. These increases in capacity would be made possible by adding more pump stations. Completion of the 500,000-barrel phase was expected by 1972 when the formal application for pipeline right-of-way and permission to build the necessary haul roads was submitted to the Bureau of Land Management (Alaska) in June 1969.

The Secretary of the Interior, Walter Hickel, outlined conditions for granting permits that indicated a long delay. Matters were further complicated by congressional passage of the National Environment Protection Act (NEPA) in December 1969 (approved January 1970). Indeed, the project was delayed four years because of environmental opposition, debate, legal actions, and Congressional action.

During the period of opposition and debate, TAPS had relatively little control of events and was essentially forced into a position of reacting. The original design plan had to be modified from one in which about 95 percent of the pipeline would be buried to one in which over one half (420 miles) would be above ground supported by expensive piling. Increasingly tighter stipulations proposed by the Interior Department further restricted Alyeska's* freedom of choice in design and construction practices.

5.2 THE ENVIRONMENT

The Trans-Alaska Pipeline System (TAPS) traverses the flat North Slope to enter the Brooks Range, where it climbs 4739 feet from sea level to crest Atigun Pass. It then descends to cross the wide Yukon River near Fairbanks, 450 miles from Prudhoe Bay. For the final 350 miles, TAPS passes through the Alaska Range at 3430 feet, descending and climbing again to top Thompson Pass at 2812 feet. It then drops down to Keystone Canyon and the terminal at Valdez. The pipeline route showing physical environment and wildlife is drawn in Figure 5.1.

5.2.1 Physical Environment

The State of Alaska includes 586,000 square miles (1,517,740 km^2), or over 375 million acres of land and inland water areas. Located in a semipolar region, 83 percent of it lying north of the 60th parallel and 27 percent north of the Arctic Circle, Alaska is far removed from the U.S. mainland.

Geographical features such as mountain ranges divide Alaska into several major regions, each with distinct geographic, climatological, and ecological features.

The region north of the Brooks Range (the North Slope) has a temperature range from 90°F to less than −60°F (32 to −51°C), with a mean annual temperature of 10 to 20°F (−12 to −7°C). Because of its very low precipitation, this area is referred to as an "arctic desert," even though the presence of permafrost (a condition in which, because of the short summer season, only the surface ground melts; underneath, the ground remains permanently frozen) prevents water from being absorbed into the ground and creates an ideal nesting area for waterfowl. The interior area south of the Brooks Range and north of the Alaska Range (which includes Mount McKinley, at 20,320 feet [6195 meters] the highest point in North America) has greater temper-

* Alyeska was the name given to the pipeline corporation (consortium of oil companies) in 1970.

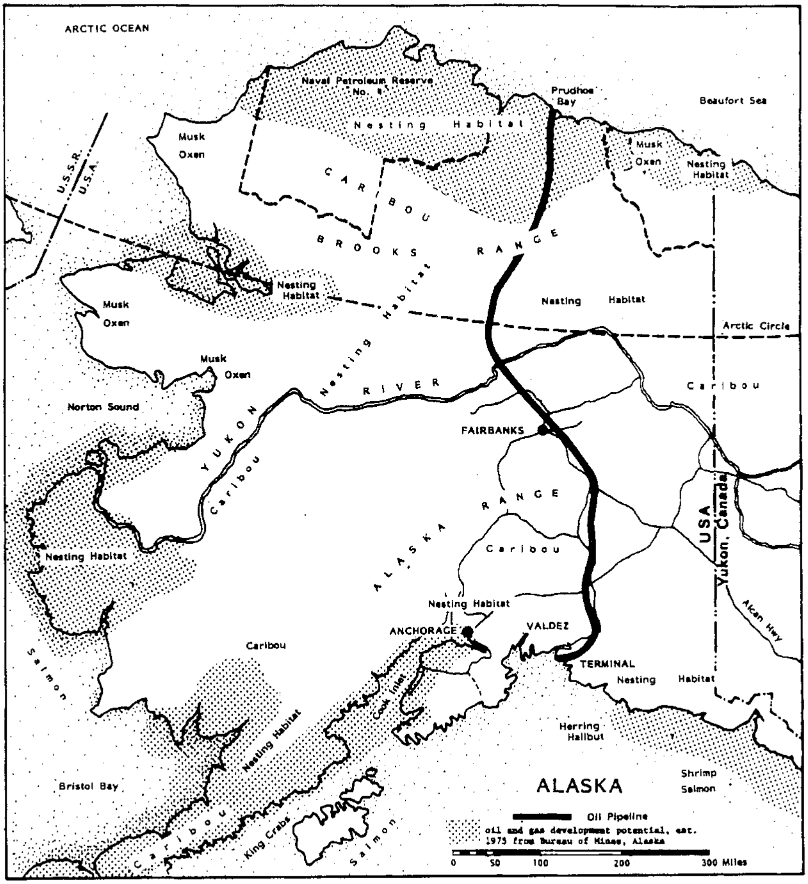

FIGURE 5.1 Pipeline route (showing the physical environment and wildlife of Alaska). (Compiled by East-West Resource Systems Institute staff.)

ature extremes, ranging from over 100°F to less than −70°F (38 to −57°C) and greater precipitation. The massive Yukon River winds its way through this region from its origins in Canada to the Bering Sea. This area includes Fairbanks, the state's second largest city.

The area south of the Alaska Range represents a transition to a maritime climate along the Gulf of Alaska's shoreline. Precipitation in this region is much higher and temperature changes are more moderate. All terminal sites that received serious consideration from TAPS were located in this maritime climate. Anchorage, the state's largest city, is located in this transition zone.

The state contains the 16 tallest mountains in the U.S., more than 120 million acres of lakes, approximately 11 million acres of glaciers, and 10,000 streams and rivers. From 50 to 90 rivers are considered by different sources to have recreational and wilderness values of national interest. Alaska has over 47,000 miles (75,639 kilometers) of tidal ocean shoreline.

Attracted by the scenery, camping, fishing, and hunting, visitors to Alaska enjoy the opportunity to experience the wilderness. The value of these resources cannot be measured solely in terms of revenue from this major industry in Alaska. The recreational opportunities and the wilderness experience are also very important to Alaskans themselves, since many moved to the state because of its wilderness character.

Alaska contains a number of minerals of national interest, including antimony, asbestos, chromium, copper, gold, iron, lead, and silver. Gold mining, an Alaska tradition, was responsible for the state's prosperity at the turn of the century, but gold now is produced on a relatively small scale. Alaska's energy-related resources include coal, uranium, a large number of hydroelectric sites, and significant geothermal potential. The most commercially exploitable resources are oil and gas. The TAPS could ultimately be expected to serve not only the Prudhoe Bay field but other northern fields as well, including offshore fields in that region.

Timber is a major harvestable resource in southeast Alaska but has minor commercial significance elsewhere. Finally, Alaska has been estimated to have great agricultural potential, even though the infrastructure to exploit it is not present and agricultural activities are of minor importance.

5.2.2 Wildlife

Because Alaska is a vast storehouse of natural resources, the state became a focal point in the battle between a development-oriented industry and environmentalists. Of particular significance to environmentalists (as well as indigenous Alaskans, fishermen, and others who utilized them for profit or for recreation) are resources such as fish, birds, and marine as well as terrestrial mammals, and a number of rare or endangered species (see Figure 5.1). Both pipeline and tankers would pass close to or through the habitats of much of this wildlife. While the oil companies assured everyone that environmental damage would be minimal, many of those outside the industry remained skeptical.

Traditionally, the primary renewable resource in Alaska has been fish. The salmon fishery, for example, is the major source of employment for many coastal communities. Additional coastal fishing resources include halibut, king crab, and shrimp. Inland fisheries are primarily sport oriented, although a number of rural-area residents depend on inland fish stocks for subsistence. An oil spill accident along the coastline or a massive leak from a pipeline in the interior, then, could endanger a substantial economic and recreational resource.

Alaska provides 70 million acres (28,329,000 hectares) of the breeding habitat for 20 percent of all North American waterfowl (see Figure 5.1), which are an important source of food to Alaskans and an important game for recreational hunters throughout the U.S.. Alaska's coastline provides a feeding and breeding habitat for 27 species of marine mammals, including whales, walrus, seals, sea lions, and sea otters.

Alaska also is the home of polar bears, caribou, moose, black and brown bears, sheep, musk oxen, and many small fur bearers. Polar bears (which were declining alarmingly just a few years ago, but which have since recovered under a hunting prohibition) are found along the northern and northwestern Arctic coast. Caribou are found throughout most of the state, especially in the Arctic areas. It was felt that the caribou's migration pattern might be altered by the disruption caused by the pipeline construction or even by its mere presence. Such a disruption might mean a drastic reduction in herd size.

5.2.3 Valdez and Prince William Sound

Prince William Sound is one of the most pristine and magnificent natural areas in the country. It is an area of great natural beauty, and its rich natural resources form the basis for major commercial fisheries for pink and chum salmon and Pacific herring. There are many smaller family-owned fisheries for halibut, sable fish, crab and shrimp. Thus, the sound is the major food source for the Alaskan Native villages on its shore.

Chugach National Forest in the sound and Kenai Fjords National Park are not far from Anchorage, making the area a favorite location for recreational users. The area is the habitat and/or nesting sites for many species of marine mammals and birds, both shore birds and waterfowl.

Thus, environmentalists began to express concern about the operations of the Valdez Marine Terminal and the oil tanker shipments as early as 1971–1972. Port Valdez is an ice-free terminal, and estimated oil tanker shipments were predicted to average at least 12 each week.

5.3 PHASE 1: PLANNING, APPRAISAL, AND DESIGN

5.3.1 Identification and Formulation

This has been covered above in Section 5.1.

5.3.2 Preliminary Design: Feasibility Studies

The preliminary route selection was based on a combination of soil borings, soil temperature readings, air temperature data, geological studies, and aerial photographic interpretations. A right-of-way 100 feet in width was recommended for construction purposes for both pipeline excavation and haul road construction.

A formal application was filed by TAPS with the Office of the State Director, Bureau of Land Management, Anchorage, on June 6, 1969, for the pipeline right-of-way.[1] The application included the need for 11 pumping station easements, each 1200 by 1600 feet. Air strips of approximately 200 by 5000 feet were requested for stations 3 and 4. The rationale for the preliminary design selection is best summarized in the following excerpt from the application:

> One of the prime considerations in selecting the route applied for herein was an in-depth analysis of soil conditions to insure a pipeline location providing maximum physical stability, maximum burial of the pipeline, and minimum disturbance of the natural environment. Extensive field examination in conjunction with ground-proofed aerial photographic interpretation was used in plotting the pipeline and construction road right-of-way alignment.
>
> There are numerous special studies in progress to determine the best method of handling the Ecological, Archaeological and Conservation problems that will be encountered during and after the construction of the pipeline and road. Results of these studies will establish procedures to be used to meet all requirements of minimum changes to the terrain.[2]

In summary, the TAPS proposal was for a 48-inch (122-centimeters) diameter hot-oil pipeline which would be buried for over 90 percent of its 800-mile (1287-kilometer) length. The initial capacity would be 500,000 barrels a day, rising in stages to 2 million barrels a day. Approximately 641 miles (1031 kilometers) of the line would be across federal lands, with completion expected some time in 1972. The application also requested a right-of-way and permit to build a haul road of slightly less than 400 miles (644 kilometers) to support construction.

At this time, a "land freeze" moratorium on the disposition of federal lands in Alaska pending resolution of indigenous Alaskans' claims was in effect, but the TAPS owners nevertheless hoped for quick approval. In their view, permits would be granted in July 1969, and construction would follow shortly thereafter. TAPS had already made a substantial financial commitment to the pipeline by ordering 500,000 tons of 48-inch (122-centimeter) pipe for U.S. $100 million from three Japanese companies earlier in the year. An additional U.S. $30 million order had also been placed for several of the giant pumps required to move the oil. ARCO's commitment already included a decision to build a new refinery at Cherry Point, Washington, to handle North Slope crude oil. (In September 1969, ARCO placed an order with the Bethlehem Steel Company for three new 120,000 dead-weight ton tankers.)

Prior to approval of the pipeline system and route, a series of debates took place between supporters and opponents in 1968 and 1969. Those who supported the project included:

- The oil industry, which had a resource but no way to reach a market.
- The State of Alaska, particularly through its government, which would derive substantial economic benefits from royal revenues and severance taxes (the state, in effect, owns 25 percent of Prudhoe Bay oil).
- Local state businesses and governments, which would benefit from increased economic activity and an increased tax base.
- Economically and defense-oriented federal government agencies, for whom economic growth, reduced balance-of-payments deficits, and energy independence were of prime importance.

Those who opposed the design choice included:

- The environmentalists, who feared irreparable damage to the environment from both the TAPS project and subsequent development.
- Federal agencies charged with preserving environmental quality.
- Some members of Congress, who either supported environmentalists or who preferred to have the oil diverted to the interior U.S., primarily the midwest.
- The indigenous Alaskans, who did not want to have land they were in the process of claiming crossed by a pipeline prior to the establishment of their claims.

Essentially, five basic alternatives emerged, apart from not developing the oil field at all. The alternatives were:

- The TAPS proposal of a combined system of pipeline and tankers, which would deliver oil to the U.S. west coast.
- A longer tanker route directly from Prudhoe, around Point Barrow, to the west coast.

- A sea route of almost 5000 miles (8045 kilometers) from Prudhoe through the Northwest Passage to the northeast.
- A railroad through Canada to the midwest.
- A trans-Canada pipeline to the midwest.

The alternatives that received most attention were the one across the northern portion of Alaska to the Canadian border, and from there through Canada, to link up with existing pipelines leading into either the midwestern or western states (alternative 5), and the original TAPS proposal (alternative 1).

Additional environmental feasibility studies, debates, and delays resulted when the National Environmental Policy Act of 1969 (NEPA) was approved on January 1, 1970. NEPA declared a national policy of encouraging productive and enjoyable harmony between man and his environment by promoting efforts to prevent or eliminate damage to the environment, as well as stimulating the health and welfare of man. An Environmental Quality Council was created to analyze environmental trends, appraise programs, and recommend national policies promoting improvement in the quality of the environment. Section 102 of the act outlined the specific requirements that any proposed action, including the pipeline project, would have to meet in terms delineating the environmental impact and providing for public comment. The act imposed environmental impact statement (EIS) requirements on all agencies and departments, including the Department of the Interior. Part C of Section 102 specifically required identification of adverse environmental impacts, consideration of alternatives, and public distribution of these documents.

5.3.3 Pipeline System Design

To ensure that TAPS did comply with the new standards of environmental integrity and to ensure that the project could cope with the arctic environment, technical solutions representing new pipeline technology had to be developed. The principal technical problems to be overcome were:

- Insulating the permafrost from the hot oil in order to keep the permafrost stable so that the pipeline would not settle or sink and rupture.
- Providing enough flexibility in the line to handle thermal expansion as the hot oil started to move.
- Providing a design to resist rupture in case of a severe earthquake.
- Providing rupture detection systems so that, in case of rupture, the line could be shut down before much oil spilled.

- Providing rupture control by means of oil containment provisions at the pump stations and the terminal.
- Reducing air emissions of hydrocarbons at the terminal to preserve ambient air quality.
- Preventing minor oil leaks or spills in the waters of Port Valdez and providing rapid cleanup capability if such spills occurred.
- Providing collision avoidance systems in Port Valdez, particularly in the approaches to Valdez Narrows, to prevent tanker collisions.
- Providing game crossing along the pipeline route without disrupting traditional game migration patterns.

The solutions to technical design problems included the following:

- Where the pipeline is buried in permafrost, the line is insulated and the permafrost is refrigerated by pumping cold brine through buried pipes.
- Expansion due to the passage of heated oil through aboveground pipe is compensated for by building the pipe in a zigzag configuration. This converts expansion into sideways movement.
- Where required, aboveground vertical support members (VSMs) are designed with thermal radiation devices to prevent heat transfer to the permafrost.
- All tanks where bulk oil is stored are surrounded by dikes to contain any spills in case of rupture.
- Ballast water is pumped to a settling and filtration system for purification before being discharged into the sea.
- A vapor recovery system at the terminal prevents oil vapors from escaping into the atmosphere.
- Computer-aided centralized control of the system is provided by a master control station in Valdez.
- Pressure deviations and flow variations are monitored to detect any ruptures or leaks in the line. Valve shutdown will contain most of the oil within the pipeline, and cleanup crews are on standby to deal with spills. The whole line can be shut down in 10 minutes. Check valves prevent reverse flow.
- The terminal facility is designed to withstand an earthquake registering 8.5 on the Richter scale. Storage tanks are surrounded by dikes.
- Stringent enforcement of the “rules of the road” by the Coast Guard in the Valdez Narrows and its approaches, utilizing control concepts analogous to air traffic control, is designed to minimize the possibility of grounding or collision.

In summary, TAPS called for construction of (1) a haul road, (2) the pipeline itself, (3) pumping stations, and (4) the Valdez terminal. However, was this the total system required to transport oil and gas to markets? Actually, only part of the problem was solved. The west coast could only absorb a limited amount of Alaskan crude oil for its own use, and the high sulfur content of Alaskan oil made it difficult to refine in the facilities existing in that region. But shipping oil east from the west coast would require connections to the pipeline systems in the interior of the U.S.

5.4 PHASE 2: SELECTION, APPROVAL, AND ACTIVATION

5.4.1 Selection

Evaluation of the alternatives and final selection did not take place as an orderly sequence of analysis and review under the supervision of any single agency or individual. The process that took place is best described as adversary rather than as analytic. Each group attempted to advance its views through a combination of purportedly objective studies designed to reinforce its arguments, public relations efforts, congressional lobbying, and legal test actions.

The actions of the Interior Department, which apparently favored the TAPS concept throughout the process, were designed to issue a permit as soon as possible, provided that the permit could be linked to a framework which would ensure a certain amount of protection for both the environment and the claims of indigenous Alaskans. The latter objective was met by passage of the Alaska Native Claims Settlement Act (ANCSA) in 1971. The Interior Department's way of ensuring environmental protection was to link the permit to a set of contractual stipulations which would govern construction, and adherence to which would be enforced by an on-the-scene "authorized officer" representing the department. The department also started to study a 12-mile wide transportation corridor along the proposed route, which would allow for some flexibility in response to conditions encountered during actual construction.

Despite the favorable attitude of the Interior Department, officially authorized construction in 1969 was relatively minor. Preliminary work on ground clearing at the Valdez terminal site was authorized by the Forest Service (the site lay in the Chugach National Forest). A short segment of the haul road connecting the south bank of the Yukon River to the end of the state highway system was authorized by the Interior Department.

The environmentalists adopted a number of tactics designed to prevent or slow down approval. Public relations tactics depended primarily on the use of the media to acquaint Americans with the potential dangers of the project and to mobilize citizen pressure on Congress. Lobbying and direct testimony at each of the several congressional hearings was used to try to influence members of Congress directly. However, the most effective delaying tactic for the environmentalists turned out to be the court suit.

In January 1970, the Secretary of the Interior issued a Public Land Order establishing a transportation corridor, which would presumably have been followed by the appropriate permits for the pipeline itself. Opponents and critics of the pipeline turned to the courts. In March and April 1970, several suits were filed in the federal courts by both indigenous Alaskan groups and environmental organizations. The three basic sources of legal grounds for challenging the TAPS plan were:

1. The 1920 Mineral Leasing Act, which specified that a pipeline right-of-way should consist of the ground necessary for the width of the pipe plus 25 feet (8 meters) on either side. TAPS required a 100-foot (30-meter) right-of-way. The Mineral Leasing Act provided a legal basis for those opposed to the pipeline to delay it through court challenge. (In reality, the extra width presented no problem in terms of land availability, but it did provide the technical grounds for challenge.)

2. The Alaska land freeze brought about by the claims of indigenous residents. Resolution of those claims was required before a permit would be granted.

3. NEPA, which became the primary basis for legal challenge to TAPS plans.

In April 1970, three environmentalist groups (the Wilderness Society, the Environmental Defense Fund, and the Friends of the Earth) petitioned in court to bar issuance of permits under provisions of NEPA and the Mineral Leasing Act. Initial arguments based on NEPA contended that an EIS had not been prepared, as required by law, and that opportunities for public input had not been sufficient. When the courts finally refused to accept the environmentalists' contention of noncompliance with NEPA, the environmentalists returned to the right-of-way width issue as a legal basis of argument. On this issue the courts upheld their position, and the Interior Department was not allowed to issue the requisite permits. The Trans-Alaska Pipeline Authorization Act finally removed this barrier.

Indigenous Alaskan groups at first had thought that the TAPS project would offer them jobs, and several villages had signed waivers allowing

TAPS to cross the lands they were in the process of claiming in return for a promise of jobs on the project. However, when TAPS announced the first awards of contracts, indigenous businesses failed to get even a single contract and disillusionment set in. The villages withdrew the waivers and instituted a law suit. For a period of time the environmentalists and indigenous residents were allies, but as the oil company lobbyists interceded on behalf of interests in Congress, the alliance weakened. The passage of ANCSA destroyed the basis for large-scale indigenous opposition, while the provision of the act which created profit-seeking indigenous regional corporations also created a powerful incentive for indigenous residents to support economic growth and development in Alaska. Over a period of time, local residents would assume ownership of 44 million acres of land, some of which would have oil and gas potential. A pipeline would also be required to transport their oil. ANCSA also removed the original basis for the land freeze in Alaska.

During this period of opposition and debate, TAPS (which was reorganized and incorporated as the Alyeska Pipeline Service Company [Alyeska] in 1970) had relatively little control of events and was forced into essentially a position of reaction. *The original design plan had to be modified from one in which about 95 percent of the pipeline would be buried to one in which only about half would be buried.* Increasingly tighter stipulations proposed by the Interior Department further restricted Alyeska's freedom of choice in design and construction practices.

