The handbook of LOGISTICS and DISTRIBUTION MANAGEMENT

3rd edition

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Preface

The prime objective for writing the first edition of this book was to provide an up-to-date text at a reasonable cost. We also felt that there was a significant gap in the literature for a book that offered a broad framework as well as a clear and straightforward description of the basic functions and elements related to logistics and distribution. The feedback that we received indicated that we had met these goals and that the book was the core text for its subject area.

In the second edition of the book, published in 2000, we provided a significant revision of the original text. The continued high rate of development and change in business and logistics has necessitated this new third edition, which also includes some major revisions. The objectives of the original book are unchanged, however: to provide a text with both simplicity of style and relevance of context.

The scope of logistics has continued to grow rapidly, and this is reflected in the content of the book. We have included key aspects of supply chain philosophy and practice, but have tried to retain the focus on distribution and logistics that was a feature of the first edition.

As with the previous editions of the book, it has not been possible to cover all of the associated functions in the depth that we might have liked. Shortage of space has necessitated this compromise. Thus, such elements as manufacturing and procurement are featured, but only at a fairly superficial level and only in-depth when there is a relevant interface with distribution and logistics. In addition, it should be noted that we have attempted to reflect the general principles of logistics and distribution that can be applied in any country throughout the world. Clearly, for some aspects, there are differences that can only be generalized with difficulty. Where this is the case we have tended to use the European model or approach as our foundation, but we have included some international material. Within the scope of a book of this size, it is impractical to cover all issues from a world perspective.

John Oxley has retired, and Peter Baker has taken over his role. Peter has many years' experience as a managing consultant and as a lecturer in logistics and distribution. His extremely valuable input has led to a substantial revision of the warehousing content in the book as well as an influential contribution in other areas. Phil Croucher is again a co-author of the new edition. Phil has put his practical, strategic and operational knowledge in planning and managing distribution and logistics into good effect in his contribution to the book. As well as his enthusiasm, he has provided a pragmatic and very experienced input.

Some of the content of the book is based on material that has been developed for the various Master's courses in logistics and supply chain management at the Cranfield Centre for Logistics and Supply Chain Management, Cranfield School of Management, with which we have been involved. We undoubtedly owe our colleagues and our graduates many thanks - and apologies where we have included any of their ideas in the book without directly acknowledging them. Other content is drawn from the research that we have undertaken, from company training courses that we have run, from a multitude of consultancy assignments and from the managing of logistics operations.

The logistics industry continues to change radically and to grow in importance. The quality of logistics managers and staff has also developed with the growth in responsibility and scope that a job in logistics entails. We hope, once again, that this book will help in logistics managers' quest to improve service and reduce cost, as well as keeping them aware of the many different facets of logistics and the supply chain. It should be of interest to practising managers and supervisors, to candidates undertaking examinations for the various professional institutes, and to undergraduate and graduate students who are reading for degrees in logistics, distribution and supply chain management or where these subjects are an integral part of their course. It should also provide strong support for those participating in web-based training in logistics.

This edition of the book is divided into six distinct parts, each covering a key subject area in logistics. These are:

1. Concepts of logistics and distribution;
2. Planning for logistics;
3. Procurement and inventory decisions;

4. Warehousing and storage;
5. Freight transport;
6. Operational management.

Part 1 considers the key *concepts of logistics and distribution.* The first chapter of the book provides an introduction to the subject area and some definitions are given. The main elements and functions are reviewed, together with a brief look at the historical development of distribution and logistics up to the present day. Some statistics are introduced that indicate the importance of logistics to both companies and economies. Chapter 2 concentrates on the integrated nature of logistics and the supply chain. The traditional, but still very relevant, total logistics concept is explained, and typical trade-offs are considered. A planning hierarchy for distribution and logistics is outlined. Finally, in this chapter, some of the main developments towards integration are discussed.

Customer service is a major aspect within logistics, and this is considered in Chapter 3. The components of customer service are described, and two models of service quality are considered. An approach to developing a customer service policy is outlined. The key elements of customer service measurement are reviewed. Chapter 4 concentrates on channels of distribution - the different types and different structures. A method of channel selection is considered. Also, the all-important question of whether to contract out logistics is assessed. Alternative types of third-party operation are reviewed, together with the many services that are offered. The key drivers for contracting out are described. The final chapter of this first part of the book reviews some of the main issues and challenges for logistics, from external influences to consumer-related developments.

Part 2 covers the ways and means of *planning for logistics.* Chapter 6 begins with an overview of the strategic planning process and then considers a specific logistics design framework. The next chapter concentrates on one of the main aspects of this design framework - the planning of logistics processes. The key logistics processes are described, and then an approach to process design or redesign is proposed. Some of the main tools and techniques are explained. Chapter 8 considers the planning of physical distribution activities - the more traditional pastures of depot location decisions. A discussion on the role of depots and warehouses is followed by a detailed assessment of the different cost relationships that are fundamental to the physical distribution planning process. A planned approach to designing an appropriate strategy is included.

Chapter 9 is concerned with the way in which logistics and distribution are organized within the company. The relationship with other corporate functions is considered. The need to develop more process-oriented organizational structures, rather than maintaining the traditional functional perspective, is proposed. The specific role of the logistics and distribution manager is described. Some payment schemes and mechanisms that are common to the industry are outlined.

The final chapter in this part of the book is concerned with manufacturing and materials management. Manufacturing is rarely a function that is found directly within the auspices of logistics. It is, however, a major factor within the broader context of the supply chain and is a principal interface with logistics. Thus, some of the key elements in manufacturing and materials management are introduced in this chapter.

Part 3 concentrates on those issues that are involved with *procurement and inventory decisions*. Chapter 11 covers basic inventory planning and management. The reasons for holding stock are considered, and the different types of stock are outlined. The implications of stock-holding on other logistics functions are described, and the use of different inventory replenishment systems is explained. Reorder quantity decisions are discussed, and the EOQ method is outlined. Simple demand forecasting is introduced. Chapter 12 describes some of the recent developments in inventory planning, particularly the way that inventory is viewed across the supply chain as a whole. The important relationship of inventory and time is explored. Key advances in inventory planning for manufacturing and for retailing are outlined. The final chapter in this part covers some of the main principles concerned with procurement. This is another area within the supply chain that has a significant interface with logistics, so a broad overview of key elements is described.

In Part 4, consideration is given to those factors that are concerned with *warehousing and storage*. Chapter 14 introduces the main warehousing principles and also provides an outline of the main warehouse operations. Palletized storage and handling systems are considered in Chapter 15. Included here are the principles of storage as well as descriptions of the various types of storage systems and storage equipment that are available. Chapter 16 concentrates on the many different non-palletized handling systems and equipment types that are used. In Chapter 17, order picking and replenishment are reviewed in some detail. The main principles of order picking are explained, and the various order picking methods are outlined.

Chapter 18 considers another key warehouse function: receiving and dispatch. The major factors are outlined within the context of overall warehouse operations. An approach to warehouse and depot design and layout is described in Chapter 19. The methods described here are an essential guide to ensuring that a warehouse or depot is designed to be effective in the light of the logistics operation as a whole. Chapter 20 explores the operational management of warehouses, the associated performance measures, and the latest information technology available to support these activities.

Part 5 concentrates on those areas of logistics and distribution specifically related to *freight transport*. Chapter 21 considers international logistics and the choice of transport mode. Initially, the relative importance of the different modes is reviewed. A simple approach for modal choice selection is then proposed, including operational factors, transport mode characteristics, consignment factors and cost and service requirements. Finally, there is a brief review of some key aspects of international trade. In Chapter 22, the use of intermodal transport is discussed. Different types of equipment and vehicles are described and the intermodal infrastructure is outlined.

The remaining chapters in this part of the book are concerned with aspects of road freight transport. Vehicle selection factors are described in Chapter 23. Included here are the main types of vehicle and vehicle body, different operational aspects, and load types and characteristics. In Chapter 24, vehicle and fleet costing is considered. The main transport costs are indicated, and whole life costing is described. Various elements concerning road freight transport legislation and the implications for fleet operations are outlined in Chapter 25. The final chapter of Part 5 of the book, Chapter 26, concentrates on the planning and resourcing of road freight transport operations. This includes the need for planning, and the important use of vehicle routeing and scheduling to aid this process. The main objectives of routeing and scheduling are indicated, and the different types of problem are described. The basic characteristics of road transport delivery are discussed, and they are related to broad data requirements. Examples of both manual and computer routeing and scheduling methods are outlined.

The final part of the book, Part 6, considers a number of aspects related to the *operational management* of logistics and distribution. This begins with Chapter *27,* where cost and performance monitoring of logistics and distribution operations is discussed. A description of a formal approach to logistics monitoring and control is outlined. Several different means of measurement are introduced, and a number of areas of best practice are considered. Examples of detailed key performance and cost indicators are given. Chapter 28 describes the use of benchmarking as a major technique for identifying best practice in logistics. As well as an overview of benchmarking procedures, a detailed approach to benchmarking distribution activities is outlined. Chapter 29 considers the different information systems that can be used in the supply chain. There have been, and continue to be, many major advances in information communication and technology. This chapter serves to provide an overview of some of those elements that are particularly important to logistics and the main components of distribution.

The question of whether or not to contract out logistics was assessed in an early chapter. The actual process of selection is described in Chapter 30. A step-by-step guide is given, from the initial need to identify the type of service that is required through to the need to manage the contract once it has been implemented. Chapter 31 covers a very important area of responsibility in logistics - that of security and safety. Many aspects that are relevant to logistics planning and operations are discussed. Another important consideration is the impact of logistics operations on the environment. This is reviewed in Chapter 32.

We all hope that this latest edition of *The Handbook of Logistics and Distribution Management* will continue to serve as a useful aid to understanding this wide-ranging and increasingly important business area.

Alan Rushton

Abbreviations

NB: This section is designed to demystify many of the more common abbreviations and acronyms used in the industry. Most, but not all, of these appear in the text. Readers may consult this section quite independently.

3D	three-dimensional
3PL	third-party logistics
4D	four-directional
4PL	fourth-party logistics
ABC	activity-based costing
ABC curve	Pareto or ABC inventory analysis
ADR	Accord Dangereux Routier (European agreement regarding the road transport of dangerous goods)
AGV	automated guided vehicle
AMR	Advanced Manifest Regulations
APR	adjustable pallet racking
APS	advanced planning and scheduling
artic	articulated (vehicle)
ASEAN	Association of South East Asian Nations
ASME	American Society of Mechanical Engineers
ASN	advance shipping notice
AS/RS	automated storage and retrieval system

ATP Accord relative aux transports internationaux de denrees perissables (European agreement regarding the international transport of perishable goods)
B2B business to business
B2C business to consumer
BOM bill of materials
BS British Standard
BSI British Standards Institution
CB truck counterbalanced fork-lift truck
CBFLT counterbalanced fork-lift truck
CBP United States Bureau of Customs and Border Protection
CCTV closed circuit television
CD compact disc
CDC central distribution centre
CFR cost and freight
CIF cost, insurance, freight
CILT(UK) The Chartered Institute of Logistics and Transport (UK)
CIM computer integrated manufacturing; Convention internationale concernant le transport des marchandises par chemin de fer (European agreement regarding the international transport of goods by rail)
CIP carriage and insurance paid to...
CIPS Chartered Institute of Purchasing and Supply
CM category management
CMI co-managed inventory
CMR Convention relative au contrat de transport international de marchandises par route (European convention regarding international transport contracts of goods by road)
CNG compressed natural gas
CO certificate of origin
COD cash on delivery
CPFR collaborative planning, forecasting and replenishment
CPT carriage paid to...
CRM customer relationship management
CRP continuous replenishment programme
CSCMP Council of Supply Chain Management Professionals
CSI Container Security Initiative
CT community transit
C-TPAT Customs-Trade Partnership against Terrorism

DAF delivered at frontier
dB (a) decibel
DC distribution centre
DCF discounted cash flow
DCM demand chain management
DDP delivered duty paid
DDU delivered duty unpaid
DEQ delivered ex-quay
DERV diesel-engined road vehicle
DES delivered ex-ship
DfT Department for Transport
DMAIC define, measure, analyse, improve and control
DME dimethyl ether
DPP direct product profitability
DRP distribution requirements planning
EAN European article number
EBQ economic batch quantity
ECR efficient consumer response
EDI electronic data interchange
EEE electrical and electronic equipment
EFTA European Free Trade Area
ELA European Logistics Association
EOQ economic order quantity
EPOS electronic point of sale
ERP enterprise resource planning
ES exponential smoothing
EU European Union
EXW ex works
FAS free alongside ship
FAST Free and Secure Trade
FCA free carrier
FCL full container load
FEM Federation Europeenne de la Manutention (European federation of material handling)
FEU forty feet -equivalent unit
FG finished goods
FGI finished goods inventory
FGP factory gate pricing
FIBC flexible intermediate bulk container

FIFO first in first out
FILO first in last out
FLT fork-lift truck
FMCG fast-moving consumer goods
FMS flexible manufacturing systems
FOB free on board
FOC fire officer's committee; free of charge
FRES Federation of Recruitment and Employment Services
FTA Freight Transport Association
FTL full truck load
GDP gross domestic product
GIS geographic information systems
CMOs genetically modified organisms
GPS global positioning system
GSM global system for mobiles
GTIN global trade item number
GVW gross vehicle weight
HGV heavy goods vehicle
HSE Health and Safety Executive; health, safety and environment
HSWA Health and Safety at Work Act
IBC intermediate bulk container
ICT information, communication and technology
IGD Institute of Grocery Distribution
IJPDLM International Journal of Physical Distribution and Logistics Management
ISO International Standards Organization
IT information technology
ITT invitation to tender
IWW inland waterways
JIC just-in-case
JIT just-in-time
KPI key performance indicator
LC letter of credit
LCL less than container load
LED light-emitting diode
LGV large goods vehicle
LIFO last in first out
LLOP low-level order picking truck
LNG liquefied natural gas
LOLO lift on lift off

LPG	liquefied petroleum gas
LSP	logistics service provider
LTL	less than truck load
MAM	maximum authorized mass
MBO	management by objectives
MHE	materials handling equipment
MIS	management information systems
MPG	miles per gallon
MPS	master production schedule
MRO	maintenance, repair and overhaul
MRP	materials requirements planning
MRPII	manufacturing resource planning
NA	narrow aisle
NAFTA	North American Free Trade Association
NCPDM	National Council of Physical Distribution Management
NDC	national distribution centre net present value
NPV	optical character recognition
OCR	on time in full
OTIF	pick up and deposit station
P&D	personal computers
PCs	political, economic, socio-cultural and technological analysis
PEST analysis	product life cycle
PLC	particulate matter
PM	proof of delivery
POD	point of sale
POS	personal protective equipment
PPE	powered pallet truck
PPT	People's Republic of China
PRC	pounds per square inch
PSI	quality assurance
QA	quality control
QC	quality function deployment
QFD	quick response
QR	research and development
R&D	regional distribution centre; radio data communication
RDC	radio data terminal
RDT	radio frequency
RF	request for information
RFI	

RFID	radio frequency identification
RFP	request for proposal
RFQ	request for quotation
RFS	road-friendly suspension
RH&D	receipt, handling and dispatch
RM	raw materials
ROCE	return on capital employed
RofW	rest of world
ROI	return on investment
ROL	reorder level
RORO	roll on roll off
ROS	return on sales
RT	reach truck
SAD	single administrative document
SC	supply chain
SCEM	supply chain event management
SCM	supply chain management
SCOR model	supply chain operations reference model
SCP	supply chain planning
SEM	Single European Market
SEMA	Storage Equipment Manufacturers' Association
semi	semi-trailer (articulated truck trailer)
SKU	stock-keeping unit
SOP	sales order processing
SOW	scope of work
SRM	supplier relationship management
SSAP 21	Statement of Standard Accounting Practice 21
STGO	special types general order
SWL	safe working load
SWOT	strengths, weaknesses, opportunities and threats
tare weight	unladen or empty weight
TEU	twenty feet equivalent unit
TIR	Transport International Routier (international road transport convention)
TL	truck load
TLC	total logistics concept
TQM	total quality management
TUPE	Transfer of Undertakings (Protection of Employment)

UN/EDIFACT	United Nations/Electronic Data Interchange for Administration, Commerce and Transport
UPC	universal product code
VAS	value added services
VAT	value added tax
VIN	vehicle identification number
VMI	vendor-managed inventory
VNA	very narrow aisle
WEEE	waste electrical and electronic equipment
WIP	work-in-progress
WMS	warehouse management system

Part 1

Concepts of logistics and distribution

i

Introduction to logistics and distribution

INTRODUCTION

The key components of distribution have been an important feature of industrial and economic life for countless years, but it is only in the relatively recent past that distribution has been recognized as a major function in its own right. The main reason for this has probably been the nature of distribution itself. It is a function made up of many sub-functions and many sub-systems, each of which has been, and may still be, treated as a distinct management operation.

Both the academic and the business world now accept that there is a need to adopt a more holistic view of these different operations in order to take into account how they interrelate and interact with one another.

The appreciation of the scope and importance of distribution and logistics has led to a more scientific approach being adopted towards the subject. This approach has been aimed at the overall concept of the logistics function as a whole and also at the individual sub-systems. Much of this approach has addressed the need for, and means of, planning distribution and logistics, but has also considered some of the major operational issues.

This first chapter of the book provides an introduction to some of the very basic aspects of distribution and logistics. It begins with a consideration of the scope and definition of distribution and logistics, and then looks at some of the main elements that are key to the function itself. A review of the historical growth of distribution and logistics is followed by an assessment of its importance throughout the world. Finally, a typical distribution and logistics structure is described and discussed.

SCOPE AND DEFINITION

Parallel to the growth in the importance of distribution and logistics has been the growth in the number of associated names and different definitions that are used. Some of the different names that have been applied to distribution and logistics include:

- physical distribution;
- logistics;
- business logistics;
- materials management;
- procurement and supply;
- product flow;
- marketing logistics;
- supply chain management;
- demand chain management;

and there are several more.

There is, realistically, no 'true' name or 'true' definition that should be pedantically applied, because products differ, companies differ and systems differ. Logistics is a diverse and dynamic function that has to be flexible and has to change according to the various constraints and demands imposed upon it and with respect to the environment in which it works.

So these many terms are used, often interchangeably, in literature and in the business world. One quite widely accepted view shows the relationship as follows:

Logistics = Supply + Materials management + Distribution

As well as this, logistics is concerned with *physical* and *information* flows and storage from raw material through to the final distribution of the finished product. Thus, supply and materials management represents the storage and flows into and through the production process, while distribution represents the storage and flows from the final production point through to the customer or end user. Major emphasis is now placed on the importance of information as well as physical flows and storage, and an additional and very relevant factor is that of reverse logistics - the flow of used products and returnable packaging back through the system. Figure 1.1 illustrates these different elements and flows, as well as indicating how some of the associated logistics terminology can be applied.

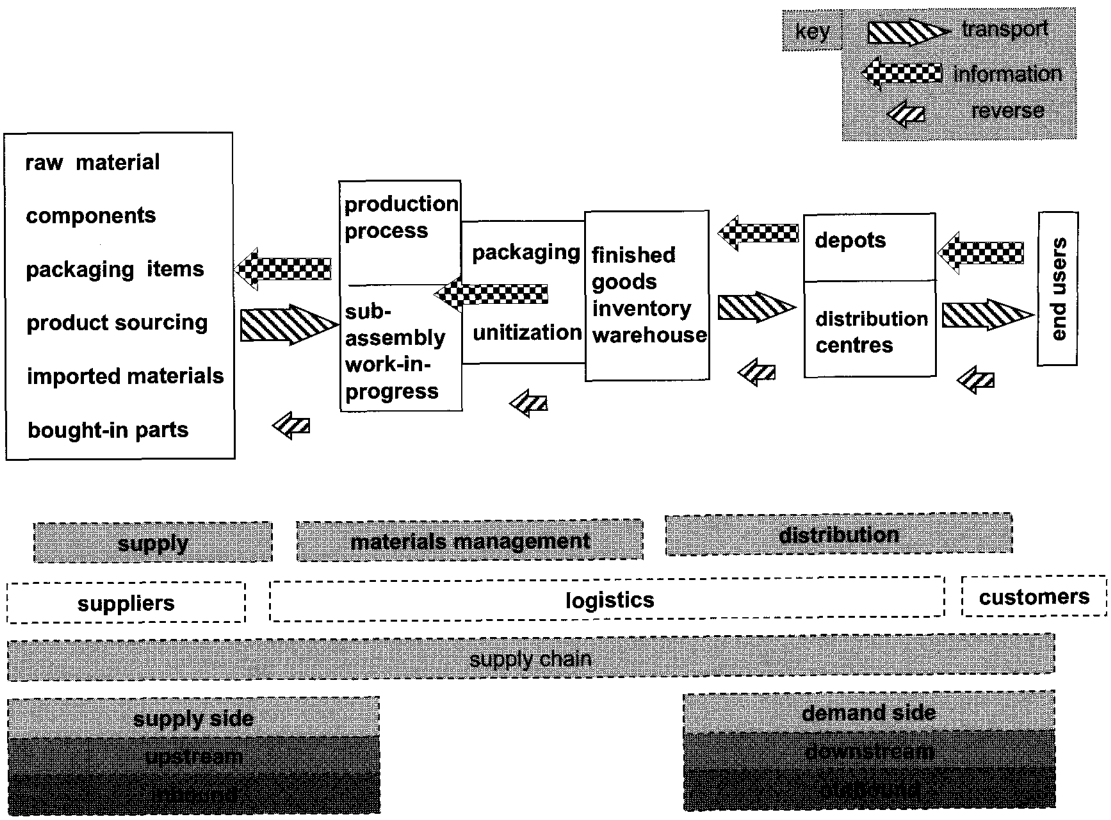


Figure 1.1 A logistics configuration of an FMCG company showing the key components, the major flows and some of the different logistics terminology

The question of the most appropriate definition of logistics and its associated namesakes is always an interesting one. There are a multitude of definitions to be found in textbooks and on the internet. A selected few are:

> Logistics is... the management of all activities which facilitate movement and the co-ordination of supply and demand in the creation of time and place utility.
>
> (Hesket, Glaskowsky and Ivie, 1973)

> Logistics is the art and science of managing and controlling the flow of goods, energy, information and other resources.
>
> (Wikipedia, 2006)

> Logistics management is... the planning, implementation and control of the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customer requirements.
>
> (CSCMP, 2006)

> Logistics is... the positioning of resource at the right time, in the right place, at the right cost, at the right quality.
>
> (Chartered Institute of Logistics and Transport (UK), 2005)

It is interesting to detect the different biases – military, economic, academic, etc. An appropriate modern definition that applies to most industry might be that logistics concerns *the efficient transfer of goods from the source of supply through the place of manufacture to the point of consumption in a cost-effective way whilst providing an acceptable service to the customer*. This focus on cost-effectiveness and customer service will be a point of emphasis throughout this book.

For most organizations it is possible to draw up a familiar list of key areas representing the major components of distribution and logistics. These will include transport, warehousing, inventory, packaging and information. This list can be 'exploded' once again to reveal the detailed aspects within the different components. Some typical examples are given in Figure 1.2.

All of these functions and sub-functions need to be planned in a systematic way, in terms both of their own local environment and of the wider scope of the distribution system as a whole. A number of questions need to be asked and decisions made. The different ways of answering these questions and making these decisions will be addressed in the chapters of this book as consideration is given to the planning and operation of the distribution and logistics function. In addition, the total system interrelationships and the constraints of appropriate costs and service levels will be discussed.

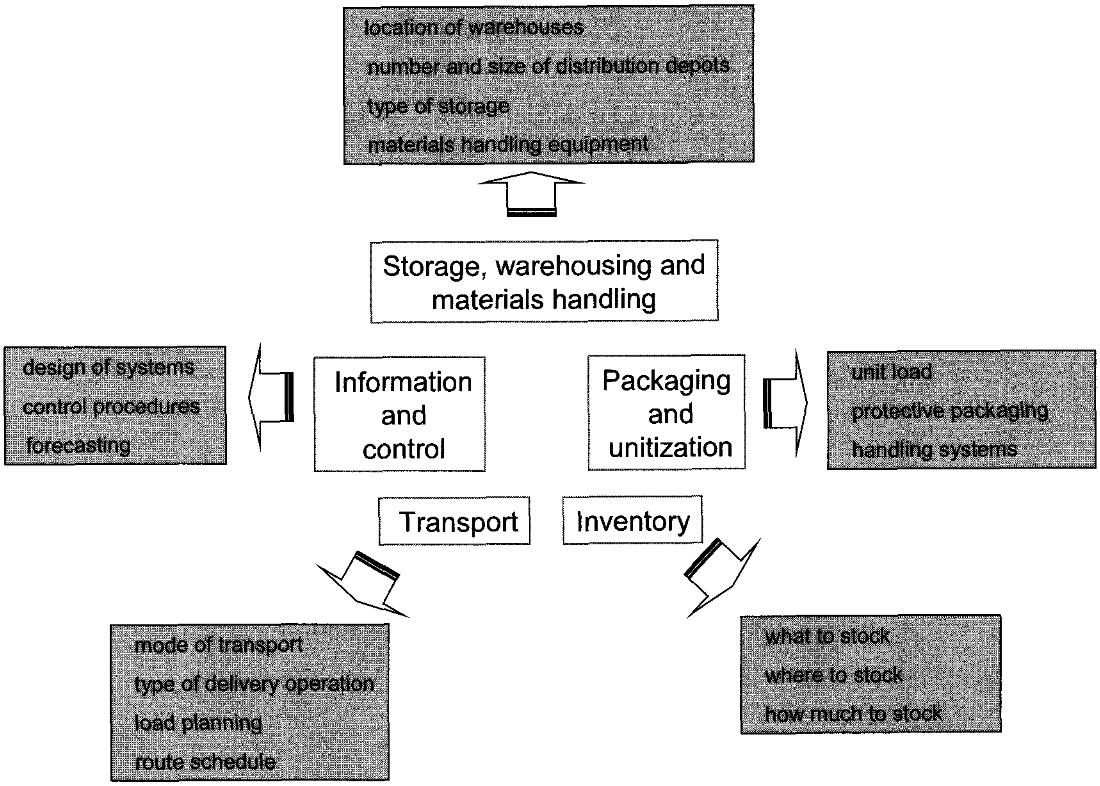


Figure 1.2 The key components of distribution and logistics, showing some of the associated detailed elements

HISTORICAL PERSPECTIVE

The elements of distribution and logistics have, of course, always been fundamental to the manufacturing, storage and movement of goods and products. It is only relatively recently, however, that distribution and logistics have come to be recognized as vital functions within the business and economic environment. The role of logistics has changed in that it now plays a major part in the success of many different operations and organizations. In essence, the underlying concepts and rationale for logistics are not new. They have evolved through several stages of development, but still use the basic ideas such as trade-off analysis, value chains and systems theory together with their associated techniques.

There have been several distinct stages in the development of distribution and logistics.

1950s and early 1960s

In this period, distribution systems were unplanned and unformulated. Manufacturers manufactured, retailers retailed, and in some way or other the goods reached the shops. Distribution was broadly represented by the haulage industry and manufacturers' own-account fleets. There was little positive control and no real liaison between the various distribution-related functions.