The State of Alaska suggested its own solutions: first, by proposing to build the haul road itself, and second, by suggesting that the state take over the pipeline's financing in an effort to increase the state's own assets. Both concepts were rejected by Alyeska, which was now estimating project costs at U.S. $3 billion or more.

Major discussion about basic alternatives quickly began to focus on the two fundamental possibilities: the TAPS proposal and the trans-Canada alternative. Although a complete tanker system and a railroad system continued to be advocated by some, these systems never generated sufficient support to become serious contenders. Transportation of oil directly by tanker from the North Slope presented the massive problems previously outlined. Although a basic decision to build a pipeline had already been reached by the oil companies, the experimental voyages of the specially constructed *S.S. Manhattan* are illustrative of the problems with a tanker system. The *Manhattan* was a reinforced tanker which Humble leased for a test voyage from the east coast to Prudhoe Bay through the Northwest Passage. Accompanied by an icebreaker, the *Manhattan* experienced much difficulty with the ice. Despite its special construction, it had to be freed from the ice on several occasions, and on the voyage back from Prudhoe, a projection of ice ripped a long gash in the hull.

Transportation by railroad would involve immense construction expense, with many of the environmental problems associated with a pipeline, as well as significant operating costs. The oil companies had briefly considered a railroad but quickly rejected this concept. (An Interstate Commerce Commission report in 1969 showed that the average railroad charge per ton-mile was five times as high as that for pipelines.) A variety of studies examined the cost and environmental characteristics of most major alternatives. Because each had to make economic and other assumptions in the analysis, the results were often contradictory and open to criticism.

5.4.2 Environmental Concerns

The oil companies were surprised that permits were not granted rapidly. After all, the economic benefits to the nation and to Alaska of developing the North Slope oil were obvious. While there would be some environmental damage as a result of construction, the oil companies were prepared to take steps they considered reasonable to minimize it. Besides, the damage would be limited to a very tiny proportion (about 0.01 percent) of Alaska. Hardly anyone lived there. In many of the foreign countries where oil companies operated, the authority for making this kind of decision would be clear and a rapid response could be expected. Even in the U.S., such decisions in the past had been made in a relatively straightforward manner.

TAPS, however, had underestimated the complexity of the situation. Environmentalists and many others were not ready to accept assurances by TAP that good pipeline design would automatically mean minimum environmental damage or to agree that all questions surrounding the TAPS project should be project specific. The TAPS proposal would be attacked as bad design, as environmentally undesirable, and as socially disruptive. The resulting debate would take four years.[3]

Opposition from the environmental movement became especially strong when those who placed a high value on environmental protection and preservation became aware of the proposed pipeline and its basic design.

In the view of environmentalists, major damage to the environment (both an esthetic heritage and the basis for subsistence economy for rural people) could occur through at least four distinct scenarios. First, poor construction practices and carelessness could pollute and scar the environment along the pipeline corridor. Because of Alaska's short growing season and the delicate character of the tundra in permafrost areas, recovery from local environmental damage would be a slow process at best. Stream siltation during construction and any oil spills that might occur could destroy the spawning grounds of anadromous fish. Second, since the proposed design called for burying the hot oil line in most areas where it crossed permafrost, the line would then be inadequately supported and subject to buckling or rupture. Third, the route of the line crossed areas of severe earthquake activity, and the terminus would be located in an area which had experienced a massive earthquake (8.5 on the Richter scale) in 1964. Thus, a severe earthquake which could rupture the line and the storage tanks could cause a massive oil spill. Finally, the oil would be transported from the terminal at Valdez to the U.S. west coast in large supertankers. En route the tankers would have to pass through several narrow channels where the possibility of grounding or collision, again in the view of the environmentalists, would be great.

To critics, it appeared that the TAPS concept had been chosen prematurely, without adequate consideration of alternatives, and that no permit should be granted until all alternatives had been fully investigated. The answers to the North Slope Task Force seemed to confirm that the design was based on partial data and that the design was itself incomplete. TAPS executives, however, pointed out that pipelines (unlike most projects) could be designed and built sequentially. Despite criticism from environmentalists, economists, and others concerned with both oil and impact, the oil companies (which could finance such a massive project) held unflinchingly to their first choice.

5.4.3 Approval

Over a period of time, the courts had considered the arguments of those opposing the pipeline and the counter arguments of those favoring it. On August 15, 1972, District Court Judge George L. Hart ruled that the legal requirements of NEPA had been met and that the Interior Department could deal with the right-of-way width problem by issuing special land use permits. However, an appeals court reversed that ruling because of the Interior Department's lack of authority to issue special permits. The U.S. Supreme Court then refused to review the appeals court decision. Thus, in 1973, the issue was back in Congress, which now alone had the power, in effect, to authorize the pipeline through special legislation.

Indications of an energy crisis were by now apparent to many in Congress. A number of bills were introduced by members, and the hearings process started once again. As an acceptable bill began to evolve, events in the Mideast dramatized the seriousness of the energy problem for the U.S.. The Trans-Alaska Pipeline Authorization Act of 1973 passed overwhelmingly in both houses of Congress. The way was clear for the issuance of the required permits, but the estimated cost of the pipeline had now climbed past $4 billion. In addition, the act provided for formal public agency involvement which would influence project construction, as noted in the Supervision and Control Task.[4]

5.4.4 Activation

In planning for implementation of the TAPS project, attention had to focus on the Alaskan construction cycle. The traditional construction cycle in Alaska begins in winter, when temperatures drop to −75°F (−59°C). In this viciously cold portion of the year, the Arctic tundra is frozen and its delicate surface is less likely to be damaged by the movement of the equipment. During the dead of winter, heavy equipment and materials are moved to construction sites across temporary snow roads and ice bridges made by compacting several layers of snow and ice on the top of frozen ground, river, and lake surfaces. The next step in the construction cycle begins in early spring. Warm weather by late March or early April allows workers to achieve normal productivity levels. Once begun in spring, work often continues around the clock either until the project is completed or the weather cools in the fall. Most construction not completed by late September or early October is abandoned until the following spring; winter construction normally is too costly. Significantly, projects that are even one month off schedule in October are potentially months behind. Work not finished by October must wait up to seven months, until the following April, to be completed.

Decision making on project organization, bidding and contracting, information and control systems, and resource procurement and allocation was handled by the Alyeska owner companies. The eight firms that controlled the pipeline venture comprised the owners' committee. The owners retained direct responsibility for setting overall project policy, acquiring capital, and sharing profits or losses. Agreement on project policy by the owners was a common prerequisite for major construction decisions and actions. For example, agreement between the owners was necessary before major contractual arrangements could be formalized by Alyeska, such as which construction management contractor (CMC) to hire. Contractual arrangements, however, were just one of hundreds of necessary policy making decisions, since almost every aspect of construction was touched by the owners. In short, since each owner company was a massively large employer in its owner right (ARCO, for example, had about 55,000 employees), it was able to use some of its own employees at every stage of the project to gain valuable information for decision making.

One of the more efficient information-gathering structures for owner decision making was the ad hoc subcommittee system, by which technical and expert advice flowed up the chain of command from the subcommittees and Alyeska. Then, once policy was made, the owners controlled the implementation process down the chain of command by allowing the ad hoc subcommittees to work with all levels of the organization.

Throughout the 1969–1973 debates, Alyeska was tireless in its promises to provide blue-ribbon environmental protection. At an oil spill conference in the nation's capital in 1973,[5] for example, Alyeska presented a paper that it reprinted for distribution. In that paper, the pipeline company described its ambitious environmental plans. Among the claims of that brochure that were never implemented:

- Tankers calling at Valdez would be no larger than 150,000 deadweight tons;
- The pipeline would be welded and inspected to national welding standards;
- The leak detection system would detect all but very small leaks;
- The entire pipeline could be shut down in five minutes;
- The oil spill contingency plan would be completed and tested one year before start-up.

With impending war in the Middle East threatening the U.S. oil supply, in July 1973 Congress ended the protracted environmental debate and authorized the construction of TAPS. The agreements contained stipulations that spelled out, in virtually identical language, stringent requirements addressing a wide variety of environmental concerns. These included contingency plans for oil spill response, a quality control program, and a requirement that every mainline field weld be X-rayed to ensure its adequacy. The legal arrangements also guaranteed that the construction of TAPS would be overseen by a large monitoring bureaucracy; they did not guarantee the effectiveness of that effort.

To build the pipeline in 1969 the owners formed the Trans-Alaska Pipeline System (TAPS) with personnel borrowed from the parent companies. To bring the project together, they formed a committee system with an eight-person Owners Management Committee and a three-person Project Management Committee. The duplicative committee structure resulted in what a spokesman for one owner called "organizated chaos".[4]

In an effort to create a more efficient arrangement, the owners incorporated Alyeska in August 1970.[4] The name "TAPS" stayed with the pipeline; so did the organizational problems. After all, the new corporation was only a shell with no history or experience. Much of its staff was on loan from the parent companies. To spend money to plan and build the pipeline, Alyeska still had to obtain approvals from the various owner committees.

Alyeska wanted to retain Bechtel Corporation as a supervisory planning contractor to plan the pipeline and roads portion, which was then thought to be the greater challenge. The owners refused. Instead, the owners mandated a limited planning assistance contract with Arctic Constructors, a construction consortium headed by Texas-based Brown and Root. In doing so, the owners ignored Alyeska's concern that Arctic Constructors lacked the resources for even the limited job the owners had authorized.

After Congress approved the project in 1973, the owners authorized Alyeska to enter into negotiations with Bechtel to develop plans for construction that included transportation, camps, contracting, and quality control. Alyeska did secure approval to retain Fluor Engineers and Constructors (Fluor) for terminal and pump station construction planning and management — then thought by Alyeska to be a more or less routine undertaking. Review of management communications confirms that the engineering and construction process Fluor supervised was chaotic. The extent of the problem became evident early in the project, as Fluor quickly discovered shortcomings in the engineering drawings and design data Alyeska provided. The West Tank Farm for oil storage had to be relocated and redesigned; piping and material specifications were inadequate. By May 1973 — five months after Fluor began work — cost of the preconstruction design and procurement phase of the contract was increased from $7 million to $17 million.

Throughout 1973 design work lagged behind schedule. Major components of this delay were the terminal's power plant and vapor recovery system (VRS). In mid-1973, design of these facilities was slated for completion by the middle of the next year; by November 1973, design completion was moved back to later in 1974. By June 1974, completion of terminal engineering design work was further delayed into 1976 — the year that terminal construction was supposed to be complete. Fluor required the extra time to complete terminal engineering because of "changes brought about by the Terminal Tank Farm redesign, reassessment of electrical work turned over by Alyeska which Fluor claimed was incomplete, and some omissions in Fluor's base estimate."

5.5 PHASE 3: OPERATION, CONTROL, AND HANDOVER

5.5.1 Implementation

5.5.1.1 Brief Overview

The builders of the Trans-Alaska pipeline tried to follow Alaska's traditional construction cycle. Snow roads and ice bridges were built following construction permit authorization in December 1973. Heavier equipment and materials were moved across the frozen arctic surface to construction camps between January and April 1974. Official construction commenced on April

29, 1974, in warmer weather. Workers and remaining materials were airlifted to construction zones after the snow and ice bridges had melted. The entire first portion of the construction plan — the haul road — was completed during the first construction season. Most of the other portions of the construction plan — the 800 miles (1287 kilometers) of pipe, the pump stations, and the marine terminal in Valdez — were completed during the 1975 and 1976 construction seasons. Some final construction was accomplished early in the 1977 season. Oil was introduced into the pipeline at Prudhoe Bay as scheduled on June 20, 1977.

The project's organization structure and manpower level tended to change with the flow of construction activity. In July 1974, the proportionate ownership of the pipeline changed; Sohio, ARCO, Exxon, and British Petroleum now owned 90 percent. During that same summer, the highest number of administrative and craft workers — approximately 3400 — were employed. Major portions of actual construction were completed during the 1975 and 1976 construction seasons. Employment levels reached 21,000 during the summers of 1975 and 1976, with approximately 26 million employee-hours totaled by craft workers in each construction season. In 1977, Alyeska began to demobilize itself as a construction company and shifted its organization structure to that of an operating company. The level of construction tapered off in 1977 to a total of less than 11,000 workers.

An example of the project's organization structure in 1975 is shown in Figure 5.2. Responsibility and authority for all construction rested at the top of the management pyramid. This meant that the relatively few firms at the head of the organization, such as Alyeska, supervised all portions of construction simultaneously. In contrast, each of the many firms at the middle and bottom levels of the organization had only limited responsibility and authority by contract for a portion of the haul road, the pipeline, the marine terminal, or the pump stations.

5.5.1.2 Construction of Haul Road

Private management's coordinated effort to build the haul road is indicative of the massive scale of the entire project. Some 358 miles (576 kilometers) of highly compacted and graded gravel surface road were constructed in the arctic wilderness, along with 39 bridges, 1029 culverts, 11 airports, and 135 mineral acquisition sites. Over 7000 employees attended the one-day orientation necessary for authorization to pass north through the Yukon River checkpoint; 3596 employees (including cooks, drivers, and janitors) made up the on-site support force for the equally large construction crews (tradesmen and supervisors), all of whom were warned not to disturb any of the area's wildlife.[4]

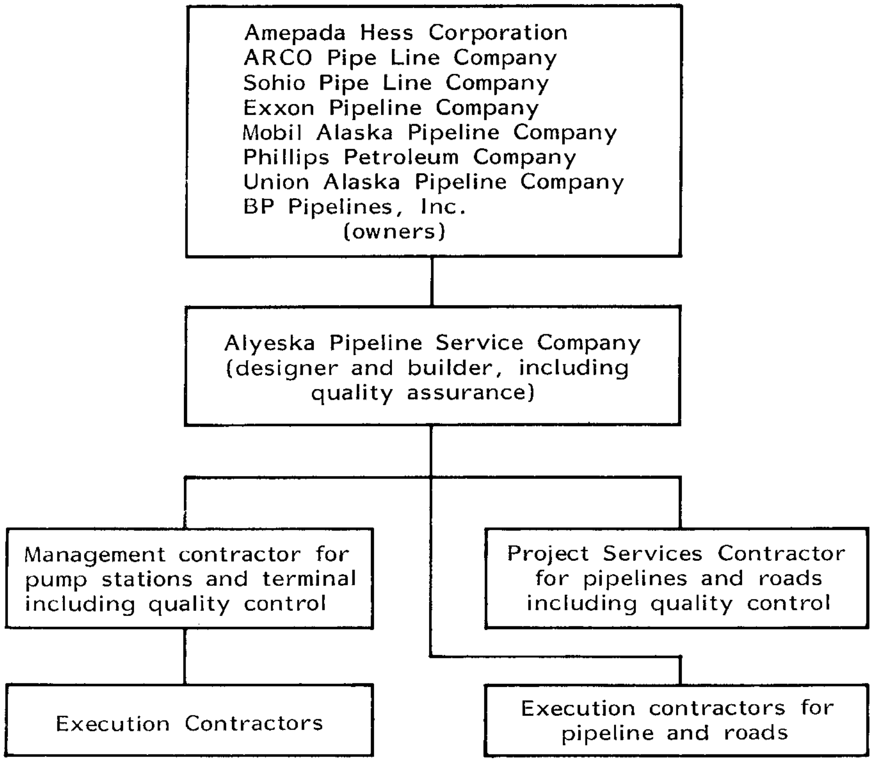

FIGURE 5.2 TAPS Project: revised organization structure (summer 1975). (From Trans-Alaska Oil Pipeline—Progress of Construction Through November 1975. Report to Congress by the U.S. Comptroller General, February 1976.)

Although Alyeska had exclusive use of the highway during pipeline construction, its ultimate ownership reverted to the State of Alaska. The haul road was begun at Livengood in May 1970 and was completed at Prudhoe Bay in September 1974. Because of complications and delays caused by competing interest groups (similar to those associated with all phases of construction), more than five years were required to design, gain approvals for, and complete a road that required only nine months of actual construction time. The road itself was divided into eight sections. Five construction contractors were assisted by 7 local contractors and regulated by at least 14 government agencies, including 8 federal agencies and 6 from the State of Alaska.

Within the first six-month period allowed by the traditional construction cycle, employees working on the haul road had to learn how to use the special arctic equipment, to understand the constantly changing land forms of Alaska (from arctic desert to the highest mountains in North America) and soil characteristics, and to construct the road across pristine wilderness.

Coordinating construction was complicated because Alyeska's corporate headquarters was maintained in Anchorage, but actual haul road construction headquarters were 355 miles (571 kilometers) to the north, in Fairbanks. In addition, no connecting roads or normal communication links existed. Coordinating haul road construction was further complicated by arctic weather and atmospheric conditions. Specifically, changing arctic weather patterns often delayed the delivery of airlifted workers, supplies, and equipment to construction points. Arctic atmospheric conditions are among the strangest in the world. Communication by voice radio is unreliable at best. In sum, the normal supervision and control methods for building the haul road, indeed all portions of the project upon which management relied, were thwarted by the size, geographic location, uniqueness, and complexity of the project.

5.5.1.3 Pipeline Construction

The scope of the Trans-Alaska pipeline project is massive by any standard. It is often described as the largest construction project undertaken by private industry in history. While such a claim is difficult to prove, it is probably fair to say that it is the largest construction project undertaken by contemporary private industry. The scope is vast for each of the four parts of the project's construction. In comparison, the work associated with the pipeline itself was probably greater than that of the other three parts of the project (haul road, pump stations, and marine terminal). Nearly 15,000 workers were assigned to pipe installation and related tasks during the summer peak in 1975 and 1976. The workers assigned to lay pipe worked on clearing the right-of-way, laying a gravel pad to protect the environment from damage by heavy equipment, or installing the pipe itself.

The first 1900 feet (579 meters) of pipeline was buried beneath the Tonsina River on March 27, 1975. Tractor-backhoes ditched the Tonsina to depths of 18 feet (5 meters) below the stream bed and up to 10 feet (3 meters) below the maximum scour depth of the river channel. Each 300-foot (90 meters) section of pipe was precoated with 9 inches (22.9 centimeters) of concrete to combat the buoyancy of the empty line. The cement coating, which weighed 80,000 pounds per 40 feet (12 meters) of pipe, anchored the pipe in its burial ditch. Tractors with side-mounted booms picked up the sections of pipe in webbed slings, holding the pipe for welding of additional sections to each end until the 1900-foot (579 meters) span was completed. As more pipe installation continued along the right-of-way, the realities of the Alaskan terrain began to cause engineering and design modifications. Alyeska engineers had detailed the pipe-laying work on a mile-by-mile basis from Prudhoe Bay to Valdez before construction began, but these plans had to be constantly changed. When crews drilled holes for vertical support members (VSMs), for example, subsurface soil conditions often caused the pipeline to be moved from one side of the right-of-way to the other; or, more expensively for Alyeska, portions of the pipeline planned for burial had to be elevated to avoid harm to the permafrost. But despite design changes, actual pipe laying moved quickly.

Pipe-laying activities forged ahead of other portions of the project during 1975 because pipe burial and installation did not require the extensive site preparation common to terminal and pump station construction. By 1977, however, pipe laying had slowed; three sections of the line were part of the last construction completed on the entire project. First, glacial soils in the original burial route and avalanche danger at the 4790-foot (1460 meters) Atigun Pass in the Brooks Range led to several route and design changes. An 8-square foot (2 m^2), 6000-foot long (1829 meters long) concrete box with the pipe inside in a 21-inch (53 centimeters) thickness of Styrofoam was built. This entire unit was then placed at a steep vertical angle along the side of the right-of-way crossing Atigun Pass.

At Keystone Canyon, Section 1, the pipeline had to be rerouted along the canyon's 4-mile (6 kilometers) lip because the highway prevented the laying of pipe on the canyon floor. At first, tracked vehicles such as bulldozers pulled materials and equipment up the canyon walls, but the rock faces proved too steep for drilling crews. Heavy equipment and materials were disassembled, flown to the top of the canyon, and reassembled above the rock face. Helicopters airlifted crews and materials to one of four canyon-top staging areas where, when work resumed, portions of the pipe were laid along a 60 percent grade. At the 2500-foot (762 meters) Thompson Pass, Section 1, crews were faced with several miles with 45° slopes. Since the pipeline route followed an almost vertical grade, heavy equipment was anchored to the slopes by cables; in fact, the pipe itself was winched up the side of the pass with a cable tramway system. Welders lashed to the pipe to keep their footing worked the entire 1976 construction season to complete the job. Not surprisingly, the last portion of pipe to be laid was at Thompson Pass.

The contractors (ECs) for the pipeline were Morrison-Knudsen (145.24 miles); Perini Arctic Assoc. (148.89 miles); H. C. Price Co. (151.84 miles); Assoc. Green (127.34 miles); and Arctic Constructors (222.17 miles).

5.5.1.4 Construction of the Marine Terminal and Pump Stations

Responsibility for the marine terminal in Valdez and the initial eight pump stations was contracted to the Fluor Corporation on December 21, 1972. Fluor completed most of the major planning and design work for its two portions of the project by July 1974, although some engineering changes occurred as late as the summer of 1977. Fluor's management activities are distinguished from those of the rest of the pipeline project by a number of important characteristics. First, since much of Fluor's work was performed indoors, crews worked all winter. Also, because the crews worked year round, workforce levels tended to remain relatively small. Fluor used 5000 to 6000 workers during the construction peak in the summers of 1975 and 1976. The construction crews at Pump Section 1, Prudhoe Bay, fluctuated between 270 and 430 workers between January and August 1976.