1960s and early 1970s

In the 1960s and 1970s the concept of *physical distribution* was developed with the gradual realization that the 'dark continent' was indeed a valid area for managerial involvement. This consisted of the recognition that there was a series of interrelated physical activities such as transport, storage, materials handling and packaging that could be linked together and managed more effectively. In particular, there was recognition of a relationship between the various functions, which enabled a systems approach and total cost perspective to be used. Under the auspices of a physical distribution manager, a number of distribution trade-offs could be planned and managed to provide both improved service and reduced cost. Initially the benefits were recognized by manufacturers who developed distribution operations to reflect the flow of their product through the supply chain.

1970s

This was an important decade in the development of the distribution concept. One major change was the recognition by some companies of the need to include distribution in the functional management structure of an organization. The decade also saw a change in the structure and control of the distribution chain. There was a decline in the power of the manufacturers and suppliers, and a marked increase in that of the major retailers. The larger retail chains developed their own distribution structures, based initially on the concept of regional or local distribution depots to supply their stores.

1980s

Fairly rapid cost increases and the clearer definition of the true costs of distribution contributed to a significant increase in professionalism within distribution. With this professionalism came a move towards longer-term planning and attempts to identify and pursue cost-saving measures. These measures included centralized distribution, severe reductions in stock-holding and the use of the computer to provide improved information and control. The growth of the third-party distribution service industry was also of major significance, with these companies spearheading developments in information and equipment technology. The concept of and need for integrated logistics systems were recognized by forward-looking companies that participated in distribution activities.

Late 1980s and early 1990s

In the late 1980s and early 1990s, and linked very much to advances in information technology, organizations began to broaden their perspectives in terms of the functions that could be integrated. In short, this covered the combining of materials management (the inbound side) with physical distribution (the outbound side). The term 'logistics' was used to describe this concept (see Figure 1.1). Once again this led to additional opportunities to improve customer service and reduce the associated costs. One major emphasis recognized during this period was the importance of the informational aspects as well as the physical aspects of logistics.

1990s

In the 1990s the process was developed even further to encompass not only the key functions within an organization's own boundaries but also those functions outside that also contribute to the provision of a product to a final customer. This is known as *supply chain management* (see Figure 1.1). The supply chain concept thus recognizes that there may be several different organizations involved in getting a product to the marketplace. Thus, for example, manufacturers and retailers should act together in partnership to help create a logistics pipeline that enables an efficient and effective flow of the right products through to the final customer. These partnerships or alliances should also include other intermediaries within the supply chain, such as third-party contractors.

2000 and beyond

Business organizations face many challenges as they endeavour to maintain or improve their position against their competitors, bring new products to market and increase the profitability of their operations. This has led to the development of many new ideas for improvement, specifically recognized in the redefinition of business goals and the re-engineering of entire systems.

One business area where this has been of particular significance is that of logistics. Indeed, for many organizations, changes in logistics have provided the catalyst for major enhancements to their business. Leading organizations have recognized that there is a positive 'value added' role that logistics can offer, rather than the traditional view that the various functions within logistics are merely a cost burden that must be minimized regardless of any other implications.

Thus, the role and importance of logistics have, once again, been recognized as a key enabler for business improvement.

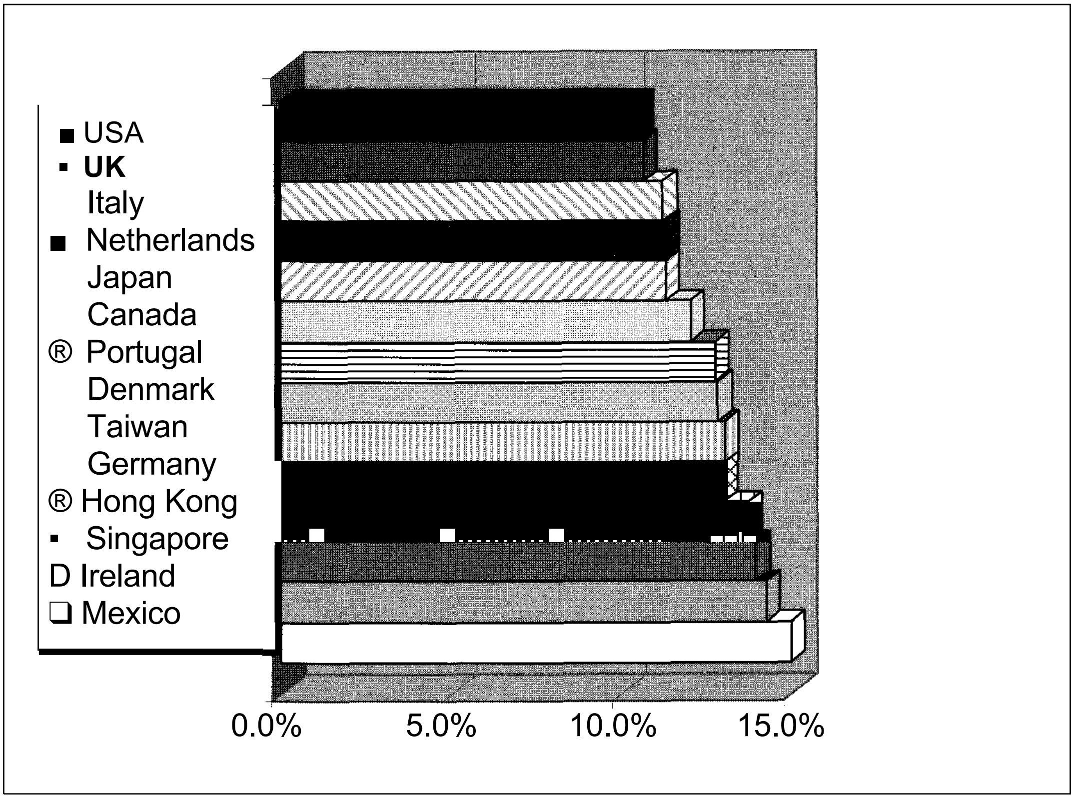
IMPORTANCE OF LOGISTICS AND DISTRIBUTION

It is useful, at this point, to consider logistics in the context of business and the economy as a whole. Logistics is an important activity making extensive use of the human and material resources that affect a national economy. Several investigations have been undertaken to try to estimate the extent of the impact of logistics on the economy.

One such study indicated that about 30 per cent of the working population in the UK are associated with work that is related to logistics. A recent study undertaken in the USA indicated that logistics alone represented between 10 and 15 per cent of the gross domestic product of most major North American, European and Asia/ Pacific economies. This is summarized in Figure 1.3. These numbers represent some very substantial costs, and serve to illustrate how important it is to understand the nature of logistics costs and to identify means of keeping these costs to a minimum. The two lowest-cost countries are the UK and the United States, probably because there has been a greater recognition of the importance of logistics in these two particular countries for many years now. The average for all countries is only about 2. 5 percentage points higher: relatively low, because in recent years the importance of logistics has been recognized in many more countries. About 20 years ago, if the same statistics had been available, these percentage elements would undoubtedly have been a lot higher in all of these countries. In the UK, records go back for 20 years, and logistics costs were then around the 18 to 20 per cent mark.

The breakdown of the costs of the different elements within logistics has also been included in a number of surveys. A survey of US logistics costs undertaken by Herbert W Davis & Company (2005) indicated that transport was the most important element at 45 per cent, followed by inventory carrying cost (23 per cent), storage/warehousing (22 per cent) and administration (10 per cent).

These broad figures are supported by a European logistics productivity survey, produced by A T Kearney. These results, covering the major EU economies, placed



Source: CSCMP Toolbox 2004

Figure 1.3 Logistics costs as a percentage of GDP for selected countries

transport at 41 per cent, inventory carrying cost at 23 per cent, warehousing at 21 per cent and administration at 15 per cent of overall costs. In both studies, therefore, the transport cost element of distribution was the major constituent part.

It is interesting to see how the relative make-up of these costs varies from one company to another and, particularly, from one industry to another. Listed in Table 1.1 are some examples of logistics costs from different companies. These are taken from an industry cost audit carried out in the UK by Dialog Consultants Ltd. There are some quite major differences amongst the results from the various companies. One of the main reasons for these cost differences is that logistics structures can and do differ quite dramatically between one company and another, and one industry and another. Channels can be short (ie very direct) or long (ie have many intermediate stocking points). Also, channels may be operated by

Table 1.1 Logistics costs as a percentage of sales turnover

Main Company Business	Cost as Percentage of Turnover				
	Transport Cost	**Warehouse/ Depot Cost**	**Inventory Investment/ Holding Cost**	**Administration Cost**	**Overall Logistics Cost**
	%	%	%	%	%
Office equipment	3.20	10.70	0.87		14.77
Health supplies	1.36	9.77	0.66	0.19	11.98
Soft drinks	2.53	2.71	0.44		5.68
Beer (food and drink)	8.16	2.82	0.56	2.19	13.74
Spirits distribution	0.37	0.27	0.07	0.10	0.81
Cement	25.20	9.10	7.10	4.60	46.00
Automotive parts	2.07	6.35	1.53		9.96
Gas supply (non-bulk)	9.41	2.45	0.02		11.98
Computer maintenance	0.45	0.10	0.29	0.05	0.88
Computer supply	0.65	0.78	0.09		1.52
Healthcare	0.96	1.08	1.21		3.25
Specialist chemicals	7.23	1.95	0.20	0.49	9.87
Fashion	0.38	1.31	0.33		2.02
Food packaging	3.14	3.73	0.85		7.72

Source: Benchmark survey of UK companies by Dialog Consultants Ltd

manufacturers, retailers or, as is now becoming increasingly common, specialist third-party distribution companies. In the examples shown in Table 1.1, the relative importance of logistics is, of course, measured in relationship to the overall value of the particular products in question. Cement is a low-cost product (as well as being a very bulky one!), so the relative costs of its logistics are very high. Spirits (whisky, gin, etc) are very high-value products, so the relative logistics costs appear very low. These and other associated aspects are discussed in subsequent chapters.

LOGISTICS AND DISTRIBUTION STRUCTURE

The discussion in the previous sections of this chapter has illustrated the major components to be found within a logistics or distribution system. The fundamental characteristics of a physical distribution structure could be considered as the flow of material or product, interspersed at various points by periods when the material or product is stationary. This flow is usually some form of transportation of the product. The stationary periods are usually for storage or to allow some change to the product to take place – manufacture, assembly, packing, break-bulk, etc.

A simple physical flow is illustrated in Figure 1.4. The different types of transport (primary, local delivery, etc) and stationary functions (production, finished goods inventory, etc) are shown.

There is also, of course, a cost incurred to enable the distribution operation to take place. The importance of this distribution or logistical cost to the final cost of the product has already been highlighted. As has been noted, it can vary according to the sophistication of the distribution system used and the intrinsic value of the product itself. One idea that has been put forward in recent years is that these different elements of logistics are providing an 'added value' to a product as it is made available to the final user – rather than just imposing an additional cost. This is a more positive view of logistics and is a useful way of assessing the real contribution and importance of logistics and distribution services. Figure 1.4 also provides an example of this cost or added value for a typical low-cost product. The added value element varies considerably from one product to another.

SUMMARY

In this initial chapter, a number of subjects have been introduced. These will be expanded in subsequent chapters of the book.

The rather confusing number of associated names and different definitions was indicated, and a few of the very many definitions were considered. No 'true' or definitive definition was offered, because logistics and distribution can and do differ dramatically from one industry, company or product to another.

The recent history of distribution and logistics was outlined, and a series of statistics served to illustrate how important logistics and distribution are to the

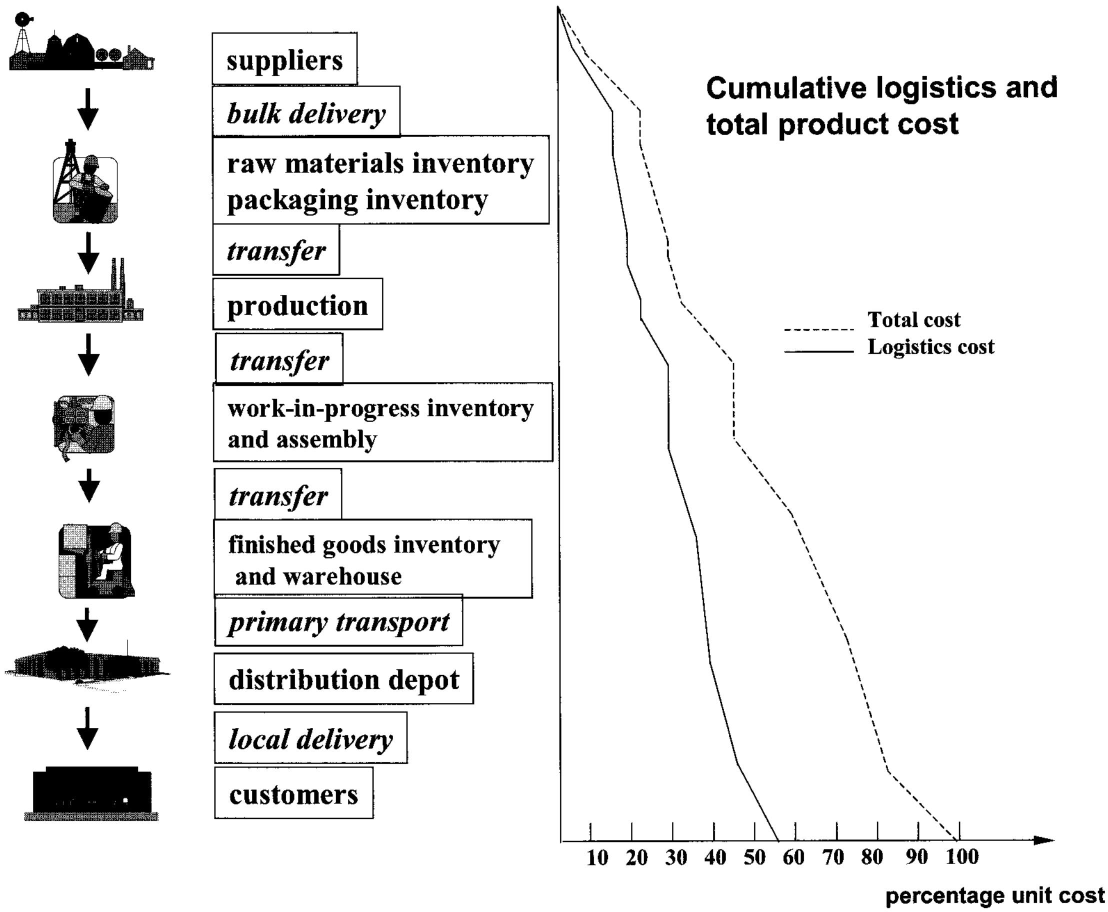


Figure **1.4** Atypical physical flow of material from suppliers through to customers, showing stationary functions and movement functions, linked to a diagram that reflects the 'value added' nature of logistics

economy in general and to individual companies. The breakdown between the constituent parts of distribution was given.

The basic structure of distribution and logistics was described, and the concepts of material and information flow and the added value of logistics were introduced.

2

Integrated logistics and the supply chain

INTRODUCTION

In the first chapter, different definitions of logistics were introduced, and the main components of distribution were outlined. It was shown that the various logistics and distribution functions are part of a flow process operating across many business areas. In this chapter, the emphasis is on the need to integrate the various distribution and logistics components into a complete working structure that enables the overall system to run at the optimum. Thus, the concept of 'total logistics' is described, and the importance of recognizing the opportunities for appropriate trade-offs is discussed. Some key aspects of planning for logistics are reviewed, and the financial impact that logistics has in a business is described. Finally, a number of recent developments in logistics thinking are put forward, including the impact of the globalization of many companies, integrated planning systems, the use of logistics to help create competitive advantage and the development of supply chain management.

THE TOTAL LOGISTICS CONCEPT

The total logistics concept (TLC) aims to treat the many different elements that come under the broad category of distribution and logistics as one single integrated system. It is a recognition that the interrelationships between different elements, for example delivery transport and storage, need to be considered within the context of the broader supply chain. Thus, the total system should be considered and not just an individual element or subsystem in isolation.

An understanding of the concept is especially important when planning for any aspect of distribution and logistics. A simple, practical example helps to emphasize the point:

> A company produces plastic toys that are packaged in cardboard boxes. These boxes are packed on to wooden pallets that are used as the basic unit load in the warehouse and in the transport vehicles for delivery to customers.
>
> A study indicates that the cardboard box is an unnecessary cost because it does not provide any significant additional protection to the quite robust plastic toys and it does not appear to offer any significant marketing advantage. Thus, the box is discarded, lowering the unit cost of the toy and so providing a potential advantage in the marketplace.
>
> One unforeseen result, however, is that the toys, without their boxes, can -not be stacked on to wooden pallets, because they are unstable, but must be stored and moved instead in special trays. These trays are totally different to the unit load that is currently used in the warehouse and on the vehicles (ie the wooden pallet). The additional cost penalty in providing special trays and catering for another type of unit load for storage and delivery is a high one – much higher than the savings made on the product packaging.

This example illustrates a classic case of *sub-optimization* in a distribution system. It shows how the concept of total logistics can be ignored at some significant cost. As the product packaging costs have been reduced, those concerned with this company function will feel that they have done their job well. The overall effect on the total logistics cost is, in fact, a negative one. The company is better served by disregarding this potential saving on packaging, because the additional warehouse and transport costs mean that total costs increase.

This simple example of sub-optimization emphasizes the point concerning the interrelationships of the different logistics elements. A more positive viewpoint is to interpret these and other interrelationships in a planned approach to identifying and determining *cost trade-offs*. These will provide a positive benefit to the logistics system as a whole. Such a trade-off may entail additional cost in one function but will provide a greater cost saving in another. The overall achievement will be a net gain to the system.

This type of trade-off analysis is an important part of planning for logistics. Four different levels of trade-off have been identified:

1. *Within distribution components:* those trade-offs that occur within single functions. One example would be the decision to use random storage locations compared to fixed storage locations in a depot. The first of these provides better storage utilization but is more difficult for picking; the second is easier for picking but does not provide such good storage utilization.
2. *Between distribution components:* those trade-offs between the different elements in distribution. To reverse the previous packaging example, a company might increase the strength and thus the cost of packaging but find greater savings through improvements in the warehousing and storage of the product (ie block stacking rather than a requirement for racking).
3. *Between company functions:* there are a number of areas of interface between company functions where trade-offs can be made. This is illustrated in Figure 2. 1, which lists some potential trade-offs and indicates how the different company functions might be affected. An example is the trade-off between optimizing production run lengths and the associated warehousing costs of storing the finished product. Long production runs produce lower unit costs (and thus more cost-effective production) but mean that more product must be stored for a longer period (which is less cost-effective for warehousing).
4. *Between the company and external organizations:* where a trade-off may be beneficial for two companies that are associated with each other. For example, a change from a manufacturer's products being delivered direct to a retailer's stores to delivery via the retailer's distribution depot network might lead to mutual savings for the two companies.

These types of trade-offs are thus at the heart of the total logistics concept. For the planning of distribution and logistics, it is important to take this overall view of a logistics system and its costs. The other side of the equation is, of course, the need to provide the service level that is required by the customer. This balance of total logistics cost and customer service level is essential to successful logistics.

Trade-off	Finance	Production	Distribution	Marketing
Longer production runs	Lower production unit costs	Lower production unit costs	More inventory and storage required	Lower prices
Fewer depots	Reduced costs	No impact	Less complicated logistics structure	Service reduction due to increased distance of depots from customers
Lower FG stocks	Reduced costs	Shorter production runs so higher production unit costs	No need to expand storage facilities	Poorer product availability for customers
Lower RM and component stocks	Reduced costs	Less efficient production scheduling due to stock unavailability	Lower stock-holding requirements	No direct impact
Less protective transport packaging	Reduced costs	No impact	Reduced transport modal choice	Increase in damaged deliveries
Reduced warehouse supervision	Cost savings through lower headcount	No impact	Reduced efficiency due to less supervision	Lost sales due to less accurate order picking

Figure 2.1 Some potential trade-offs in logistics, showing how different company functions might be affected

PLANNING FOR DISTRIBUTION AND LOGISTICS

In order to ensure that the concept of total logistics is put into practice and that suitable trade-offs are achieved, it is essential that a positive planning approach is adopted. In this section, the various planning horizons with their associated logistics decisions are discussed. In Chapter 6, a more formalized planning framework will be discussed. This will be developed in subsequent chapters into a more practical and detailed approach to logistics planning.

Planning should be undertaken according to a certain hierarchy that reflects different planning time horizons. These are generally classified as strategic, tactical and operational. They are represented in Figure 2.2. There is an overlap between the main planning stages, which emphasizes that there are many planning factors that can be covered by different stages in this planning hierarchy. The relative importance of these various aspects of logistics may differ between one company

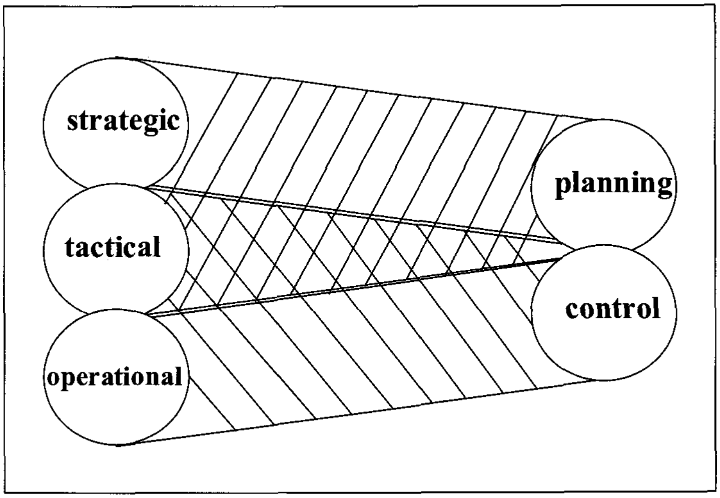


Figure 2.2 Logistics planning hierarchy

and another. The choice of transport mode could, for example, be an initial strategic decision and also a subsequent tactical decision for the same company. It might be a strategic decision for a company that is setting up a new global logistics operation, but might be a tactical decision for another company that is principally a supplier to a locally based market and only occasionally exports over long distances.

Figure 2.2 also indicates the interrelationship of planning and control within this hierarchy. Both of these different elements are essential to the running of an effective and efficient logistics operation. One way to envisage the difference between these two concepts is as follows: *planning is* about ensuring that the operation is set up to run properly - it is 'doing the right thing' or preparing for and planning the operation 'effectively'; *control is* about managing the operation in the right way - it is ' doing the thing right' or making sure that the operation is being run 'efficiently'.

Once again it is not relevant to define exactly which strategic, tactical and operational decisions or tasks within a company should be classified as either planning or control. Most elements need to be planned correctly in the first place, and then subsequently they need to be monitored and controlled to ensure that the operation is running as well as it should be. The practical means of monitoring and controlling logistics are described in Chapter 27.

Some of the major aspects and differences between the three time horizons are summarized in Figure 2.3. The importance and relevance of these different aspects

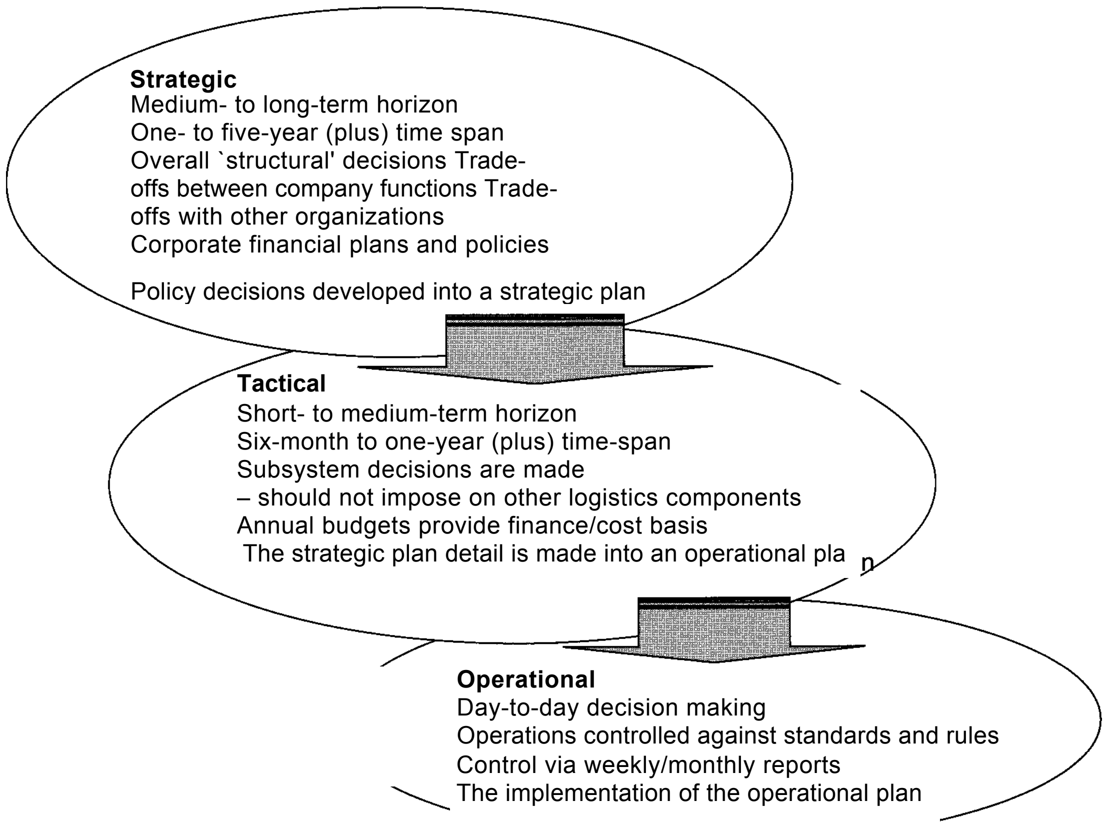


Figure 2.3 The major functions of the different planning time horizons

will, of course, vary according to the type and scale of business, product, etc. It is helpful to be aware of the planning horizon and the associated implications for each major decision that is made.

It is possible to identify many different elements within distribution and logistics that can be broadly categorized within this planning hierarchy. As already indicated, these may vary from one company to another and from one operation to another. Some of these - in no particular order - are as indicated in Figure 2.4.

These examples serve to emphasize the complexity of distribution and logistics. In addition, they underline the need for appropriate planning and control. Distribution and logistics are not merely the transportation of goods from one storage point to another. There are many and varied elements that go together to produce an effective distribution and logistics operation. These elements interrelate, and they need to be planned over suitable time horizons.

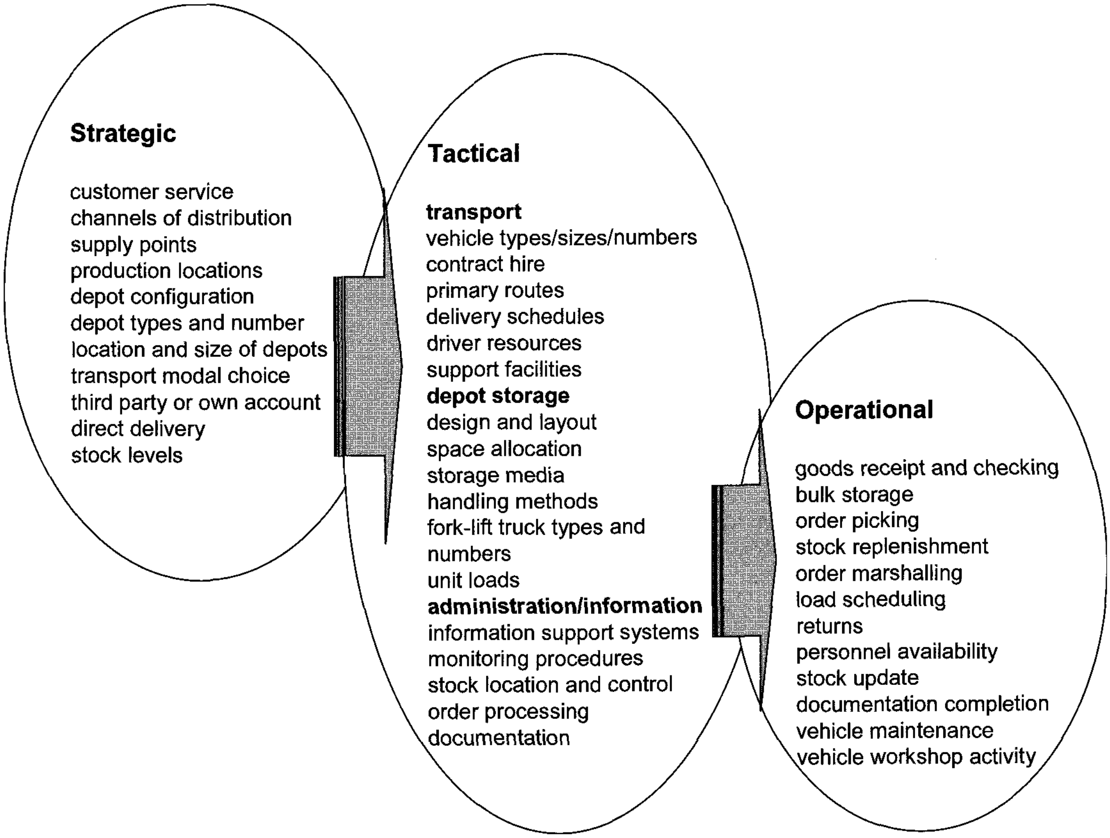


Figure 2.4 Some of the main logistics elements for the different planning time horizons

The planning and control of an operation can also be described within the context of a broader planning cycle. This emphasizes the need for a systematic approach, where continual review takes place. This is an important idea in logistics, because most operations need to be highly dynamic - they are subject to continual change, as both demand and supply of goods and products regularly vary according to changes in customer requirements for new products and better product availability. One example of a fairly common framework is shown as the planning and control cycle in Figure 2.5.

The cycle begins with the question 'Where are we now?' Here the aim is to provide a picture of the current position. This might be through an information feedback procedure or through the use of a specific logistics or distribution audit.

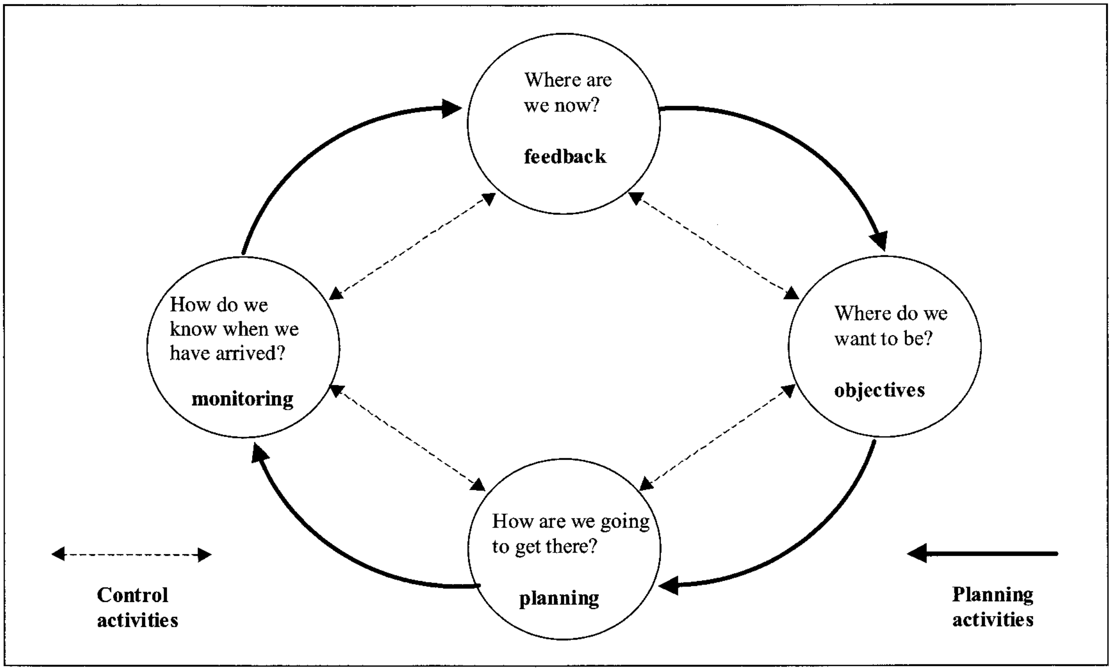


Figure 2.5 The planning and control cycle

The second stage is to determine the objectives of the logistics process, to identify what the operation should be trying to achieve. These need to be related to such elements as customer service requirements, marketing decisions, etc.

The third stage in the cycle is the planning process that spans the strategic and operational levels previously discussed. Finally, there is a need for monitoring and control procedures to measure the effectiveness of the distribution operation compared to the plan. The cycle has then turned full circle, and the process is ready to begin again. This allows for the dynamic nature of logistics, the need for continual review and revision of plans, policies and operations. This must be undertaken within a positive planning framework in order to ensure that continuity and progress are maintained.

THE FINANCIAL IMPACT OF LOGISTICS

Distribution and logistics can have a variety of different impacts on an organization's financial performance. This particularly applies when the whole of a business is considered. Traditionally seen as an operational necessity that cannot be avoided, a good logistics operation can also offer opportunities for improving financial performance.

For many companies, a key measure of success is the return on investment (ROI): the ratio between the net profit and the capital employed in the business. For improved business performance, this ratio needs to be shifted to increase profits and reduce capital employed. There are many different ways in which logistics can have both a positive and a negative impact on the ROI. These are outlined in Figure 2.6. This shows ROI as the key ratio of profit and capital employed, with the main elements broken down further as sales revenue *less* cost (representing profit) and inventory *plus* cash and receivables *plus* fixed assets (representing capital employed).

Profit can be enhanced through increased sales, and sales benefit from the provision of high and consistent service levels. One of the aims of many service level agreements is to try to achieve OTIF (on time in full) deliveries - a key object ive of many logistics systems. On the other hand, costs can be minimized through

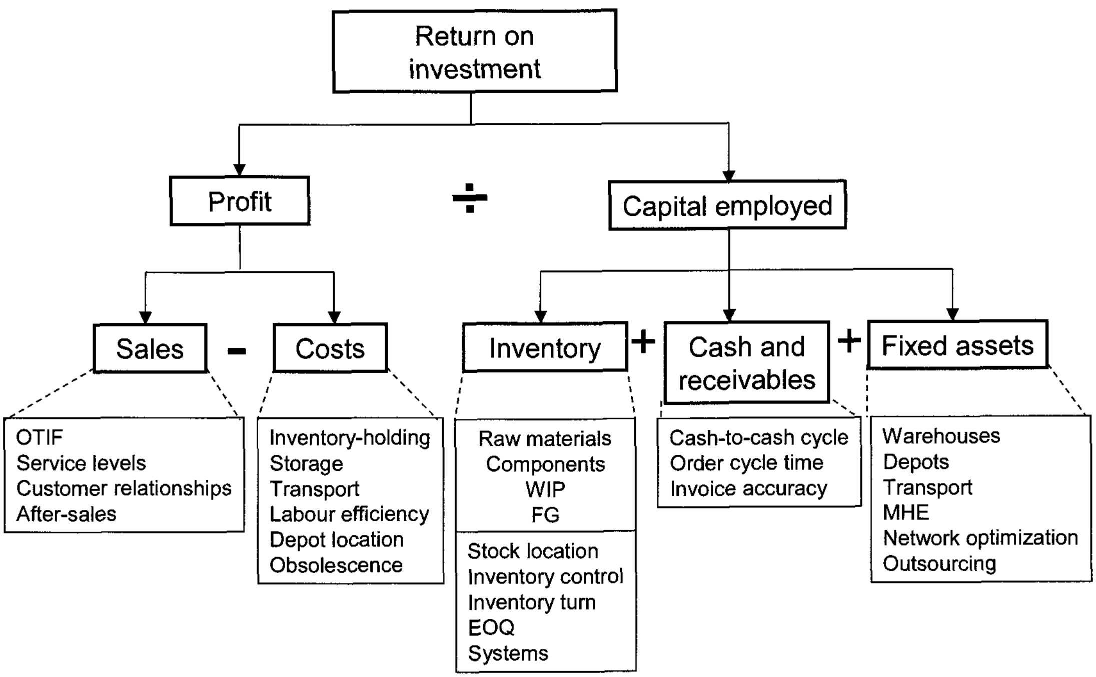


Figure 2.6 The many ways in which logistics can provide an impact on an organization's return on investment

efficient logistics operations. There are a number of ways that this might happen, including reductions in transport, storage and inventory holding costs, as well as maximizing labour efficiency.

The amount of *capital employed* can also be affected by the different logistics components. There are many different types of inventory held by companies, including raw materials, components, work-in-progress and finished goods. The key logistics functions impact very significantly on the stock levels of all of these. This impact can occur with respect to stock location, inventory control, stock-holding policies, order and reorder quantities and integrated systems, amongst others. Cash and receivables are influenced by cash-to-cash and order cycle times - both of these being key logistics processes. Finally, there are many fixed assets to be found in logistics operations: warehouses, depots, transport, and material handling equipment. The number, size and extent of their usage are fundamental to effective logistics planning. Also, there may be good opportunities to outsource some or all of these operations, which has a significant effect on reducing fixed assets.

Much of this book is taken up with the practical logistics issues that enable the maximization of profit, the minimization of costs and thus the improvement of ROI.

GLOBALIZATION AND INTEGRATION

One area of significant change in recent years has been the increase in the number of companies operating in the global marketplace. This necessitates a broader perspective than when operating as an international company. In the latter, although companies may have a presence across a wide geographic area, this is supported on a local or regional basis through local or regional sourcing, manufacturing, storage and distribution. In the former, the company is truly global, with a structure and policy that represent a global business. Typical attributes will include:

- global branding;
- global sourcing;
- global production;
- centralization of inventories;
- centralization of information;

but with the ability to provide for local requirements, be these electronic standards for electrical goods, language on packaging or left-/right-hand-drive alternatives in the automotive industry.

To service global markets, logistics networks become, necessarily, far more expansive and far more complex. Once again, the need is to plan and manage logistics as a complete and integrated system. As well as the attributes already mentioned, companies operating in a global market are often involved with the outsourcing of some manufacturing and the use of 'focused' factories that specialize in a limited number of products.

The major logistics implications of globalization are:

- extended supply lead times;
- extended and unreliable transit times;
- multiple break-bulk and consolidation options;
- multiple freight mode and cost options;
- production postponement with local added value.

It is obvious from this that there is a direct conflict between globalization and the move to the just-in-time operations that are being sought by many companies. In global companies there is a tendency to see order lead times increase and inventory levels rise because of the distances involved and the complexity of logistics. In companies moving to the just-in-time philosophy there is a desire to reduce lead times and to eliminate unnecessary stock and waste within their operations. For those companies trying to achieve both goals, there is a clear challenge for logistics.

INTEGRATED SYSTEMS

To support the need to develop more integrated operations there have been a number of recent developments in logistics and distribution systems that have the concept of total logistics as their basis. Thus, quite revolutionary 'trade-offs' are now being practised. The major reason for this explosion of new ideas is twofold. The first is the realization of the importance, cost and complexity of logistics. The second is the progress made in the field of information technology, which has enabled the development of sophisticated information systems to support and enhance the planning and management of logistics operations, whereby very detailed data collection and analysis can be undertaken that was previously impossible. Some of these alternative approaches to integrated physical and information systems are described in Chapter 29, where information systems in the supply chain are discussed. In addition, some of the key aspects of integration are reviewed in Chapter 10, 'Manufacturing and materials management'. Many of the origins of integrated systems have a background in manufacturing.

Direct product profitability (DPP)

DPP is a technique of allocating all of the appropriate costs and allowances to a given product. All distribution costs (storage, transport, etc) are therefore assigned to a specific product rather than taking an average over a whole product range. Thus, in the same way that a budgetary system operates, the actual costs of distributing a product are monitored and compared to a standard cost determined using DPP. In this way, areas of inefficiency throughout the whole logistics operation can be identified. DPP techniques can identify the costs of specific products to individual customers and so provide invaluable information for effective marketing strategies.

Materials requirements planning (MRP) and distribution requirements planning (DRP)

MRP/DRP systems have been developed as sophisticated, computerized planning tools that aim to make the necessary materials or inventory available when needed. The concept originated with materials requirements planning, an inventory control technique for determining dependent demand for manufacturing supply. Subsequently, manufacturing resource planning (MRPII) was developed with the objective of improving productivity through the detailed planning and control of production resources. MRPII systems are based on an integrated approach to the whole manufacturing process from orders through production planning and control techniques to the purchasing and supply of materials (see Chapter 10 for further discussion). Distribution requirements planning is the application of MRPII techniques to the management of inventory and material flow - effective warehousing and transportation support.

DRP systems operate by breaking down the flow of material from the source of supply through the distribution network of depots and transportation modes. This is undertaken on a time-phased basis to ensure that the required goods 'flow' through the system and are available as and when required - at the right place, at the right time, one of the classic distribution definitions. Integrated systems of this nature require sophisticated, computerized information systems as their basis. The benefits of an effective system can be readily seen in terms of reduced freight, storage and inventory holding costs and improved customer service.

Just-in-time (JIT)

JIT originated as a new approach to manufacturing and has been successfully applied in many industries such as the automotive industry. It has significant implications for distribution and logistics. The overall concept of JIT is to provide a production system that eliminates all activities that neither add value to the final product nor allow for the continuous flow of material – in simple terms, that eliminates the costly and wasteful elements within a production process. The objectives of JIT are vitally linked to distribution and logistics, including as they do:

- the production of goods the customer wants;
- the production of goods when the customer wants them;
- the production of perfect-quality goods;
- the elimination of waste (labour, inventory, movement, space, etc).

There are a number of JIT techniques used to a greater or lesser extent by the generally large companies that have adopted the JIT philosophy, and these are explained in Chapter 10.

As with all such approaches, JIT has some negative points as well as the more positive ones listed above. It can, for example, lead to increased traffic flows due to the need for smaller but more frequent deliveries of goods to the customer.

COMPETITIVE ADVANTAGE THROUGH LOGISTICS

Attitudes towards distribution and logistics have changed quite dramatically in recent years. It has been a long-held view that the various elements within logistics have merely created additional cost for those companies trying to sell products in the marketplace. Although there is, of course, a cost associated with the movement and storage of goods, it is now recognized that distribution and logistics also provide a very positive contribution to the value of a product. This is because logistics operations provide the means by which the product can reach the customer or end user in the appropriate condition and required location.

It is therefore possible for companies to compete on the basis of providing a product either at the lowest possible cost (so that the customer will buy it because it is the least expensive) or at the highest possible value to the customer (eg if it is exactly where and how the customer wants it). Some companies may, indeed, try to achieve both of these objectives. This is particularly important these days, as there are many products that are not sold on the basis of their brand name alone but that are, in fact, like commodities sold on the basis of availability or price. This applies to many food products as well as technical products, such as mobile phones and personal computers.

These ideas are illustrated in Figure 2.7. This shows that a company may compete as *a service leader,* where it is trying to gain an advantage over its competitors by providing a number of key service elements to differentiate itself. Or it may compete as *a cost leader* where it is trying to utilize its resources so that it offers the product at the lowest possible cost, thus gaining a productivity advantage. Examples of how this might be achieved are given in Figure 2.7. For a value advantage, this might include the provision of a specially tailored service or the use of several different channels of distribution so that the product is available in the marketplace in a number of different ways. It might include a guaranteed service level or a regular update on the status of orders. For a cost/productivity advantage, this will include a number of different means of cost minimization, such as maintaining very low levels of inventory and ensuring that all manufacturing and distribution assets are kept at a high utilization.

It should also be emphasized that for many companies it is necessary to develop differently configured logistics structures to cater for the variety of service offerings

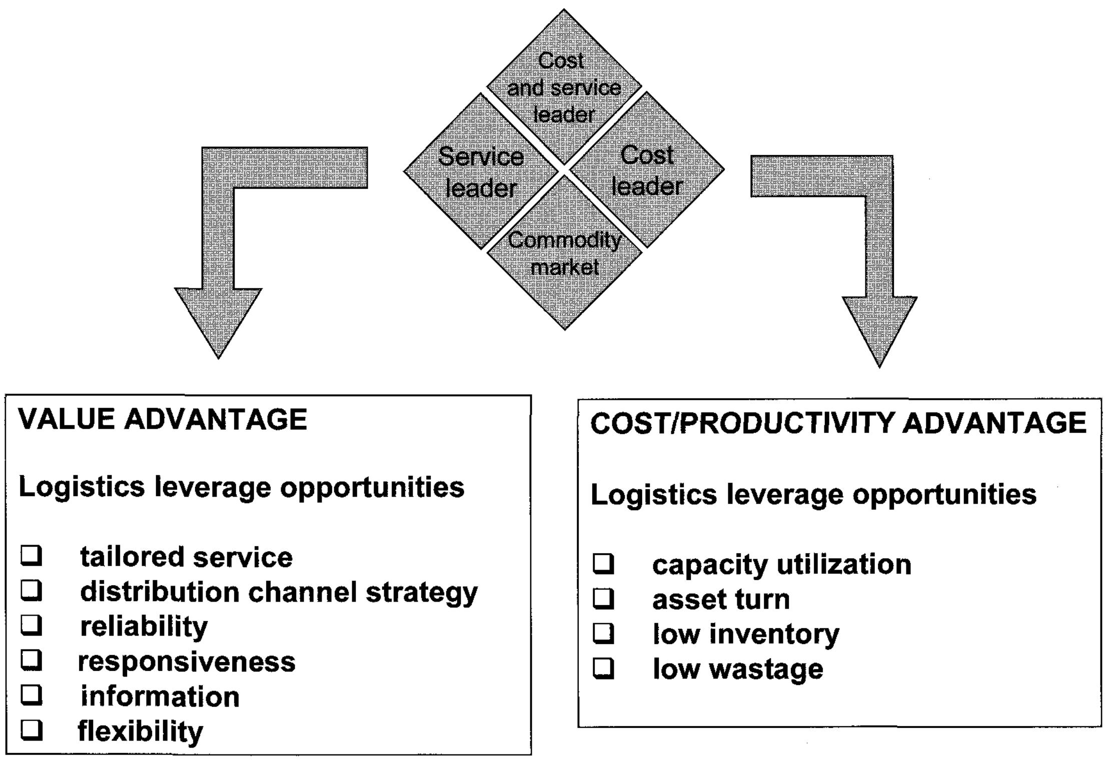


Figure 2.7 The logistics implications of different competitive positions that they need to provide. It is now appreciated that a 'one-size-fits-all' approach to logistics is usually too limited, because suppliers need to take account of a range of different customer requirements and make sure that their competitive advantage is understood and applied in all market segments. As noted in a recent European Logistics Association (ELA) survey (2004): 'One size fits all policies will rarely work when applied to modern, diverse service offerings... Leading companies are segmenting their supply chains according to the service and cost needs of the customer.'

LOGISTICS AND SUPPLY CHAIN MANAGEMENT

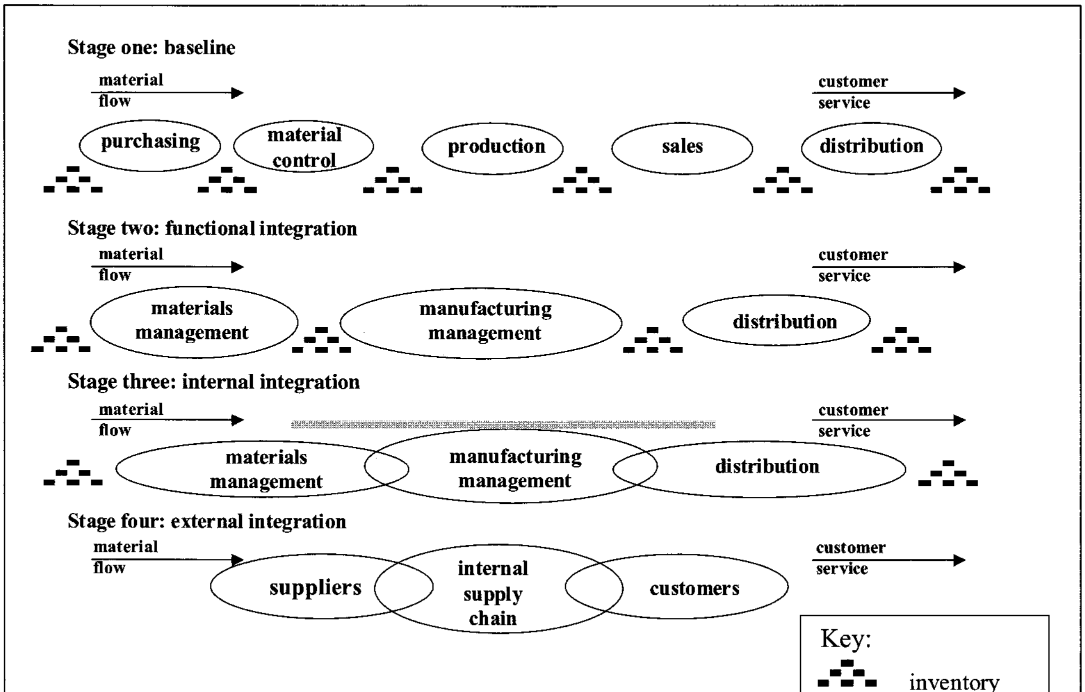
The term 'supply chain management' is now commonly used. This is, in reality, an extension of the ideas that have been developed in this and the previous chapter concerning the integrated nature of logistics. The total logistics concept advocates the benefits of viewing the various elements of logistics as an integrated whole. Supply chain management is similar, but also includes the supplier and the end user in the process or, as indicated in Figure 1.1, the upstream (supply side) and downstream (demand side) partners in the supply chain. This is the major difference between supply chain management and traditional logistics.

There are four distinct differences claimed for supply chain management over the more classic view of logistics, although some of these elements have also been recognized as key to the successful planning of logistics operations. These four are:

1. The supply chain is viewed as a single entity rather than a series of fragmented elements such as procurement, manufacturing, distribution, etc. This is also how logistics is viewed in most forward-looking companies. The real change is that both the suppliers and the end users are included in the planning process, thus going outside the boundaries of a single organization in an attempt to plan for the supply chain as a whole.
2. Supply chain management is very much a strategic planning process, with a particular emphasis on strategic decision making rather than on the operational systems.
3. Supply chain management provides for a very different approach to dealing with inventory. Traditionally, inventory has been used as a safety valve between the separate components within the pipeline – thus leading to large and expensive stocks of products. Supply chain management aims to alter this perspective so that inventory is used as a last resort to balance the integrated flow of product through the pipeline.

4. Central to the success of effective supply chain management is the use of integrated information systems that are a part of the whole supply chain rather than merely acting in isolation for each of the separate components. These enable visibility of product demand and stock levels through the full length of the pipeline. This has only become a possibility with the recent advances in information systems technology.

The move towards integration within different supply chains has been relatively slow; indeed, most companies have fairly limited integration within their own organizations. Full external integration is thus still a 'Holy Grail' that many organizations are striving to achieve. Many companies have moved to functional integration, with some achieving an element of full internal integration. Figure 2. 8 illustrates the different levels of integration a company might reach. The figure shows that for poorly integrated organizations there is a need to hold large inventories at frequent intervals throughout the supply chain.



Source: Stevens (1989)

Figure 2.8 Supply chain integration

SUMMARY

The realization of the need for the effective planning and control of distribution, coupled with the obvious interrelationships within distribution and logistics systems, has led to the development of several new approaches towards integrated systems. The recent advances in information technology have made the practical application of these new approaches feasible. All in all, there has been a very positive move towards an integrated approach to logistics, although for many companies, both large and small, there is still considerable scope for improvement.

The more complex and sophisticated systems and concepts such as DPP and DRP have been adopted by a number of large, generally multinational, companies. Smaller companies have been slower to adopt these concepts, despite the clear benefits to be gained. The main reasons for this are:

- a lack of organizational integration that reflects the role and importance of logistics and distribution;
- a failure to develop adequate long-term plans for logistics strategy; and
- insufficiently developed information structures and support systems to provide the appropriate databases for good logistics planning and management.

For many small and medium-sized companies, there is also the very pertinent factor that they need to learn to walk the distribution/logistics path before they attempt to run on it. But even for companies such as these, there is a great deal to be gained from taking those first few steps towards recognizing that logistics should be viewed as an integrated system and that there is a strong interrelationship between the different elements of transportation, storage, information, etc. In addition, there is the need to adopt a positive approach to the planning and control of those systems.

Fortunately, in the past few years, companies have, to a greater or lesser extent, realized the importance and relevance of distribution and logistics to their business as a whole. Thus, organizational structures and planning policies are now beginning to reflect this integrated approach.

In this chapter, the 'total logistics concept' has been introduced, and the need to recognize the opportunities for logistics trade-offs has been emphasized. The financial impact that logistics has in a business has been described. The importance of the need to integrate the various distribution and logistics components into a complete working structure that enables the overall system to run at the optimum

Finally, a number of recent developments in logistics thinking have been put forward, including the globalization of companies, integrated planning systems, the use of logistics to help create competitive advantage and the concept of supply chain management.

3

Customer service and logistics

INTRODUCTION

The vast majority of companies consider customer service to be an important aspect of their business. When pressed, however, there are many companies that find it difficult to describe *exactly what they mean by customer service* or provide *a precise definition of customer service measures*. Traditionally, service provisions have been based on very broad assumptions of what customers want, rather than taking into account the real requirements of customers or at least customers' perceptions of what they require.

There are several major points that need to be considered. One is the definition of customer service and another is its measurement. It is also important to understand that customer service and customer service requirements can and will differ not just between industries and companies but additionally between the market segments a business might serve.

Another relevant factor is the recognition of the complexity of customer service provision. Customer service is inextricably linked to the process of distribution and logistics. Within this process, there are many influences that may be relevant to customer service. These range from the ease of ordering to stock availability to delivery reliability. Finally, there is the need to balance the level of service provided with the cost of that provision. The downfall of many a service offering is often the unrealistic and unrecognized high cost of providing a service that may, in the event, be greater than is required by the customer.

The key to achieving a successful customer service policy is to develop appropriate objectives through a proper framework that includes liaison with the customer, and then to measure, monitor and control the procedures that have been set up.

THE IMPORTANCE OF CUSTOMER SERVICE

As already suggested, there are few companies that do not recognize the importance of the provision of good customer service. But, why is it so important? There are many different answers to this question, ranging from the growth in competition to the raising of customers' expectations to the similarity of the basic products that are offered. One way of considering customer service is to differentiate between the core product itself and the service elements related to the product. This is depicted in Figure 3.1. The core product concerns the item itself: the technical content, the product features, the ease of use, the style and the quality. The service elements, which can be called the 'product surround', represent the availability of the product, the ease of ordering, the speed of delivery, and after-sales support. There is a long list (as we shall see later in this chapter), and clearly not all of the service items on our list are relevant to all products.