Fluor's management, however, did find its tasks to be more complicated than those on previous pipeline construction projects. Welding required extra ability because of the special chemistry of the low-temperature metallurgy. Unusual stress, snow loads, permafrost, earthquake safety requirements, and government monitoring stipulations combined to make the Alaska terminal facility and pump stations unique. Fluor supervised the terminal construction separately from the pump station construction.

5.5.2 Supervision and Control

Alyeska Pipeline and Service Company was responsible for overall project management, with Bechtel, Incorporated, and the Fluor Corporation as CMCs. Since the Alyeska Project Management (Alyeska) had responsibility and authority for construction, it implemented the policies set by the owners. Specific tasks performed by Alyeska to meet its responsibilities depended upon the stage of construction — from planning and engineering to building. When during planning, for example, several companies were interested in becoming CMCs, Alyeska reviewed their initial proposals and recommended to the owners which firms should be awarded contracts.

Alyeska's engineering tasks included the design of the pipeline (originally planned for burial over 90 percent of its length). The engineering team revised this original design almost continuously throughout the project, so that at completion approximately 52 percent of the pipeline was buried. Alyeska's building task was to supervise the firms doing the actual construction. As project manager, Alyeska did not wish to supervise on-site construction; it intended to audit and ensure fulfillment of contractual obligations by the CMCs.

Among the other responsibilities delegated to Alyeska were preparation, revision, and control of the project budget. Constant revisions were necessary in order to maintain control of the budget because it escalated from U.S. $900 million initially to U.S. $4.5 billion in 1974, to U.S. $6.5 billion in 1975, to U.S. $7 billion in 1976, to U.S. $8 billion in 1977, and growing. Estimates attribute approximately 50 percent of these budget revisions to inflationary pressure, 30 percent to environment requirements, and 20 percent to other items such as design changes or changes in engineering standards imposed by reviewing government agencies.

In addition to these more usual management duties, Alyeska provided a focal point for extensive government regulatory activity. Government agencies found it easier to go directly to Alyeska rather than to deal with each owner individually. Acting in this capacity, Alyeska satisfied environmental protection regulations by providing a steady stream of reports concerning the impact on the approximately 30,000 acres (12,141 hectares) of land disturbed by construction. Government agencies required Alyeska to make reports regarding erosion control, construction-related oil spillage, sewage treatment standards at the construction camps, fair employment commitments, and damage to wildlife, for example. Alyeska was also responsible for public relations, including hosting government officials inspecting pipeline progress.

The CMC duties were divided. Bechtel was responsible for construction of the haul road and pipeline, and Fluor for the pump stations and marine terminal. Each CMC was given decision-making latitude within the boundaries of its specific tasks. However, Alyeska and the owners expected the CMCs to develop transportation plans for equipment to the job site, to plan construction camps, to set up policies and procedures to be followed by the execution contractors (ECs), to establish an organization for on-site quality inspection, to determine a method for strengthening control over the ECs, and to set up a procurement organization to achieve cost savings by buying needed supplies and equipment in bulk.[6]

The relationship between the CMCs and other members of the organization differed. On the one hand, Fluor worked in conjunction with Alyeska to design the pump stations and marine terminal. Accordingly, Fluor was intimately familiar with the engineering aspects of its tasks. Since much of the engineering design directly supervised by Fluor was then built by its own subsidiary, the Fluor Construction Company, rather than another EC, the transfer from design to finished product was much simpler on the Fluor-supervised portion of the project. In addition, Fluor's supervisory communication links were relatively simple because each of its tasks was centrally located. On the other hand, Bechtel did not work in conjunction with Alyeska to design the pipeline and haul road. Alyeska's engineering of both left

Bechtel to manage the actual building through a multitude of ECs. Since it was responsible for building the pipeline and haul road according to Alyeska's specifications, Bechtel, unlike Fluor, began its duties without intimate familiarity with the engineering aspects of its tasks. Thus, at first, Bechtel could not supervise as closely the work being done by its ECs. Also, unlike Fluor, Bechtel's supervisory communication links were relatively complex because its two tasks were spread out over 800 miles (1287 kilometers) of Alaskan wilderness. Bechtel's ability to supervise and control its portions of the project, therefore, was somewhat reduced.

Alyeska's management role was modified greatly by top-level management decisions. In practice, Alyeska's role became that of mediator among the various management levels in the organization. As already suggested, the opinions of the owners, their ad hoc subcommittees, and Alyeska differed.

Alyeska's project management team, as well as most of its internal organization, consisted of employees on loan from the owner companies. These employees had the management philosophy and style associated with their own companies. Consequently, Alyeska's organization encompassed every management approach from democratic to authoritarian; no particular management philosophy prevailed. In addition, Alyeska's employees generally did not have a career-oriented commitment to the firm.

In summary, supervision and control left much to be desired because of lack of coordination and cooperation in a complex project plagued by inadequate planning and a duplicative four-tiered management structure established by the owner companies: (1) the owners' committee, (2) Alyeska, (3) Bechtel (pipeline and haul road) and Fluor (pump stations and terminal), and (4) ECs.[7] The owners terminated Bechtel's employment in 1975, with Alyeska assuming responsibility as CMC.

Superimposed on this cumbersome and inefficient management structure was the public agency involvement at both federal and state levels. Public management was formally organized so that the federal authorizing officer, the state pipeline coordinator, and the Joint Fish and Wildlife Advisory Team did most of the monitoring. These three agents, along with several others, had the power to halt the project if construction activities violated the law.

5.5.3 Completion and Handover

To Alyeska, perhaps the final measure of the success of the project was the call for "oil in" at Prudhoe Bay in 1977. Start-up of Alaska's oil pipeline presented unique technical problems. The oil was hot and the pipeline was cold. The pipeline heated while the air cooled until the two reached the same temperature. The temperature difference at the beginning was great; the oil reached the pipeline at a temperature as high as 160°F (71°C); the pipeline's average temperature was 20°F (–7°C). The conventional method of starting a pipeline is to fill it with water in order to remove oxygen that could explode when mixed with hydrocarbons, place a separator called a "pig" in the line, and remove the water by moving crude oil through the line behind the separator. In Alaska, however, this method could not be used because the water would freeze. Rather than using water, the Alaska pipeline used nitrogen, which is an inert gas that cannot support combustion. The oil was put in the line and a ground party moved southward from Prudhoe Bay. The ground party inspected for oil leaks, checked clearances between shifting pipe and pipe supports, and looked to see that the vertical support members were able to accommodate the weight of the filled pipeline. For several weeks, crews continued to check and double-check for oil leaks and weight distortion.[3]

Oil spills along the pipeline are not desirable for anyone. Nonetheless, they are almost inevitable. The pipeline design included highly sensitive oil leak detection devices. Public management required workers to report all oil spills regardless of size. When oil leaked, Alyeska would advise the proper government regulatory agency. Apparently, four major oil spills occurred during construction.[8,9] First, an estimated 60,000 gallons of fuel leaked from a buried pipeline at Galbraith Lake. This was not discovered immediately because the holding tanks feeding the line were filled on a routine schedule and no control existed over the amount of fuel being consumed. Second, an explosion at Isabel Pass caused havoc in a fuel yard. Barrels of fuel were crushed by falling rock, and workers spent two days cleaning the areas, as well as bringing in new soil to cover the spill. Third, a tanker truck overturned at Chandalar, spilling 8500 gallons of fuel. A fourth spill of about 70,000 gallons occurred at Prudhoe Bay in January 1976. Fuel tanks were mistakenly topped off when the temperature was –50°F (–46°C). When the temperature rose to 60°F (15.5°C) in 12 hours, a valve burst and oil spilled on the tundra. The cause of the spill appears to have been a lack of understanding about the special weather conditions of the far north. Because so many possibilities exist for oil spills unrelated to the actual movement of oil through the pipeline, Alyeska trained and equipped an oil spill cleanup crew, which was kept on immediate standby.

For the most part, the pipeline start-up process was relatively smooth, with only a few minor problems typical of those encountered in the early stages of any massive system. There was one major exception, however. At Pump Station 8, a relatively minor problem of cleaning a strainer was compounded by human error (which itself may have been made possible by an inadequate fail-safe feature in design). The result was an explosion and a fire which destroyed the station, killed one man, and injured several others. The damage was estimated at tens of millions of dollars, and without the pressure of the pumps at Station 8, the pipeline had to be operated for months at a flow rate of 800,000 barrels per day — two thirds of the initial expected operating rate. The owner companies thus experienced a consequent loss of revenue.

Alyeska found itself with huge amounts of surplus construction equipment that had to be sold at the completion of the project. This sale, which took approximately two years to complete, was perhaps one of the largest surplus equipment sales ever recorded, save after major wars. Alyeska's list of over 20,000 items of used equipment had cost U.S. $800 million to purchase and included 240 cranes, 119 backhoes, 719 bulldozers, pipe layers and loaders, 1340 generators, 1357 trucks, 3315 other vehicles, and 1637 welding machines, as well as 1500 gas-heated outhouses, originally priced at $10,000 each. Aside from its size, this surplus sale is significant for the several hundred million dollars in revenue that it generated, which had to be deducted from the total construction costs.

The owner companies were guaranteed a reasonable rate of return on their investments based on the cost of building the pipeline. Similarly, the State of Alaska was to receive a royalty that could be affected by the cost of building the pipeline. Thus, both private and public management were concerned with the surplus-sale dollars. Private industry needed to dispose of the extra equipment. Public management needed to ensure that the surplus equipment brought a reasonable price because Alaska's royalties on Prudhoe Bay production would be reduced for years to come if the equipment was sold for too little.

The organization and construction work described previously evolved to build the Alaska pipeline. When construction of the project was completed during the summer of 1977, Alyeska was demobilized. In simplistic terms, Alyeska's construction company was dissolved and replaced by its operating company. All employment contracts were officially terminated, so that employees could return to their parent company or elect to stay in Alaska as part of Alyeska's operating company. The responsibility of the Alyeska construction company had been to build the Trans-Alaska pipeline. The responsibility of the Alyeska operating company is to operate and maintain the pipeline.

5.6 PHASE 4: EVALUATION AND REFINEMENT

5.6.1 Evaluation of Phases 1 to 3

Results and problems were analyzed in the framework of the integrated planning and quality management system (IPQMS).

5.6.1.1 IPQMS Phase 1

Phase 1 commenced in July 1968 with pipeline feasibility studies and continued through November 1973 with passage of the Trans-Alaska Pipeline Authorization Act. This formative or preconstruction phase was plagued by many legal challenges which delayed the start of construction. Unfortunately, the owners failed to take advantage of the lengthy delay to plan and design the pipeline, the pump stations, and the marine station in a systematic and thorough manner. The basic problem inherent in phase 1 and subsequent phases was one of mismanagement and indifference to project costs. The lack of adequate planning by the owners was exacerbated by their lack of understanding of the need for a *single* project management team to oversee the entire integrated project cycle.

Of particular concern in the feasibility studies was (1) inadequate geotechnical studies for later design and construction of the various structures, including the pipeline, and (2) lack of understanding of worker productivity, material procurement, and communication problems in the arctic environment. Indeed, there is no evidence that the feasibility studies seriously considered personnel needs to properly control and direct the project.

Inadequate design data were prepared for all components of TAPS. The consequent need to constantly revise designs during construction contributed greatly to the cost overruns. This was especially serious in the construction of the pipeline, pump stations, and marine terminal.

5.6.1.2 IPQMS Phase 2

One of the crucial problems of the TAPS project was that its organizational hierarchy and management structure were poorly conceived from the outset and were only marginally improved as the project progressed. Despite the ample time available to Alyeska and the owner companies prior to the start of construction, the available evidence shows inadequate planning and preparation for construction, as well as an ineffective management structure characterized by duplication and unclear lines of responsibility and authority.

Because of the confusing lines of management authority, the owners and Alyeska failed to establish (1) a project cost estimate plan and related control systems for implementation/expenditures and (2) viable contractor incentive plans for work in a difficult environment.

In addition, the management of TAPS failed to develop systems and procedures to ensure that construction equipment, material, and spare parts were purchased, delivered, and inventoried in a cost-effective manner. The result was an often chaotic situation. Execution contractors (ECs) desperately sought to requisition spare parts which were already located in their own warehouses. Because of inadequate warehouse space, equipment and material were often stored outdoors and became lost after the first snowfall. By the time the spring thaw came, much material had either been ruined by the weather or stolen.

Equally serious was the failure to provide sufficient labor camp facilities, a cost-effective food catering service, and an adequate communications system. Again, as a result of late planning, TAPS construction began without adequate housing, catering control, or communication facilities in place. As a result, not only did expenditures for these vital support functions far exceed expectations, but the housing and communications problems delayed construction. They also caused numerous adverse ripple effects.

In sum, making policy decisions critical to the success of phase 2 was clearly influenced by self-interest on the part of the owners, compounded by lack of understanding of the project's needs. Indeed, this attitude prevailed in all of the phases.

5.6.1.3 IPQMS Phase 3

It is readily apparent from the previous discussions that there were serious disputes among the owners, Alyeska, and Bechtel concerning the appropriate scheduling of design and manpower, as well as the basic contracting strategy to be pursued with the pipeline's ECs. For example, Bechtel strongly recommended negotiating of contracts with ECs at the earliest possible time to allow their involvement in planning for the road and pipeline construction schedule for 1974. When this strategy was arbitrarily rejected, Bechtel correctly predicted that the resulting loss of construction and planning time would produce substantial cost overruns.

The Bechtel-Alyeska-owners dispute reflects a more profound problem. The duplicative management structure developed by the owners led not only to excessive administrative costs but also to paralysis of management's decision-making process. Confusion pervaded all levels of the project while the ECs, labor, Bechtel, Alyeska, and the owners attempted unsuccessfully to sort out their relationships and responsibilities. There is irony in Alyeska's and Bechtel's assessment of the same problems and their diametrically opposed solutions. For example, while Bechtel was demanding increased compensation for additional personnel to correct alleged Alyeska errors, Alyeska was criticizing Bechtel for utilizing unnecessary personnel in handling contractual duties.

Another serious and highly publicized implementation problem was that of workers frequently idle at the job site (including sleeping on buses and sunbathing along the right-of-way). Alyeska's own documents show that the principal responsibility for idleness rested with management's poor supervision and utilization of the work force. Most of the workers were willing to work but lacked "adequate direction and support" from a disorganized project management.

The impact of late and inadequate design work affected all ECs. The three major components of construction — the pipeline, marine terminal, and pump stations — were adversely impacted. The results of these deficiencies included (1) numerous and costly delays as men and equipment awaited overdue engineering decisions, (2) problems with efficient work rescheduling as contractors tried to build around those areas for which they lacked sufficient engineering, and (3) in some instances, work that had to be redone because of inadequate engineering studies and deficient designs.

5.6.2 Refinement

The final task in the IPQMS is an evaluation of the three phases or the lessons learned from each completed project to provide a basis for refinement of the integrated project cycle. This task should provide useful insights for improving policy decisions, planning, design, and management of future projects. Geistauts and Hauck provide an interesting summary discussion of TAPS in the integrated project cycle framework.[11] Unfortunately, the oil companies and Alyeska did not perform this task.

A special study of construction costs was mandated by the Alaska Pipeline Commission. The resulting report concluded that over $1.5 billion were lost to waste, fraud, and mismanagement.[4]

5.7 LESSONS LEARNED

Many of the TAPS construction problems could have been avoided if the owners and their project management group (the Alyeska Pipeline Service Company) had recognized the importance of teamwork among owners, planners, designers, constructors, and managers of projects during the preconstruction period (1968–1973). This basic need relates directly to the priorities of the construction industry in particular and to all projects in all sectors in general. Thus, this need becomes the basic lesson, which can be applied to all problem areas ranging from the TAPS project to the Spacecraft Challenger disaster on January 28, 1986.

The second lesson is the need for a detailed checklist of questions to be prepared by the owners and their representative, Alyeska, preparatory to commencing the feasibility studies. The checklist could be adapted from the guidelines in Appendix B. Equally important, the checklist would ensure proper attention to the feasibility studies, which should become the basis for preliminary designs, technical and environmental alternatives, and the subsequent tasks in the IPQMS.

The third lesson is the overdue need for a data base for planning, designing, and constructing a variety of public works and private sector projects in different environments. For example, a data base containing case histories of projects such as the Distant Early Warning (DEW Line) System would have been invaluable for the owners and Alyeska in planning TAPS. Indeed, the development of a data base for public works projects that would include case histories of a representative cross section of projects, both successes and failures, would provide valuable lessons and insights for the planning and management of future projects in the dual interest of safety and cost effectiveness.

A fourth lesson is the need for detailed feasibility studies, which serve a multitude of purposes ranging from preliminary design refinement (for cost estimates and manpower/equipment needs) to development of necessary baseline data for ongoing evaluation of subsequent tasks and environmental impact (both short- and long-term). It is clear that such detailed information would have avoided the majority of design and construction problems encountered with TAPS.

Related to the first four lessons are the lessons learned regarding the need for project responsibility and accountability, which cut across proper planning and implementation of communications systems, material and equipment procurement systems, construction control systems (including management of labor/worker productivity), cost control systems, and so on.

In sum, the lessons learned from the TAPS project are profound and have many implications for both educators and practitioners — for educators because of the overdue need to include public policy, project planning, and project evaluation in engineering curricula, and for practitioners (consulting firms, for example) who must interact with educators in developing the badly needed data bases discussed earlier. The TAPS experience confirms repeatedly the many problems that can occur when there is no teamwork and no accountability. It further emphasizes the importance of IPQMS case histories for both educators and practitioners. It also confirms the inseparable process of going from planning to design and through completion.

Unfortunately, the oil companies and Alyeska did not learn from their mistakes in the planning, design, and construction of the pipeline system.[12] This becomes apparent in the operation of the system (Chapter 6).

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6 The Trans-Alaska Pipeline System (TAPS): Operations of the Pipeline (1977–1997)

6.1 BRIEF OVERVIEW

The Trans-Alaska Pipeline System began pumping oil June 20, 1977. The second postmortem was conducted in the context of the impact of the operation on public health, worker safety, and the environment.

The U.S. depends on TAPS to deliver nearly one out of every ten barrels of the oil this nation consumes daily. The pipeline transports approximately 1,500,000 barrels per day from Prudhoe Bay, on Alaska's North Slope, to the Valdez Marine Terminal (VMT), on Prince William Sound, 800 miles away.

TAPS is owned and operated by seven* major oil companies through their wholly owned subsidiary, the Alyeska Pipeline Service Co. (Alyeska). ARCO, British Petroleum (BP), and Exxon — three companies who control more than 90% of the crude oil produced from Alaska's North Slope bonanza — own a similar percentage of TAPS. In seeking permission to build what Alyeska called the largest privately financed construction project in the world, the developers promised that elaborate environmental safeguards would protect worker safety and minimize both the likelihood of, and damage to the environment from, oil spills.

Oil receipts from TAPS make up 80 to 85 percent of the state's revenue. This is an important factor in the context of the influence of the major oil companies in violating both state and federal laws pertaining to public health/safety and the environment. This blatant lack of accountability has been ongoing since 1977.

Alyeska did not learn any lessons from the extensive waste, fraud, and mismanagement that occurred during the design and construction of the pipeline system. Now responsible for the operation of the system, it began

* There were eight oil companies at the outset.

to violate the quality control procedures established to protect the integrity of the pipeline and the port. There were numerous violations of both state and federal laws that protect public health, safety, and the environment. Alyeska employees spoke quietly about these violations but did not blow the whistle for fear of losing their jobs.

This postmortem shows the influence of big money in the oil industry trying to silence whistleblowers from exposing numerous violations of state and federal laws pertaining to public health and safety and the environment. Of particular concern was the polluting of Prince William Sound with highly toxic hydrocarbons in the 1980s. It clearly demonstrates on-going problems of mismanagement and indifference on the part of the oil companies.

6.2 MONITORING TAPS

In IPQMS phase 1 (Chapter 5), the TAPS owners promised to protect the 800-mile corridor and the port area in order to receive approval for the project.[1] Indeed, Congress authorized prompt construction of the pipeline and directed the Secretary of the Interior and other appropriate federal agencies to administer various authorizations; the secretary also was given power to provide greater environmental protection by modifying the route during construction. Congress also stipulated that:

- Holders of the right-of-way would be liable, on a no-fault basis, for damages along or near the right-of-way except for damages caused by an act of war or by U.S. government negligence or by the damaged party. No-fault liability would be limited to U.S. $50 million for any one incident and would be in proportion to ownership interest; liability for damages beyond this amount could be pursued under the ordinary rules of negligence.
- Polluting activities by or on behalf of the holder of the right-of-way would have to be controlled and stopped at the holder's expense.
- The owner and operator of each vessel used to transport oil from the pipeline would be liable without regard to fault for all damages resulting from discharges of oil from each vessel.

During the construction of TAPS between 1974 and 1977, separate state and federal regimes approved plans for specific aspects of pipeline construction and then monitored that effort to ensure that the plans were executed as promised. During construction, the primary federal monitoring agency, the

Alaska Pipeline Office (APO) functioned as an independent unit in the Department of the Interior, monitoring pipeline plans and construction on federal land. Its state counterpart, the State Pipeline Coordinator's Office (SPCO), was nominally housed within the Alaska Department of Natural Resources (ADNR). The federal Environmental Protection Agency (EPA) and its state counterpart, the Alaska Department of Environmental Conservation (ADEC) had authority to ensure that construction complied with existing environmental laws. Fish and wildlife stipulations were monitored by a combined entity, the Joint Fish and Wildlife Advisory Team (JFWAT). Until mid-1975, when problems validating X-rays required for more than 50,000 field welds that tied the 800 mile pipeline together drew the federal Department of Transportation's Office of Pipeline Safety (OPS) into the picture, that agency played a negligible role in TAPS oversight; thereafter, the OPS role was narrowly defined and minimal.[2]

At best, quality control and oversight were lax until the *Exxon Valdez* incident in March 1989. In an attempt to improve the oversight,* the Joint Pipeline Office (JPO) was established in 1990. JPO is a collaborative effort of 11 state and federal agencies. Participating agencies with personnel at JPO included the following five state departments and/or agencies:

- Natural Resources
- Environmental Conservation
- Fish & Game
- Labor
- Division of Governmental Coordination

In addition, there are three federal agencies:

- Federal Bureau of Land Management
- Department of Transportation (Office of Pipeline Safety)
- Environmental Protection Agency

Participating agencies with no personnel located at JPO included:

- Alaska Department of Transportation and Public Facilities
- U.S. Coast Guard
- U.S. Army Corps of Engineers

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* The owners and Alyeska continued to be responsible for quality control.