It is recognized by the marketing departments of many companies that the product surround elements are very important in determining the final demand for a product. In addition, these aspects often represent only a small percentage of the cost of a product. Thus, true to the Pareto 80/20 rule, it is estimated that product surround or logistics elements represent about 80 per cent of the impact of the product but only represent 20 per cent of the cost. Thus, no matter how attractive the product may be, it is essential that the customer service elements are satisfactory and, as we shall see, logistics plays a crucial role in providing good customer service.

One of the definitions of logistics that was provided in the first chapter referred to 'the positioning of resource at the right time, in the right place, at the right cost, at the right quality'. This definition can be expanded into what might be considered as the seven 'rights' of customer service. These are the right quantity, cost, product, customer, time, place and condition; and the concept of applying these to customer service can be seen in Figure 3.2. All of these different aspects can be key requisites of a good customer service offering – indeed, each of them may be essential to ensure that a product achieves its expected sales in the various markets where it is made available. It is notable that all of these elements are affected by the standard and quality of the logistics operations that are an integral part of getting a product

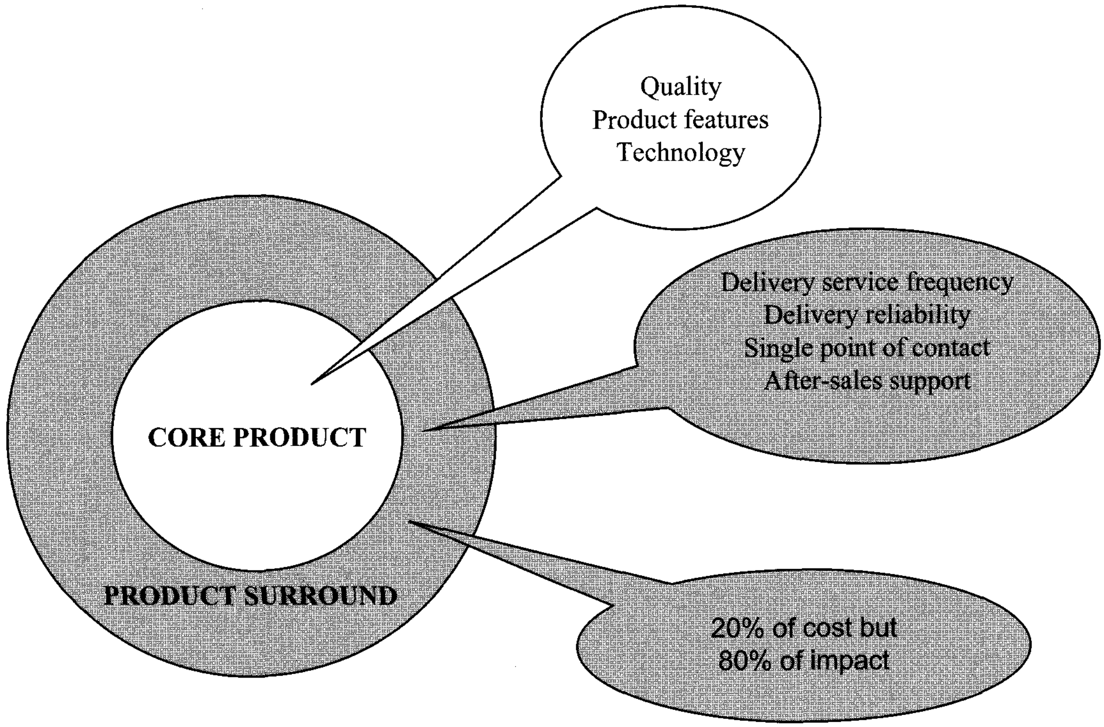


Figure 3.1 Core product versus product 'surround', illustrating the importance of the logistics-related elements

to market. Thus, these elements can provide the basis for identifying the different aspects of logistics that should form a part of any customer service offering, and also, and this is of equal importance, these elements should become the basis of the key measurements that are used to monitor operational success or failure. This will be considered in the final sections of this chapter.

THE COMPONENTS OF CUSTOMER SERVICE

The logistics components of customer service can be classified in different ways. They may be seen as transaction-related elements, where the emphasis is on the specific service provided, such as on-time delivery, or they may be seen as functional attributes that are related to overall aspects of order fulfilment, such as the ease of order taking.

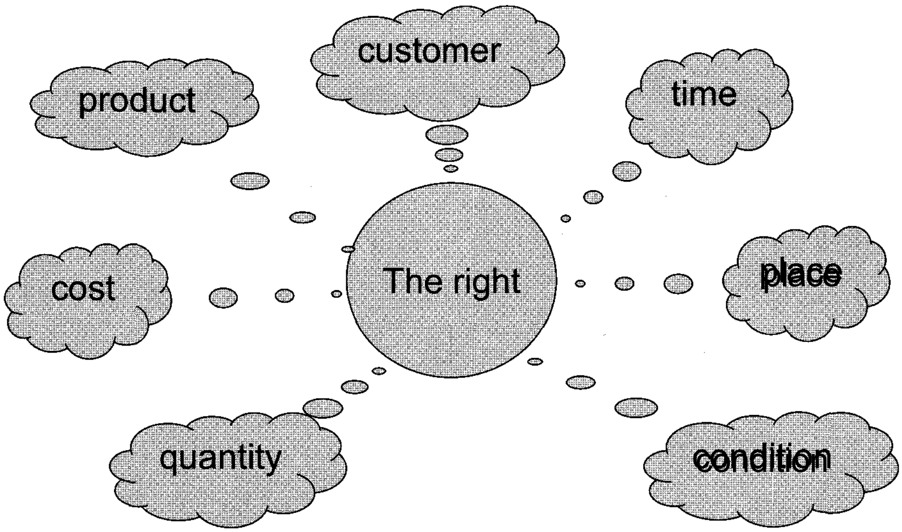


Figure 3.2 The seven 'rights' of customer service, showing the main service classifications

Transaction elements are usually divided into three categories. These reflect the nature and timing of the particular service requirements (before, during and after delivery of the product):

1. *Pre-transaction elements:* these are customer service factors that arise prior to the actual transaction taking place. They include:
   - written customer service policy;
   - accessibility of order personnel;
   - single order contact point;
   - organizational structure;
   - method of ordering;
   - order size constraints;
   - system flexibility;
   - transaction elements.
2. *Transaction elements:* these are the elements directly related to the physical transaction and are those that are most commonly concerned with distribution and logistics. Under this heading would be included:
   - order cycle time;
   - order preparation;

– inventory availability;
– delivery alternatives;
– delivery time;
– delivery reliability;
- delivery of complete order;
– condition of goods;
– order status information.

3. *Post-transaction elements:* these involve those elements that occur after the delivery has taken place, such as:

availability of spares;
call-out time;
– invoicing procedures;
– invoicing accuracy;
product tracing/warranty;
returns policy;
– customer complaints and procedures;
claims procedures.

Customer service elements can also be classified by *multifunctional dimensions.* The intention is to assess the different components of customer service across the whole range of company functions, to try to enable a seamless service provision. Time, for example, constitutes a single requirement that covers the entire span from order placement to the actual delivery of the order – the order cycle time. One of the main consequences of this approach is that it enables some very relevant overall logistics measures to be derived. These will be considered later in this chapter. The four main multifunctional dimensions are:

1. *time* – usually order fulfilment cycle time;
2. *dependability* – guaranteed fixed delivery times of accurate, undamaged orders;
3. *communications* – ease of order taking, and queries response;
4. *flexibility* – the ability to recognize and respond to a customer's changing needs.

Each of these can be broken down into further detailed elements. This has been undertaken for time in Figure 3.3. The total order fulfilment cycle time has been split into the five main time-related components from order receipt to final delivery, plus a preliminary step from order placement to order receipt, which is not considered by some companies because it is deemed to be part of the customer's ordering process. When identifying and measuring order fulfilment cycle time it is important

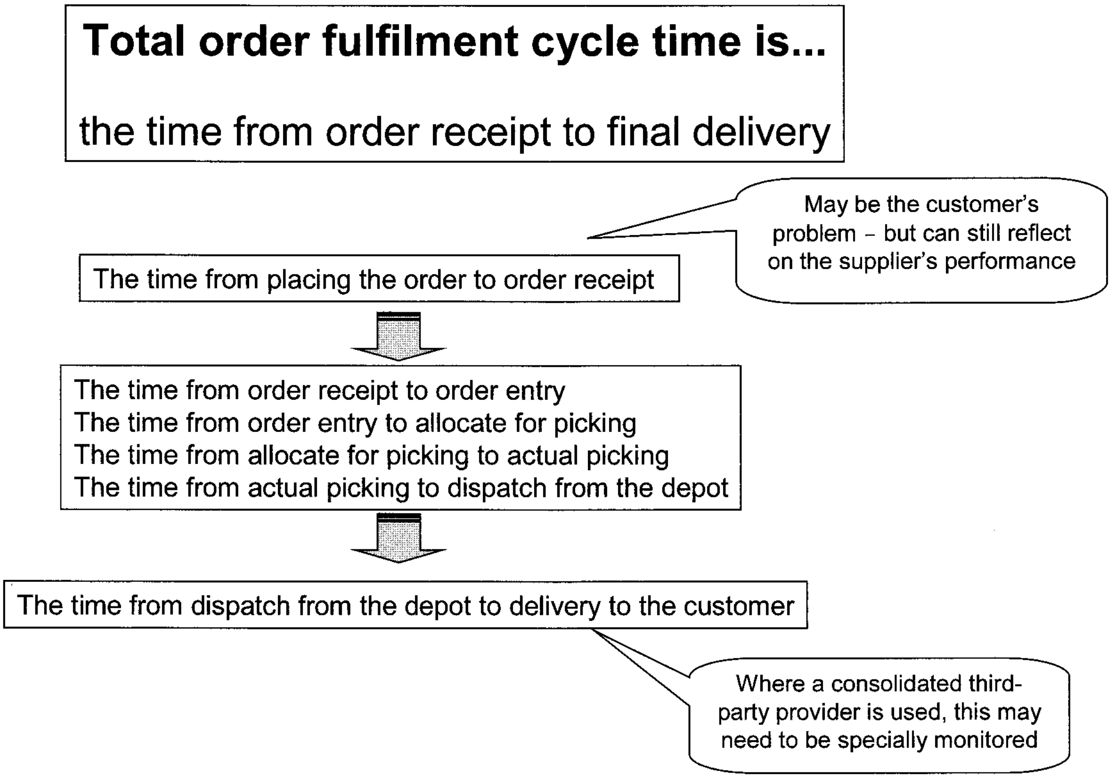


Figure 3.3 The constituent parts of total order fulfilment cycle time

to be able to break it down to all of the key components. Thus, if there is a customer service problem it can be measured and traced quickly and easily and the actual detailed problem can be identified and remedied.

As indicated here, there are many different elements of customer service, and their relevance and relative importance will vary according to the product, company and market concerned.

TWO CONCEPTUAL MODELS OF SERVICE QUALITY

Service quality is a measure of the extent to which the customer is experiencing the level of service that he or she is expecting. Thus, a very simple, yet effective, view of service quality is that it is the match between what the customer expects and what the customer experiences. Any mismatch from this can be called the 'service quality gap'. Note that the customer viewpoint is what the customer perceives or believes to be happening, not necessarily what is *actually* happening in terms of what the supplier is providing (or thinks he or she is providing). Perceived quality is always a judgement that the customer makes — whatever the customer thinks is reality is reality, no matter what the supplier may believe to the contrary! This is another reason why careful measurement of customer service is necessary: to be able to demonstrate that certain agreed standards are being achieved.

Thus, service quality is what the customer thinks that it is:

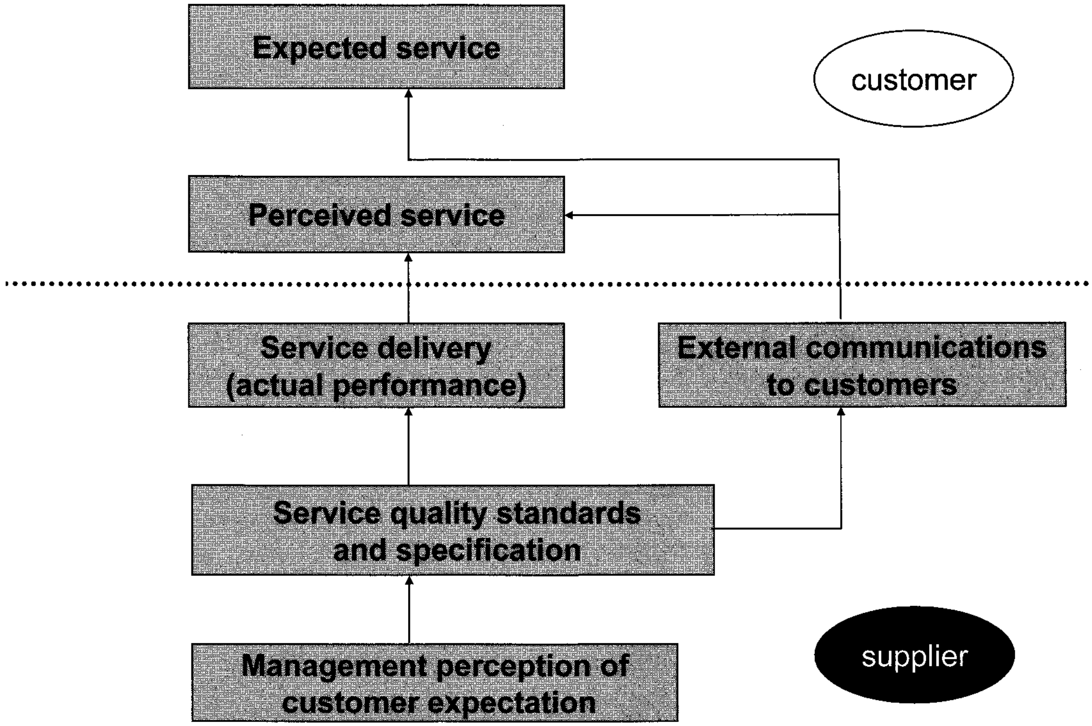
$$\text{Service quality} = \frac{\text{perceived performance}}{\text{desired expectations}} \times 100$$

A rather more complicated approach can also be used as a conceptual model of service quality. This is outlined in Figures 3.4 and 3.5. The aim of this approach is to identify the various different service gaps that can or might appear throughout the customer service process. Measures are then set up to assess the relative importance of each of these gaps and to monitor them on a regular basis.

The boxes in Figure 3.4 represent the key steps in the process of providing a service to customers. The starting point is the supplier's perception of what he or she thinks is the customer's service expectation. From this, the supplier should develop appropriate service quality standards and specifications. These should then be communicated to and agreed with the customer. Subsequently, the service is provided by the supplier via the logistics operation. The customer will then have a certain expectation of the service level to be provided and can compare this to the service that he or she perceives is being received.

In Figure 3.5, this concept is developed to illustrate the potential areas for service failure. Working backwards, the main issue is likely to be the one between the service that the customer expects and the service that the customer perceives to be provided (Gap 6). This is the perceived service—expected service gap, and for both the customer and the supplier it is the major aspect of service quality that needs to be measured. How is this undertaken? As described later in this chapter, there are a number of different types of customer service studies that can be carried out to achieve this. However, it is also important to be able to identify *why any* such service failure has occurred, and the different reasons can be identified by measuring the other service gaps that appear in Figure 3.5. These are as follows:

Gap 5: actual service—perceived service gap: this is the difference between the service that the supplier is providing and the service that the customer thinks



(Based on work by Parasuraman and Zeithaml)

Figure 3.4 A conceptual model of service quality: the basic elements

is being received. This gap may, typically, be caused because the supplier and the customer are measuring service in a different way.

- *Gap 4: service delivery—external communication gap:* this is the difference between the actual service that is provided and the promised level of service that was communicated to the customer. This gap may be caused by a misunderstanding in communication.
- *Gap 3: service standard—service delivery gap:* this is the difference between the actual service that is provided and the planned level of service based on the service specification that has been set. The cause for this gap may be inefficiency within the delivery service.
- *Gap 2: management perception—service standard gap:* this is the difference between the service specification that is set and the supplier management assessment of

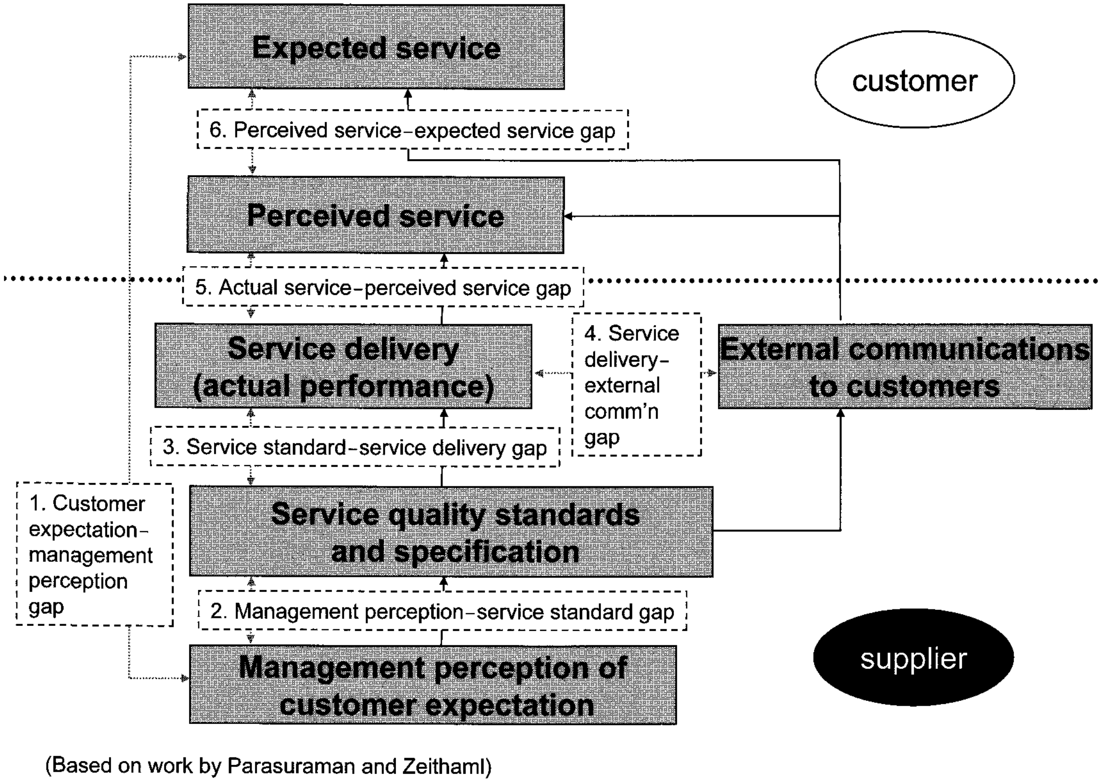


Figure **3.5** A conceptual model of service quality: the service gaps

customer service requirements. This gap is likely to be caused by an inadequate initial operational set-up.

- *Gap 1: customer expectation–management perception gap:* this is the difference between the service that the customer expects and the service level that the supplier thinks that the company wants. This gap is usually caused because the supplier does not understand the real customer requirements.

Conceptual models of this nature are valuable to help the understanding of the underlying issues that are involved. They need to be interpreted into a practical format to enable actual service policies to be derived. The remaining sections of this chapter address this requirement.

DEVELOPING A CUSTOMER SERVICE POLICY

An appropriate customer service policy needs to be developed based on identifiable customer service requirements, and a suitable logistics operation must be established to provide this service. The next few sections of this chapter describe how this can be done. Because there are so many different elements of customer service, this policy must be very clearly and carefully defined. Also, there are many different types of customer even for the same product. A can of cola, for example, may be bought in a supermarket, a corner shop or a petrol station, or from a self-service dispensing unit. It is unlikely that a manufacturer of cola would wish to provide exactly the same level and style of service to all these very different customer types. This is why many companies segment their customers into different customer categories. It is also an additional reason for having a distinct customer service policy.

Many studies have been undertaken to measure the effects of poor customer service. These studies conclude, quite categorically, that, where stock is not available or where delivery is unreliable, many buyers will readily turn to an alternative supplier's products to fulfil their requirements.

It is also important to understand what minimum requirements are necessary when identifying any particular service policy. A supplier is really working towards meeting customers' minimum requirements to cross the threshold of customer satisfaction. If these minimum requirements are not met, the supplier cannot even expect to be considered as a feasible supplier. Once these requirements are met and the supplier begins to exceed them, it then becomes possible to achieve customer satisfaction and begin to add value to the supply relationship.

Once the positive need for a customer service policy has been accepted, it is useful to adopt a recognized approach to determine the basic requirements and format of this policy. One such approach is outlined in Figure 3.6 and described in the remainder of this section. As well as showing the major steps that should be taken, the figure also indicates how these steps can be carried out. This is a six-step plan to identify key customer service components and then to design and maintain a suitable customer service package.

The main steps are:

1. *Identify the main elements of service and identify suitable market segments.* The first step is to identify those elements of service that are most highly rated by customers. Only then can the company's resources be concentrated on these key factors. The main means of determining these key elements are by market research techniques. These processes might include:

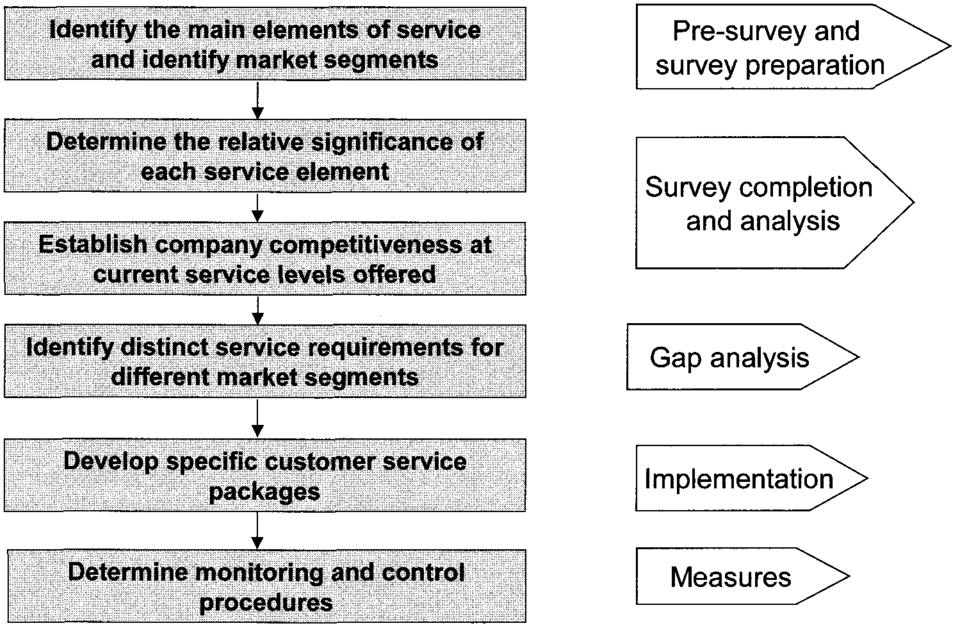


Figure 3.6 An overall approach for establishing a customer service strategy

the identification of the main decision maker or buyer of the product;
the use of personal interviews to determine the importance of customer service and the different elements within customer service;
the use of group interviews to determine the same.

The importance of this stage is to identify relevant measures of service that are generated by customers themselves and not imposed arbitrarily by 'best guesses' from outside. A major output from this stage of the study is to enable an appropriate survey questionnaire to be designed.

In addition, it is important at this stage to identify the different market segments or customer types that exist. It is highly unlikely that a universal level of customer service will be appropriate for all customers. Most customer populations consist of a range of customers of different size and importance. Part of this preliminary stage is, therefore, to try to identify broad customer categories and to ensure that any questionnaire is designed to enable the different requirements of these different categories to be identified.

It should be noted that there is a variety of types of customer service study that can be used. These are summarized in Figure 3.7. For some companies it is relevant to use several of these for different purposes.

Approach	Comment
Complaint analysis	Qualitative. Statistically limited. Limited to those who do complain.
Critical incident studies	Qualitative. Relevant to individual customers only. Limited scope.
Customer panels	Limited coverage. Qualitative information. Would not show priorities.
Key client survey	Useful Pareto approach. Not valid across whole client base. Qualitative and quantitative.
Customer survey/questionnaire	Good overall coverage (statistical sampling). Qualitative and quantitative.

Figure 3.7 Different types of customer service study

The most common approach for the major element of a study is likely to be a detailed questionnaire-based customer survey. This can be undertaken in a number of different ways including telephone, mail/post, face to face or web-based. The key advantages and disadvantages of these different approaches are described in Figure 3.8.

Survey or questionnaire design is a vital part of the overall process, and when putting together a questionnaire it is sensible to refer to one of the many books that have been written that address the topic specifically. The major steps can be summarized as follows:

- Clarify the purpose and objectives.
- Identify any specific information required.
- Select the most appropriate survey type.
  Determine the resources required to undertake the survey.
  Determine who should undertake the survey.
  Determine who should complete the survey.
- Identify key customer/market segments.
  Identify key service elements to include.
  Prepare the question and answer format.
  Design the analysis and reporting format.
- Determine the sample size and selection.
  Pilot the survey.
  Adjust and finalize.

Type	Advanta • es	Disadvantages
Telephone	Can probe interviewee. Control over response rates. Can control questions answered. Can ensure appropriate respondent. Can be quick.	Expense. Possible interviewer bias. Time-restrictive. Not anonymous.
E-mail	Inexpensive. Fast response.	Limited interaction. Limited response. Not anonymous.
Fax	Inexpensive. Quite fast response. Flexible time for respondent to complete.	Can't probe/clarify answers. Low response rates. Non-response to some questions.
Web	Inexpensive. Quick response. Flexible time for respondent to complete.	No control over respondents. Limited to internet/computer users.
Mail	Inexpensive. Flexible time for respondent to complete. Anonymous. No interviewer bias.	Time-consuming. Limited response. Non-response to some questions. Can't probe/clarify answers.
Face to face	Can probe. Can ensure appropriate respondent. Can control questions. Allows greater complexity. All questions answered.	Expensive. Limited sample. Very time-consuming. Possible interviewer bias. Not anonymous.

Figure 3.8 The advantages and disadvantages of different survey approaches

2. *Determine the relative significance of each service element.* Recognized research techniques can be used within the questionnaire to enable measurement of the relative importance of the different service components identified. For a fairly small list of components, some form of order ranking ('most' to 'least' important) or rating scale (1 to 6 according to importance) can be used. A further technique is that of trade-off analysis. This provides a more sophisticated format for considering and measuring the *relative* importance of different combinations of service components, rather than just scoring them on an individual basis. Straightforward rating of the key elements is often sufficient. A simple example of such a rating table is shown in Figure 3.9. It is also possible at this stage to identify what the minimum requirements are for customer service – that threshold below which it is unlikely that a customer will consider a company as a feasible supplier.
3. *Establish company competitiveness at current service levels offered.* Having identified the key service components and their relative importance to the customer, the

How would you rate these different elements of customer service?