In spite of the foregoing, violations of worker safety, public health, and the environment continued. Recently, disclosure was made of illegal hazardous waste disposal on Alaska's North Slope.[3]

6.3 THE WHISTLEBLOWERS

Who are the whistleblowers? They are mainly concerned professional people willing to put their careers and personal lives on the line to alert the public, the President, and the Congress about dangerous or illegal situations. They are the engineers who tried to warn of the deadly design flaw in the space shuttle Challenger. They are the engineers and scientists who continue to warn about the nuclear contamination of the environment from the Hanford Nuclear Reservation in the State of Washington. They are the scientists who exposed the fraudulent research on the multi-billion dollar Star Wars in the early 1990s. They are now referred to as ethical resisters who have blown the whistle against their powerful employers.[4] Regarding TAPS, they are the inspectors responsible for quality control of the operations of the pipeline and the marine terminal.

The inspectors had been reporting serious problems regarding worker safety and health, in addition to pollution of the environment. However, they were ignored by Alyeska and the oil companies. When they persisted, they were subjected to intimidation and harassment, and threatened with loss of jobs. The professional engineers responsible for quality control were following the National Society of Professional Engineers' Code of Ethics, Section II, Rules of Practice, which states:

> Engineers shall hold paramount the safety, health, and welfare of the public....If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.

When there is a collapse of ethics, there is an attendant collapse in accountability. In the case of the violations of state and federal laws by Alyeska, it took a non-engineer to publicly question lack of accountability.

In 1985, an independent oil industry broker finally blew the whistle on Alyeska. Chuck Hamel exposed the fact that Alyeska's tanker ballast wastewater treatment facility was polluting Prince William Sound with highly toxic hydrocarbons. This encouraged Alyeska employees to contact him with numerous other violations. However, the power and arrogance of the oil companies stalled government action for over five years.[5]

In 1990, Alyeska hired a security firm named Wackenhut to uncover Hamel's sources and recover documents he had obtained that verified environmental violations in Alaska and elsewhere. Wackenhut set up a phony "environmental legal services company" staffed by its own agents, who posed as environmentalists. The agents contacted Hamel, expressing interest in his work, and offering legal and financial support for his investigations. Meanwhile, the same agents were secretly intercepting his phone calls, videotaping his conversations, obtaining copies of his phone records and credit history, and stealing his trash and mail — all in an attempt to discover Hamel's sources.

The operation came to an abrupt end when Wackenhut agent Gus Castillo blew the whistle on the company's activities. Subsequent congressional hearings sponsored by Representative George Miller (D-CA), chairman of the House Natural Resources Committee, blew the sting operation wide open. Wackenhut agents "took the Fifth", refusing to testify on the grounds that their testimony could be self-incriminating. The committee's report issued in July 1992 found numerous violations of state and federal laws.

Hamel went to the Government Accountability Project (GAP)* in 1991 for legal assistance. With GAP assistance, Hamel filed a lawsuit against seven major oil companies, Alyeska, and the Wackenhut Corporation. The legal struggle leading up to the settlement in 1993 was heated. Hamel's lawyers were outnumbered ten to one and grossly out-spent as the defendants sank an estimated $15 million into the case. Yet after three weeks of hearings and arguments, the oil industry failed to convince Federal Judge Stanley Sporkin of the legality of its spy operation against Hamel.

In another noteworthy ruling, Judge Sporkin refused to order Hamel to turn over to Alyeska the names of his whistleblower contacts. The judge ruled that it would be wrong to allow the defendants to obtain whistleblower identities through the court. In delivering his far-reaching legal decision to protect whistleblowers, Judge Sporkin cited the book *The Whistleblowers* by Myron and Penina Glazer[4] and a 1987 federal court decision that GAP won against the federal government. In that case, the Justice Department under Ronald Reagan unsuccessfully sued GAP for the identities of whistleblowers who had confidentially provided GAP lawyer Billie Garde information about safety problems at the South Texas Nuclear Power Plant. Billie Garde was the lead attorney for Hamel.

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* The mission of the Government Accountability Project is to protect the public interest and promote government and corporate accountability. Founded in 1977, GAP is a non-profit organization based in Washington, D.C. It provides legal and advocacy assistance to concerned citizens who choose to "blow the whistle" on threats to public health and safety and the environment by both government and industry.

After extensive debate, the judge allowed Alyeska to obtain the names of Hamel's whistleblowers — as long as the company agreed to post a job protection bond covering the lifetime salaries of any of its employees who were identified as whistleblowers. Hamel was immediately besieged by calls from eager Alyeska employees who wanted to be placed on his list of sources — and not surprisingly, the defendants suddenly lost interest in the names.

In the end, Hamel and his attorneys proved that the truth is more powerful than big oil. According to settlement papers, no one won and no one lost, and the public is not supposed to know the amount of the settlement. Associated Press reports, however, have indicated that Hamel received a sizable settlement. Hamel's lead counsel, former GAP staff counsel Billie Garde and GAP outside counsel Mona Lyons, won excellent reviews for their courtroom performance from many observers, including the Judge.

In 1993, the Alyeska Pipeline Service Co. agreed to rehire a group of Trans-Alaska Pipeline safety inspectors who suffered systematic harassment and intimidation after reporting serious environmental and safety concerns on the pipeline. Two years later, the same inspectors — along with others who have since joined their ranks — were on their way back to court alleging more violations and reprisals.[6]

It is obvious that the power and influence of the oil companies is the controlling factor! However, the Government Accountability Project (GAP) continues to work with the oil industry whistleblowers to monitor and curb the abuses of the large oil corporations operating in Alaska. More recently, the Alaska Forum for Environmental Responsibility (formed in 1994) became involved. The Alaska Forum works with GAP, Public Employees for Environmental Responsibility (PEER), and numerous Alaskan organizations to protect Alaska's environment. The Alaska Forum has become a solid partner in GAP's efforts to assist pipeline employees who are trying to resolve employee quality and safety concerns, and end retaliation against whistleblowing employees.

In November 1993, employees of pipeline owners ARCO, British Petroleum, and Exxon testified before Congress about the deteriorating condition of the pipeline system and the pervasive atmosphere of intimidation facing those employees who raise safety and quality concerns. The November testimonies followed a July 1993 hearing, in which five inspectors detailed their wrongful termination, the total breakdown of the quality control program at Alyeska, and their concerns that Alyeska's attitude toward safety and quality problems could lead to a disaster.

A number of audits and reports have confirmed the whistleblowers' complaints. In 1993, the Bureau of Land Management hired the Quality Technology Company (QTC) to perform an audit of the pipeline's condition.

The QTC report confirmed the questionable state of the pipeline, and the existence of serious problems of harassment and intimidation. Another report authored by the Arthur D. Little Company found numerous deficiencies requiring repair, modification, and redesign in order to assure the pipeline's continued integrity. And a third study, by the Stone and Webster Company in early 1994, has identified numerous problems throughout the pipeline.[5] The company's auditors attempted to investigate the pipeline on the basis of the allegedly current design drawings and concluded that there was 100 percent noncompliance with configuration control of the pipeline. In other words, not a single drawing reviewed by the auditors, as maintained by Alyeska, represented the actual built and modified condition of the pipeline. In one startling example, the drawings incorrectly located the pipeline a mile off of its actual location.

The problems go beyond programmatic deficiencies. One regulator, the Joint Pipeline Office, identified almost 5000 problems. The company noted that some 100 of the items refer to structures, systems, and components that prevent significant harm to the health and safety of the public, significant harm to the environment, or significant loss of pipeline integrity.

For the employees who attempt to raise safety concerns, meanwhile, working on the pipeline has become a never-ending ordeal. In 1993, the Department of Labor ruled in favor of whistleblower Richard Green, and soon after Alyeska settled with other whistleblowers. When Alyeska proved clearly unwilling to rehire the whistleblowers — despite their eligibility and the Department of Labor ruling — the whistleblowers were forced to file another Department of Labor complaint. DOL ruled in their favor and ordered Alyeska to rehire them and pay them backpay. Alyeska appealed and requested an administrative hearing, which was scheduled for August 1995. The whistleblowers were represented by GAP attorneys Alene Anderson and Tom Carpenter, and cooperating attorneys Billie Garde of Hardy & John in Houston, and Thad Guyer of Medford, Oregon.

The manipulation of the hiring process has extended to contract inspectors. In 1993, Alyeska began to use the services of Arctic Slope Inspection Services (ASIS). In 1995, an ASIS manager testified that ASIS was being removed from its status as a preferred "Alliance Contractor" because the company had employees blowing the whistle on the pipeline. According to case testimony, an Alyeska vice president announced at an Alliance meeting that the reason ASIS was losing its status was because of its "personnel problems".

Alyeska has sealed the fate of the whistleblowers' employability in Alaska — at a high cost not only to the professional careers of dedicated employees but to the safety of the public and the environment. No other

Alliance Contractor will offer employment to a whistleblower out of fear that it too will lose its unique status if it is unable to silence those employees prepared to expose safety problems on the pipeline.

6.4 THE *EXXON VALDEZ* OIL SPILL

Shortly after midnight on March 24, 1989, the 987-foot tank vessel *Exxon Valdez* struck Bligh Reef in Prince William Sound, Alaska. What followed was the largest oil spill in U.S. history — over 10 million gallons of crude oil. The oil slick had spread over 3000 square miles and onto over 350 miles of beaches in Prince William Sound, one of the most pristine and magnificent natural areas in the country.[7]

The very large spill size, the remote location, and the character of the oil all tested spill preparedness and response capabilities. Government and industry plans, individually and collectively, proved to be wholly insufficient to control an oil spill of the magnitude of the *Exxon Valdez* incident. Initial industry efforts to get equipment on scene were unreasonably slow, and once deployed the equipment could not cope with the spill. Moreover, the various contingency plans did not refer to each other or establish a workable response command hierarchy. This resulted in confusion and delayed the cleanup.[8]

Once the *Exxon Valdez* spill occurred, a number of circumstances combined to complicate the response action. That the spill took place in a remote location complicated an expeditious and effective response. The sheer size of the spill, which was larger than contingency planning had anticipated, posed particular problems. The magnitude of the spill was beyond the physical capability of skimmers and booms currently being used in the U.S. Moreover, the first equipment to control the spill arrived on the scene over ten hours after the incident, after more than 10 million gallons of oil already were in the water.

A number of contingency plans were in place. Alyeska had a contingency plan. National, regional, and local plans mandated by federal regulation all had been developed. These contingency plans served as the basis for response actions. In the absence of realistic worst-case scenarios and without adequate booms and barges on hand to contain the spill, however, these plans were not effective.[9]

Investigations pointed to a change in oil tanker design from double hull construction to single hull in the interest of saving money. This change had been approved by the U.S. Coast Guard.

The oil had moved out of Prince William Sound into the Gulf of Alaska within three weeks after the spill. Immediate spill effects were most visible on marine birds and sea otters. Twenty-three species of marine mammals live in the sound and the Gulf of Alaska either year-round or during the summer. These mammals include gray, humpback, and killer whales, various porpoises and dolphins, harbor seals, sea lions, and sea otters. Of these animals, the sea otters are by far the most sensitive and vulnerable to spilled oil.

The bird population of Prince William Sound and the Kenai/Kodiak area is diverse and abundant. The Fish and Wildlife Service (FWS) counted more than 91,000 water birds (mostly diving ducks, grebes, and loons) in the sound immediately after the spill.[7] About half of these birds were in or near areas affected by floating oil. In addition, large numbers of waterfowl and shore-birds stop to feed in the Prince William Sound area and potentially could be exposed to the spilled oil. Many of these birds may be affected either directly by oil or indirectly through the loss of food sources. April also represents the beginning of the breeding season for many seabirds.

6.5 THE ALASKA FORUM FOR ENVIRONMENTAL RESPONSIBILITY

The Alaska Forum for Environmental Responsibility is the culmination of many years of struggle for environmental accountability on the Trans-Alaska Pipeline System. Its mission is to hold industry and government accountable to the public mandate to protect the environment and public health and safety, provide a safe and retaliation-free workplace, and achieve a diverse and sustainable economic future for all Alaskans.

The Alaska Forum began as a special project of the Government Accountability Project (GAP) in September 1994. GAP defends whistleblowers and advocates for their concerns through public education, legislative reform, and legal channels. In addition to GAP, the Alaska Forum also works closely with Public Employees for Environmental Responsibility (PEER), a group that works with public employees across the nation to promote environmental ethics and reform in government agencies. Jeff DeBonis, founder and Executive Director of PEER, serves on the Alaska Forum's Board of Directors. The Alaska Forum also has several founding members whose identity must remain anonymous to prevent harassment, intimidation, and reprisal by their employers.

The oil industry dominates Alaska. Nearly 25% of U.S. domestic crude oil flows through the Trans-Alaska Pipeline, and 85% of the state's operating revenues are generated by oil royalties. British Petroleum (BP), Exxon, and Atlantic Richfield (ARCO) — the Pipeline's majority owners — have taken advantage of Alaska's dependence on oil and physical remoteness to set standards of environmental care that are lower than in the rest of the nation and in many other developed countries. They have repeatedly violated promises they made in Congressional hearings and state and federal right-of-way leases to protect public health and the environment. Monitoring and compliance of pipeline operations have been thwarted by unreliable industrial self-monitoring and inadequate government oversight.

The Alaska Forum believes that conscientious government and industry employees are the first line of defense for protecting Alaska's environment. But without freedom from reprisals and the support of concerned citizens and citizen groups, the efforts of these workers are in vain. Therefore, the Alaska Forum works to unite citizens and citizen groups concerned about Alaska's environment and economic future with conscientious government and industry employees who speak out about activities that threaten to degrade Alaska's environment. By uniting these two allies, the Forum sends a message to industry, regulators, and elected officials that there is widespread public support for environmental accountability and responsible natural resource development in Alaska.

In September 1996, the Alaska Forum released Pipeline in Peril: A Status Report on the Trans-Alaska Pipeline, a detailed report on the host of problems that plague the pipeline.[10] From the regular occurrence of potentially serious incidents to lax government oversight to persistent reprisals against whistleblowers, the report provided ample evidence that all is not well on the pipeline. As Pipeline in Peril reports, "Alaska's environment is increasingly at risk as TAPS ages."

Since October 1996, several events have confirmed the findings of Pipeline in Peril. Examples include the following:

- Shortly after the report was released the public learned that lower oil throughout resulted in violent pipeline shaking near Thompson Pass. In combination with long known but not yet fixed deformities in the line in the same area, the shaking threatened pipeline integrity and the nearby Lowe River. Alyeska was slow to recognize and respond to these serious threats.
- In February 1997, a master's thesis by an Alyeska engineer demonstrated that Alyeska's oil spill contingency plan still did not meet industry standards. Eight years after the *Exxon Valdez* oil spill, this study called into question the company's ability to contain and control a pipeline spill.[11]
- Finally, in March 1977, an evaluation of Alyeska's employee concerns program revealed that the majority of pipeline workers still fear reprisals for speaking the truth about problems on the pipeline. Alyeska promised to end its "shoot the messenger" mentality over three years ago.

6.6 EVALUATION OF QUALITY CONTROL PROGRAMS

The evaluation of the first postmortem (Chapter 5) clearly demonstrated the lack of quality control for all phases. Thus, over $1.5 billion was lost to waste, fraud, and mismanagement.[12] It is now clear that Alyeska and the owners did not learn any lessons from Part One.

Despite Alyeska's repeated promises, the outlay of hundreds of millions of dollars and the oil industry's lavish public relations campaigns, this section presents evidence that Alyeska's efforts to refurbish the pipeline — and its image — do not ensure safe and reliable transport of the crude oil that TAPS carries. The findings demonstrate that Alyeska's current efforts are not sufficient to protect the environment of TAPS and the health and safety of its workers from the increased risks associated with the problems faced by the aging pipeline.

Indeed, Miller's MBA thesis (Reference 11) included a thorough investigation of TAPS crude oil leaks and spills from 1977 through 1993. He has worked for Alyeska as an engineer for over 20 years, overseeing oil spill response on the pipeline. Table 6.1 is a history of crude oil leaks from 1977 startup through 1993.

When a pipeline is not pumping oil it is not making money. Therefore, the incidence of shutdowns should serve as a warning that something is amiss, even though shutdowns should not be taken as an authoritative measure of the condition of a pipeline system. During the first 18 years since crude oil arrived at the Valdez Terminal on July 28, 1977, Alyeska listed 60 pipeline shutdowns.[10] An evaluation of these shutdowns is summarized as follows:

- A major portion of the line's reported stoppages and downtime occurred during the first two years of operations.
- In the 14.5 years between the halt to repair the Atigun Pass break in mid-1979 and the end of 1993, TAPS averaged about two shutdown incidents per year, resulting in line-wide pump idling for approximately 22 hours annually.
- In 1994 and 1995, the shutdown rate exceeded 8 per year, with 33 hours per year of down time. Both shutdown events and lost-time figures for 1994 and 1995 exceeded by large margins the average established between mid-1979 and the end of 1993.

The first significant oil loss from the pipeline in more than a decade — an estimated 476-barrel (20,000 gallon) spill — resulted from a problem in one of 42 buried pipeline check valves near Black Rapid Glacier, in central

TABLE 6.1
History of TAPS Crude Leaks: Number and Volume (1977 Pipeline Startup Through 1993)

Year	No.	Amount
1977	34	81,144, gal/1,932 bbls
1978	24	672,546 gal/16,013 bbls
1979	43	233,772 gal/5,566 bbls
1980	55	149,478 gal/3,559 bbls
1981	32	63,336 gal/1,508 bbls
1982	30	1,654 gal/39.4 bbls
1983	17	168 gal/4 bbls
1984	32	3,402 gal/81 bbls
1985	32	1,134 gal/27 bbls
1986	40	1,680 gal/1,982 bbls
1987	37	168 gal/4 bbls
1988	36	672 gal/16 bbls
1989	26	Ttl. amt. Unknown/tracking sys error
1990	28	245 gal/5.8 bbls
1991	55	460 gal/10.95 bbls
1992	54	805 gal/19.17 bbls
1993	67	363 gal/8.64 bbls

Data courtesy of Alaska Forum.

Alaska, April 20, 1996.[10] On February 6, 1996, TAPS monitors had written Alyeska a letter expressing concern over Alyeska's cancellation of a program to investigate problems with valves in the buried portion of the pipeline. Three weeks after the April 20 spill and three months after receiving the letter from the monitors, Alyeska was still trying to decide whether to accelerate a five-year schedule to investigate the extent of its — and Alaska's — problem with buried pipeline valves.[10]

The April 1996 spill was not an isolated incident. Rather, it was the most recent in a series of potentially serious and increasingly frequent operating problems that plague the aging oil delivery system. Throughout 1994 and 1995, TAPS experienced more than three potentially serious operating problems per month. Few of these problems caused oil spills and none caused contamination beyond the confines of the Alyeska right-of-way. However, these incidents caused Alyeska to shut down the 800-mile pipeline or a number of its huge pump station jet turbines on the average of once a month. While data are not available for earlier years,[10] it appears that operating problems on the 19-year-old pipeline are occurring with increasing frequency.

Despite the frequent occurrence of operating problems, Alyeska is initiating other actions that require sweeping changes to established operating procedures. These include the pipeline company's decision to shut down two pump stations during the summer of 1996 (followed, in all probability, by two more in 1997).[13,14] The station closings will alter pipeline flow scenarios, requiring workers to establish and learn new operating practices. These operational changes will be taking place while large-scale, line-wide personnel cuts continue.*

Introducing these major changes to a system that has experienced demonstrable difficulties fixing its existing problems can only add to the rocky history of the TAPS regulatory system. The Joint Pipeline Office (JPO), a collaborative effort of 11 state and federal oversight agencies, must become more accountable and responsible in ensuring safe pipeline operations, a safe workplace, and environmental protection.

6.7 LESSONS LEARNED

The single outstanding lesson learned from this postmortem is the need for scientific and engineering recommendations and decisions to be upheld by management, especially when quality control procedures to protect worker safety, public health, and the environment are involved. This is still not being done today, despite the first public disclosure of violations of both federal and state laws that mandate protection as far back as 1985. There is simply no accountability, which relates to the collapse of ethics.

It is clear that the influence of big business (oil industry) is instrumental in minimizing the necessary oversight and control by government regulatory agencies. There is need to introduce ethics and teamwork into all sectors of the economy and society. This is especially true in government and big business.

6.8 EPILOGUE

The *Exxon Valdez* oil spill of 1989 was an environmental disaster. Exxon was forced to pay $900 million by an Alaska state jury for partial restoration of the environment. Meanwhile, the oil company is appealing another $5.3

* Alyeska reduced its staff from 1352 people in October 1994 to 1053 by the end of 1995, with a target of 839 employees in 1999. (David Pritchard, 1995 Operating Plan [memorandum to Alyeska Employees, Oct. 17, 1994], 1; and Alyeska Pipeline Service Co., 1997 Business Plan and Long Range Plan, July 1, 1996, 62.)

billion awarded for the damage the oil spill did to fishermen and homeowners in the vicinity.