(Score from 1—6; 1 = not at all important, 6 = extremely important)

	Please circle					
Frequency of delivery	1	2	3	4	5	6
Reliability of delivery	1	2	3	4	5	6
Stock availability and continuity of supply	1	2	3	4	5	6
Orders filled completely	1	2	3	4	5	6
Accuracy of invoices	1	2	3	4	5	6
Customer query handling	1	2	3	4	5	6

Figure 3.9 Rating table for selected customer service factors

next step is to measure how well the company is performing for each of these key components. This can also be achieved using the questionnaire. The list of key components can be rated by the respondent on perceived performance. This will provide an indication of where the company is both underperforming and overperforming and where it has got it about right. Figure 3.10 shows that there is a target area for service in which the company should be operating. It will highlight those areas where there is room for improvement and those areas where too much effort is being spent. There is little benefit in performing extremely well in those areas that are of little consequence to the customer.

It is also important to be aware of the company's own position compared to that of its major competitors. Respondents can be asked to rate each competing company in a similar way as a part of the questionnaire. The results will indicate how each competitor performs according to the key service components. The company's performance can then be compared to the competition's and also to the most important service elements as identified in the previous stage of the study. This will provide some very useful information on how well the company is performing compared to its competitors, but more importantly this can be related directly to the customers' key customer service requirements. Figure 3. 11 gives an example of this.

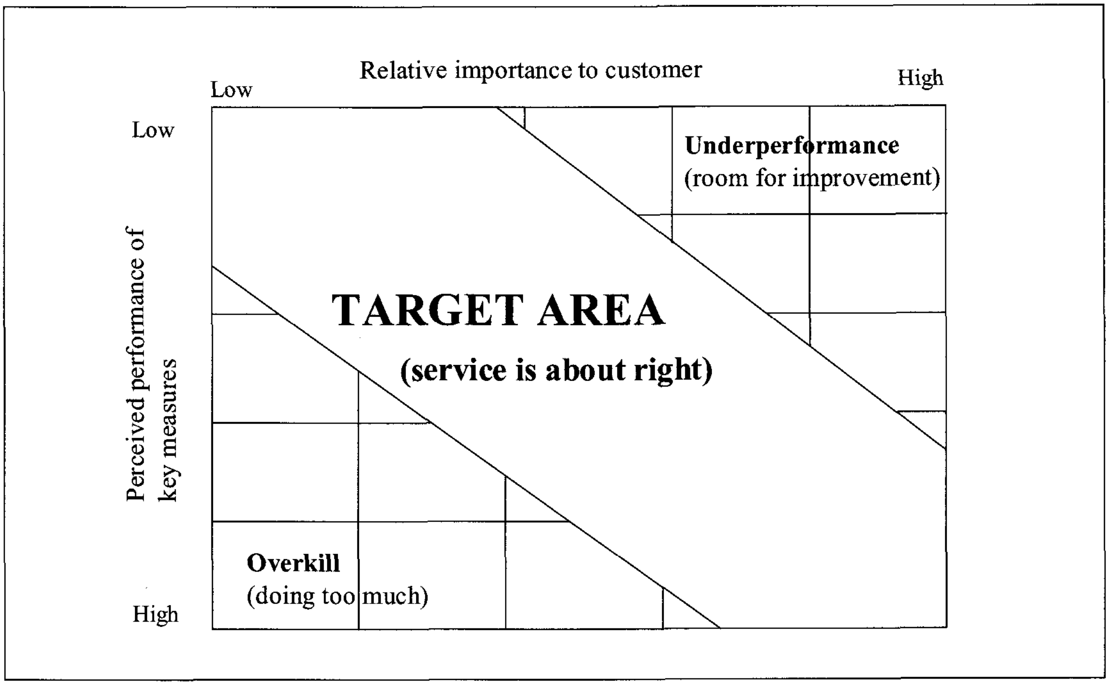


Figure 3.10 Customer service targets

Here it can be seen that our company is performing reasonably well *overall* compared to our key competitor (the right-hand side of the figure), but that our competitor is actually performing much better than our company *in those elements that are most important to the customer* (the left-hand side of the figure). The usefulness of such an approach is clearly demonstrated by this simple example. This is often known as competitive benchmarking. From this type of information, a detailed customer service strategy can be developed.

4. *Identify distinct service requirements for different market segments.* As already indicated, the needs of different customer types can vary quite substantially. This may be true in terms of product quality, method of ordering, level of service or any other of the many different service elements that can be identified. Within a total market, it is possible to identify distinct submarkets or segments. A typical example might be the supply of stationery items. These might be supplied to retailers for sale to the public, to wholesalers for further distribution or direct to public service bodies or private companies for their own consumption. Each segment of the overall market may require a distinctly different level of service,

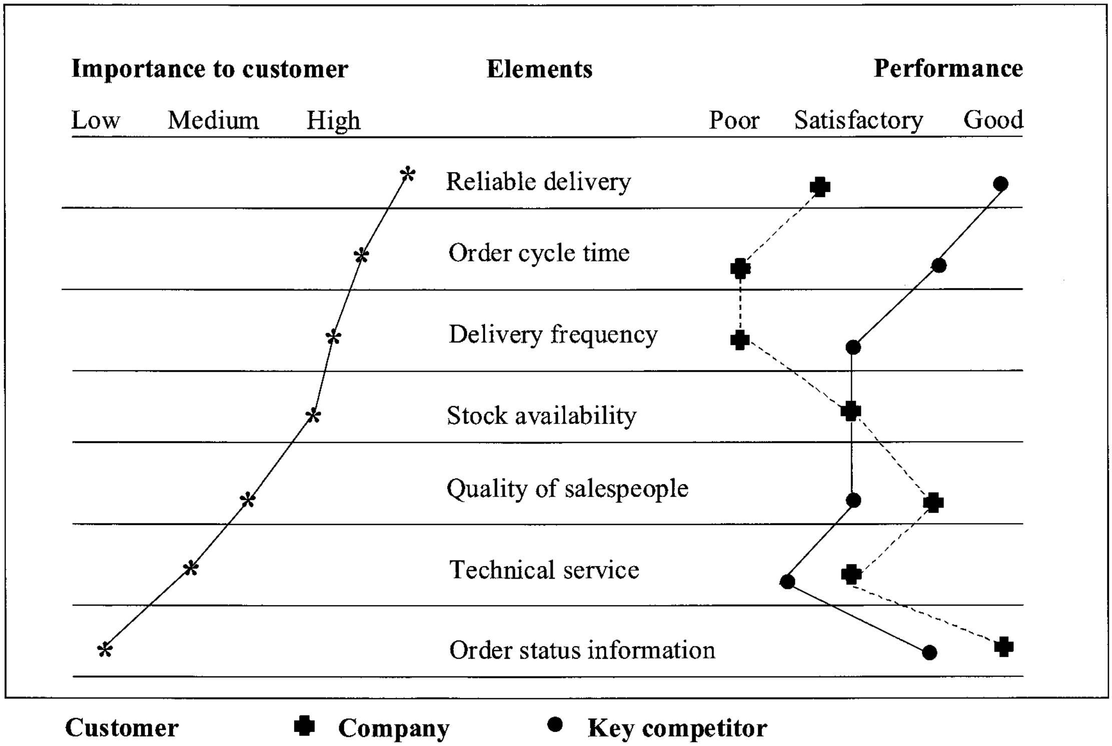


Figure 3.11 Competitive benchmarking showing opportunities for improving service when comparisons are made with customer requirements and the performance of key competitors

or may react differently to certain deficiencies of service. The cola example discussed earlier in this chapter provides another example of different types of service requirement. Once different market segments have been identified, a number of specific customer service policies can be developed, each of which should suit the relevant groups or segments.

The determination of the detailed service requirements can be undertaken by what is known as 'gap analysis'. This is the practical means of enabling actual service policies to be derived based on the approach discussed in the conceptual models described earlier and in Figure 3.5. This is achieved by using the survey results to identify the major performance gaps (such as 'reliable delivery' in our example in Figure 3.11) for each market segment or customer group that is being considered. The key customer service elements should be ranked in order of importance to the customer (to identify the essential ones) and degree of change required (to identify the easy ones or 'quick wins'). Brainstorming and/or some form of process analysis can then be used to identify appropriate remedies or solutions for improving these key elements of service. These are then assessed and ranked according to factors such as cost of change, ease of change, etc. An example of the gap analysis results for one of these solution areas is shown in Figure 3.12.

5. *Develop specific customer service packages.* This is the implementation phase and it will depend on the results obtained from the stages that have been described. Alternative packages for the different market segments need to be costed accordingly and the most suitable packages determined.
6. *Determine monitoring and control procedures.* It is vital to ensure that any service policy implemented is also monitored. This requires an effective focus on the measurement of the service provided, involving a systematic and continuous concentration on monitoring and control. In practice, it is rare for this to be adequately carried out: firstly, because companies do not have a recognized customer service policy and, secondly, because companies find it difficult to construct quantifiable standards that are capable of measurement. The first task, then, is to identify the factors that need to be measured. These should be

Order picking accuracy				
Improvement	**Import-ance**	**Timescale**	**Cost**	**Difficulty**
Increase number of order checks	high	short	medium	medium
Brief operatives of importance of accuracy	high	short	low	low
Continuous feedback from customers	high	medium	medium	medium
Adapt warehouse management system for picking	medium	long	high	high

Figure 3.12 A practical example of gap analysis

based on the major elements identified in the customer service packages that are developed. The second task is to produce a measure or series of measures. This can be undertaken in different ways for different elements, but must be fair and appropriate for the task in hand. The development of such measures, together with relevant examples, is described later in this chapter. One final point concerns the need to ensure that any service measures are periodically reviewed. Businesses change fairly rapidly, with new products and new customers appearing continually. A regular updating of service measures is relevant, so that old measures are discarded as they become redundant, and new measures are created as they become necessary. Some large companies carry out regular customer service studies designed to identify such changes in service requirements.

LEVELS OF CUSTOMER SERVICE

It has already been stressed that there is a need to balance the level of customer service with the cost of providing that service. This balance is not easy to define, although it can be described quite easily as the point where the additional revenue for each increment of service is equal to the extra cost of providing that increment.

It is seldom possible to devise a policy that is absolutely optimal in terms of the cost/service balance. Some companies adopt a cost minimization approach where specific service objectives are laid down and met at a minimum cost. Others choose a service maximization approach where a distribution budget is fixed, and the ' best' service supplied within this cost constraint. The most appropriate approach to adopt will depend on particular product, business or market situations.

One factor that is clear, however, is the relationship between cost and service. This is shown in Figure 3.13. The cost of providing a given service is markedly higher the nearer it reaches the 'perfect service' — that is, the 100 per cent mark. Thus, an increase of 2 per cent in service levels will cost far more between 95 and 97 per cent than between 70 and 72 per cent. It should also be noted that a service increase from, say, 95 to 97 per cent may well have little, if any, noticeable impact on the customer's perception of the service being provided, even though it is a costly improvement.

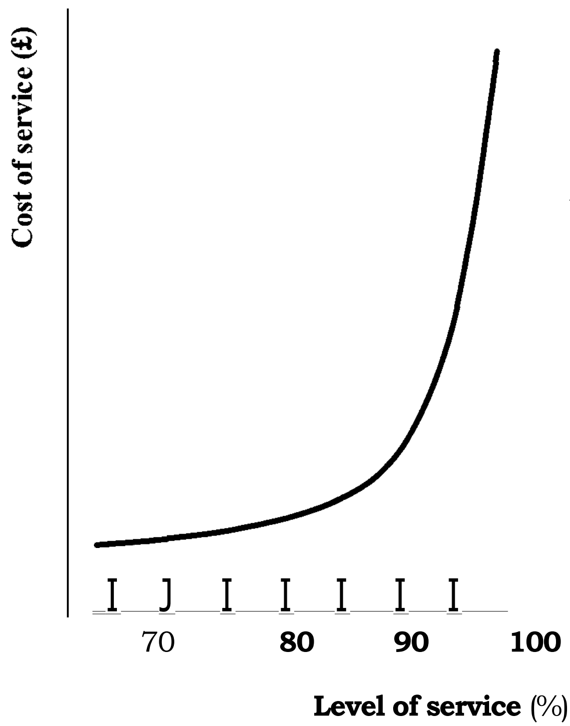


Figure 3.13 The relationship between the level of service and the cost of providing that service

MEASURING CUSTOMER SERVICE

It is probably quite clear from reading this chapter that there are many different measures of customer service that might be used. The most important message is that, whatever measures are used, they must reflect the key service requirements for the customer in question. This is not always as obvious as it might seem. One particular example is that of *order fulfilment*. It is possible to measure this in a number of different ways:

- the number of orders completely satisfied, say 18 out of 20, over a period (90 per cent);
- the number of lines delivered from a single order, say 75 out of the 80 lines requested (94 per cent);
- the number of line items or cases delivered from a single order, say 75 out of the 80 lines requested, but only 1,400 of the 1,800 total line items (78 per cent);
- the value of the order completed, say €750 of the €900 order (83 per cent).

Any or all of these might be used, and there is no right or wrong one. The most appropriate is the one that best suits the operation in question. As will be shown later, it may also be relevant to use a combination of these measures.

There are other measures that can be made. These measures might, for example, be aimed at assessing the timeliness of delivery operations. Many express parcels companies set great store by the speed of their delivery operations, and calculate in detail the time taken from receipt of order or parcel collection to final delivery. This idea is also used for conventional operations. Thus, order fulfilment can also be measured with respect to the *order cycle time* or the actual lead time from the receipt of the order to its final delivery to the customer. For a typical stock order this will be made up of the following discrete times:

- order receipt to order entry;
- order entry to allocation for picking;
- allocation to dispatch;
- dispatch to delivery.

Some companies now recognize what is called the '*the perfect order*'. This is a measure that attempts to take into account all of the main attributes that go towards the completion of an order that absolutely satisfies customer requirements. This is sometimes known as 'on time in full' or OTIF. The key components are:

- delivered complete to the quantities ordered;
- delivered exactly to the customer's requested date and time;
- no delivery problems (damage, shortage, refusal);
- accurate and complete delivery documentation.

There are also several variations of 'the perfect order' to include such elements as accurate invoicing, etc. Whatever is included, perfect order fulfilment can be measured as:

$$\text{perfect order fulfilment} = \frac{\text{number of perfect orders}}{\text{total number of orders}} \times 100\%$$

Organizations must therefore set clear, customer-service-driven measures of performance that reflect the real standards they are aiming to achieve. These, typically, ask severe questions of many logistics operations. For realistic measurement, any discrepancies should be assessed cumulatively. Thus, if they include

orders received on time	actual 95%	target 98%
orders received complete	actual 98%	target 99%
orders received damage-free	actual 99%	target 99%
orders filled accurately	actual 97%	target 99%
orders invoiced accurately	actual 94%	target 98%

the actual customer service measure achieved is (95 x 98 x 99 x 97 x 94 =) 84 per cent. This is not as good as it first looks when considering each measure individually.

Clear and simple visual methods of presenting data such as these are also important. Figure 3.14 shows a radar gram of these data such that the actual and target figures can be compared at a glance. Chapter 27 provides some additional comment on the development and presentation of key performance indicators.

THE CUSTOMER SERVICE EXPLOSION

The role of customer service as a critical success factor for most companies has, once again, become very significant. There are, perhaps, many different reasons for this resurgence in importance, but the major change stems from a growing realization that satisfying the customer is the key to achieving competitive success. Companies that fail to appreciate this do so at their peril because they may lose significant market share. Service, nowadays, is the key factor of differentiation in a customer's decision to buy one brand rather than another. In other words, good customer service can provide the distinctive difference between one company's offer and its competitors'. Thus, customer service strategy must play a major role in the determination of company strategy.

One key lesson that also comes through is the important role that logistics plays in providing good customer service. The ability to improve service levels and to maintain this improvement is a challenge that faces many companies. What has led to this change? The major factors are:

- the growth in customer expectations — thus service fulfilment has become a priority for any successful strategy;
- the growing professionalism of buyers — many buyers now recognize the importance of service as well as price in the product offering;
- markets have become increasingly service-sensitive — there is little else to differentiate between products;
- the diminution of brand loyalty, particularly with respect to FMCG, where immediate product availability is the vital factor;

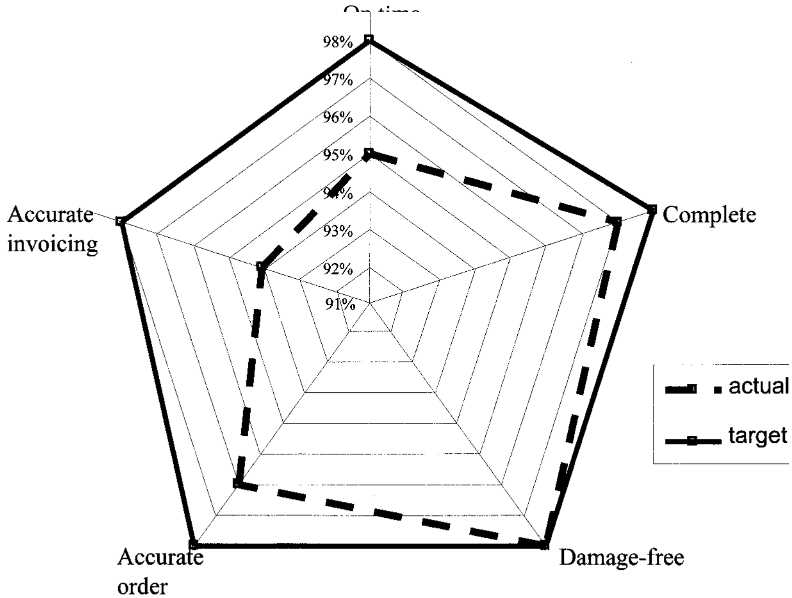


Figure 3.14 Radar gram showing the perfect order targets and achievements

- the development of new ideas such as relationship marketing where fulfilling service expectations is the key and customer retention is a priority.

SUMMARY

This chapter has considered some of the key aspects of customer service and logistics. The major components of customer service were described. They were summarized as:

1. *pre-transaction elements:* these are customer service factors that arise prior to the actual transaction taking place;
2. *transaction elements:* these are the elements directly related to the physical transaction and are those that are most commonly concerned with distribution and logistics;
3. *post-transaction elements:* these involve those elements that occur after the delivery has taken place.

Two conceptual models of customer service were considered, and the need for an appropriate customer service policy was emphasized. An approach for developing such a policy was outlined. This included six main steps:

1. Identify the main elements of service and identify market segments.
2. Determine the relative significance of each service element.
3. Establish company competitiveness at the current service levels that are being offered.
4. Identify distinct service requirements for different market segments.
5. Develop specific customer service packages.
6. Determine monitoring and control procedures.

The importance of accurate customer service measurement was explained. Different measures of order fulfilment were described, and the concept of 'the perfect order' was put forward — 'on time in full' or OTIF.

Achieving appropriate and effective customer service has become a critical factor for success for most companies operating in today's competitive environment. This chapter has considered some of the key requirements for successful customer service in logistics.

4

Channels of distribution

INTRODUCTION

This chapter looks at the alternative ways in which products can reach their market. Different types of distribution channel are discussed, and an approach to channel selection is described. Finally, the very important question of whether to run an own-account distribution operation or whether to use a third party is reviewed.

Physical distribution channel is the term used to describe the method and means by which a product or a group of products are physically transferred, or distributed, from their point of production to the point at which they are made available to the final customer. In general, this end point is a retail outlet, shop or factory, but it may also be the customer's house, because some channels bypass the shop and go direct to the consumer.

In addition to the physical distribution channel, another type of channel exists. This is known as the *trading or transaction channel*. The trading channel is also concerned with the product, and with the fact that it is being transferred from the point of production to the point of consumption. The trading channel, however, is concerned with the non-physical aspects of this transfer. These aspects concern the sequence of negotiation, the buying and selling of the product, and the ownership of the goods as they are transferred through the various distribution systems.

One of the more fundamental issues of distribution planning is regarding the choice and selection of these channels. The question that arises, for both physical and trading channels, is whether the producer should transfer the product directly to the consumer, or whether intermediaries should be used. These intermediaries are, at the final stage, very likely to be retailers, but for some of the other links in the supply chain it is now very usual to consider a third-party operator to undertake the operation.

PHYSICAL DISTRIBUTION CHANNEL TYPES AND STRUCTURES

There are several alternative physical channels of distribution that can be used, and a combination of these maybe incorporated within a channel structure. Figure 4.1 illustrates the main alternative channels for a single consumer product being transferred from a manufacturer's production point to a retail store or shop. The circles in the figure indicate when products are physically transferred from one channel member to another. There are, of course, other channels that are used - channels from industrial suppliers to industrial customers, or channels that are direct to the final consumer - and these are discussed separately to the channels shown in the figure.

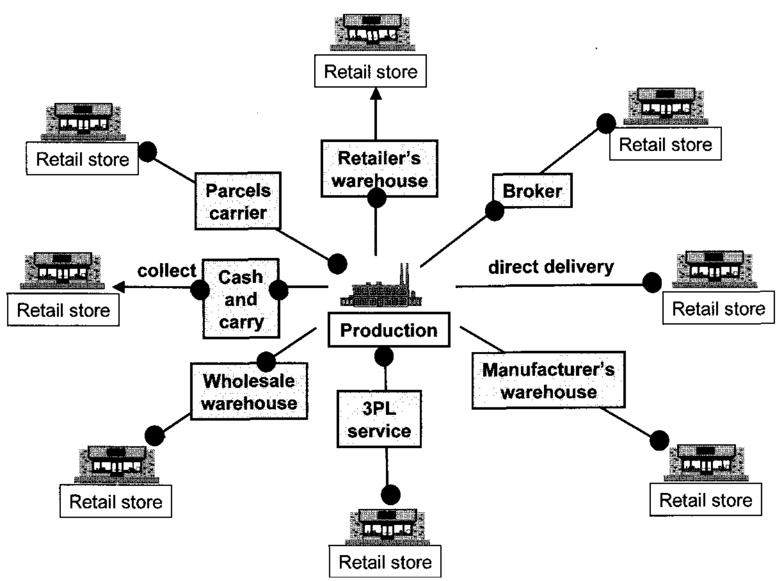


Figure 4.1 Alternative distribution channels for consumer products to retail outlets

The alternative channels in Figure 4.1 are:

- Manufacturer direct to retail store. The manufacturer or supplier delivers direct from the production point to the retail store. As a general rule, this channel is only used when full vehicle loads are being delivered.
- Manufacturer via manufacturer's distribution operation to retail store. This was one of the classic physical distribution channels and the most common channel for many years. Here, the manufacturer or supplier holds its products in a finished goods warehouse, a central distribution centre (CDC) or a series of regional distribution centres (RDCs). The products are trunked (line-hauled) in large vehicles to the sites, where they are stored and then broken down into individual orders that are delivered to retail stores on the supplier's retail delivery vehicles. Since the 1970s, the use of this type of physical distribution channel has decreased in importance due to a number of developments in alternative channels of physical distribution. This type of channel is still commonly used by the brewing industry.
- Manufacturer via retailer distribution centre to retail store. This channel consists of manufacturers supplying their products to national distribution centres (NDCs) or RDCs, which are sites run by the retail organizations. These centres act as consolidation points, as goods from the various manufacturers and suppliers are consolidated at the site. The retailers then use their own delivery vehicles to deliver full vehicle loads of all the different manufacturers' products to their own stores. In the UK, this type of distribution channel grew in importance during the 1980s as a direct result of the growth of the large multiple retail organizations that are now a feature of the high street and of the large retail parks. Most retailers now use third parties to run these final delivery operations.
- Manufacturer to wholesaler to retail shop. Wholesalers have acted as the intermediaries in distribution chains for many years, providing the link between the manufacturer and the small retailers' shops. However, this physical distribution channel has altered in recent years with the development of wholesale organizations or voluntary chains. These wholesaler organizations are known as 'symbol' groups in the grocery trade. They were generally begun on the basis of securing a price advantage by buying in bulk from manufacturers or suppliers. One consequence of this has been the development of an important physical distribution channel because the wholesalers use their own distribution centres and vehicle fleets.
- Manufacturer to cash-and-carry wholesaler to retail shop. Another important development in wholesaling has been the introduction of cash-and-carry

businesses. These are usually built around a wholesale organization and consist of small independent shops collecting their orders from regional wholesalers, rather than having them delivered. The increase in cash-and-carry facilities has arisen as many suppliers will not deliver direct to small shops because the order quantities are very small.

- Manufacturer via third-party distribution service to retail shop. Third-party distribution or the distribution service industry has grown very rapidly indeed in recent years. In the UK, the industry has grown for a number of reasons, the main ones being the extensive rise in distribution costs and the constantly changing and more restrictive distribution legislation that has occurred. Thus, a number of companies have developed a particular expertise in warehousing and distribution. These companies consist of those offering general distribution services as well as those that concentrate on providing a 'specialist' service for one type of product (eg china and glass, hanging garments) or for one client company. Developments in third-party distribution are considered at the end of this chapter.
- Manufacturer via small parcels carrier to retail shop. Very similar to the previous physical distribution channel, these companies provide a 'specialist' distribution service where the 'product' is any small parcel. There has been an explosion in the 1980s and 1990s of small parcels companies, specializing particularly in next-day delivery. The competition generated by these companies has been quite fierce.
- Manufacturer via broker to retail shop. This is a relatively rare type of channel, and may sometimes be a trading channel and not a physical distribution channel. A broker is similar to a wholesaler in that it acts as intermediary between manufacturer and retailer. Its role is different, however, because it is often more concerned with the marketing of a series of products, and not really with their physical distribution. Thus, a broker may use third-party distributors, or it may have its own warehouse and delivery system. The broker can provide an alternative physical distribution channel.

The main alternative physical distribution channels previously described refer to those consumer products where the movement is from the manufacturer to the retail store. There are additional channels for industrial products and for the delivery of some consumer products that do not fit within the structure of Figure 4.1 because they bypass the retail store. They necessitate the consideration of different types of distribution channel:

- Mail order. The use of mail order or catalogue shopping has become very popular. Goods are ordered by catalogue, and delivered to the home by post or parcels carrier. The physical distribution channel is thus from manufacturer to mail order house as a conventional trunking (line-haul) operation, and then to the consumer's home by post or parcels carrier, bypassing the retail store.
- Factory direct to home. The direct factory-to-home channel is a relatively rare alternative. It can occur by direct selling methods, often as a result of newspaper advertising. It is also commonly used for one-off products that are specially made and do not need to be stocked in a warehouse to provide a particular level of service to the customer.
- Internet and shopping from home. There is now an important development in shopping from home via the internet. Initial physical distribution channels were similar to those used by mail order operations —by post and parcels carrier. The move to internet shopping for grocery products has led to the introduction of specialist home delivery distribution operations. These are almost all run by third-party companies. In addition, it is now possible to distribute some products, such as music, software and films, directly, computer to computer.
- Factory to factory/business to business. The factory-to-factory or business-to-business channel is an extremely important one, as it includes all of the movement of industrial products, of which there are very many. This may cover raw materials, components, part-assembled products, etc. Options vary according to the type and size of product and order, may range from full loads to small parcels, and may be undertaken by the manufacturers themselves or by a third party.

It can be seen from the list of alternative channels that the channel structures can differ very markedly from one company to another. The main differences are:

- the types of intermediaries (as shown above);
- the number of levels of intermediaries (how many companies handle the product); and
- the intensity of distribution at each level (ie are all or just selective intermediaries used at the different levels?).

An individual company may have many different products and many different types of customer. Such a company will therefore use a number of different channels within its distribution operation. This, together with the large number of variable factors and elements possible within a channel structure, makes it difficult to summarize effectively. Figure 4.2, however, gives a fair representation of a typical single-channel structure. Note the different physical and trading channels.