In 1991-1992, the Exxon Valdez Oil Spill Trustee Council was established to facilitate the restoration of the fish, seabirds, and marine mammals lost. The Trustee Council is a direct result of the State/Federal Natural Resources Assessment Plan for the Exxon Valdez Oil Spill that was created in August 1989. It seeks to establish a Restoration Reserve or savings account of $140 million by the year 2002. This will enable the Council to continue a long-term restoration program after Exxon's last payment from the $900 million settlement in 2001 (10-year payments).

The Trustee Council is conducting surveys and other monitoring of fish and wildlife in the spill region to determine population trends among the various species that were impacted. As of 1996, only the bald eagle population had rebounded to pre-spill numbers. The Council also determined that the extent of the oil spill was far more severe than previously estimated. Portions of 1500 miles of coastline were oiled, with areas still covered in 1997. Among the most affected marine life are the harbor seals and sea otters.

Another issue to be resolved is the on-going need for an oil spill plan that satisfies state and federal laws. These laws call for plan review and renewal every three years. Alyeska's last oil spill plan expired September 1, 1997. Since then, government regulators have extended Alyeska's now outdated plan four times. The Alaska Forum is striving for a strong plan that will correct the many weaknesses based on past experiences. A citizens advisory committee has been proposed by the Alaska Forum.

It is clear that the oil companies and Alyeska have not learned any lessons from past mistakes. This causes much concern as the oil pipeline reached 20 years of operation (June 20, 1977 to June 20, 1997). A new megaproject is beginning to emerge: the Trans-Alaska Gas System (TAGS).

For the past 14 years, Yukon Pacific Corporation has been quietly building momentum behind its North Slope gas export megaproject, the Trans-Alaska Gas System (TAGS). Yukon Pacific has secured virtually all of its major permits and has developed good relations with potential Asian customers.[15]

TAGS would deliver 6 trillion cubic feet or more of natural gas from the North Slope's Point Thompson gas field to Valdez. The project includes a new pipeline from Prudhoe Bay to a new marine terminal in Valdez, where specially designed tankers would load super-cooled liquid natural gas for delivery to customers, primarily the largest electrical utilities in Japan, Taiwan, and South Korea.

As pressure builds to make TAGS a reality, environmentalists have had a hard time getting anyone to focus on the inevitable impacts. This megaproject promises to alter Alaska's social, political, and environmental landscape much the way the Trans-Alaska (oil) pipeline did more than 20 years ago. All the effects of a population boom — housing shortages, increased pollution, higher demand for government services, and rising pressure on fish, wildlife, air and water quality — should be expected.

Meanwhile, as the Alaska Forum reports in Pipeline In Peril, TAPS continues to pose risks to the environment because of ongoing quality control problems. The need to make the oil companies who own TAPS accountable to both Alaskans and our country is a vital issue that must be resolved now. The pumping of oil, and possibly natural gas, from the North Slope could continue for another 40 to 50 years.

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7 The Washington Public Power Supply System: Nuclear Power Plants 1968-1992

7.1 BRIEF OVERVIEW

The Washington Public Power Supply System (WPPSS) was formed in 1957 as a construction and power generating arm of Washington State utilities. In October 1968 The Bonneville Power Administration (BPA), a federal agency, announced plans to build 19 or 20 nuclear power plants in the Pacific Northwest by 1990. This decision was supposedly based on energy forecasting needs by BPA and the Pacific Power Utilities Conference Committee, predicting brownouts in the 1980s and possible blackouts by 1990. WPPSS became the financier and contractor for five of these plants in the State of Washington, WNP-1, -2, -3, -4, and -5. BPA agreed to back the financial plans for WNP-1, -2, and -3 only. Eighty-eight public utility districts (PUDs) agreed to back municipal bonds for WNP-4 and -5 in 1976.

Waste and mismanagement plagued all five projects, with much rework required and costs escalating far beyond the original estimates of $5.7 billion for the five plants. In January 1982, WPPSS canceled projects 4 and 5 after expending $3.2 billion, including $2.25 in municipal bonds. Projects 1 and 3 were “shelved” later that year after completing over 65 percent and 75 percent of the construction, respectively. Project 2 came on line in December 1984 at a cost of $3.35 billion. WPPSS incurred a total debt of over $24 billion by 1988, including default on $2.25 billion in municipal bonds, litigation, and interest payments.

This chapter will examine and discuss the background of the five nuclear power plants, the myriad of problems encountered in design and construction, and demonstrate how an integrated planning and quality management system (IPQMS) could have avoided the many mistakes made.

7.2 BACKGROUND

The Washington Public Power Supply System (WPPSS) was created in 1957 as a construction and power generating arm of the Public Utilities Districts (PUDs) and city utilities. It is a joint operating agency, not a utility. Its mandated purpose is to finance, build, and operate power generating plants. As such, it is one of a number of power supply systems that furnish electricity for the Bonneville Power Administration (BPA) grid in the Pacific Northwest.

BPA was established in 1937 by President Roosevelt and Congress as part of the Public Works Administration (PWA) created by the federal government to institute and administer projects for the construction of public works across the country. BPA was under the Department of the Interior until the creation of the Department of Energy in 1977, its new home. It markets and transmits electrical power for the Pacific Northwest. The service area takes in the states of Washington, Oregon, and Idaho, Montana west of the Continental Divide, and some adjoining portions of Wyoming, Utah, Nevada, and California. The area encompasses 300,000 square miles and has a population of about 9 million.

BPA markets power for 30 U.S. multipurpose dams in the Columbia River Basin, which supplies almost half of the Pacific Northwest's electric power needs. Unlike the Tennessee Valley Authority, BPA cannot build its own generating facilities. BPA does pay the costs of thermal power plants whose power it acquires. This includes the WPPSS Project 2, called WNP-2. It encouraged the design and construction of WNP-1 and WNP-3, which will be discussed later.

The WPPSS or Supply System was initially governed by a board of directors made up of one representative from each member utility. There were 17 PUDs in 1957, and this body chose a seven-member executive committee to run the day-to-day business of building and operating its projects. Municipal utilities became members of the Supply System in the 1970s. These included Seattle, Tacoma, and Richland.

7.2.1 The Initial WPPSS Experience

In 1962, the board of directors approved the first Supply System project at Packwood Lake, about 20 miles southeast of Mt. Rainier. The hydroelectric project was financed by bond sales totaling $13.7 million. It began operating in June 1964 and is expected to produce more than $60 million in revenue over its lifetime. It has already produced more than 2 billion kilowatt hours of electricity. It has a capacity of 27.5 megawatts.

During the late 1950s and early 1960s, the Supply System also explored generating electricity using byproduct steam from a federal defense reactor used in World War II. The Atomic Energy Commission (AEC) had done extensive studies on the idea of a dual-purpose reactor at Hanford. When Congress turned down an AEC request to fund the generating plant, the Supply System drew up its own proposal.

On September 26, 1963, President Kennedy signed a bill that authorized the AEC to sell byproduct steam from the N-Reactor to the Supply System. The law stipulated that no federal funds could be spent on the generating portion of the plant and that half of its electricity would be offered to private utilities and the other half to public utilities. (The latter was necessary to overcome private power opposition to the project.) A $122 million revenue bond sale was arranged to finance construction of the Hanford Generating Project (HGP). When completed in 1966, the HGP/N-Reactor complex was the largest nuclear power plant in the U.S.with a capacity of 860 megawatts. As of 1987, it had produced more than 65 billion kilowatt hours of electricity.

In 1987 the nuclear reactor at Hanford was shut down for safety improvements, placed in dry status in 1989, and in August 1991, the Secretary of Energy announced the decision to place the nuclear reactor in permanent shut-down in the future.* Thus, the action eliminated the original Hanford nuclear reactor as a steam source for the HGP. The HGP electric generators are at standby and being preserved by the WPPSS as a potential future energy source.

7.2.2 The Hydrothermal Power Program

The Supply System's experience with these two projects, especially HGP, gave it an excellent reputation that greatly influenced the next series of regional power planning decisions. This was a cooperative venture with private utilities to build the thermal generating plants thought necessary to meet electrical loads through the end of this century. Because of its reputation, the Supply System was given an important part of this "Hydrothermal Plan". (Thermal power plants are those that use steam generated by coal, oil, gas, or nuclear reactors.)

The hydrothermal plan came in two parts. The first, made public in 1968, called for the construction of eight large plants, including the Supply System's first three units: WNP-1, -2, and -3. Despite the addition to these planned power plants, energy forecasters continued to project power deficits in the 1980s. The hydrothermal plan was revised to include eleven more

* See Chapter 9, The executive summary of the Hanford Nuclear Reservation.

generating units, including WNP-4 and WNP-5, which were planned to be built as twin units of WNP-1 and WNP-3 to take advantage of the cost savings of dual-unit construction.

By January 1975, the necessary agreements for WNP-4 and -5 had been drafted. Public hearings were held throughout the region as various PUDs, electrical coops, and city utilities decided whether to participate. Opposition to the two proposed units was minimal, although there were notable exceptions, such as Seattle City Light's decision not to participate, made after considerable debate.

Endorsements came from power authorities such as the Public Power Council, which represents the power supply and planning interests of the region's publicly owned utilities. The council urged each utility's "prompt and positive consideration" of participation in WNP-4 and -5, citing the region's demand forecasts and the expected low cost of nuclear energy from the two plants compared to other available generating alternatives.

In addition, BPA issued a "notice of insufficiency" in June of 1976 to its public utility customers. The notice stated that after June 20, 1983, BPA would not have enough power available to meet its utility customers' additional power needs.

Unfortunately, the energy needs forecasting was not analyzed critically by professional experts and the public and private utility districts. With five large nuclear plant projects implemented at the same time, financial chaos resulted, popularly known as the "WHOOPS matter". Due to mismanagement and waste, construction costs escalated from the original estimates of $5.7 billion to over $20 billion. These costs included default of $2.25 billion in bonds by the State of Washington, the first such default in the U.S.

7.3 RESULTS

Table 7.1 presents a summary of pertinent information by plant number, with summary sheets for WNP-1, -2, and -3. WNP-4 and -5 are twin designs of WNP-1 and WNP-3, respectively.

7.3.1 Costs and Schedules, WNP-1, -2, -3

These data were obtained from both WPPSS and a paper on "WHOOPS" by John Boyer, Field Representative, the Associated General Contractors of America, Oregon Columbia Chapter, 1983.[1,2] Table 7.2 presents a summary of costs and schedules. Boyer's paper was presented at an East-West Center Seminar for "Training of Trainers for Managers of Public Works Projects", Honolulu, Hawaii, March 1983. WNP-2 cost information was confirmed by telephone interviews with Burns & Roe in 1987.

TABLE 7.1
Summary: General Information/WNP-1, -2, -3

	WNP-1	WNP-2	WNP-3
Location	Hanford	Hanford	Satsop
Capacity	1250 Mwe[a]	1100 Mwe[a]	1240 Mwe[a]
Type	Pressurized water reactor	Boiling water reactor	Pressurized water reactor
Reactor	Babcock & Wilcox	General Electric	Combustion Engineering
Architect engineer	United Engineers	Burns & Roe	Ebasco
Construction manager	Bechtel	Bechtel	Ebasco
Private utility participation	0	0	30%
No. of public utility participants	104	94	103

[a]Mwe, megawatt electrical.

TABLE 7.2
Costs and Schedules (in $ billions)

	WNP-1	WNP-2	WNP-3
First official estimate	$1.2 (9/75)	$.5 (6/73)	$1.4 (12/75)
1982 construction budget[a]	$4.3	$3.35	$4.9
Cost to complete[b]	$1.5	0	$1.4
First estimate of commercial operation	9/80	9/77	9/81
Current estimate of commercial operation	Indefinite	Dec. 13, 1984	Indefinite
Percent complete	65	Complete	76

[a]Plant 2 entered commercial operation on December 13, 1984 which closed the books on construction costs at approximately $3,350,000,000.00.

[b]Figures do not include interest or preservation costs.

7.3.2 The Decision to Build WNP-4 and -5

These two plants were financed directly by WPPSS after 88 Public Utility Districts (PUDs) agreed to back tax-exempt bonds in July 1976. The original estimate for the two plants was $2.60 billion, and WPPSS issued the first of its long-term bonds in February 1977. Construction commenced with costly overruns, resulting in new estimates exceeding $5 billion by July 1979. In March 1981, WPPSS issued the last of its $2.25 billion in long-term bonds. It was estimated two months later that construction costs could escalate to $12 billion. Construction was halted immediately. In January 1982 WPPSS canceled the two projects. The outstanding debt exceeded $3.2 billion, and in July 1983 WPPSS defaulted on $2.25 billion. Construction completion for WNP-4 and -5 was 24 and 16 percent, respectively. As of June 1991, substantially all the utility plant assets of WNP-4 and -5 were sold.

Nuclear power plants 4 and 5 were financed together as one utility system. All other WPPSS projects are financed separately. The BPA assisted in the funding of nuclear projects 1 to 3. The revenue bonds issued for each project are payable solely from the revenues of the projects.

Following the termination of WNP-4 and -5, a lawsuit was filed by 12 electrical cooperatives seeking relief from debt payments. The participants' agreement with the Power System provided that the public utilities participating will pay their respective share of annual costs, including debt service on bonds, whether or not the projects were completed. Debt service payments were due January 1983. However, as a result of the Washington State Supreme Court ruling declaring the participants' agreement invalid, payments were not made and a default occurred in July 1983.

Hundreds of attorneys nationwide were involved in dozens of lawsuits spawned by the default of WNP-4/5 bonds, construction termination (shelved) of projects 1 and 3, and other aspects of the WPPSS situation.

The total debt costs for all five plants, including interest but excluding litigation, had exceeded $24 billion.

7.3.3 Attempts at Management Reforms Which Came Too Late

In 1980, the Supply System board of directors made a mid-course correction, replacing senior management with a new team. Following is a brief synopsis of major management changes and initiatives undertaken by the new Supply System management:

- The Supply System projects were put in the hands of a new team of managers with considerable practical experience in building large nuclear power plants.
- The Bechtel Corp., one of the nation's more experienced nuclear power plant constructors, was brought in to manage construction at the three Hanford site projects.

- Steps were taken to reduce costs and unnecessary expenditures. The Supply System got out of costly uranium exploration projects and filed a successful lawsuit against the Exxon Nuclear Co. to hold that company to its original contract.
- The Supply System requested and received changes to state laws to negotiate for a single completion contractor at Plant 2.
- Labor stabilization agreements were negotiated at both Satsop and Hanford to avoid costly strikes over jurisdictional disputes. The number of work hours lost to such disputes fell markedly during 1981 and 1982.
- To identify the true costs to complete the projects, a "bottoms-up" review of all costs and schedules was ordered. The review took into account every yard of concrete, inch of pipe, and the best estimates available of interest rates and inflation.

In addition to the above, the Washington State Senate conducted an extensive investigation of the Supply System and its problems.[3] One of its recommendations: "The WPPSS Board of Directors should be strengthened to improve its capability to set policy, oversee management performance, and maintain the financial viability of the projects." It further recommended placing several individuals professionally trained in the management and construction of nuclear or other complex projects on the board and executive committee or replacing the executive committee with a full-time committee of professionals. (During most of its history, the Supply System was governed by a board of directors made up of one representative from each member utility. This body chose a seven-member executive committee to run the day-to-day business of building and operating its projects. Most of the board members were elected PUD commissioners or city councilmen from their respective utilities and cities. Some were farmers and ordinary citizens who knew nothing about nuclear plants.)

In 1981, the legislature acted on this recommendation, passing the first "board bill". It replaced the executive committee with a new executive board made up of seven members from the full board and four additional members appointed by the full board from outside the Supply System. Subsequently, four distinguished northwesterners were appointed.

But the first board bill soon ran into trouble. The duties of the two boards were divided awkwardly, with the full board retaining such important powers as approval of construction budgets, appointment of treasurer, and approval of bond sales. In January 1982, three "outside" members abruptly resigned because the system of divided authority was unworkable. In 1982, the legislature passed the second board bill. It created a new executive board, composed of five members drawn from the full board, three appointed by the governor, and three appointed by the full board from outside the Supply System orbit. The new executive board was given full power for managing the projects under construction. Thus, WPPSS appeared to have resolved its managerial problems regarding personnel at tremendous costs and loss of time. However, the financial and technical problems and related litigation resulted in the completion of only one power plant, with two canceled and two shelved.

7.4 WHAT WENT WRONG?

Initial estimates of $5.7 billion in 1973–1975 ballooned to over $24 billion by 1988 with only one plant on line (WNP-2), two terminated, and two shelved (WNP-1, 65 percent complete, and WNP-3, 75 percent complete).

The many factors involved in the huge cost escalation are discussed, showing how sound planning and good management *before* the five projects were designed and implemented could have prevented this financial disaster. The focus will be on the comprehensive feasibility studies that are an integral part of planning. Prior to this discussion, it is extremely worthwhile to summarize the highlights of the questions that should have been raised during the feasibility studies. This will enable us to pinpoint specific areas of investigation that were either ignored or treated lightly in this second stage of the project cycle (phase 1).

1. Economic study
   a. Is the project responsive to an urgent present or anticipated economic social need?
   b. Will the project's planned economic outputs adequately serve the intended purpose?
   c. Will the services proposed to be performed through the project and the benefits produced by the project justify its cost?
2. Technical study
   a. What are the costs of constructing and operating project facilities (and services), including machinery, equipment and spare parts, as appropriate?
   b. What are the manpower requirements, from professional to labor, and are they locally available?
3. Administrative/managerial
   a. Will the internal organization proposed to implement the project be comprehensive enough to provide the necessary leadership and unified control?

b. Who will have complete responsibility and accountability for successful completion of the project?
c. Are there adequate personnel with the necessary skills for implementation of all project activities?
d. Are internal lines of communication well established and lines of authority clearly defined?

4. Financial study
   a. What are the magnitudes of the capital and operating costs of the project?
   b. What are the sources of funds and draw-down schedules, and are they sufficient to cover costs of activities and implementation?
   c. What is the projected cash flow of the project? To what extent are necessary borrowings scheduled to meet running deficits at activation?

The major problems encountered in the WPPSS financial mess are related directly to all items in the foregoing checklist of questions. The *real* need for five nuclear power plants in the 1970s to prevent the forecasted brownouts by 1985 and possible blackouts by 1990 was never challenged by the board of directors of the Supply System or any of the participating public utility districts and city utilities. Unfortunately, the Supply System had less than 100 employees with relatively little engineering and management expertise when the five plants were initiated. Thus, there was lack of adequate manpower and planning at the outset, exacerbated by lack of understanding of the complexities that would arise in attempting to design and build five nuclear power plants simultaneously.

Without the benefit of an IPQMS checklist, compounded by inadequate planning, the inevitable happened: mind-boggling financial chaos with only one plant on line by December 1984, the first-ever default of municipal bonds in the amount of $2.25 billion in the U.S., and a total debt of over $24 billion by 1988. Litigation is still on going and reports indicate WPPSS might have to sell the two “shelved” plants, WNP-1 and -3.

The Supply System did not understand how to cope with the changing regulatory requirements of the Nuclear Regulatory Commission (NRC) or the technological and systems problems inherent to lack of unified and competent control over the construction of all five large and complex projects. In addition, the simultaneous construction of five nuclear power plants in one state created an instant and enormous demand for both craftsmen and labor, escalating costs rapidly in both Washington and neighboring states. This resulted in economic depression of the construction industry in the region, with the State of Oregon especially hard hit.

7.5 EVALUATION

As envisioned the WPPSS projects looked great. Five nuclear plants that would have cost $5.7 billion would contribute an additional 7.2 megawatts of electricity to the Pacific Northwest grid. Attractive revenue bonds sold very well to finance the projects. The projects enjoyed the highest favorable ratings in Wall Street. In the end, however, $24 billion were spent, with only 1.1 megawatt harnessed on WNP-2. What really happened? To understand this debacle, the authors analyzed the projects in the IPQMS framework. These analyses, coupled with various reports, including those obtained from the Washington State Senate Energy and Utilities Committee,[3] resulted in the following:

- Lack of leadership and expertise of the board of directors and top management on nuclear energy development and construction.
- Lack of accountability, teamwork, and coherence between the various participants, such as the WPPSS board and top management, architects/engineers, contractors, labor force and a number of public agencies such as BPA.
- Lack of quality control measures that should have been based on comprehensive feasibility studies (as outlined in the previous section).
- Absence of realistic, disciplined budget and schedule processes and effective mechanisms to use these processes in management of the projects.
- Failure to develop schedules that integrated construction, engineering, and procurement. It was observed that there were at one time 40 to 65 contractors, small and large, working in one location.
- Confusion on the appropriate contracting methods, formats, and contractual terms. Change orders costing millions of dollars, not subject to open-bid competition, became a standard. WPPSS started with fixed price contracts, then went to target man-hour terms, and later unit price/level of effort plus fixed-fee terms.
- Missed, crossed and blocked communication lines between the WPPSS and the contractors, consultants, Nuclear Regulatory Commission, state legislature, and BPA, despite the presence of hired technical staff of many man-years of experience in nuclear energy.

Overall the WPPSS lacked an effective corporate mission and philosophy. As an organization it became a bureaucratic nightmare. There was an almost limitless inflow of money coming from the efficient sales of bonds nationwide. It was believed that money could solve problems of waste, mismanagement and incompetence. Even when construction deteriorated, no one would take responsibility and there was no accountability for the failures. There was finger-pointing, buck- and paper-passing, and a general no-care attitude as long as everyone on the project got their share of the jobs and contracts.

This postmortem clearly shows all principals involved with the five nuclear power plants must share the responsibilities for the many problems. In addition, the media must be faulted for ignoring the growing financial crisis. In short, criticism must be directed at the following groups:

- WPPSS top management and the board of directors: The board of directors was composed of rural folk, farmers, ranchers, and small businessmen who did not know much about nuclear power generation. They abandoned their policy-making and program formulation power to top management. The board did not ask the why and wherefore of proposals, and many times, the board would approve multimillion dollar cost overruns with little or no discussion. The way events unfolded, the top management and the board were responsible for mismanagement, wastage, cost increases, schedule confusion, and delays. The BPA, the architects/engineering (A&E) staff, the numerous consultants, the contractors, and labor unions, and other project groups contributed to the poor and hurried decisions of top management and the board of directors. The ultimate responsibility, however, rested on the board and top management. With simultaneous construction of five nuclear plants, of two different designs, at three different locations, with thousands of workers on site, the top management and the board found itself in dire straits.
- Architects and engineering firms: They were hired to design the plants and manage the construction process. On a fast-track arrangement, construction commenced even when designs were incomplete. The blueprints did not come as timely as they should. Many high crews were idle for months waiting for the plans. Unfortunately, they had to be paid just the same. The A&E companies sometimes blamed the Nuclear Regulatory Commission (NRC) for the delay. They claimed decisions were to emanate from the NRC on critical design aspects of the projects.
- Contractors: Many contractors, winners of a very large number of low-bid contracts, were not qualified to perform. Numerous pieces of work had to be redone to conform to specified quality. With such repeat activities in the work areas, there were huge delays in schedule. The first contract approach to projects was on the basis of man-

hours spent. This led to contractors stretching out the job for as long as they could. WPPSS then switched to fixed-cost contracts which became easily amendable through change orders. Without monetary and schedule constraints, performance was relinquished to the background.

- Labor unions: Labor unions, using the threat of strikes to settle disputes, disrupted work and threw schedules off. Delays in the sites costs millions of dollars a day. Labor unions demanded and received some of the best wages and benefit packages in the country.
- Consultants: Consultants for engineering, financial, legal, and other aspects of the projects were hired by the WPPSS to give the system an objective view to turn things around. The objective view never came, the status quo remained, and matters degenerated all the more. The consultants fed heavily from the fees paid them.
- Washington State government: The state legislature failed to act early despite the incoming flow of bad information. The lawmakers waited too long to institute changes in the composition of the board of directors. They were not successful the first time they did, and had to reorganize the board again. They failed to devise a less painful remedy bailout or settlement that would have distributed the cost of the default for WNP-4 and -5 in an equitable, or at least acceptable, manner. The bondholders should not have been left holding the empty bags. The legislative inaction was a result of weak political leadership. The legislators embraced wholly the statement that although WPPSS was created by state law, it was not normally subject to state oversight. Its directors were not appointed by state authority. The WPPSS was a creature of the participating public and private utility districts, with participants in several states and therefore subject to contractual oversight by a federal agency, not by the state. The passing of the buck was crucial to the failure.
- The Bonneville Power Administration: The BPA convinced and possibly applied pressure to WPPSS participant utilities to accept erroneous power forecasts to justify the Ten-Year Hydrothermal Power Program. This led to the decision to build nuclear plants in the state. BPA, supposedly doting father to the projects, failed to recognize the problems early enough. It lacked the foresight to develop and improve project management. Later, it became obsessed with trying to control administrative details when mismanagement problems became more obvious. BPA even became a

protagonist to the WPPSS in the 1970s during the System's public relations campaign.

- Courts: The Washington State Supreme Court decision on June 15, 1983 invalidating the take-or-pay, or so-called "hell-or-highwater" contracts for WNP-4 and -5 resulted in the default. However, events since the default indicated that at least some of the utility companies never could have raised their electric rates high enough to pay for their shares of the bond payments. They would have surely lost industrial customers and gone bankrupt anyway. In short, long-term default would have occurred even if the validity of the contracts had been upheld in court.
- The federal government: Congress and federal regulatory agencies such as the Nuclear Regulatory Commission (NRC) and the Securities and Exchange Commission (SEC) just stood by as observers while most of the WPPSS debacle was taking place. The NRC action on design clearances was slow. Contractors and workers were idled for days and weeks waiting for the design and plan clearances from the NRC. The Congress and federal agencies, with its silence on the very important questions of policies, created vacuums of responsibility in areas of industrial nuclear power development, regional power planning, municipal financial disclosure, quality assurance in construction, and default crisis resolution. These vacuums were filled by other groups whose interests were not broad enough to serve public purposes adequately.
- The news media: The media ignored the brewing story of the WPPSS drama until it was too late. The WPPSS was allowed to construct and operate in virtual isolation. The late entry of the news media came about only because the BPA hiked electricity rates in the 1970s that led to a public outcry and demanded explanation from the BPA and WPPSS. The BPA rate hike was passed on to the consumers through their respective utility companies. Public debate and news leaks contributed to the growing hostilities between BPA and WPPSS that worsened the problem. By the early 1980s many journalists were writing about contract frauds and managerial incompetence.

7.6 LESSONS LEARNED

Two basic lessons emerge from the evaluation of this postmortem. The first is the financial and managerial chaos that results from a combination of lack of comprehensive feasibility studies and no accountability. Economic justification, such as costs and benefits, would clearly challenge the real need for five nuclear power plants to be designed and constructed simultaneously. This challenge would have been reinforced by the administrative and managerial studies that would show WPPSS could not provide the necessary skilled manpower to oversee the work of the design professionals — the architecture-engineering (A&E) firms.

The second lesson clearly showed that the role of policy as articulated in Chapter 2 was simply not there, including BPA, Washington State, and the Nuclear Regulatory Commission. Indeed, experience shows that policy makers usually do not emphasize the importance of planning to the future success (or failure) of projects (see Chapters 6, 8, and 9). This is unfortunate because policy should be the unifying force in the IPQMS.

There are a number of related lessons from this postmortem, as follows:

- The need for detailed guidelines and checklists based on carefully prepared feasibility studies, whether the project is fast tracked or not.
- There was no compelling need for five nuclear power plants to be constructed, partly because the projections provided by the supposed authorities were not analyzed critically. This problem became more critical when it was decided to build the plants at the same time, of different designs, at various locations.
- Management studies and reforms for WPPSS were necessary even before undertaking the planning, design, and construction of *one* nuclear power plant. These reforms should have included attention to the composition of the board of directors, personnel needs and skills, contract process, project management, scheduling and reporting procedures, and other aspects to implement the projects efficiently.
- The need for teamwork among utility districts, through the board of directors, legislators, managers, planners, designers, constructors, and other participants in the projects.
- The need to pinpoint responsibility and accountability for the various component parts of the project, from conception through completion.
- The policy was not clear on whether public utilities districts that did not have expertise in nuclear energy generation should have been given the latitude to build nuclear power plants.
- The oversight role of either the federal agency (BPA) or the state was not clearly defined.

- The cash flow and other financial and manpower requirements of the project should have been thoroughly understood by all responsible parties, including the ratepayers who will eventually take the brunt of repaying the loans.

The lessons learned from the WPPSS mismanagement of the planning, design, and implementation of five nuclear power plants, coupled with an international study of nuclear operations from 1975 to 1984 (by Kent Hansen et al.) provide a number of insights.[6] Ever-changing safety regulations and environmental concerns hamper both the construction and operation of plants in the U.S. The construction delays are readily apparent in Table 7.3, where Tokai 2 was completed on its original schedule some six to seven years ahead of three plants in the U.S., including WNP-2.

TABLE 7.3
Plant 2 Schedules Compared with Contemporary Boiling Water Reactors[a]

Event	Plant 2	LaSalle 2	Susqueanna 2	Tokai 2
Construction permit issued	Mar. 19, 1973	Sept. 10, 1973	Nov. 2, 1973	May 31, 1973
Fuel load commenced	Dec. 25, 1983	Dec. 17, 1983	Mar. 24, 1984	Dec. 23, 1977
Full power license	Mar. 30, 1984	Mar. 23, 1984	June 17, 1984	N/A
Commercial operation	Dec. 14, 1984	April 20, 1984	Feb. 12, 1985	Nov. 28, 1978

Note: All plants in the illustration above are boiling-water reactors in the 1100 megawatt range using General Electric reactors. As noted, all four started at roughly the same time, but only the Japanese power plant, Tokai 2, was completed on its original schedule.

[a] LaSalle 2 was built by Commonwealth Edison Co. of Illinois, Susquehanna 2 by Pennsylvania Power & Light Co., and Tokai 2 by Japan Atomic Power Company.

In general, nuclear power plants in France, Japan, Sweden, Switzerland, and West Germany outperformed U.S. plants in both design categories: pressurized-water reactors and boiling-water reactors. Each country has its own independent regulatory agency such as the U.S. Nuclear Regulatory Commission (NRC) to set operating guidelines. However, two major differences stand out between the U.S. and the five other countries:

1. Teamwork between utilities and suppliers regarding information exchange, equipment improvement, and self criticism (feedback).

2. Foreign utilities have a healthier attitude on (a) pursuing long-term gains rather than short-term savings, e.g., huge contract awards to

very few competent and reliable contractors instead of the many low-cost bidders who could not deliver the product; and (b) providing short-term savings, in-house training programs, academic-degree programs, and staff exchange programs for improving the quality productivity of their staff members at all levels.

In summary, the nuclear power industry in the U.S., if it expects a resurgence, must initiate planning, design, and management reforms that will promote both long-range planning and teamwork to ensure accountability, cost effectiveness, and quality. Again, the lessons from the past show the need for an integrated planning and quality management system with checklists on quality control to meet these objectives.

7.7 EPILOGUE

The WPPSS continued to improve its administrative and managerial capabilities in the late 1980s. With assistance from the Pacific Northwest Congressional Delegation and BPA, a refinancing effort for the debt incurred in WNP-1, -2, and -3 was effected. This effort enabled WPPSS to re-enter the bond market in late 1989. The Supply System was authorized to issue up to $2 billion in advance refunding funds before 1992.

The sale of utility plant assets of WNP-4 and -5, coupled with BPA guarantees in 1991, enabled WPPSS to market $3.3 billion in WNP-1, -2, and -3 bonds as part of the refinancing plan. This refinancing, coupled with increased utility rates and tax credits, had reduced the outstanding debt to $17+ billion by June 1991. Since then, WNP-2 was finished, while projects 2 and 3 are still mothballed "waiting" for the proper time when the projects shall be resumed again. There is news that they might well wait forever.

According to Leigland and Lamb, the various roles of the participants in the WPPSS fiasco have been revised and redefined:[4]

1. A formalized regional planning process is now a reality in the Pacific Northwest. The process involves the public and private power utilities, academic community, legislature, the BPA and other parties.
2. The NRC has refocused some of its attention to management quality, in both hardware and human resources. The NRC wants to ensure quality in all current and new projects.
3. The Securities and Exchange Commission investigated the possibility of new regulations for the investment community.

4. Bond attorneys and bond holders are now more wary of the risks involved, and are testing contracts before they are signed, or recommending precautionary legislation.
5. Rating agencies have developed more sophisticated criteria to evaluate the overall track records of public authorities.
6. Voters and ratepayers in the Pacific Northwest are more carefully monitoring the activities of their public officials to ensure accountability and cost effectiveness.

The WPPSS saga reinforces the need for a unified, comprehensive system of project development and management as enunciated by the IPQMS to prevent chaos in all aspects of the work.

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8 The EPA Superfund Programs 1, 2, and 3, 1980–1995

8.1 BACKGROUND

The Superfund Program was created by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980. The program was in response to the need to clean up the nation's worst hazardous waste sites. At that time, the extent and severity of the hazardous waste problems were felt to be limited. As discussed in Chapter 1, headline stories in the 1970s had a focus on Love Canal in New York, Valley of the Drums in Kentucky, and Times Beach in Missouri, where lives were disrupted because of public health problems.

CERCLA authorized EPA to:

- Protect human health and the environment against threats posed by uncontrolled releases of hazardous substances;
- Manage a $1.6 billion Hazardous Substance Response Trust Fund, the "Superfund", created from a "front end" tax on crude oil and other commercial chemical feedstocks;
- Identify and prioritize responses to releases, or threats of releases, of hazardous substances that pose a potential threat to human health and/or the environment;
- Ensure that sites and releases are cleaned up to mitigate both the short-term and long-term threats;
- Require responsible parties to pay for cleanups wherever possible through enforcement provisions;
- Allocate Superfund dollars for cleanups in cases where the responsible parties could not be held accountable;
- Develop a mechanism for the federal government to recover costs of its cleanup actions from those responsible for the problems.

Section 105 of CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires the Environmental Protection

Agency (EPA) to maintain a National Priorities List (NPL) of hazardous waste sites with known or threatened releases. The NPL identifies abandoned or uncontrolled hazardous waste sites that warrant further investigation to determine if they pose a threat to human health or the environment. Only sites on the NPL are eligible for Superfund-financed remedial action under CERCLA. However, removal and enforcement actions may be taken at sites that are not on the NPL but pose a threat to human health and the environment. The EPA may delete a site from the NPL if it determines that no further response is required to protect human health and the environment.

The law authorizes the federal government to respond directly to releases, or threatened releases, of hazardous substances that may endanger public health, welfare, or the environment. Legal actions can be taken to force parties responsible for causing the contamination to clean up those sites or reimburse the Superfund for the costs of cleanup.

Superfund budgets come from excise taxes on petroleum and feedstock chemicals, a tax on certain imported chemical derivatives, an environmental tax on corporations, appropriations made by Congress from general tax revenues, and any monies recovered or collected from parties responsible for site contamination.

The Superfund Program received a $1.6 billion budget in 1980 to clean up the nation's priority sites. However, the number of highly toxic waste sites was grossly underestimated, and the program has been reauthorized twice: in 1986 for five years and $8.5 billion, and in 1991 for three years and $5.1 billion. This postmortem goes through 1995.

8.2 FEDERAL LAWS GOVERNING CLEANUP OF THE ENVIRONMENT

Superfund was created by the passage of CERCLA in 1980 to complement other federal environmental laws that emphasize reducing new emissions of hazardous substances or cleaning up narrower categories of sites. Among the more relevant ones are:

1. *The Resource Conservation and Recovery Act of 1976 (RCRA)*, which amended the Solid Waste Disposal Act of 1965, and established in its Title C a national program for tracking and managing hazardous wastes and a corrective action program requiring cleanup of such wastes released into the environment at treatment, storage,

or disposal (TSD) facilities, which include many industrial plants. The corrective action program is defined more narrowly than the Superfund program, which covers a broader class of hazardous substances and is not limited to releases occurring at facilities; also, some TSD facilities are likely to end up as Superfund sites because their owners and operators are unable or unwilling to comply with the corrective action requirements. Nonetheless, the large number of TSD facilities potentially requiring cleanup may make total cleanup costs under RCRA higher than under Superfund. The initial RCRA statute did not direct the EPA to regulate underground storage tanks containing chemical products as opposed to wastes; nor did the 1980 Superfund law authorize the agency to clean up leaks of petroleum and petroleum products (which are generally excluded from the Superfund definition of hazardous substances) from such tanks. These gaps in authorization were filled in 1984 and 1986. Among the many changes made to RCRA by the Hazardous and Solid Waste Amendments of 1984 were provisions requiring EPA to set standards for the design, operation, and cleanup of underground tanks containing petroleum or hazardous products. Authorization for EPA to clean up leaks from petroleum tanks was included in the 1986 amendments to Superfund, which also created a smaller Leaking Underground Storage Tank Trust Fund to finance such cleanups. The 1984 amendment also resulted in a stronger focus on the Corrective Action Program by having the companies responsible for the hazardous wastes clean up the contamination themselves.

2. *The Clean Water Act*, formally the Federal Water Pollution Control Act Amendments of 1972, which created the federal authority to regulate cleanup of oil spills that pose a threat to surface water. The Oil Pollution Act of 1990 authorized using the existing Oil Spill Liability Trust Fund to pay for cleanup, raised existing limits on spillers' federal liability, and authorized the Coast Guard to require that owners and operators of oil-related facilities and vessels have plans for containing and removing such spills in coastal areas.

3. *The 1976 Toxic Substances Control Act (TSCA)*, which authorized EPA to regulate both the use, labeling, and disposal of new and existing chemicals used in manufacturing and commerce and the cleanup of spills of polychlorinated biphenyls (PCBs). The Asbes-

tos Hazard Emergency Response Act amended TSCA in 1986, adding requirements that EPA set standards for cleaning up asbestos in school buildings. Superfund cleanups must meet the TSCA standards where applicable or "relevant and appropriate."

4. *The Surface Mining Control and Reclamation Act of 1977*, which established a permitting program in the Department of the Interior to require active coal mining operations to meet environmental and reclamation standards. It also placed a tax on current coal production to fund reclamation of mines abandoned before 1977 or before enactment of the regulations implementing the law. The tax money, however, cannot be used to clean up mines for which a responsible former operator could pay; in such cases, cleanup can proceed only under Superfund or state authorization. Amendments passed in 1990 also prohibit this money from being used to clean up mines listed as NPL sites, even if no solvent operators exist.

5. *The Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA)*, which directed the Department of Energy to clean up sandlike tailings left from uranium-processing operations at 24 specific inactive sites. These sites are excluded from the Superfund program, as are any releases of radioactive substances from nuclear power plants. Other radioactive wastes, including uranium tailings at milling sites not included in the UMTRCA list, can be cleaned up under either Superfund or the Atomic Energy Act of 1954, as amended.

6. *Superfund Amendments and Reauthorization Act* — in October 1986, the Superfund Act was amended under the Superfund Amendments and Reauthorization Act (SARA). These amendments provide mandatory schedules for the completion of various phases of remedial response activities, establish detailed cleanup standards, and generally strengthen existing authority to effect the cleanup of superfund sites.

7. *Emergency Planning and Community Right-to-Know Act* — also known as SARA Title III, this act is intended to encourage and support emergency planning efforts at the state and local levels and to provide local residents with information concerning potential chemical hazards in their communities. Section 313 of the act requires manufacturers to report to the EPA and to the states the amounts of over 300 toxic chemicals that they release to the air, water, or land, or that they transfer to off-site facilities that treat or dispose of wastes. The law also requires the EPA to compile these

reports into an annual assessment called the Toxic Release Inventory — also available to the public in a computerized database.

In addition to the foregoing, there have been a number of Executive Orders issued by the President, ostensibly to strengthen the implementation and enforcement of the laws pertaining to the environment and public health. Unfortunately, the pollution of our environment goes on, with continued damage to public health, waterways, and wildlife.

8.3 PROCEDURES FOR NPL SITE CLEANUPS

The Superfund program has two basic types of cleanups: short-term cleanups (removal actions) and long-term cleanups (remedial actions).[1] In the Superfund removal program, actions are taken to mitigate immediate and significant threats, such as those stemming from contaminated drinking water or unrestricted access to hazardous waste sites. These actions are generally of a short-term and emergency nature, such as providing alternative drinking water supplies and cleaning up chemical spills caused by transportation accidents.

To perform a remedial action, EPA must go through the formal process of placing a site on its National Priorities List (NPL). EPA may then go through a series of steps to perform the cleanup:

Step 1: Conduct a site study to identify wastes and to evaluate and select a remedy for the contamination identified. This phase is known as the remedial investigation and feasibility study (RI/FS or site study).

Step 2: The period of time between the end of the study phase (RI/FS) and the beginning of the next phase (remedial design) can be a significant factor in the length of time expended on the cleanup process.

Step 3: Design methods for implementing EPA's chosen remedy. This phase is known as remedial design (RD).

Step 4: Construct and implement the remedy. This phase is known as remedial action (RA).

Step 5: Prepare an operations and maintenance (O&M) plan for each cleanup remedy. During O&M, the site must be continually monitored to ensure the effectiveness and integrity of the cleanup activities.

Step 6: NPL deletion indicates that all cleanup activities at a site are complete and the site is considered safe for a particular use. The site is then monitored for five years before deletion from the NPL.

Any or all of the cleanup phases may be paid for and performed by a responsible party (RP) under a legally enforceable agreement with EPA. Superfund money is used in the event the responsible party cannot be found. CERCLA does provide for recovery of the costs after the cleanup. Cleanup work at a specific site is sometimes broken into separate projects (referred to as operable units). Thus, a site may have a site study ongoing for one of its operable units and design work ongoing for another. Once EPA and the state in which the site is located have determined that all work at a site has achieved the desired cleanup goals, the site can be removed (deleted) from the NPL.

It is significant to the foregoing to note that EPA has 10 regional offices across the country, with each one semi-autonomous in managing site cleanups in its particular region. The senior author noted the wide variations in remedial actions in his meetings with EPA senior staff in both 1983 and 1993.

8.4 MONITORING SITE CLEANUPS

Concerned citizen groups began to monitor the site cleanup programs in 1983. Congress investigated allegations of political manipulation and mismanagement in 1983, resulting in the resignation of EPA's administrator and the incarceration of the Superfund top official. The General Accounting Office (GAO), the investigative arm of Congress, initiated studies and reports on waste, fraud, and mismanagement in EPA's contracts to carry out Superfund cleanups as early as 1987.[2] Congress itself has been critical of the Superfund Program through the Committee on Environment and Public Works (Senate) and the Office of Technology Assessment (OTA).

8.5 RESULTS AND PROBLEMS

In 1980, Superfund Program Number 1 evolved with an initial budget of some $1.6 billion to commence the task of cleaning up the hundreds of leaking toxic waste sites across the country that pose a serious threat to public health. This budget was depleted by 1985, with only six sites reported to be cleaned up, and the number of toxic waste sites was increasing.

Superfund Program Number 2 was approved by Congress in 1986, giving EPA $8.5 billion to clean up approximately 300 sites over a five-year period. EPA expended that budget as of the end of fiscal year 1991, reporting only

57 additional sites being cleaned up, including sites pending close out approval (a total of 63 out of a list of 1250 NPL sites).