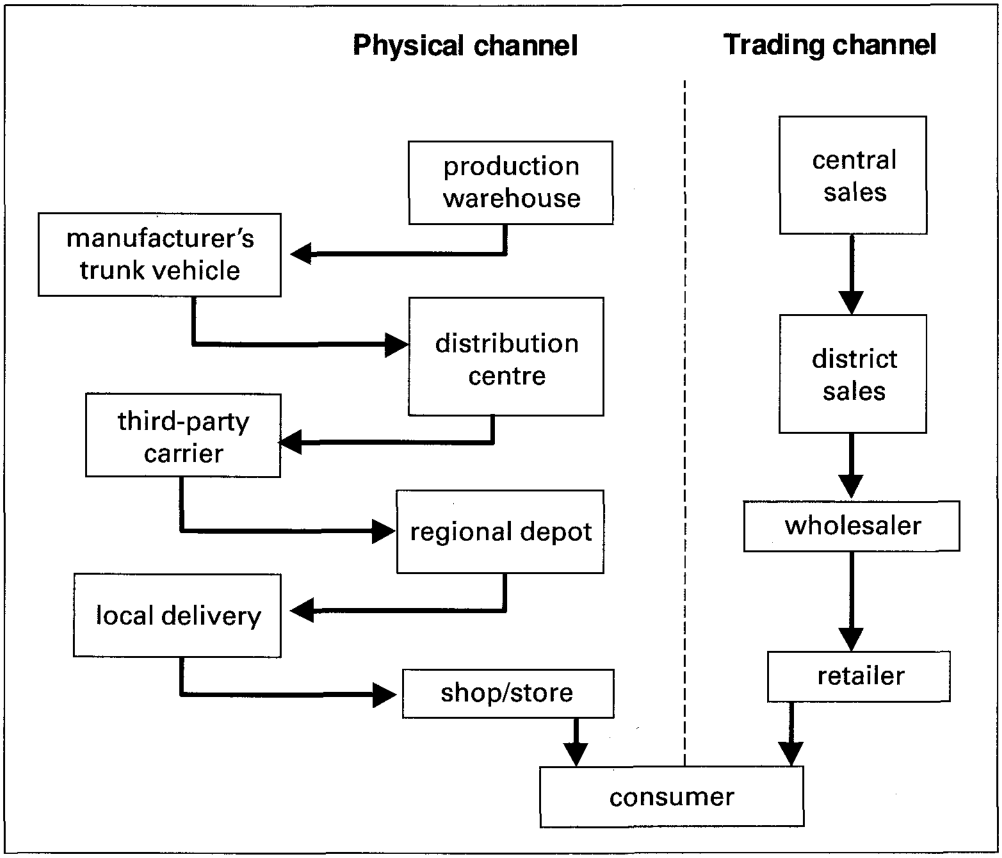


Figure 4.2 Typical channel of distribution, showing the different physical and trading routes to the consumer

CHANNEL SELECTION

Channel objectives will necessarily differ from one company to another, but it is possible to define a number of general points that are likely to be relevant. These should normally be considered by a company in the course of its distribution planning process to ensure that the most appropriate channel structure is developed. The main points that need to be addressed are as follows:

- *To make the product readily available to the market consumers at which it is aimed.* Perhaps the most important factor here is to ensure that the product is represented in the right type of outlet or retail store. Having identified the correct marketplace for the goods, the company must make certain that the appropriate physical distribution channel is selected to achieve this objective.

- *To enhance the prospect of sales being made.* This can be achieved in a number of ways. The most appropriate factors for each product or type of retail store will be reflected in the choice of channel. The general aims are to get good positions and displays in the store, and to gain the active support of the retail salesperson, if necessary. The product should be 'visible, accessible and attractively displayed'. Channel choice is affected by this objective in a number of ways:
  – Does the deliverer arrange the merchandise in the shop?
  - Are special displays used?
  - Does the product need to be demonstrated or explained?
  – Is there a special promotion of the product?
- *To achieve co-operation with regard to any relevant distribution factors.* These factors may be from the supplier's or the receiver's point of view, and include minimum order sizes, unit load types, product handling characteristics, materials handling aids, delivery access (eg vehicle size) and delivery time constraints, etc.
- *To achieve a given level of service.* Once again, from both the supplier's and the customer's viewpoints, a specified level of service should be established, measured and maintained. The customer normally sees this as crucial, and relative performance in achieving service level requirements is often used to compare suppliers and may be the basis for subsequent buying decisions.
- *To minimize logistics and total costs.* Clearly, costs are very important, as they are reflected in the final price of the product. The selected channel will reflect a certain cost, and this cost must be assessed in relation to the type of product offered and the level of service required.
- *To receive fast and accurate feedback of information.* A good flow of relevant information is essential for the provision and maintenance of an efficient distribution service. It will include sales trends, inventory levels, damage reports, service levels, cost monitoring, etc.

The main objectives that a company needs to clarify when determining the most appropriate physical distribution channels to use have been outlined above. A number of important associated factors also need to be considered. These factors clearly affect the decisions that need to be made when designing a channel or channels used in a distribution system. They can be summarized with respect to the following general characteristics.

advantage, especially for those products where it is very difficult to differentiate on quality and price.

Company resources

In the final analysis, it is often the size and the financial strength of the company that is most important in determining channel strategy. Only a fairly large and cash-rich company can afford to set up a distribution structure that includes all of its own warehousing and transport facilities. With these, the company has more control and can provide the service it thinks its customers require. Smaller and less financially secure companies may have to use intermediaries or third-party organizations to perform their distribution function. In these instances, it may be less easy to ensure provision of the service they feel their customers would like.

These factors will all need to be taken into account when designing a channel structure and selecting the appropriate channel members. A formalized approach that might be adopted when undertaking the design of a channel structure is set out in Figure 4.4.

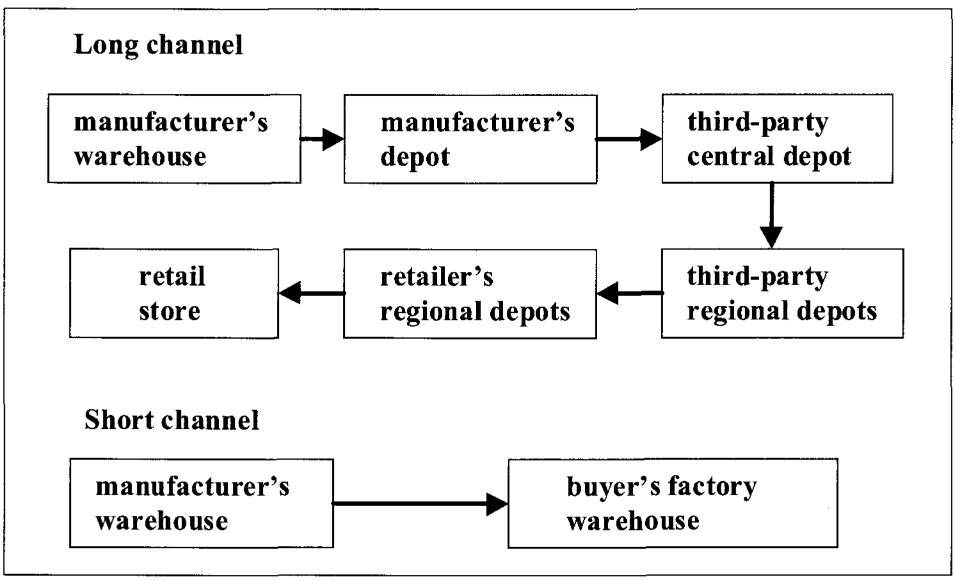


Figure 4.4 Designing a channel structure - a formalized approach

distribution costs that are usual from short channels. In addition, the security aspects of highly priced items (eg jewellery, watches, CDs, etc) make a short channel much more attractive because there is less opportunity for loss and theft than with a long channel.

- Complex products often require direct selling because any intermediary may not be able to explain how the product works to potential customers.
- New products may have to be marketed directly or by mail order because traditional outlets may be reluctant to stock the product.
- Products with a time constraint need a 'fast' channel, for obvious reasons, eg bread, cakes, newspapers, etc.
- Products with a handling constraint may require a specialist physical distribution channel, eg frozen food, china and glass, hanging garments.

Channel characteristics

As well as taking account of market and product characteristics, another aspect to be considered concerns the characteristics of the channel itself. There are two different factors that are important. Firstly, does the channel being considered serve or supply the customer in the way required? A simple example might be a new grocery product that needs to be demonstrated or tested in the shop. There would be no point in distributing this product through a small self-service store where no facilities can be provided for a demonstration. Secondly, how efficient is the channel being considered? Efficiency may include a number of different features related to sales or distribution. These might include the sales potential in the outlets served, the size of orders placed, the frequency of delivery required, etc.

Competitive characteristics

Competitive characteristics that need to be considered concern the activities of any competitors selling a similar product. Typical decisions are whether to sell the product alongside these similar products, or whether to try for different, exclusive outlets for the product to avoid the competition. It may well be that the consumer preference for a wide choice necessitates the same outlets being supplied. Good examples include confectionery and most grocery items.

Also of very real significance is the service level being offered by the competition. It is essential that channel selection is undertaken with a view to ensuring that the level of service that can be offered is as good as, or better than, that which is being provided by key competitors. This may well be the main area for competitive advantage, especially for those products where it is very difficult to differentiate on quality and price.

Company resources

In the final analysis, it is often the size and the financial strength of the company that is most important in determining channel strategy. Only a fairly large and cash-rich company can afford to set up a distribution structure that includes all of its own warehousing and transport facilities. With these, the company has more control and can provide the service it thinks its customers require. Smaller and less financially secure companies may have to use intermediaries or third-party organizations to perform their distribution function. In these instances, it may be less easy to ensure provision of the service they feel their customers would like.

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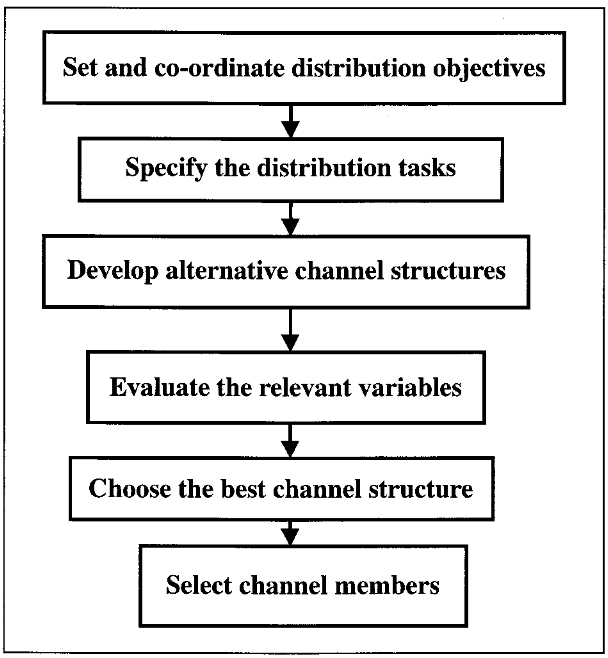


Figure 4.4 Designing a channel structure - a formalized approach

THIRD PARTY OR OWN ACCOUNT?

The most common channel decision for those operating in physical distribution is whether to use a third-party distribution or logistics service, or whether to run an own-account (in-house) distribution operation. Third-party logistics has been an important alternative in the UK for many years. Across most of continental Europe and also North America, the use of third-party logistics (3PL) service providers has also grown significantly. Figures 4.5 and 4.6 provide a breakdown of 3PL usage for a number of different countries and regions. Figure 4.5 gives actual annual 3PL logistics revenue in billions of euros. It can be seen from this that North America has the biggest spend. Figure 4.6 shows the extent of logistics outsourcing in different countries, indicating that outsourcing is particularly strong in certain European countries: the UK and Benelux.

The own-account/third-party decision is rarely a straightforward one, especially as there are a number of different types of third-party distribution operation available. The main ones include the following:

- *Dedicated (or exclusive) distribution operation.* This is where a complete distribution operation is provided by a third-party company. The third party undertakes to provide the customer with all its distribution requirements, exclusively, on a national or regional basis. The resources used will include warehouses, distribution centres, transport fleets, managers, etc. These are obviously con-fined to very large companies. This type of service is very common in the UK and has now been developed across the rest of Europe and North America.
- *Multi-user (or shared-user) distribution operation.* Multi-user distribution operations are similar to dedicated operations, the principal difference being that a small group of client companies is catered for, rather than just a single client. One of the characteristics of this type of service is that ideally the clients are all manufacturers or suppliers of goods and their products are all delivered to the same or similar customers, for example grocery products to grocery stores, supermarkets, catering establishments, etc. These are also known as shared-user operations. The advantage of this approach is that expensive distribution costs are shared between the clients, so all parties enjoy the benefits.
- *Specialist distribution operation.* These distribution operations are used for the storage and movement of products that require special facilities or services, and the distribution operation run by the third-party company is especially tailored to suit these needs. There are several examples, such as frozen food and hanging garment distribution.

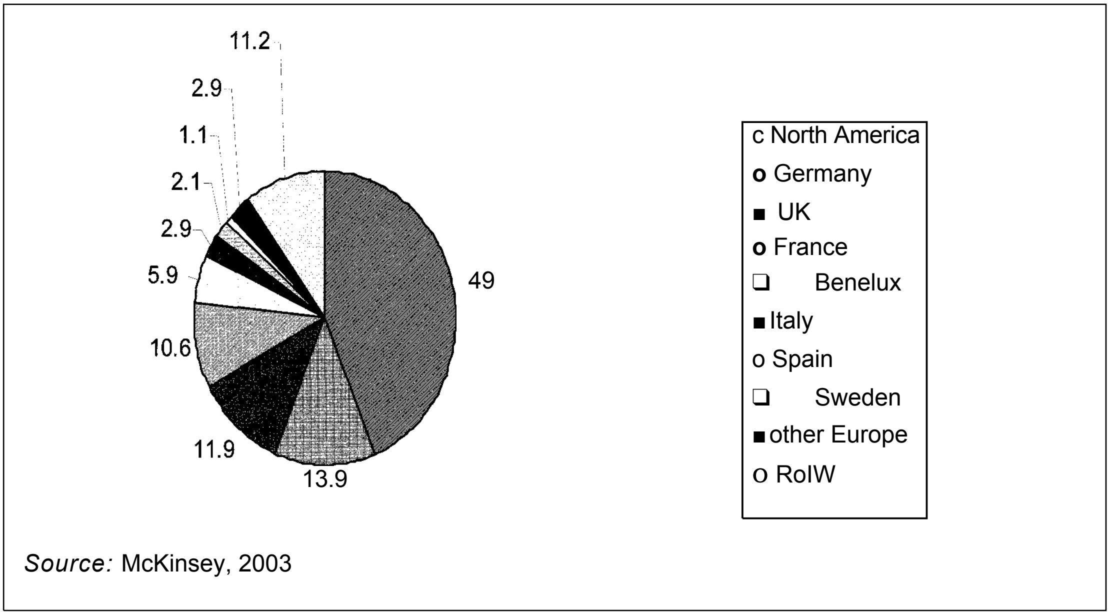


Figure 4.5 3PL annual revenue in billions of euros for 2003

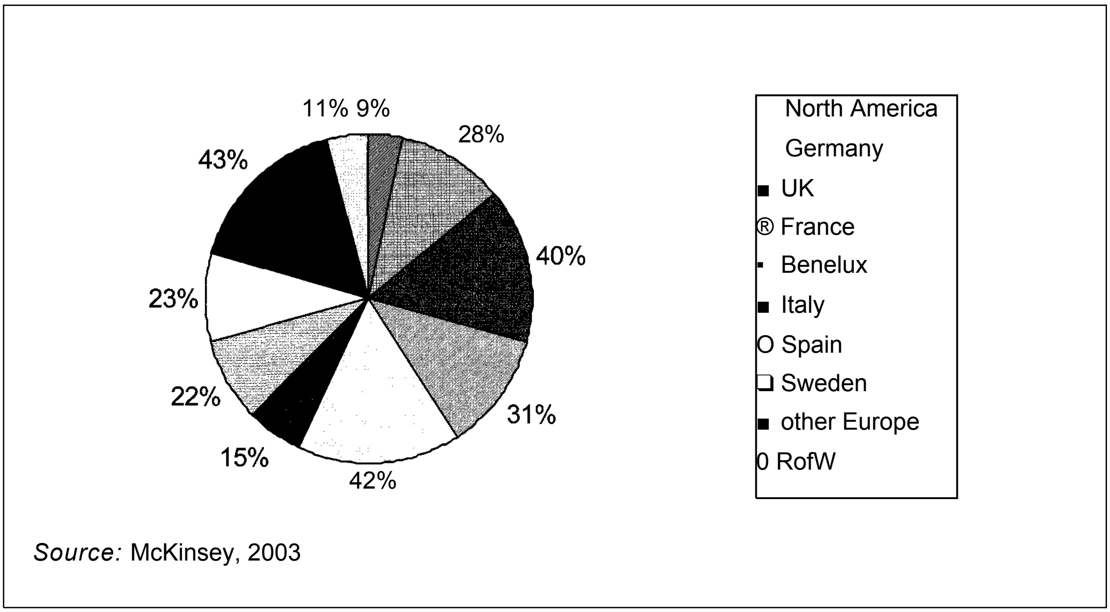


Figure 4.6 The percentage share of the 3PL market in certain countries and regions

- *Regional multi-client distribution operation.* These operations are provided for any number of clients and for most product types. They are usually provided by a ' general' third-party distributor that has probably started as a very small operation and grown into a regional operation concentrated in a specific small geographic area.
- *National multi-client distribution operation.* This category is very similar to the previous one, a service being provided for any number of clients and pro-duct types. The main difference relates to the size of the operation. This is nationwide, and would include a trunking (line-haul) operation between the companies' sites, so that if necessary a client company can have a delivery service to anywhere in the country.
- *Satellite or cross-docking operation.* These are operations where the operator is not involved in the storage of any products, but is only providing a collect, break-bulk and delivery service. Thus, no unordered stocks are held, although some minor stock-holding may occur for a limited number of product lines.
- *Joint venture. A* limited number of operations have been set up whereby a third-party operator and a client company form a separate distribution company called a joint venture. This may occur where a company with its own distribution operation has some underutilized resources. It will then link up with a third-party operator and offer the services on a wider basis. This has occurred in the hanging goods and the high-tech sectors.
- *International distribution operations.* These may be dedicated but are most likely to be multi-user, enabling a client to achieve international movements between sites and delivery to final customers over a broad international area. It is still very difficult in a European context to find a single third-party operator that can provide such a universal service.
- *Occasional use.* Many companies use third-party services on an occasional basis or as an aid to support their own-account operations. There are a number of reasons why a company might do this: to cover seasonal peaks in demand; to cover weekly demand peaks; for non-standard products that don't fit easily into their own operation (very small or very large products); to deliver to peripheral geographic areas where there is only limited demand for their products; or for non-standard operations (returns, collections, etc).

Third-party distribution has developed rapidly over the past few decades and has become a very competitive and dynamic industry. There has been a significant growth in both the number and the size of companies. In recent years a number of major players have come to the fore, from a variety of different backgrounds, as companies from different sectors bid to cut themselves a slice of the distribution service market. This has been particularly true for those companies trying to develop pan-European operations. In Europe, for example, key players have evolved from existing logistics service providers, freight forwarding companies, general hauliers and air and sea freight companies.

DIFFERENT SERVICES THAT ARE OFFERED

The result of this fast growth and robust competition has meant that third-party companies now offer many distribution and distribution-related services. It is important to understand the breadth of services that are available and to be able to select those that are most appropriate for a user company.

Breadth of outsourcing

As already indicated, there is a vast choice of different operations and services that can be outsourced. Third-party companies have continued to expand the many services that they offer in order to succeed within a very competitive marketplace.

For a user company, it is important to understand that in distribution and logistics probably every different aspect can be outsourced! But many users do not wish to outsource everything, only certain parts of their operation. One useful way to view this is as a continuum of services, ranging from total internal logistics management to total external logistics management. This is illustrated in Figure 4.7.

The continuum shown in Figure 4.7 demonstrates the different opportunities that are available across the whole scope of outsourcing. There are some important reasons for viewing these opportunities in this way, in particular when it comes to making the final decision with respect to a specific contract. These are:

- To identify where the major benefits of outsourcing might be.
- To be clear exactly what is included and what is excluded as far as the contractor and the associated contract are concerned. This is important to the subsequent running of the operation. It needs to be clear what the third-party logistics contractor (3PL) is responsible for but also what remains as the responsibility of the user company. The service provided by many logistics operations has failed badly when this is not clear from the outset.
- To be clear where the boundaries of responsibility change. This is similar to the last point, but is one that needs emphasizing also because of the problems that can result if this is not transparent.

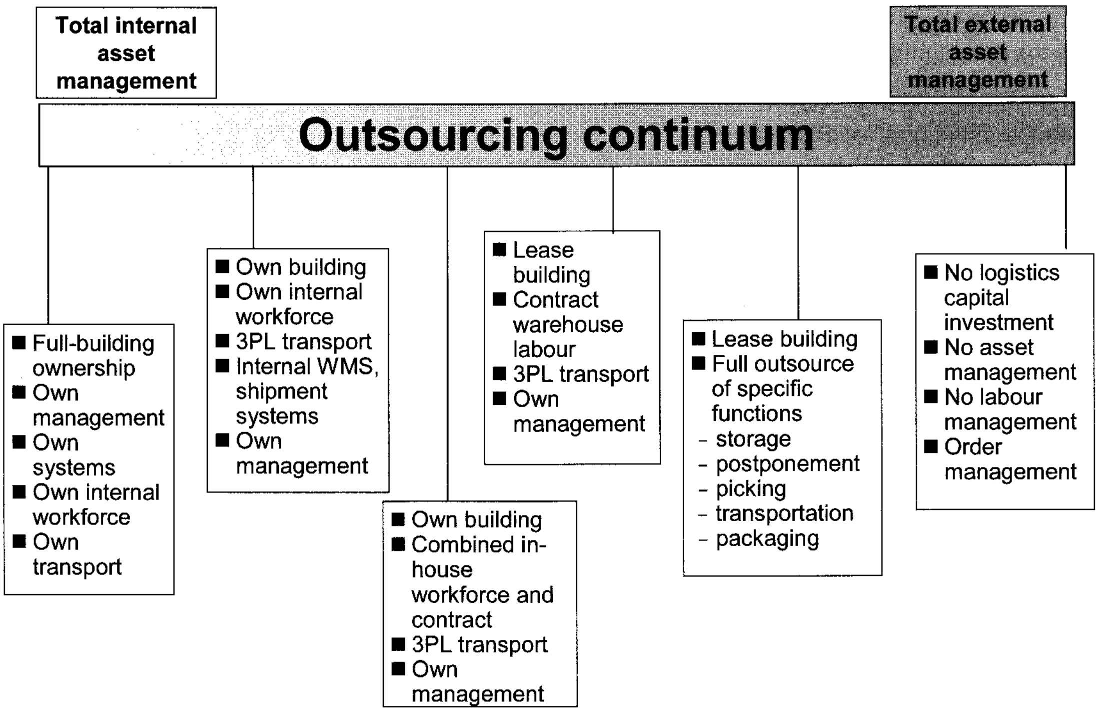


Figure 4.7 Continuum of logistics outsourcing, showing the range of functions and services that might be outsourced

- To identify the 'gains' or 'wins' expected from a contract, whether these are cost- or service-related. These will help in the final decision-making process of whether or not to outsource, as well as being important for post-contract evaluation.

Basic *services*

The basic types of service can vary from contract hire to the provision of single vehicles or a fleet of vehicles to fully dedicated operations, including storage, primary and secondary transport, management services, order processing and stock control. A list of the most common services includes:

- primary transport (trunking, line-haul);
- collection;
- break-bulk;

- fleet management;
- telesales;
- management information;
- local delivery;
- stock-holding warehouse;
- trans-shipment;
- cross-docking;
- order picking;
- inventory management;
- general management;
- contract hire;
- home delivery;
- production inspection;
- packing;
- reverse logistics;
- merchandisii

Value added services

There are also many other services offered. Some of these are known as 'value added' services because they reflect, in particular, those items or services that add a lot of additional value to the product being distributed. Examples of these are:

- *Specialist or niche services,* where the operation is specifically designed for a particular product. There are many examples in a number of different market sectors - automotive, electrical/electronic, hanging garments, high-tech, etc. The development of hanging garment distribution is typical - here the entire distribution operation, from production point through finished goods warehouse, primary transport, distribution centre, delivery transport and into the retail store, is all provided *on* hanging rails. Products are thus stored and moved as ' sets' of garments on hangers. Some of the storage operations are very sophisticated automated systems.
- *Time-definite services,* which are set up to support the just-in-time operations of major manufacturers. Typical here are the sequencing centres that have been developed in the automotive industry to support line-side production. TNT, Hays, and Ryder have provided these for Rover, General Motors, and Nissan, whereby line-ready production modules are supplied direct to the production line so that the relevant components can be introduced into the manufacturing process at exactly the appropriate time.

- *Production and assembly*, where the final manufacturing or assembly of products takes place outside the manufacturing environment but within the logistics operation. The computer industry offers a number of examples where basic products, such as PC monitors or processing units, are initially distributed to the relevant market before being finally made ready for the end customer. This is likely to include the 'badging' of the equipment with the appropriate name and the installation of the final-language software. This is often undertaken by the third-party distributor.
- *Repacking is* another area of value added development. A typical example might be the need to blister-pack two different items that are to go out as a distinct retail product, eg a torch together with a battery. This is another niche operation favoured by a few specialist distribution companies.
- *Refurbishment:* in the light of current environmental legislation, many manufacturing companies have endeavoured to re-engineer their products so that parts from some used products can be reused in new products. It is necessary to return these parts through the supply chain – not an easy task, as most distribution operations tend to be geared to moving products out to the customer and not back from the customer to the manufacturer. This has provided an opportunity for third-party companies to offer this return-and-refurbishment operation.
- *Packaging returns:* again linked to environmental legislation, there is a need to collect packaging for reuse or disposal. A number of third-party operators have set up reverse logistics operations for the large grocery multiples. Examples include the development of recycling centres for the disposal of waste and the repair and washing of reusable containers.
- *Inbound logistics:* the provision of goods into a manufacturing company is also seen as an area for additional value added service. This involves the co-ordination of the raw material, component and packaging products that a manufacturing company requires. It typically might include not just the collection and transport of all these different products, but also the stock control, ordering and order progress chasing. It is a much-neglected area, and offers a good opportunity for cost saving and improved stock and supplier control.
- *Pre-retailing:* here, products are prepared for immediate use in the retailing environment. This may involve de-packaging from outers, labelling, etc. In the clothing industry, particularly for boxed items, additional services will include cleaning and pressing to make the garments shop-ready.
- *E -fulfilment:* the growth in internet sales has led to a similar growth in the demand for the fulfilment of these internet orders. A number of large and small

specialist companies, such as Business Express, Beck and Call, have developed an expertise for such distribution operations - often now known as home delivery. Many traditional parcels operators also specialize in home delivery for a variety of different clients.

A summary of the traditional breakdown of broad service types is given in Table 4.1. This considers the different types of service or operation against four of the main attributes - asset dedication, speed of delivery, size of consignment and contractual basis. The key question of cost is negotiable as and when the service is required.