Superfund Program Number 3 was approved in 1991 for an additional $5.1 billion through 1994. As of September 30, 1994, another 27 sites were fully restored. Another 150 NPL sites were in various stages of cleanup, but their statuses (steps 1, 2, etc.) were not clear. Meanwhile, the NPL sites have increased to 1320. The average cost of cleaning a site is over $30 million, according to EPA senior staffers. The average total time to completely clean a site (NPL) is eight years.

Thus, after 14 years and over $14 billion expended, approximately 90 NPL sites have been eliminated out of an estimated 1,320, and the number of NPL sites is increasing. The $14 billion is Superfund money, which is approximately 50 percent of the total costs involved (responsible parties' obligations). There has been criticism of the Superfund Program by the University of Tennessee Waste Management and Research Institute (1991),[3] the American Society of Civil Engineers (Civil Engineering Magazine),[4] Office of Technology Assessment (OTA — a support agency of Congress), Clean Sites,[5] the General Accounting Office (GAO),[6] and many others. The most extensive monitoring has been done by Clean Sites, a consortium of industry and environmental leaders committed to solving America's hazardous waste problems.*

The end result after 14 years is a fragmented program saturated with waste and mismanagement. Moreover, each day more and more communities discover that they are living near hazardous waste dumps contaminated by dioxin, vinyl chloride, PHB, PCB, lead, mercury, and arsenic. These critical sites are compounded by the thousands of sites contaminated by nuclear weapons research and production facilities from 1947 to 1992.[7]

The GAO listed the Superfund Program Management as one of 17 programs considered high-risk — especially vulnerable to waste, fraud, abuse, and mismanagement (GAO).[6] This report was part of a high-risk series prepared for the incoming Clinton Administration in December 1992. There has been no attempt to develop a systematic program that would integrate the planning, design, and implementation of each cleanup for future planning. In addition, there has been no attempt to initiate a data base of lessons learned from each site cleaned up.

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* Clean Sites was established in 1984 by a coalition of businesses, environmental groups, and administration officials. It is a nonprofit organization.

In 1989, then-new EPA Administrator William Reilly initiated a 90-Day Study of the Superfund Program. He emphasized the need to improve performance of NPL site cleanups. He also called for forcing responsible parties (PRPs)* to take responsibility for cleanups through an aggressive use of unilateral cleanup orders. This policy shift, for the first time, was a conscious, positive strategy designed to accomplish the goals of the law.

In an effort to shorten lengthy (and expensive) cleanups, EPA has introduced the Superfund Accelerated Cleanup Model (SACM). SACM works mainly in the "front end" of the Superfund process. It reduces the individual steps by allowing initial one-step screening and risk assessment, followed by actions to reduce immediate site risks. It separates out those sites that require long-term cleanup, a period of five years or longer. ASCE (March 1993)[4] feels the implementation system, including controls, will determine how successful SACM will be.

The Superfund Revitalization Office (SRO) was established in 1991 to "encourage new and innovative approaches in the Superfund program." The success of SRO will depend upon the ability of the EPA to improve its planning and management systems, including oversight of all contracts. Experience to date clearly shows that the EPA Superfund has a poor track record. It needs to be reorganized to make it both accountable and cost effective.

EPA's new administrator, Carol Browner, gave testimony before the Senate Subcommittee on Superfund, Recycling and Solid Waste Management in May 1993. She said she would find an answer to the question, "Are we getting full value for our money?". Yet, EPA continues to resist innovative change to realize accountability and cost effectiveness. This is apparent in an in-depth report by GAO to Congress in September 1994.[8] The senior author encountered the same resistance to change during an invited informal seminar on the use of the IPQMS for Superfund at EPA in Washington in June 1993.

8.5.1 Use of Contractors

According to the GAO, EPA is relying too heavily on contractors to clean up the NPL sites.[9] The basic problem is lack of EPA oversight, exposing the cleanups to fraud, waste, and abuse. For example, in March 1992 GAO gave testimony that CH_2M Hill, a consulting engineering firm and one of Superfund's largest contractors, included expenses in its indirect cost pool (a

* PRP, potentially responsible party.

portion of which is charged to EPA) that were not allowable under the Federal Acquisition Regulations (FAR).[10] In examining selected indirect cost accounts, such as meals, lodging, and relocation expenses, GAO identified about $2.3 million in indirect costs that the FAR does not allow. These expenses included tickets to professional sporting events, alcohol at company parties, and travel by nonemployee spouses.

This discussion has been limited to Superfund, which badly needs a data base for scientific decision making, as covered later. However, it must be emphasized that there are untold contaminated sites on many military bases, possibly 11,000 created by the Pentagon alone (*U.S. News and World Report*, December 14, 1992).[11] The Comptroller General of the United States covered the sites contaminated by the Departments of Defense and Energy in the GAO High-Risk Series for the incoming Clinton Administration (GAO).[12]

An update of the high-risk programs cited in 1992 was conducted by GAO in 1994. Again, EPA Superfund was cited for making little progress in reducing the risks of mismanagement and vulnerability to waste and fraud.[13] According to GAO, EPA has not established priorities for cleaning up nonfederal sites (sites not on military bases or nuclear weaponry research and development). This finding is consistent with the senior author's recommendation in 1993 that Superfund initiate IPQMS case histories for the lessons learned. GAO further noted that EPA had recovered only a fraction of the monies that it has spent on cleanups from responsible parties.

The EPA Superfund Program is beset with many problems, especially in the areas of management and lack of scientific guidelines for actual cleanup of toxic waste sites. Because of these gaps, the program is fragmented, with no evidence of any teamwork. Thus, a large number of major problems are apparent with the Superfund scenario for completion and deletion of National Priorities List sites (NPLs). Among the most critical are:

- Lack of adequate managerial and technical skills within EPA itself, compounded by lack of teamwork. These facts are confirmed by senior EPA staffers who see both fragmentation in the Superfund Program and imbalance regarding the backgrounds of decision-making staff members. There are simply too few experienced engineers and managers (see GAO references and source materials).
- Extensive use of outside consultants (engineers) and contractors with no effective oversight by either headquarters or field personnel on work performed and budget expended. EPA itself admits that large amounts of money are being wasted. The Office of Technology Assessment (OTA) reports that 80 to 90 percent of the Super-

fund budget has gone to EPA consultants and contractors, and the program is still in a state of disarray.*

- Lack of continuity in leadership. This is a general problem in the federal government because of the nature of our political system which provides for political appointments for positions of administrators and deputy or assistant administrators in every federal agency such as EPA.
- There is uncertainty as to which cleaned-up sites are really safe and for how long.

8.6 EVALUATION

This postmortem clearly shows that the EPA Superfund program established in 1980 and reauthorized in 1986 and again in 1991 is not operating well. The program is beset with conflicts, fraud, mismanagement, and waste, despite reports by the GAO. The cleanup program has been extremely controversial since it began and the number of hazardous waste sites continues to increase at a frightening rate. Clear Sites reported in 1994 that EPA has identified almost 39,000 potentially contaminated sites, with over 1200** on the National Priorities List (NPL).[14] As we discussed in Chapter 1, the number of sites contaminated as a result of nuclear weaponry research and development (1947-1992) is astronomical.

The GAO reported in 1997 that the EPA Superfund program continues to be vulnerable to waste, fraud, and mismanagement, especially in the contracting area.[15] While about half of the Superfund program's budget annually goes to site cleanup contractors, EPA has had long-lasting problems in controlling contractors' charges. Lack of adequate oversight, compounded by lack of guidelines, result in a high percentage of contract costs going to administrative expenses rather than to actual cleanup work. In addition, there has been an ongoing backlog of 500 or so unfilled requests for audits.[15] Similar problems prevail in the Department of Energy, which is charged with the cleanup of the old nuclear weaponry sites.[15]

The necessary legislation is in place to clean up the environment. Unfortunately, the cleanup program has been extremely controversial since it began, and the intensity of that controversy has grown over the years.[16] In 1995, 11 years after Congress created the Corrective Action Program to clean up contamination at operating facilities, cleanup progress is limited.

* Information obtained from one of the senior author's graduate students working for GAO (March 1994).
** This number is on the low side as discussed earlier.

Although some cleanup activity is taking place under other programs, the fact remains that less than 10 percent of the facilities have completed cleanups under the Corrective Action Program, and about half of them have not even begun their cleanups under the program. While several factors influence the time it takes to complete a cleanup, two stand out:

- First, the step-by-step process for cleanup is drawn out and cumbersome, and the cost of implementing it discourages companies from initiating more cleanups.
- Second, protracted disagreements among EPA, the states, and affected companies over the cleanup standards to be met and the methods used to meet them have also delayed cleanups.

Both of these factors can contribute to the economic disincentives that companies face in performing cleanups. Furthermore, these two problems are exacerbated by the limited resources EPA and the states have for implementing the program. The cleanup program is not working the way it should. It needs to be changed. However, the necessary change can only come with teamwork among the principal parties involved.

8.7 LESSONS LEARNED

The outstanding lesson learned is the need for an overall management team trained in the IPQMS methodology to ensure cohesive teamwork of planners, designers, constructors, and managers for successful completion of all future toxic waste cleanup projects. At the same time, the policies and guidelines will be adapted to ensure successful cleanup of existing leaking toxic sites. This is consistent with the request made by W. R. Ruckelshaus in 1983.[17]

It is necessary to initiate a long overdue case history library of a representative cross section of toxic waste site cleanup projects, both successes and failures. These case histories should be researched, analyzed, evaluated, and published in the conceptual framework of an integrated planning and quality management system (IPQMS).

The IPQMS forcefully demonstrates the benefits to all the principal groups involved in projects in any sector when the groups work together as members of a team. EPA career staff members should be trained and organized in the IPQMS framework. They should then be trained to research and document IPQMS cases of at least six Superfund sites in the category of "completion". The lessons and insights from these cases will demonstrate the significance of the IPQMS methodology in improving the planning, design, and management of future projects in this crucial field. The end result will be guidelines and checklists to ensure teamwork, accountability, and cost effectiveness.

New policies and guidelines will be developed from IPQMS case histories of a representative cross section of toxic waste site cleanup projects, both successes and failures. These cases will form an overdue data base. The cases will document each site regarding nature of problems, procedures used to clean up the site, overall results including costs, and a comprehensive evaluation of each task in the cleanup.

Senior EPA career staff members must be appointed as administrators or directors of the various programs and projects to ensure the necessary continuity in leadership. They will be trained in the IPQMS methodology.

EPA officials have ignored recommendations by some of its senior staffers who have studied the benefits of the IPQMS. Indeed, one was forced into early retirement because of her "whistleblowing".

The lessons learned from this postmortem will also be beneficial to the cleanup of the thousands of sites contaminated by the military (Chapter 1).

8.8 EPILOGUE

The EPA Superfund program has not been reauthorized by Congress since its 1991–1994 authorization. EPA has been spending about $1.4 billion a year since early 1995 to continue the Superfund cleaning up of the nation's worst hazardous waste sites (NPL sites).[16] The total costs of cleaning up nonfederal hazardous waste sites (mainly industrial) is far greater than EPA or Congress estimates. There are over 1300 NPL sites with another 21,000 or more to assess. Cost estimates range from $16 billion (EPA) to $151 billion (University of Tennessee).[3] These are federal costs only, with responsible parties costs equal or greater.

Meanwhile, the Department of Defense (DOD) faces a massive cleanup problem extending to some 27,700 potentially contaminated sites located on over 9,700 military installations and former defense properties in all 50 states. The DOD estimated in late 1994 that the program could cost about $30 billion.[18] Experience with Superfund estimates and actual costs from 1980 to 1995 is such that this figure will be much larger, possibly $60 billion.

Chapter 1 briefly discussed the contamination from over 50 years of secret research and development of nuclear weapons. The nuclear complex of the Department of Energy (DOE) consists of 16 major facilities or installations spread over 13 states. Today that complex holds in storage over 100 million gallons of highly radioactive waste, 66 million gallons of waste contaminated with plutonium, and even larger volumes of waste with lower levels of radioactivity. In addition, radioactive and other hazardous substances have contaminated soil and groundwater at DOE's installations. Although some of DOE's environmental problems involve conventional contaminants that are common to many cleanup tasks, the vast majority of its pollutants contain some level of radioactivity and so pose challenges unique to DOE.

In 1989, DOE created the Office of Environmental Restoration and Waste Management (EM), which has primary responsibility for cleanup activities. Since its inception, the office has experienced rapid budget increases. Its budget has risen from $1.6 billion in 1989 to more than $6 billion in 1995, representing over $29.0 billion in seven years. Funding devoted to the cleanup program is projected to continue to increase, rising to more than $7 billion annually by 2000.

How much the cleanup program will ultimately cost taxpayers is unknown. In 1988, DOE estimated that the cost would be between $66 billion and $110 billion, but estimates keep rising. In 1993, DOE officials suggested the cost could range from $400 billion to $1 trillion.[19] But no one can make an estimate with any degree of confidence until the Congress and regulators clarify the ultimate goals of the program, which include reducing health and safety risks to humans and mitigating damage to the environment. The goals may also include restoring sites to make them available for other uses — industrial, commercial, residential, or recreational.

Six of DOE's 16 major facilities — Hanford, Savannah River, Oak Ridge, Fernald, Idaho National Engineering Laboratory, and Rocky Flats — account for more than 60 percent of the budget of DOE's environmental cleanup program. Hanford alone is responsible for nearly a quarter of the budget. Hanford, in Richland, Washington, was the premier bomb factory in the country, and also the most contaminated. The Hanford Nuclear Reservation occupies 560 square miles. It includes 177 underground storage tanks which were constructed between 1943 and 1986. The tanks contain over 61 million gallons of high-level radioactive waste, with a history of poor maintenance of the gauges that detect leaks.[20] Also, many of the initial tanks are single shell (149 in all), with over half leaking radioactive wastes into the ground and the groundwater that flows into the Columbia River.

A more detailed summary of the background, problems, and lessons learned from Hanford is presented in Chapter 9.

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10 How to Use Lessons Learned in Rebuilding Infrastructure and Cleaning the Environment

Chapters 5 through 9 clearly demonstrate the significance of understanding and using the many lessons learned from past mistakes and scandals. They further demonstrate that proper introduction and use of the IPQMS methodology will restore accountability, cost effectiveness, and quality in all programs and projects.

An IPQMS case history data base should be generated for both private and public sectors. The guidelines and checklists developed from the case histories will serve to eliminate waste, fraud, and mismanagement once and for all. Of equal importance, these guidelines and checklists will also prevent disasters such as the spacecraft Challenger disaster in January 1986.

This chapter shows how to use the IPQMS to plan, design, and implement the rebuilding of America's infrastructure and cleaning up the environment. The primary focus will be on a training program in each of the 50 states for the planners, designers, and managers.

10.1 A $35 BILLION PROGRAM TO REPAIR INFRASTRUCTURE AND CLEAN UP THE ENVIRONMENT

Chapter 1 emphasized the serious state of the nation's infrastructure, the impact it has on the quality of life, and the impact it has on the nation's economy. Without continuous investments in infrastructure, a modern economy fails to grow.

Our research shows that $35 billion every year for 10 years will create 1 million jobs to rebuild the nation's decaying infrastructure and clean up the contaminated environment. This amount would pay an average salary of $25,000 per year plus $5,000 for fringe benefits per worker. There would be an additional $5,000 for the necessary IPQMS training for the professional planners, designers, and managers. It is emphasized that the $35 billion per year is only for the manpower requirements and will come from federal sources. The funds for materials and equipment to be used could come from existing federal budgets for infrastructure, such as the recently enacted Transportation Equity Act, popularly known as TEA-21. This provides $216 billion from 1999 to 2004.

Each state would also administer the necessary job training on a partnership basis with both the federal Department of Transportation (DOT) and the Environmental Protection Agency (EPA) to oversee the monumental rebuilding (repairs and retrofit) of highways and bridges, airports, water supply and waste disposal systems, and other public facilities such as schools.

The $35 billion from the federal government could come from $20 billion in the Defense Peace Dividend, $10 billion from Corporate Welfare, and $5 billion in Social Welfare savings. An alternative could be to take the entire $35 billion from Corporate Welfare. Congressional records show that these amounts are attainable.

Why infrastructure and the environment? There is a vital link between infrastructure investment and the nation's productivity and competitiveness. National organizations involving contractors, engineers, architects, and state/county officials have been warning Congress and the White House since the early 1980s about the dire consequences of substandard infrastructure. In a report released in March 1998, the American Society of Civil Engineers (ASCE) gave the nation's infrastructure an overall average grade of D and said it would take more than $1 trillion — as a public-private partnership — to fix the long-neglected problems. There are supposed to be trust funds to maintain highways and airports and waterways, but the funds for these purposes have been diverted in the past.

There is also a link between capital investment in infrastructure and quality of life. When public health becomes an issue, we must combine investment in infrastructure with investment in cleaning up the nation's worst hazardous waste sites. EPA's track record in cleaning up toxic waste sites through Superfund programs (Chapter 8) has not been successful. The environment has been worsened, as discoveries are made, by the illegal dumping of nuclear wastes from Cold War bomb factories across the nation.

Past studies indicate the rebuilding of our infrastructure will take at least 10 years, most probably longer. In addition, a maintenance budget of around 15 percent of the cost to rebuild should be set aside for the purpose, every year.

Aside from rebuilding the infrastructure, the infusion of 1 million jobs to the economy will increase federal receipts from the expanded tax base. It will result in benefits regarding (1) public health in general, and (2) saving industry at least $30 billion annually in avoiding detours from unsafe bridges and roadways.

Another benefit, possibly the greatest one, is the opportunity to plan, design, implement, and manage the 1 million jobs using the IPQMS. Experience with the IPQMS shows it ensures teamwork, accountability, and cost effectiveness. Thus, it eliminates waste, fraud, abuse, and mismanagement. A cost-effective program will be ensured by a combination of job training and overall management in the IPQMS framework.

10.2 THE IPQMS ERA HAS ARRIVED

Rebuilding our deteriorating infrastructure calls for new approaches that transcend disciplinary boundaries, thus promoting teamwork and accountability.

The IPQMS provides a dynamic and holistic approach to management which considers the entire range of a program or project's activities, from planning through implementation, evaluation and refinement, with the central function of policy providing focus and direction throughout the life of the project. Thus, it serves as a basis for integrating (instead of fragmenting and compartmentalizing) and organizing all project teams to provide the necessary leadership, teamwork, and information flows for cost effectiveness, efficiency, and safety — ingredients necessary for accountability and total quality. Of equal importance, it provides the framework for improved project management, education, and training.

The IPQMS is effective for engineering and public works projects where various components and stages are well defined. Checklists corresponding to each of the components are prepared in detail and are evaluated at any time during the cycle. The IPQMS can also be used in other areas such as agriculture, defense, environmental protection — and indeed, in various other aspects of government and the private sector.

The IPQMS is a powerful management tool that provides solutions to complex problems of people, organizations, finance, materials, and time — facilitating decision-making and eliminating problems that might arise during implementation. With the advent of very efficient computer systems, the IPQMS becomes doubly easy to adopt. Warning indicators can be introduced so that projects, when something goes wrong, can be corrected in time. Graft, or overspending, can be pinpointed in all areas, and waste can be minimized. Mismanagement will be identified as soon as it happens and thus curtailed. An IPQMS-run project is a fail-safe project. Thus, an IPQMS-run project, from conception through completion, will avoid litigation.

10.3 OUTLINE FOR IPQMS SEMINAR COURSE

The senior author has extensive experience in planning and conducting training programs for senior scholars and practitioners on the use of the IPQMS methodology for public works projects. The authors, with a colleague, designed a training program for the EPA Superfund program in 1993 to (1) initiate a data base of IPQMS case histories of six NPL sites cleaned up, and (2) provide scientific guidelines from the initial data base for cleaning up the remaining 1300± NPL sites.

With this background, an outline for an IPQMS seminar course has been designed. It is shown below, designed as a weekly seminar course to introduce the IPQMS as a new model to optimize available resources for accountability, cost effectiveness, and quality. Useful lessons to improve the process of planning, design, implementation, and management are drawn from postmortems of past programs and projects. Group term papers are required to encourage teamwork and provide hands-on experience with the IPQMS methodology, case histories, guidelines, and checklists. This book would be used for the training program. Prerequisites for this course are an undergraduate degree in engineering, architecture, business administration, public administration or economics, and approval from the instructor.

10.4 INTENSIVE TWO-WEEK TRAINING PROGRAM FOR PLANNERS, DESIGNERS, AND MANAGERS

The foregoing semester course can be readily adapted to an intensive 2 week training program for the various state agencies concerned with infrastructure and the environment. The first year of the $35 billion rebuilding program will focus on the Departments of Transportation. The second year focus will be on the Departments of Environmental Protection (names vary from state to state). The training cycle repeats itself during the 10 year program to ensure an adequate reservoir of IPQMS trained planners, designers, and managers.

The trainers would be senior scholars and practitioners who are qualified to introduce the IPQMS as a new model to ensure accountability, cost effectiveness, and quality.