Table 4.1 Breakdown of broad service types by attribute

Broad Service Type	Asset Dedication	Speed of Delivery	Size of Consignment	Contractual Basis
Express	shared	next day	small	transaction
Groupage	shared	slower than express	larger than express	transaction
General Haulage	shared	slower than express	as required	transaction or contract
Shared or Multi-user Distribution	shared	slower than dedicated	as required	contract
Dedicated Contract Distribution	dedicated	as required	as required	contract

KEY DRIVERS FOR THIRD-PARTY DISTRIBUTION

There are a large number of advantages and disadvantages claimed for and against both third-party and own-account distribution. Some of these can be objectively assessed. Others are subjective, relating more to historical convention and personal preference than to anything else. The major drivers for and against the use of a third party can be split into four broad categories covering cost, service, organizational and physical factors.

Some of the issues that will be referred to may apply more specifically to multi-user operations rather than to dedicated operations or vice versa. Generally, a client requiring a dedicated operation is able to define and buy a specially designed service from the supplier, so many of the issues will not apply. Thus, as well as the main decision whether or not to use a third party, there is also a crucial decision for a company to make as to whether to use a dedicated or a multi-user operation. The decision, as so often in distribution and logistics, is a question of trade-off between cost and service. However, there are also other aspects that need to be considered.

Cost *factors*

There are several cost advantages claimed because of the elimination of asset ownership. In particular, there are *capital cost* advantages through using third-party distribution because the client company does not have to invest in facilities and resources such as distribution centres and vehicles as it would for its own operation. Thus, the capital can be invested in more profitable areas of the business, such as new production machinery, retail stores, etc.

Associated with the elimination of asset ownership is that the reduction of ownership and responsibility for plant, property and equipment means that these items can be taken off the balance sheet. This may make the company more attractive from an accounting perspective, as *fixed costs are converted to variable costs.*

A particular advantage for multi-user operations is the opportunity to benefit from cost savings through *economies of scale.* Many own-account operations are too small to be run economically in their own right. If these operations are run together by a third-party company, the larger system that results will be more economic because a single large distribution centre may replace the three or four sites used by the different smaller companies. This will provide cost savings through reduced overheads, better utilization of equipment and labour, etc.

Linked closely to the previous point, and an advantage for multi-user distribution, is that third-party operations will provide day-to-day *operating cost* savings. This is because the various labour and equipment resources can be run more efficiently at the operational level.

Third-party distribution allows for *a clearer picture of actual operating costs.* Payments need to be made on a regular basis, usually every month, and this makes the actual distribution costs very visible. Reporting systems are generally more transparent than for own-account operations.

For individual client companies, there can be a cost advantage through *a cost lag* or cushion effect. This can occur when the effect of increased costs in various distribution elements, such as labour or fuel, are delayed before the third-party company can pass them on to the client – usually at the end-of-year contract review. This is particularly relevant in times of high inflation.

It maybe the case that the *changeover costs* of moving from own-account to third-party distribution are such that it does not make good economic sense. Problem areas are the sunk costs of existing owned sites, fixed low rents and vehicles and equipment.

Service factors

It is a question of some debate as to whether or not *service levels* are better or worse amongst third-party distributors compared to own-account operators.

For dedicated operations, there should be no significant difference because the outsourced operation is an exclusive one and thus similar to an own-account operation in that respect. Indeed it may be more difficult to achieve service level improvement in an existing own-account operation because of inertia within the operation.

For multi-user operations, service should not be poorer, because many third-party distributors make frequent and regular deliveries to their varied delivery points. Indeed, in remote rural areas, the use of a third party can greatly improve service levels because deliveries are likely to be more frequent than a small own-account operation can undertake.

The use of a third-party distribution operation should offer *greater flexibility* to the user company. This is particularly true as a company seeks to develop new products and services and new markets.

A company that intends to launch its products into a new geographic area will find it far more economical to use a third-party service provider rather than developing an expensive new logistics infrastructure in an area where initial sales are likely to be low and subsequent success for its products is not guaranteed. This has been seen, for example, by companies moving into the evolving markets of Eastern Europe.

As a company introduces new products and services, it may find that they do not fit easily into their existing logistics structure. Third-party operations may fill these gaps more effectively. For example, many companies that now offer internet sales and home delivery outsource the physical elements of the operation to specialist home delivery service providers.

As indicated in a previous section of this chapter, third-party companies are able to offer a number of *value added services*. These may provide a significant added attraction to user companies. For example, the use of a track-and-trace facility may be a competitive advantage that has a very positive impact for key customers.

It is often thought to be easier to initiate logistics service improvements via a third party rather than through an own-account operation. This is because incentives for service improvement can be written into service contracts for third-party companies. These are likely to be *performance-related incentives*.

Service level improvement may be achieved through a multi-user third-party operation via *more frequent delivery*. As already indicated, the use of a third party can greatly improve service levels because deliveries are likely to be more frequent than can be undertaken by a small own-account operation.

Organizational factors

One of the prime reasons quoted for the move to the use of a third-party distribution company is the opportunity for users to *focus* on their *core business*, be this manufacturing or retail. There are both organizational and cost benefits to be gained from this. The cost advantages have been identified in the capital cost savings outlined in a previous section. The organizational advantages are less obvious, but concern the opportunity for companies to streamline their organizations and particularly to concentrate management expertise in the core business areas.

The use of a third-party company can provide the user company with *access to wider knowledge*. This may be through the opportunity to use leading-edge technology, such as radio frequency identification (RFID), track and trace and geographic information systems (GIS), a broader management experience and knowledge beyond that of their own industry. This will enhance the opportunities to improve their operation.

Third-party distribution companies *may lack* the *appropriate experience* of client companies' products and markets, although the growth in specialist distribution companies has helped to change this point of view.

There may be an issue with *cultural incompatibility* between contractor and client. It is now recognized that company cultures can vary quite dramatically from one to another. It is important that there is no clash of culture in a contractor/client relationship because this may lead to problems in the way the operation is run.

It is claimed that the use of third-party distribution can lead to *a loss of control over the delivery operation*. This may be important if logistics is seen as a major element of competitive advantage. Any lack of control can be reduced, however, by buying the right service at the outset and by carefully monitoring the performance of the distribution company in terms of the service that it is actually providing.

There may also be *a loss of control over the company's logistical variables* if a third party is used. This means that the company is no longer in a position to define the number, type or size of distribution centres, or vehicle types and sizes, etc. Once again, if this is important, the company must choose the third-party structure that suits it the best, or it may, of course, choose a dedicated operation where these elements are provided exclusively for the company. Perhaps of greater concern, however, is that, as the contractor owns the systems and logistics resources, the balance of power shifts away from the user to the contractor.

When moving from an own-account to a third-party operation, there is *a loss of distribution and logistics expertise* in the user company. This will make it more difficult for the user company to revert to an own-account operation should it so wish. Also, distribution and logistics expertise, if maintained within the client organization, will help to enable a better monitoring and assessment of the true performance of the contractor.

The use of a third party can often mean the *loss of direct influence at the point of delivery* because the driver is delivering a number of different companies' products. This can be an issue, as the driver is very often the only direct physical link between the supplier and the customer. For multi-user operations, this can be limited if a salesperson is also used as a contact point. For dedicated operations, this should not be an issue because the driver is only delivering for a single client company.

Brand integrity cannot be guaranteed. This is not an issue for many companies, but is one that is quoted by some. Using a third party means that the company does not have its own livery and brand name on a vehicle, so the value of advertising on a vehicle is lost. For dedicated contract distribution, the livery is often used.

There may be a problem with the *confidentiality of information* when using a third-party distribution service. This may arise because products can be mixed with those of competitors. This is an issue hampering the take up of 3PL services in the vast, emerging logistics market in China since the barriers to entry for foreign 3PLs were relaxed.

Physical factors

The use of a third-party distribution operation should offer *greater flexibility* to the user company as it seeks to develop its products and markets.

For some companies, the move to a third-party operator provides a major opportunity to solve *any industrial relations problems* that might otherwise be difficult or costly to eradicate. Legislation, such as the Transfer of Undertakings (Protection of Employment) Regulations in the UK, has however diminished the potential impact of this aspect.

The *delivery characteristics* of some products may be incompatible in some third-party operations. This may relate to the frequency of deliveries required (eg a large number of small drops for high-value items) or the nature of the product itself. It is likely that some form of specialist distribution system can provide an appropriate alternative.

Vehicle characteristics and requirements can differ between products and product ranges. Vehicle size, body quality, equipment and unit load specifications may all be relevant, dependent on weight/volume ratios and any 'special' product features. Once again, the use of a specialist third-party company could be appropriate.

Basic delivery systems may be incompatible. This would apply, for example, to the use of pre-selected orders against van sales, and also the need for an assistant to help unload some bulky or heavy products. It is important to ensure that products are not being distributed via incompatible delivery systems, as this can be both costly and inefficient.

Some *products may be incompatible,* a particular problem being the danger of contamination caused by one product to another. If some food products are carried next to a product with a very strong smell then they will easily absorb the smell and be spoiled. Many third-party companies solve the problem by the use of special sections in vehicles.

Many of the debatable issues identified above refer more specifically to multi-user operations than to dedicated operations, because the client requiring a dedicated operation is able to define and buy a specially designed service from the supplier. Clearly, as well as the main decision whether or not to take the third-party route there is also a crucial decision for a company to make as to whether to use a dedicated or a multi-user operation. The decision, as so often in distribution and logistics, is a question of trade-off between cost and service. What then are these key trade-offs? They are summarized in Table 4.2.

The choice between own-account and third-party distribution needs to be carefully quantified and analysed. This should be undertaken with care, using a structured approach. Such an approach is outlined and discussed in Chapter 30 of this book.

KEY ISSUES IN THIRD-PARTY DISTRIBUTION AND LOGISTICS

In recent years there has been concern expressed by the users of third-party service providers that they are not being given the expected levels of service and business benefits. There is disappointment that agreed service levels are not maintained, that costs are higher than estimated with no evidence of clear year-on-year cost

Table 4.2 The key trade-offs between dedicated and multi-user distribution services

	Dedicated	**Multi-user**
d a a	• Organization and resources are focused exclusively on the customer • Specialism and loyalty of staff • Specialism of depots, handling equipment and delivery vehicles • Confidentiality of customers' product specifications / promotional activity	• Scale economies gained by sharing resources between a number of clients • Consolidation of loads enable higher delivery frequency • Ability to find clients with different business seasonality to maximize utilization of assets
• > u)	• Total costs of the operation are borne by the customer • Seasonal underutilization of resources	• Conflicting demands of each customer can compromise service • Staff do not gain specialist customer knowledge • Equipment is not specialized and may not exactly meet individual customer requirements

reduction, and that the quality, commitment and ability of the people used to manage their operations are insufficient.

As a solution to this, some user/third-party relationships have been developed to promote more of a *partnership approach*. One of the aims is to create a more positive and co-operative alliance between the user and the contractor and to eliminate the combative culture that has evolved in some relationships. Historically, many relationships have been very much contract-driven, with both user and third party at times squabbling over the small print of a contract to the detriment of the overall operation and of the business relationship itself. The ideal is for a constructive alliance where both parties work together to identify ways of improving service and reducing costs.

One means of creating more constructive partnerships has been the use of *incentivized contracts*. Here, the contract is drawn up with clearly defined opportunities for the service provider to identify and introduce methods of service improvement or cost reduction. The key is that the service provider is rewarded for identifying these improvements. In more traditional contracts, it is not in the interest of the service provider to introduce cost savings because the cost-plus-a-management-fee payment structure means that this would have the effect of reducing the income that the contractor receives.

Another important issue is the *lack of true pan-European and global third-party companies.* Currently, even the largest of the third-party providers can only offer a partial service across regional boundaries, having to subcontract or establish co-operative arrangements with other contractors. As manufacturers and retailers have moved towards global businesses, then they have an expectation that there should be global logistics companies to support them. These integrated global contractors have begun to evolve over the past few years.

Major users have indicated very strongly that *service providers are insufficiently proactive* in their approach to the contracted operations – that they only aim to provide the minimum and fail to enhance the operations for which they are responsible. On the other hand, service providers claim that they are seldom given the opportunity to develop new ideas and offer improvements, because users are not prepared to give them adequate information of their complete supply chains.

Some of the typical failures that have been claimed for some third-party contracts include:

- Contracts and arrangements require substantial senior management time to co-ordinate and review.
- There is an inability to broaden the service offering, and increased customer service requirements cannot be maintained.
- There are limited skills in the planning and replenishment processes (eg demand and inventory planning). The focus is mainly on transactional and execution processes (eg order picking, warehousing and transportation).
- There is a lack of network (re)design and management capabilities at a global and even continental level (eg the European Union).
- There is a lack of IT and change management capabilities.
- Contractors are often activity-driven (eg invoicing for space occupied or shipments delivered), as opposed to being value-driven (eg management of the total supply chain costs).
- The nature of contracts is such that third-party providers will concentrate on asset utilization to reduce their own costs rather than in developing a customer -focused approach to logistics.
- Third-party providers cannot contribute to opportunities to optimize operations over the wider supply chain.
- By their very nature, contractors are more likely to be concerned with one-off cost savings rather than continuous improvement, which is what users are most concerned about.

Another development has been a move to a much *more rigorous selection of contractors*. There is now a clearly laid-out process for contractor selection, which most large companies adhere to. This is described in detail in Chapter 30. However, this also raises another issue, because this type of rigorous and restrictive selection process is thought to be one of the main reasons for the inability of users to provide a more creative and successful contract relationship. The selection process is said to prevent the development of useful strategic partnerships and co-venturing initiatives, because it is outdated and inappropriate for such co-operative arrangements. This is because:

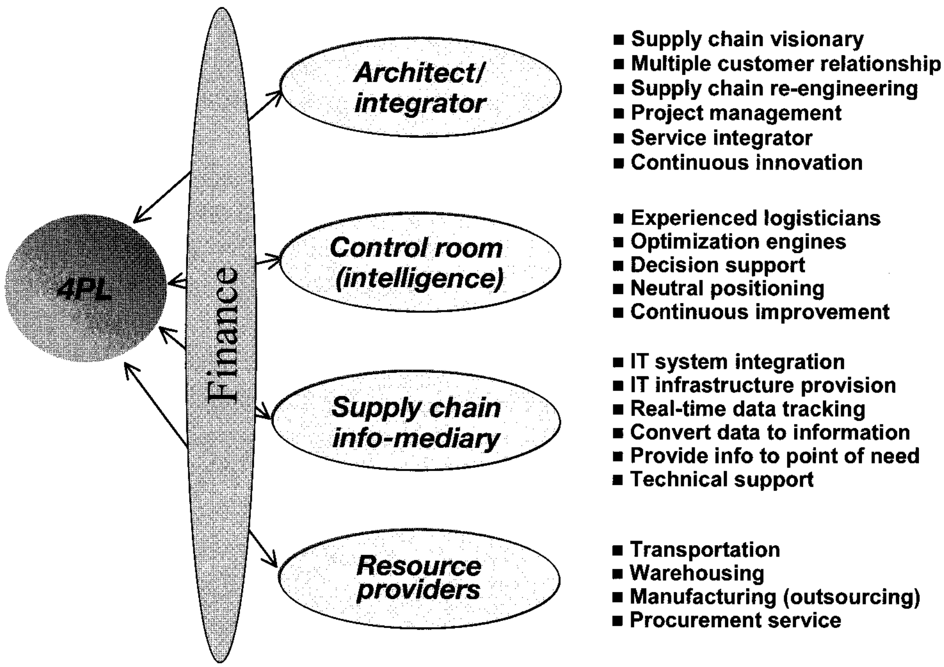
- it ignores total costs;
- its aim is to drive down suppliers' margins;
- it is an over-engineered process, which doesn't allow for innovative solutions;
- it has an over-rigid format;
- it has extensive legal phrasing;
- it is a very expensive process for the contractor;
- it doesn't allow for total supply chain solutions.

One of the consequences of these issues and, in particular, of the need for a total supply chain approach is that a different type of service provider and a different type of selection approach have been suggested. The idea is to aim to provide solutions, not just services. There are often several different organizations or participants in a supply chain, and there is clearly a need to develop partnerships and create opportunities to integrate and rationalize. One development has been the creation of an additional enterprise or organization to oversee and take responsibility for all the outsourced operations a user might have. This has become known as fourth-party logistics.

FOURTH-PARTY LOGISTICS

Fourth-party logistics is where an external organization is able to provide a user with an overall supply-chain-wide solution by incorporating the resources and expertise of any number of third parties to best effect. The fourth-party provider will be involved in both the design and the management of a client's logistics system and will act as a co-ordinator for many different types of service, which may include distribution, information systems, financial services, etc. Figure 4.8 summarizes the major opportunities in the key areas of integration, control, information and physical resources as well as financial support and services.

4PL



Source: based on Bumstead and Cannons, 2002

Figure 4.8 Fourth-party logistics, showing the main areas of service that could be provided

The idea is that co-venturer or fourth-party service providers can offer a number of enhanced services, which will enable:

- a total supply chain perspective;
- visibility along the supply chain;
- measurement along the supply chain (cost and performance);
- open systems;
- technical vision;
- flexibility;
- tailored structures and systems.

Accenture have defined a fourth-party logistics service provider as 'an integrator that assembles the resources, capabilities, and technology of its own organization and other organizations to design, build and run comprehensive supply chain solutions'. The main impetus is for the overall planning to be outsourced and that the complete supply chain operation should be included within the remit of the 4PL.

There are a number of different ways in which fourth-party logistics can solve some of the main problems that users of third-party logistics companies have experienced. The major drawbacks are likely to be the cost of using a 4PL and the loss of control over the supply chain function within the company. The main advantages are likely to be:

- *Addressing strategic failures:*
  - minimizing the time and effort spent on logistics by the user;
    a fourth-party organization is a single point of contact for all aspects of logistics;
    the management of multiple logistics providers is handled by a single organization;
  - allows for provision of broader supply chain services (IT, integration strategy, etc);
    a fourth-party organization can source different specialists with best-in-class credentials.
- *Addressing service and cost failures:*
  - the freeing of the user company's capital for core/mainstream use by selling assets;
    the continuous monitoring and improvement of supply chain processes, performance and costs;
    the benchmarking of different supply chain processes against world-class companies;
    the continuous monitoring and reassessment of service level achievements;
  - the development and use of core expertise from all logistics participants.
- *Addressing operational failures:*
    a new entity makes it easier to eradicate old industrial relations issues;
    a new entity should enable the transfer of selective personnel;
    a new and more flexible working environment can be established;
    a new company 'culture' can be created.
- *Additional benefits:*
    provision of 'knowledge management', 'the bringing together and effective sharing of knowledge among the identified stakeholders';
  - provision of supply chain accountability for achieving desired performance;

the provider assumes risk on behalf of the user in return for a share of the profit.

So far, the adoption of the fourth-party concept has been very limited, being restricted to some new ventures and to some large global organizations. It would seem that the outsourcing of complete supply chain strategies and operations is still a step too far for most organizations as they appreciate more and more the importance of their supply chain to their own business success and therefore wish to maintain control in this key area.

SUMMARY

This chapter has been concerned with channel choice and selection. The main aspects covered were:

- alternative channels of physical distribution;
- channel characteristics;
- an approach to channel selection;
- third-party versus own-account distribution;
- types of service offered by third-party companies;
- key drivers for third-party distribution;
- key issues;
- fourth-party logistics.

Channel choice and selection and particularly the increased use and sophistication of third-party distribution services are all very important aspects of modern-day logistics. This is an exciting area of change within the industry, and there is ample scope and opportunity for growth and development in the future.

5

Key issues and challenges for logistics

INTRODUCTION

In recent years there have been very significant developments in the structure, organization and operation of logistics, notably in the interpretation of logistics within the broader supply chain. Major changes have included the increase in customer service expectations, the concept of compressing time within the supply chain, the globalization of industry — in terms of both global brands and global markets — and the integration of organizational structures. These particular developments are discussed elsewhere in this book. In addition, there are a number of other influencing pressures that may impact a company's logistics system. These may be external to logistics, such as deregulation, or may indeed derive from changes within logistics, such as improved handling or information technology.

It is possible to view these different influences at various points along the supply chain. This chapter outlines these factors in relation to:

- the external environment;
- manufacturing and supply;
- distribution;
- retailing;
- the consumer.

It is worth emphasizing that, aside from external issues and developments in technology, many changes in logistics are largely conceptual in nature whereby certain aspects of logistics and the supply chain are viewed with a new or different approach. Many people, especially logistics practitioners, may feel that some of these concepts and approaches are very much like old ideas wrapped in new clothing. To a certain extent this is true; for example, much of the new process-oriented approach to logistics (see Chapter 7) is an echo of what used to be called ' work study'. The use of flowcharts for analysing workflows in distribution and logistics has always been very common.

What a number of these 'new' concepts and approaches are achieving is to re-emphasize certain ideas and to rekindle the fires of enthusiasm for constant review and change. As logistics exists in a very dynamic and ever-changing environment, this is probably not a bad development. Another relevant point is that a number of these concepts are not applicable to many operations and organizations. This is often due to their size or to their market; for example, small nationally oriented organizations are usually unaffected by globalization or supply chain agility. Nevertheless, for large multinational companies these are very important questions that need to be addressed.

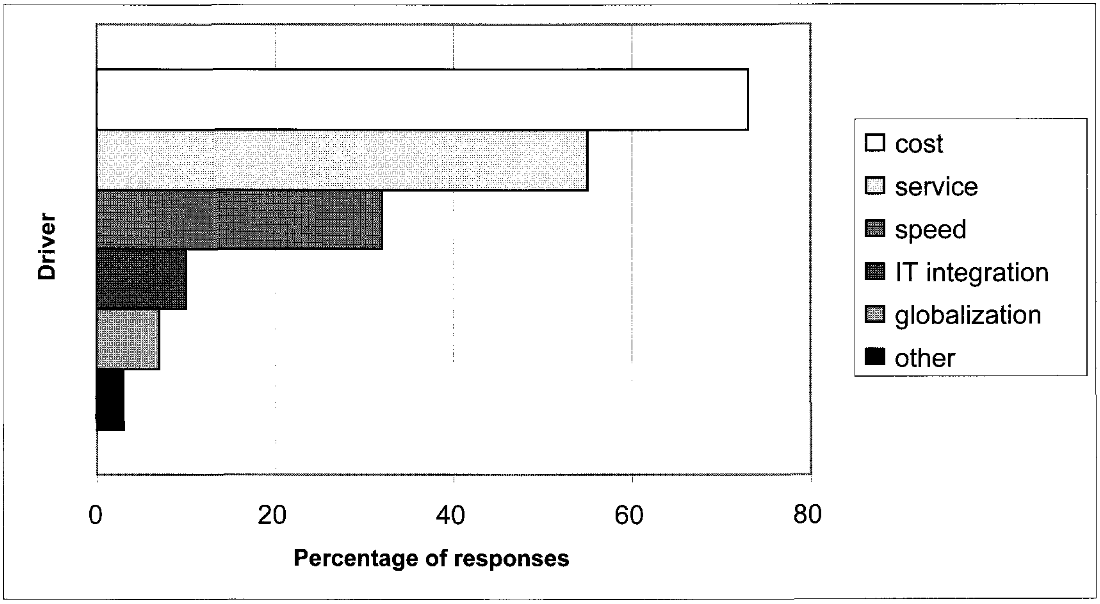
The traditional key drivers of logistics have always been cost versus customer service. This has not changed, as a recent survey confirms (see Figure 5.1).

THE EXTERNAL ENVIRONMENT

One key influence that has become increasingly important in recent years has been the development of a number of different economic unions (the EU, ASEAN, NAFTA, etc). Although the reason for the formation of these unions may be political, experience has shown that there have been significant economic changes — most of these beneficial ones (see Chapter 21 for further discussion).

One of the major consequences is *deregulation* within these internal markets, and this has a particular impact on companies' logistics strategies. Within the European Union, for example, there have been significant advances in, amongst others:

- transport deregulation;
- the harmonization of legislation across different countries;
- the reduction of tariff barriers;
- the elimination of cross-border customs requirements;
- tax harmonization.



Total does not add to 100% because of dual responses

Source: Herbert W Davis & Co, 2005

Figure 5.1 The major forces driving logistics

Within logistics, this has led many companies to reassess their entire logistics strategy and move away from a national approach to embrace a new cross-border/international structure. There are many examples of companies that have significantly reduced distribution centre (DC) numbers and associated inventory and storage costs whilst maintaining or improving customer service.

Another important development that has had a particular impact in Europe is the rise in importance of 'green' or environmental issues. This has occurred through an increasing public awareness of environmental issues, but also as a result of the activity of pressure groups. The consequences for logistics are important. They include:

- the banning of road freight movements at certain times and days of the week;
- the attempted promotion of rail over road transport;
- the recycling of packaging;
- the 'greening' of products;
- the outsourcing of reverse logistics flows;
- the design of products to facilitate repair, reuse, recycling and the minimization of packaging.

For most cities throughout the world, one very visible external impact is that of *road congestion*. The fact of severe traffic congestion may well have a very negative effect on some of the new concepts in logistics – in particular the idea of JIT and quick-response systems. Allied to this problem is that most forecasts predict a significant increase in vehicle numbers at a time when, in most countries, there are very limited road-building programmes. Many Western countries try to reduce congestion through a combination of road tolls, truck bans, access restrictions, time restrictions and usage tax – all of which have an impact on logistics costs and performance. There is no generally accepted solution. Companies try to alleviate the problem through strategies such as out-of-hours deliveries, stockless depots and the relocation of DCs closer to delivery points.

The extreme changes and developments in logistics thinking and logistics and information technology have also led to another issue – the impact that this has on the *availability of suitable management and labour*. The need for a strategic view of logistics and the need for an appropriate understanding of the integrated nature of logistics are both important for today's supply-chain-oriented networks. Many managers do not have the relevant experience or knowledge that provides this view. Add to this the rapid changes in technology, and it is understandable why there is such a shortage of suitable logistics management. This problem is also reflected in the quality of labour available to work in the many different logistics and distribution functions.

In the past few years there have been a number of unpredictable and unexpected events such as natural disasters, terrorism, corporate failures and industrial disputes that have resulted in, amongst other things, serious disruptions to supply chain and logistics activities. These events have highlighted the *vulnerability of* many *supply chains* and have shown that there is a risk to many supply chain and logistics operations that has not been adequately addressed. Many of these events are not directly related to the supply chain operations that are affected. For example, in the UK, a rise in the price of fuel for car drivers led to the blockading of fuel depots, which created a shortage of diesel for delivery transport, which in turn produced a general shortage of food because it could not be delivered to shops. There have also been examples of companies moving to a single source for the supply of a key component, only to find that the supplier becomes insolvent and cannot supply the component and that production at the company's plants is disrupted or halted. Vulnerability has become more of an issue as the complexity of supply chains has increased dramatically in recent years. Thus, appropriate risk assessment techniques and contingency plans have been developed to enable supply chains to be more resilient. See Chapter 30 for an example of a risk assessment methodology commonly used for outsourcing.

MANUFACTURING AND SUPPLY

There have been many important developments in supply or inbound logistics. These have resulted from both technological and organizational changes. Within the context of raw material sourcing and production, these include:

- *New manufacturing technology* (CIM, etc), which can accommodate more complex production requirements and more product variations.
- *New supplier relationships,* with the emphasis on single sourcing and lean supply, thus enabling suppliers and buyers to work more closely together.
- *Focused factories,* with a concentration on fewer sources but necessitating longer transport journeys.
- *Global sourcing,* emphasizing the move away from local or national sourcing.
- *Postponement,* where the final configuration of a product is delayed to enable reduced stock-holding of finished goods in the supply chain.
- *Co-makership:* the development of partnerships between supplier and buyer to help take costs out of the supply chain through quality and information improvements. This represents a positive move away from the more traditional adversarial relationship that has been common between buyers and suppliers.
- *Co-location:* the joint physical location of supplier operations on or next to customer production sites.