10.4.1 For Departments of Transportation

Each state DOT would select 20 participants for the training program. They would be persons at the middle-management level who would be trained in the use of the IPQMS methodology for rebuilding the infrastructure in their respective states. This means they must have the necessary qualifications to

Seminar Meeting	Topic For Discussion	Reading Assignments
1.	Introduction to the IPQMS: What it is and what it can do	Chapter 2
2.	How to use the IPQMS Significance of IPQMS Cases	Chapter 3
3.	Case histories by phase Significance of feasibility studies Term paper proposals	Chapter 4
4.	Lessons learned from cases Assignment of project teams for term papers (term paper topics must be approved by instructor)	Chapter 5
5.	Project accountability and evaluation Format for term papers	Chapter 4
6.	Library research for term papers	
7.	Open discussion of term papers Assignment of progress reports for next meeting	Chapter 6
8.	Progress reports Discussion of potential problems	
9.	Individual team meetings on term projects Open discussion	
10.	Application of evaluation to refinement of planning phase IPQMS checklists	Chapters 7 and 8 Appendix B
11.	Term paper progress reports	
12.	Troubleshooting problem areas IPQMS cases as a data base	Chapter 9
13.	Final library research with instructor Individual team meetings	
14.	First drafts of term papers due	
15.	Final examination: Presentation of term papers by project teams Final typing of term papers due	

assume project management positions upon completion of the training program.

The training program has been designed to be conducted 5 days a week for 2 weeks. The following program outline is based on lectures/discussions between 9 a.m. and 12 noon each day, with afternoons generally devoted to individual reading plus team (three to four participants per team) research and discussion. The trainers will be available for discussion and consultation each afternoon. Each participant will be requested to bring in a project he or she has worked on to provide a basis for selecting the course team paper research and writing requirement.

The participants will be given reading assignments on the first day of the course, and the literature on the various case histories. Readings shall be done prior to scheduled dates for case discussion.

10.4.2 Possible Problem Topics Brought in by Trainees to the Training Programs

The trainees will be asked to bring with them specific problem topics that they encounter in their respective agencies. Using the IPQMS and working in teams, by the end of the training solutions will be offered so that the trainees will find their stay relevant to their work.

For example, take the case of a certain state Department of Transportation's desire to minimize cost overruns on each construction contract that is administered. A study to investigate and identify those factors that significantly impact construction cost overruns could be undertaken by the class. The trainees could be asked to bring pertinent data relating to the number of projects during a certain period, project size, project type, level of competition (measured by the number of bids and the range of those bids), geographical district, pre-contract engineering, and frequency with which a contractor is awarded contracts. The data would also include statistical analysis of each project pertaining to design, bidding, and construction administration data. Conclusions on the occurrence of cost overruns would be drawn; thus, the trainees shall be made aware of such pitfalls and could thus avoid them in future work situations.

Some project problems may be more difficult than others; however, they could be analyzed and solved by the IPQMS methodology. Other projects involve relatively higher degrees of technical, environmental, cultural, and sociological complexity. Using the IPQMS step-by-step in more complex problems will enable the participants to appreciate the simplicity of the methodology.

10.5 CONCLUSIONS

Lessons from the IPQMS postmortems show two common threads — lack of accountability and lack of teamwork. Teamwork is beginning to receive attention today, but not accountability. Clearly, it is a management issue which must be addressed. The IPQMS fills that need. This represents a major contribution to the literature.

Sample Format For Two-Week Training Program

First Day (This could start on a Monday)

9:00 – 12:00	Introduction and overview of training course What is the IPQMS?
12:00	Lunch
1:30 – 3:00	Case History Method vis-à-vis Case Study
3:00 – 4:00	Readings and consultation[a]

Second Day

9:00 – 12:00	Participant presentations — planning, design and implementation problems in various agencies they represent
12:00	Lunch
1:30 – 3:00	Participant presentation — Continued Discussion
3:00 – 4:00	Readings and consultation
6:00 – 9:00	Social Hour and Dinner

Third Day

9:00 – 12:00	Participant presentations and open discussion Organization of various project teams to divide the participants
12:00	Lunch
1:30 – 3:00	Team meetings
3:00 – 4:00	Readings and consultation

Fourth Day

9:00 – 12:00	IPQMS — Lectures/Discussions on the elements involved in various phases of the IPQMS
12:00	Lunch
1:30 – 3:00	Discussion of the Trans-Alaska Pipeline case in the context of IPQMS Phase 1 Team discussions on the significance of feasibility studies
3:00 – 4:00	Readings and consultation

Fifth Day

9:00 – 12:00	IPQMS Phase 2: Team discussions of WPPSS Nuclear Power Plant projects
12:00	Lunch
1:30 – 3:00	Review all stages of WPPSS projects (Note: trainers available for consultation Saturday a.m.)

Sixth Day (After the Weekend)

9:00 – 12:00	IPQMS Phase 3: Team discussions
12:00	Lunch

1:30 – 3:00	Discussion of the EPA Superfund Program and Challenger Disaster in the context of IPQMS Phase 3
3:00 – 4:00	Readings and consultation

Seventh Day

9:00 – 12:00	IPQMS Phase 4: Team Presentations Open discussion
12:00	Lunch
1:30– 3:00	Discussion of Hanford Nuclear Reservation Case in the context of IPQMS Phase 4
3:00 – 4:00	Readings and consultation

Eighth Day

9:00 – 10:30	Lectures and discussion of impact analysis of projects
10:30 – 12:00	How to prepare case histories: Lecture and discussion
12:00	Lunch
1:30 – 3:00	Outline preparation of case histories related to the participants' projects in various agencies: Team presentations
3:00 – 4:00	Readings and consultation

Ninth Day

9:00 – 12:00	Group (team) reports and open discussion on the use of the IPQMS in respective agencies
12:00	Lunch
1:30 – 4:00	Group working sessions on preparing IPQMS checklists and guidelines

Tenth Day

9:00 – 12:00	Summary of highlights of training program by trainers Open discussion on role of policy in decision making Ethical issues, accountability and teamwork
12:00	Lunch
1:30 – 3:00	Need for an IPQMS data base in public works projects

a. Reading assignments will be taken from the semester program.

Rebuilding our crumbling infrastructure and cleaning up our contaminated environment calls for new approaches that transcend disciplinary boundaries. The IPQMS provides such an approach, resulting in the necessary teamwork from planners, engineers, scientists, managers, and politicians. Thus, this new methodology will ensure accountability, cost effectiveness, and quality.

The IPQMS fills a long overdue need to integrate project planning, design, implementation, and management which results in unified control of all phases and tasks in programs and projects in all sectors. Experience with the IPQMS shows this methodology will result in annual savings of $60 billion in the construction industry alone (based on 1996 estimates).

There is need for an IPQMS data base in every sector of industry and government to complete quality projects on time and within budget. The IPQMS will also prevent future disasters such as the spacecraft Challenger, rebuilding/hazard mitigation after natural disasters (Hurricane Hugo in 1989, Loma Prieta Earthquake in 1989, Hurricane Andrew in 1992, etc.). This methodology was used in the rebuilding of the island of Kauai after Hurricane Iniki in 1992.

The IPQMS has been designed and refined to be adapted to all sectors, public and private. Thus, it can be used in training programs and projects in agriculture, education, government, healthcare, and power (energy). In government, it will eliminate waste, fraud, and mismanagement once and for all.

There is also urgent need to introduce ethics, accountability, and teamwork into all aspects of the curriculum in professional schools across the country. This will initiate the long overdue process of producing cadres of young professionals who understand the benefits of teamwork and maintaining high ethical standards.

Appendix A
Abstracts of Case Studies and IPQMS Case Histories

ABSTRACTS OF BUSINESS CASE STUDIES*

Title:	Note on Design-Manufacturing Integration
Author:	Balaguer, N.S., Addonizio, M.
Publication Date:	06/14/1991
Product Type:	Note
Publisher:	Harvard Business School
Product Number:	9-191-202

Product Description:

Design-Manufacturing Integration (DMI) is becoming one of the most important trends in industry. As pressure mounts to bring higher quality, lower cost products to market as quickly as possible, the ability to couple design and manufacturing activities tightly to achieve time, quality, and cost saving benefits become critical. Organizational and technological factors that enable DMI-rotation among design and manufacturing engineers, cross-functional teams, use of a neutral transfer file, and adoption of an integrated CAD/CAM system, for example, can reduce manufacturing costs by as much as 75%, *engineering* changes by 65–70%, development time by 30–70%, and time to market by 20–90%. This note provides an overview of the concept of DMI and the organizational and technological barriers. In addition, it introduces a number of organizational and technological facilitators of DMI.

Subject:	Cross Functional Management; Information Systems; Manufacturing Strategy; Product Design; Product Development; Teams; Technology
Academic Discipline:	Computers and Information Systems
Length:	16 pages

Note: This case is out of print and no longer available for purchase.

Title:	Euclid Engineering
Author:	Kaplan, R.S.
Publication Date:	11/24/1992

* Courtesy of Harvard Business School Publishing.

Publication Revision Date: 06/18/1993
Publisher: Harvard Business School
Product Number: 9-193-031

Product Description:
Privately held engineering design and manufacturing company supplies the Big-3 U.S. auto manufacturers. To manage costs and help to keep prices down, the company develops activity-based cost (ABC) systems. Initially, the ABC system assigns manufacturing costs more accurately to products. Over time, the company uses an expanded ABC system to estimate the manufacturing cost consequences of product engineering decisions. In a recent application, the ABC system is used to provide the cost of activities performed during the design process itself.
Setting: Midwest, automotive supplier, 1991
Subject: Activity-Based Costing; Automotive; Cost Analysis; Cost System; Engineering; Management Accounting; Product Design
Academic Discipline: Accounting and Control
Length: 19 pages
Note: To order a copy of the case, please contact Harvard Business School Publishing at 1-800-988-0886 or at www.hbsp.harvard.edu

Title: Newell Co.: Acquisition Strategy
Author: Collis, D.J., Johnson, E.
Publication Date: 02/04/1994
Publication Revision Date: 03/30/1995
Product Type: Case (Field)
Publisher: Harvard Business School
Product Number: 9-794-066
Product Description:
Newell is a $1.5 billion manufacturer and distributor of low-tech home and hardware products, geared to serve volume purchasers. In 1992, Newell is considering two approaches to expand its current product line with the acquisitions of Sanford Corp., a $140 million manufacturer and marketer of writing instruments and office supplies, and Levolor, a $180 million manufacturer of window blinds. The case focuses on Newell's enduring corporate strategy as a guide for selecting appropriate acquisitions to grow the company.

Setting:	Wisconsin, consumer products, large, $1.25 billion sales, 116,800 employees, 1991—1992.
Subject:	Acquisitions; Consumer Products; Corporate Strategy; Distribution Channels; Diversification; Growth Strategy; Strategic Planning
Academic Discipline:	Industry and Competitive Strategy
Length:	24 pages

Note: To order a copy of the case, please contact Harvard Business School Publishing at 1-800-988-0886 or at www.hbsp.harvard.edu

ABSTRACTS OF ENGINEERING CASE STUDIES*

ECL 219
Difficulties with Modular Housing, G. Kardos, 1975.
This case deals with the problems of introducing an innovative form of residential housing. The problems are both technical and managerial. The housing system discussed was conceived and developed as a complete system which provides attractive housing yet offers cost advantages in production, transportation, and erection. But technical competence is not enough— the principal problem becomes one of satisfying the various regulatory bodies that the innovative methods of construction are as good as the more traditional methods. (Parts A, B, C) Total 30 pages. Instructor's Note: 2 pages.

ECL 220
The Trouble Light Recall, Robert McLaghlin, 1975.
This is the story of the Consumer Product Safety Commission's recall of a trouble light made by A.K. Electric Company. Reports on the investigation of a death involving a trouble light, and the subsequent labeling of the light by the commission as an "imminent hazard" give the reader an insight into the administrative and engineering processes of the CPSC. Total 29 pages.

ECL 256
Double Alkali Flue Gas Desulfurization: The CIPS Experience, R. Myhre, 1983.

* Courtesy of the American Society for Engineering Education.

A study of the efforts of an electric utility company to adopt a new approach to controlling emissions from a coal-burning power plant. The technical issues are examined as well as the associated legal and regulatory controversies. (Parts A, B, C, D, E, F) Total 44 pages. Instructor's Note: 6 pages

ABSTRACTS OF IPQMS CASE HISTORIES

Title:	Kabini Papers, Ltd.: A Development Project Utilizing Agricultural Raw Materials
Author:	Arvinder Brara
Published in:	*Food and Agricultural Waste Development Projects*, Louis Goodman, John Hawkins, and Tetsuo Miyabara, eds. (New York: Pergamon Press, 1982)

This case history describes the planning, design, and implementation of a mini-paper plant in a rural area of India to meet a paper shortage and to create jobs, involving both professional and technical personnel. Using locally available but unutilized agricultural resources, such as rice straw or elephant grass, the plan was designed to produce ten metric tons of "kraft paper" (ndustrial paper) per day. Highlights of the case history include the feasibility studies, the project's organizational and funding complexities, the design problems, the technical solutions, and the overall impact on rural development efforts. The case clearly demonstrates the significance of the ways in which meaningful employment can affect people's lives. In addition, it resulted in an innovative treatment of the effluent to not only avoid pollution of the environment, but also to serve as an irrigant for the local farmers. It further demonstrates how an integrated approach to project planning and management overcomes problems and produces beneficial results.

Length: 33 pages

Title:	The People's Republic of China: Energy for Rural Development — The Yaocun Project
Author:	John N. Hawkins and Shengyun Li
Published in:	*Small Hydroelectric Projects for Rural Development*, Louis Goodman, John N. Hawkins, and Ralph Love, eds. (New York: Pergamon Press, 1981)

This case history describes a small-scale hydroelectric project in rural north China. The project site was in the county of Linxian, located in the northernmost point of Henan Province. This is an area consisting of an extensive canal system from which numerous small-scale hydroelectric stations operate. The 80 or more small hydroelectric stations in the count were designed and constructed in integrated clusters. This case focuses on one such cluster of two stations, constructed during the period 1973–1977 and known as the Yaocun project. A number of problems in the management of such projects were documented: the political-economic environment; planning and management in a state socialist system; rural farmer participation; the multiple uses of water control projects; and the process of establishing a nonformal technical training program. The case is a good example of the variety of problems that emerge in project management when lines of authority are not clear and governmental decisions and messages are inconsistent.

Length: 40 pages

Title: The Trans Alaska Pipeline

Authors: George Geistauts and Vern Hauck

Published by: The East-West Center, Resource Systems Institute, Louis Goodman and Ralph Love, eds. (Honolulu, 1979)

This case history describes the conception, planning, design, and construction of the Trans-Alaska Pipeline System (TAPS). The system ultimately selected was an 800-mile pipeline from the Arctic coast to the ice-free port of Valdez. The case examines the construction of the pipeline, haul road, marine terminal in Valdez and the pump stations. The massiveness of the project was further complicated by (1) the environment, (2) the Alaska construction cycle, and (3) state government-federal government relationships.

The project was initially delayed four years (1969–1973) because of environmental opposition, legal actions and Congressional action. This delay increased the estimated cost from $900 million to $4 billion. The consortium of oil companies and their design-construct group (Alyeska) did not take advantage of this delay to conduct adequate feasibility studies. This resulted in confusing lines of management authority, with serious disputes among the owners, Alyeska, the execution contractors, and the construction managers. The end results of inadequate planning and management were insufficient labor camp facilities, lack of quality control for the various tasks in implementation, and exposure of deficient designs which required additional delays. The project was completed in 1977, costing over $8 billion. An independent study showed over $1.5 billion were lost to waste, fraud, and mismanagement.

The analysis of TAPS also included the impact of the pipeline on Alaska's communities, businesses, state government and environment. A bibliography is included for use in both the classroom and practice.
Length: 130 pages

Appendix B
Sample IPQMS Checklist

PUBLIC WORKS PROJECTS

The authors and their colleagues developed approximately 260 questions as the basis for researching and writing case histories of past projects to establish a data base for the lessons learned to improve planning and management of new projects. These questions can also be adapted to provide a sound basis for troubleshooting any problems that might arise in design and implementation of projects in all sectors.

This appendix demonstrates the application of the comprehensive set of IPQMS questions in preparing a sample checklist for public works and other construction projects. A similar checklist of questions can be prepared for any program or project in any sector, public or private. For example, a checklist of questions prepared for the Challenger program could have prevented the Challenger spacecraft disaster in January 1986 by providing unified control of the design of the pressure seal in the aft field joint of the right solid rocket motor. Additional examples of the value of a checklist of questions to ensure cost effectiveness and safety can be provided.

The following sample checklist for public works and other construction projects is prepared by project phase (see Figure 2.1):

A. Phase 1: Planning, Appraisal and Design

1. Prepare purposes and goals of project.
    a) Clarity of project statement
    b) Identification of potential problem areas in design, manpower needs, financial needs and timetables

2. Extent of preliminary design
    a) Manpower needs for preparation
    b) Reliability of design data and assumptions

3. Selection of overall project manager (or project management team) who will have responsibility and accountability for entire project.

4. Detailed layout of feasibility studies and analyses to determine if available resources (financial, manpower, materials, technological) are adequate to ensure a successful project. These studies also provide necessary baseline data for subsequent tasks.
    a) The technical feasibility studies (project location and layout, subsurface conditions and problem areas, technology needs, availability of construction materials, training of technical personnel, labor market, water supply needs, waste treatment requirements)
    b) The financial feasibility analysis (investment analysis, projected capital needs at various stages)
    c) The economic feasibility analysis (local economic benefits, cost-benefit studies of alternative designs, effect on employment)
    d) The market and commercial feasibility studies (as appropriate)
    e) The administrative, organizational, and managerial studies
    f) The environmental baseline studies
    g) The environmental impact studies (estimate impact of proposed project, both short- and long-term)
    h) The social and political impact studies

5. Outline procedures to be used for the appraisal process.
    a) Determine how many stages the process should go through
    b) Have the appraisal team make necessary on-site inspections

6. The final design should clearly and explicitly satisfy the purposes and goals of the project.
    a) Alternative designs should be considered as appropriate

7. The final design must include measurable targets for attaining purposes and goals (measuring the project's outputs).
    a) Relevant building codes must be satisfied
    b) Provisions must be made for environmental impact assessments

8. Plans, specifications, job descriptions and work schedules must be prepared in detail.

9. Provisions must be made for continuous evaluation of each task, also serving as the basis for a post-evaluation plan.

10. Baseline data obtained from the feasibility studies should now be organized to prepare guidelines and checklists for both control criteria for subsequent tasks in the IPQMS and troubleshooting any problems that might arise.

B. Phase 2: Selection, Approval, and Activation

1. The final selection and approval of the project design must include a final financial plan for funding of the project, with assurances that budgets and timetables are coordinated.

2. Outline the necessary linkages with the various agencies and civic groups interested in, and concerned with, the project.

3. The overall project manager must carefully review all project tasks in light of personnel needs, position descriptions, and budgets to organize the project internally.

4. A preliminary control system such as the critical path method (CPM) or the program evaluation and review technique (PERT) is now prepared and approved by the overall project manager. This must include:
   a) Work/activity scheduling
   b) Authority, responsibility, and supervision
   c) Communication channels among divisions and with supporting organizations
   d) Relationships between technical and administrative divisions
   e) Resource procurement and allocation
   f) Monitoring and reporting
   g) Public participation, as appropriate

5. Anticipate the possible need for on-the-job training for a select number of persons, who will assume more responsibility on future projects.

C. Phase 3: Operation, Control and Handover

1. Be prepared for intense activities as the various tasks and functions become operational in the start-up of the project.

2. The overall project manager must review the control system (CPM or PERT), and adjust if necessary to optimize coordination and control of the many diverse operations.

a) The flow of necessary resources
b) The viability of information flows and feedback systems
c) The ability to troubleshoot any problems that might arise: personnel, technical or financial

3. Responsibility for on-going evaluation of each task with weekly (or daily if necessary) meetings with the overall project manager to assure smooth operations. Any request for changes in construction must be carefully checked to ensure safety and timetables are maintained.

4. Have a plan for a smooth handover of the project to its owner or administrator, with arrangements to transfer unutilized or excess resources to other projects or organizations.

5. Project completion report.

D. Phase 4: Evaluation and Refinement

1. Prepare an evaluation report consisting of the on-going evaluations in phases 1 to 3, and a post-completion evaluation.
   a) Include evaluation parameters developed from the feasibility studies (phase 1)
   b) Measure and analyze the difference between projected and actual results

2. Will the evaluation results lead to the formulation of proposals for further projects?

3. What lessons and insights were learned from the project?
   a) Was there an analysis of the reasons for deviations in implementation from the operating plan?
   b) Did the analysis reveal both long- and short-term lessons?

4. How can these lessons be applied to refine future projects?

5. How can these lessons be applied to future policy decisions on project management?

6. How can these lessons be used to ensure total quality and cost effectiveness in all future programs and projects?

7. How can these lessons be utilized in project management education and training?

As stated earlier, the IPQMS provides a dynamic and holistic approach to management which considers the entire range of a program or project's activities, from planning through implementation, evaluation, and refinement, with the central function of policy providing focus and direction throughout the life (and afterlife) of the project. Thus, it serves as a basis for organizing all project teams to provide the necessary leadership, teamwork, and information flows for accountability, cost effectiveness, and quality. Of equal importance, it provides the framework for improved project management education and training.

Initially, the IPQMS was found very effective for engineering and public works projects for which the various components and stages are well defined. Thus, check-lists corresponding to each of the components are prepared in detail and can be evaluated at any time during the cycle. Our continuing studies show that the IPQMS can also be used in other areas such as agriculture, health, industry — indeed in every aspect of government and the private sector. The authors and a colleague have prepared a draft of an IPQMS Checklist for the EPA Superfund Program.

As discussed in Chapter 2, the IPQMS is a powerful management tool. It provides solutions to complex problems of people, organizations, finance, materials, and time — facilitating decision-making and eliminating problems that might arise during implementation.

With the advent of very efficient computer systems, the IPQMS becomes doubly easy to use. Warning indicators can be introduced so that projects, when something goes wrong, can be corrected on time. Graft, or overspending, can easily be pinpointed in all areas, and waste will be minimized. Mismanagement will be identified as soon as it happens and thus curtailed. An IPQMS-run project is a fail-safe project.

Appendix C
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