Associated with many of these developments has been the impact of changes in product range. Typical examples include the shortening of product life cycles, the wider product range expected and provided, and the increase in demand for time-sensitive products - especially fresh and prepared foods. These may all pose added logistics problems with respect to the impact on stock levels and in particular the speed of delivery required.

The results of a worldwide benchmarking programme in the automotive industry were published in a book called *The Machine that Changed the World* (Womack, Ross and Jones) in 1990. It identified huge opportunities for closing the gap between the best in the world and other manufacturers. The approach that was developed became known as *lean manufacturing,* and is based on the Toyota system of production management. The five principles of lean thinking concentrate on the elimination of waste and are as follows:

1. Specify what does and does not create value from the customers' perspective and not from the perspective of individual firms, functions and departments.

2. Identify all the steps necessary to design, order and produce the product across the whole value stream to highlight non-value-adding waste.
3. Make those actions that create value flow without interruption, detours, backflows, waiting or scrap.
4. Only make what is 'pulled' by the customer order just in time.
5. Strive for perfection by continually removing successive layers of waste as they are uncovered.

These ideas are discussed further in Chapter 10. Lean thinking owes a lot to the philosophy of just-in-time and is an extension of this type of approach.

A development of lean thinking is the concept of *the agile supply chain*. The emphasis is on the need for companies to work together across the supply chain in order to fulfil customers' requirements, and to be flexible in the way that they are organized for production and distribution. This will allow them to be responsive to any changes in customer requirements. The concept is one that recognizes the key importance of the final customer for a product and strives to set up a system and structure that can service these customer requirements in the most effective way.

Agility is, therefore, about the development of a strategic structure and operation that allows for the rapid response to unpredictable changes in customer demand. Two dictionary definitions serve to emphasize the difference between lean thinking and the agile supply chain: *lean:* 'having no surplus flesh or bulk'; and *agile:* 'quick in movement, nimble'. Some of the reasons for the need for agility in the supply chain include:

- the dramatic shortening of product life cycles - PCs have about a six-month life cycle, and mobile phones become outdated in even shorter periods;
- the rapid increase in the variety of final products in terms of colour and style refinements;
- the build-up of stock, which can quickly become obsolete as demand requirements change so rapidly, in traditional supply chains;
- developments in direct selling and buying - notably via internet shopping - that mean that customer expectations of acquiring the most up-to-date products have become even greater.

The agile approach to supply chain management aims to create a responsive structure and process to service customer demand in a changing marketplace, although in many ways this merely echoes the methods of any organization that is set up to be responsive to customer requirements. Key characteristics of an agile approach are:

- Inventory is held at as few levels as possible.
- Finished goods are sometimes delivered direct from factory to customer.
- Replenishment at the different levels in the supply chain is driven by actual sales data collected at the customer interface.
- Production is planned across functional boundaries.
- Supply chain systems are highly integrated, giving clear visibility of inventory at all levels.
- Minimum lead times are developed and used.
- The principles of the postponement of production are practised.
- The majority of stock is held as work-in-progress awaiting final configuration, which will be based on actual customer requirements.

Factory gate pricing (FGP) is another initiative that is intended to reduce logistics costs – in this case the inbound supplier's transport costs incurred while delivering to customers' manufacturing sites or distribution centres. Traditionally, many products, particularly industrial components and raw materials, have been delivered direct to customers via suppliers' own transport or a third-party contracted to the supplier. This approach disguises the real transport cost because it is included within the cost of the product. Now, some products are bought 'at the factory gate' without any transport cost included, so that the product price is transparent. The buyer can then decide whether to ask the supplier to deliver, with the transport cost indicated separately, or to collect the product using its own, or third-party, resources that it controls.

As well as the opportunity to reduce transport costs by improving the utilization of its own transport operations, this alternative approach also gives the buyer much more control over when goods are received and how much is received. This can help it to avoid stock-outs of essential products and to ensure that it does not become unnecessarily overstocked with any products.

DISTRIBUTION

In many ways, there have been fewer changes in the distribution elements of the supply chain than in most of the other elements. In an operational context, the major developments have been technology-based:

- 'new' vehicle systems — demountable bodies, etc;
- stockless depots operating cross-docking arrangements;
- paperless information systems, particularly in distribution centres;
- interactive routeing and scheduling for road transport operations.

An important and still expanding area is that of *third-party distribution*, or the outsourcing of distribution operations. This has been a significant feature of logistics in the UK for many years, and now many continental European countries have begun to follow the same track. The major advantage is that outsourcing allows a company to specialize in its own core business, be it manufacturing or retailing, without spreading its resources to cover distribution as well (see Chapter 4).

There are still major opportunities in many markets. Most third-party contractors will now claim to have one or a number of specializations (food, hanging garments, etc), and many strive to provide an increased portfolio of 'value added' activities, which allows them to obtain additional business (relabelling, assembly, etc). There is currently a move to establish partnership arrangements, but the main questions are still whether to outsource at all and what to outsource.

One interesting innovation in distribution is the development of *freight exchanges*, which are online transaction systems for shippers and carriers that enable online freight purchasing. Basically, they are internet-based trading mechanisms that facilitate the matching of shipper demand with carrier availability. They range in complexity from simple electronic bulletin boards (these allow shippers and carriers to post their needs, manually compare the two lists and then contact each other) to sophisticated algorithms (these identify suitable matches through the filtering and comparison of rates, carrier performance, service offering and equipment types).

Almost all of the sites use some form of bidding process. This is likely to be a ' reverse auction' where a carrier makes a bid to provide the transport for a particular freight movement and this bid stands until, and unless, another carrier comes in with a better (ie a lower) offer. There is a time deadline after which no more bids will be accepted. The reverse auction process tends to be liveliest shortly before the time deadline is reached. Figure 5.2 provides a summary of some of the major differences between freight exchanges. This indicates the various mechanisms that are used for establishing rates (bulletin boards, auctions, aggregation, etc), the different modes considered, the different types of owner and the matching processes.

Many such exchanges have been born and have expired in just a few years. Initially, it was thought that these exchanges would take the place of the contract arrangements made between many shippers and carriers, but it is apparent

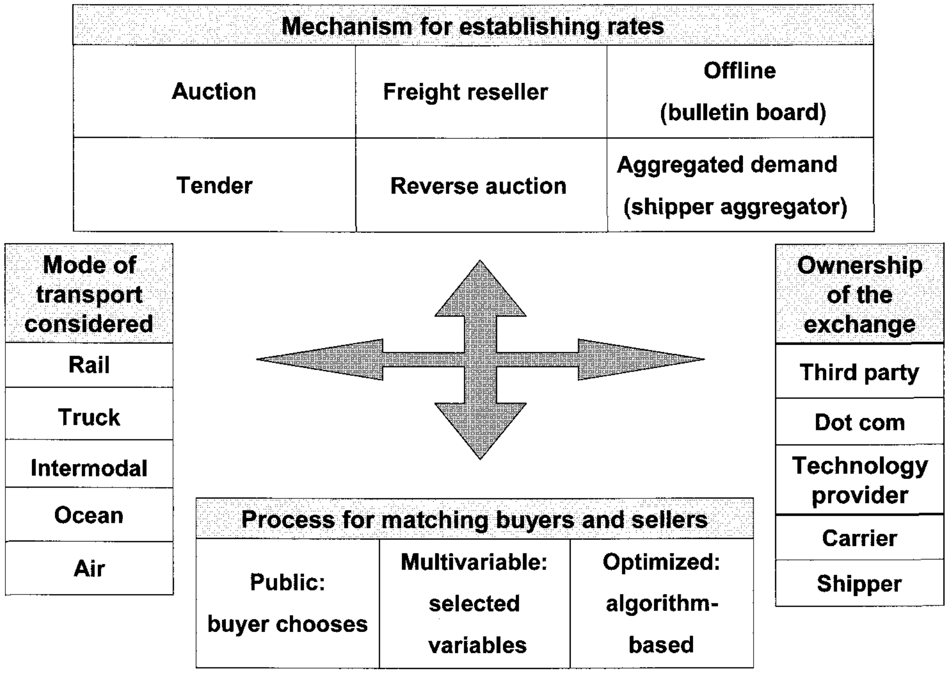


Figure 5.2 The different characteristics that distinguish freight exchanges from each other

that these contracts need to be negotiated face to face and that isolated internet contact is insufficient. Thus, exchanges are ideal for organizing 'spot' or occasional transport requirements but not for complicated long-term service contracts. An up-to-date list of exchanges can be found by interrogating search engines, such as Google, using 'Freight Exchanges' as the key words. Some sites provide very useful demonstrations of how they can be used.

Another very important development is the use of RFID: *radio frequency identification tagging*. This technology enables automatic identification through the use of radio frequency tags, data readers and integrating software. A tag has a microchip and an antenna that can store and transmit data and it can be fixed to individual products or unit loads. It can be active (send a signal) or passive (respond to a signal). The reader retrieves the data and sends them to the software, which can then interface with other logistics information systems.

The potential of RFID is now much greater due to a number of factors:

- Prices of both tags and readers have fallen dramatically.
- A number of leading grocery retailers have started to introduce tagging.
- The performance of the tags has improved substantially in terms of better and faster data transmission.
- There is a greater requirement for tags, especially for the tracing of products for consumer protection and brand integrity.

RFID tagging is still more expensive than bar-coding, but the differential is fast reducing, and the opportunities for RFID tagging are much greater. A tag can hold substantial amounts of data, has read and write capabilities, does not require line-of-sight reading but can be read via proximity, is fully automated and virtually error-free, is more durable and can operate in harsh environments. The feasible advantages from their use are numerous and help to indicate the vast potential for the technology in logistics. Some examples are:

- tracking raw materials and work-in-progress through manufacturing;
- tracking finished goods and unit loads in DCs: this could reduce labour time and costs through automated check-in, order shipment verification and stock checking;
- tracking finished goods and unit loads to shops or customers: this should enhance service provision through more accurate and timely information on order status;
- tracking reusable assets such as pallets and roll cages: this should provide significant increases in asset utilization by reducing asset cycle time and enabling better asset management.

Finally, within the aegis of distribution, one distinctive feature of recent years has been a concentration on *improving asset utilization*. This has been demonstrated in many ways: in grocery distribution with the building of composite distribution centres and the use of compartmentalized vehicles; the backloading of delivery vehicles; and the development of shared-user contract distribution. One grocery multiple retailer in the UK has integrated its entire transport operation so that all transport is centrally planned. This includes supplier deliveries and collections, primary movements between and to DCs, final delivery and packaging returns. The system uses linked technology: routeing and scheduling software, GPS, in-cab communication, etc. Although it is a complicated and time-consuming operation to plan and implement, the company has seen major improvements in the utilization of tractors, trailers and drivers, as well as a reduced impact from the problem areas of increased congestion, working time legislation and driver shortages.

RETAILING

In Europe as a whole there have been several trends in the retail sector that have had and will continue to have an impact on logistics and supply chain development. The importance of the grocery multiple retailers cannot be overestimated, as many logistics-related changes have emanated from this sector. In general, there has been a growth in multiple stores and a decline in independents. Overall the number of retail outlets is in decline, but the average size of outlets has increased considerably. A fairly universal development has been the growth of large out-of-town 'one-stop' superstores and hypermarkets.

These changes have all had an influence on logistics strategies and operations. Perhaps the most far-reaching effect, however, has been from the combination of *inventory reduction* policies. These include:

- the maximization of retail selling space – at the expense of retail stockrooms;
- the reduction in DC stock-holding due to cost-saving policies;
- the reduction in the number of stock-holding DCs;
- JIT philosophies and concepts;
- vendor-managed inventory policies.

An important retailing policy has been the move to maximize selling space in stores, often at the expense of shop stockrooms. Developments in information technology have also been at the forefront, particularly the use of electronic point-of-sale systems, which provide a much more accurate and timely indication of stock replenishment requirements at shop level. Linked to this has been the introduction in the USA of vendor-managed inventory policies whereby the supplier rather than the retailer is responsible for shop stock replenishment. Finally, many retail operations have also adopted policies to streamline the activities within the retail environment through the movement of activities back into the DC (labelling, unpacking, etc).

The consequences are that stocks and buffers in retail stores have been reduced or eliminated in favour of the continuous flow of products into the stores. This necessitates more responsive delivery systems, more accurate information and more timely information. Thus logistics operations must perform with greater efficiency but with fewer safeguards.

The out-of-stock problems created by inventory reduction at retail outlets have highlighted a number of other related issues. These are classified under the title of *'on-shelf availability'* or *'the last 50 metres'*. In its simplest definition, this refers to the ability to provide the desired product in a saleable condition when and where the customer wants it. This definition describes the effect of the problem but, in fact, there are many interrelated causes throughout the supply chain that can create the problem. Product availability tends to reduce as the product moves through the supply chain. The Institute of Grocery Distribution (IGD) (2005) research indicates that manufacturers achieve about 98 per cent availability, which reduces to 95 per cent in retailers' DCs and to about 90 per cent by the time the product reaches the shelves in the shop.

Poor in-store execution can create shortages, due to lack of replenishment staff in shops, insufficient shelf space or ineffective stock management at the shop. It is estimated that loss of sales can be quite significant because, although some shoppers will delay purchase or purchase a substitute, most are likely to buy the product from another store. Seven areas for improvement in supply have been identified, the two most important being measurement and management attention. The others are to improve replenishment systems, merchandising, inventory accuracy, promotional management and ordering systems. These are areas that require collaboration from the different players in the supply chain.

THE CONSUMER

Linked directly with retailing operations is the gradual move into non-store shopping or *home shopping*. This phenomenon has been relatively common in the USA and Europe through the use of direct selling and mail order catalogues. It has now achieved 'breakthrough' levels in sectors such as grocery and made significant inroads into more conventional retail shopping. The means for such a change have been through the development of home computers, automatic banking and, of course, the internet. These changes have begun to have a fundamental impact on logistics. The very nature of the final delivery operation has, for home delivery, altered dramatically, and this has affected the whole of the supply chain. Typical implications are:

- shops become showrooms where stock replenishment is no longer an issue;
- a major increase in direct home deliveries;
- new distribution systems (small deliveries into residential areas, community depots, etc);
- existing delivery systems may have a new life (postal service, doorstep milk delivery);

- customer ordering systems may become linked directly to manufacturers' reordering systems;
- a high rate of returns – outside of the grocery sector, this can vary between 30 and 50 per cent.

This major move to non-store or home shopping has for many years always been ' just around the corner'. With significant advances in the spread of home computers and free use of the internet, it is now reasonable to say that its time has arrived. In some sectors (eg white goods, brown goods), home delivery has been common practice for several years. There are third-party contractors who specialize in home delivery. The rapid growth in online selling companies, such as Amazon, means that home shopping is now very common, with all the implications for logistics that e-fulfilment will bring.

It is important to differentiate between home shopping and *home delivery*. 'Home shopping' refers to the different ways of shopping for and ordering products from home. 'Home delivery' refers to the physical delivery of the product to the home. Those companies involved in grocery home delivery have, for example, developed specialist vehicles that have compartments for the different types of grocery products: ambient, fresh, chilled and frozen. A number of different logistics solutions are still used for the storage and picking elements. The option of building specialist home delivery depots has generally not been successful. Most operations either stock and pick within designated areas of existing DCs or pick from the large retail hypermarkets.

Some problems have already been identified, such as the number of picking errors that occur in this type of single-item picking operation, damage to the product and the less-than-perfect quality of some fresh food items. As companies become more familiar with and practised in these operations, these problems are reducing.

As well as delivery using conventional systems, other solutions that have been considered are the provision of secure boxes outside or attached to the property. As the average grocery delivery is likely to contain some chilled and some frozen goods, this approach may pose problems. Alternative points of delivery such as the place of work or the petrol station have also been tried with varying degrees of success. Picked and packed goods are delivered to await customer collection.

Delivery drivers need to have very good interpersonal skills, as they are dealing face to face with customers in their homes. This will have implications for recruitment and training. If the goods being delivered require installation then the drivers will need appropriate training.

The key topic of *customer service* has been previously discussed (see Chapter 3). It should be re-emphasized that this continues to increase in importance and have a major impact on logistics, such that the logistics function has become the key element in customer service strategy. This includes:

- the development of 'customer-facing' organizations and operations;
- a move towards service policies based on market segmentation;
- JIT and quick-response systems requiring markedly more frequent and reliable delivery;
- 'brand image' becoming less strong - the dominant differentiator being availability.

One very recent example of the increasing importance of customer service has been the move to develop an alternative approach to the supply chain by creating what is called *demand chain management* (DCM). Here the intention is to move the emphasis away from the supply of products and towards the demand for products - to reflect the importance of what the customer requires rather that what the supplier wants to provide. Ultimately this is linking the two concepts of supply chain management (SCM) with customer relationship management (CRM), or linking logistics directly with marketing.

Information systems and technology are now capable of creating giant databases and information retrieval systems that allow for the manipulation and use of extreme amounts of very detailed data. The aim is, therefore, to integrate the two concepts and to eradicate the current isolation between producer and consumer and to do this by moving from supplier-facing systems and activities to customer-facing systems and activities. Perhaps this is only a subtle change in thinking - another new consultancy concept? - but it does have the good intention of emphasizing the need to concentrate on the customer rather than the supplier.

SUMMARY

This chapter has identified some of the most recent key impacts and influences on logistics and supply chain development. It is possible to see major changes occurring throughout all of the different links within the supply chain, as well as broader external changes.

These various developments are only symptomatic of more fundamental changes. In particular, the relationships between manufacturer, supplier, distributor and retailer may need rethinking. The concept of logistics and supply chain management is now moving towards the need for logistics and supply chain partnership. The overall trend, reinforced by information technology, is towards greater integration throughout the whole supply chain.

Part 2

Planning for logistics

6

Planning framework for logistics

INTRODUCTION

The need for a positive approach to planning was discussed in Chapter 2, together with the concept of a logistics planning hierarchy. In this chapter a more detailed planning framework for logistics is described, and some key strategic considerations are introduced. A generalized approach to corporate strategic planning is outlined, and this is linked to a specific logistics design strategy. The main elements of this design strategy are described. Finally, some of the fundamental influences on logistics network planning and design are detailed, in particular, product characteristics, the product life *cycle,* packaging and unit loads.

PRESSURES FOR CHANGE

Historically, many organizations have adopted a piecemeal and incomplete approach to their strategic planning. This is particularly true in the context of logistics where, often, individual functions within the logistics or supply chain have been sub-optimized to the detriment of the logistics chain as a whole. One of the reasons for this incomplete approach is the pressure for change exerted on companies from a wide variety of sources. Figure 6.1 provides an illustration of some of these pressures. They include:

- a significant improvement in communications systems and information technology, including such developments as enterprise resource planning (ERP) systems, electronic point-of-sale (EPOS) systems, electronic data interchange (EDI) and of course the internet;
- regulatory changes and developments, of which the Single European Market (SEM) is one example amongst many economic unions, but also including various environmental and green issues;
- increasing customer service requirements, especially where the levels of service that logistics can provide are often seen as the competitive edge between companies and their products;
- a shortening of product life cycles, particularly for high-technology and fashion products;
- the need for improved financial performance at a time when companies and economies are under severe pressure;
- the development of new players with new roles in channels of distribution - this includes the growth of third-party service providers and their move to offer global and pan-European operations and to develop supply partnerships;
- the never-ending pressures to reduce inventories and their associated costs - through depot rationalization and the adoption of JIT concepts;
- the need to adopt a wider supply chain perspective when planning and redesigning logistics operations.

The danger for any organization is to overreact to this need for change. Thus, a measured response is required that enables distribution and logistics systems and structures to be developed as a whole in the context of company strategic plans. In this way, the likelihood of the sub-optimization of some logistics activities can be avoided. The quantitative modelling of logistics requirements as a second stage of strategic business planning is an important aspect of this. This chapter thus focuses on the development and use of a framework and approach that take into account broad organizational and business issues as well as more detailed logistics issues.

STRATEGIC PLANNING OVERVIEW

A generalized approach to corporate strategic planning is depicted in Figure 6.2. This is in many ways a classic strategic planning approach. There is nothing fundamentally new in this type of overview. One important point is that it does clearly identify the logistics function as a key part of strategic planning. This is not always the case in some corporate planning processes.

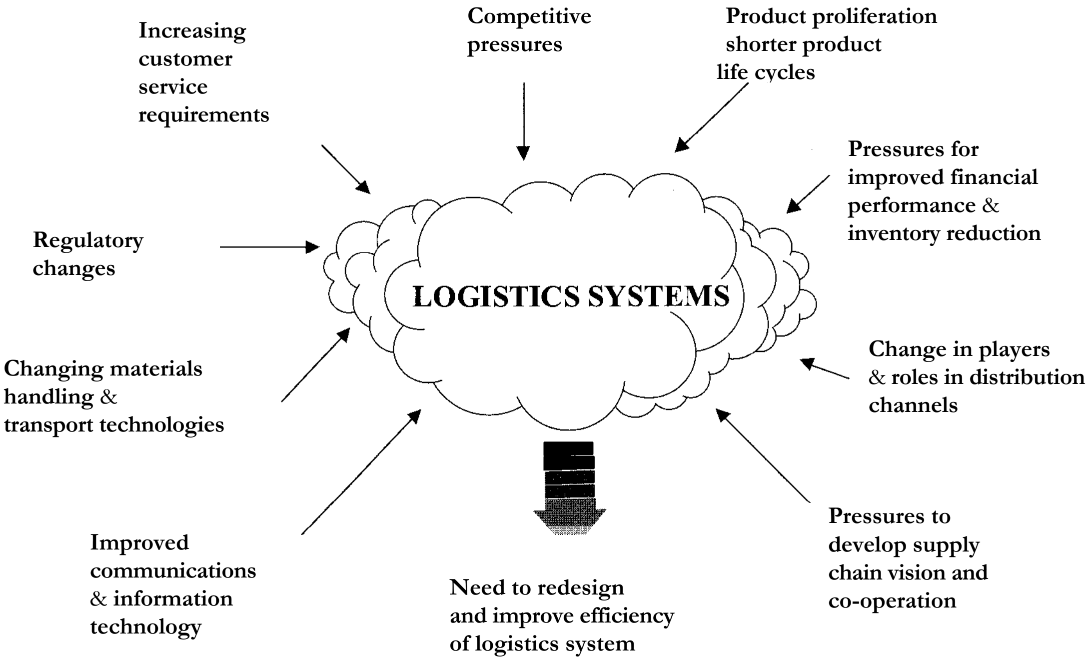


Figure 6.1 Pressures influencing logistics systems

The initial phase of a strategic study should incorporate a review of the *external environment* within which a company operates. This includes such factors as the economic climate, current regulations and potential regulatory changes, and any relevant technological developments. Also of importance for most companies would be some sort of evaluation of major competitors — particularly, in this context, any information regarding service and logistics strategies. One recognized approach to reviewing and evaluating the impact of the external environment is to undertake what is known as PEST analysis. A very broad view of external factors is taken and an assessment is made of the effects of these and how they might influence the strategy of the company. Typical factors to be assessed using PEST analysis are shown in Figure 6.3.

The analysis of relevant *internal factors is* also important. A typical approach is to undertake a form of SWOT analysis (strengths, weaknesses, opportunities and threats). This type of approach provides the opportunity for a company to review its position within the marketplace with respect to its products, the demand for its products, the service it offers its customers and the position of its competitors. This type of analysis can and should also be undertaken with respect to identifying a company's key logistical variables.

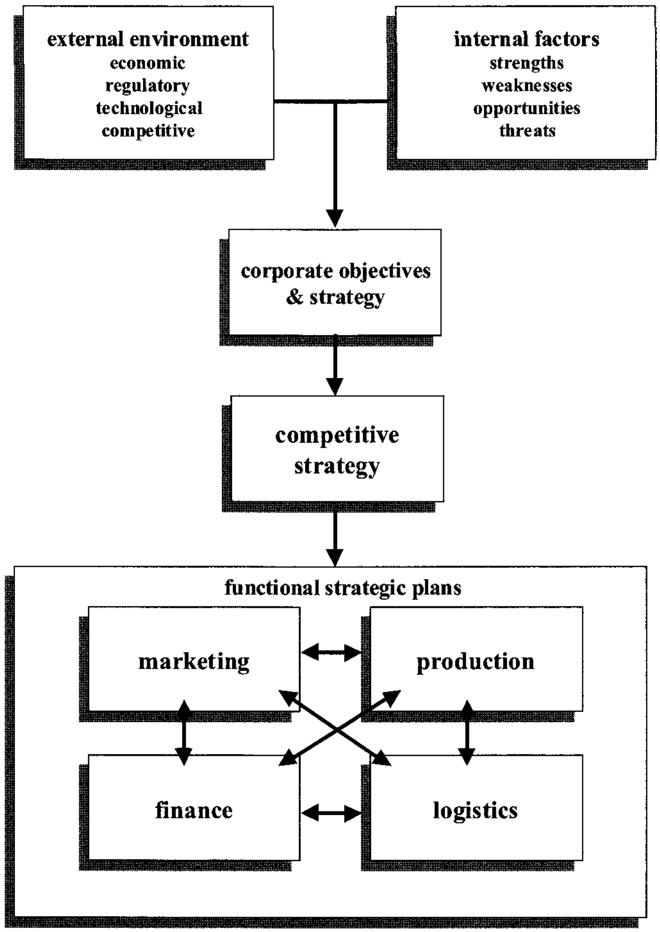


Figure 6.2 Corporate strategic planning overview

Approaches such as these enable a company to identify what its overall *corporate strategy* should be. One of the key points that must be addressed is to define what business the company is in. Many companies can be classified as 'retailers' or ' manufacturers', but often a further definition is important because it will have an influence on how the overall business is organized and structured. Beer provides a useful example. Typically, the brewing of beer has been seen as the key feature of the industry, and the brewing industry has a strong tradition that endorses this. Thus, the brewing of beer is the main activity. However, there are many different elements that need to be considered when determining how best to get the beer to the customer. There are different parts of the supply chain that can be influential and

• **Political/legal** Monopolies legislation Environmental protection laws Taxation policy Foreign trade regulations Employment law Government stability	• **Economic** Business cycles, Interest rates Money supply, Inflation Unemployment Disposable income Energy availability & cost
• **Socio-cultural** Population demographics Income distribution Social mobility, Lifestyle changes Attitude to work & leisure Consumerism, Levels of education	• **Technological** Government spending on research Government & industry focus on technological effort New discoveries/developments Speed of technology transfer Rates of obsolescence

Figure 6.3 PEST analysis: external influences

can necessitate the development of a very different type of business environment. These might be:

- *Brewing the beer:* this is the traditional role concerned with production and packaging. Beer production is often seen as a magician's art. Varieties of beer are produced, and they can be packaged in a number of different ways — barrels, kegs, cans, bottles, etc.
- *Environments in which to drink beer:* traditionally these have been pubs, clubs and bars. For the brewing industry a key question is whether or not to own these outlets (and thus have an assured sales outlet) or whether to concentrate solely on the production of the beer. A linked logistics issue is how best to get the beer to the outlets.
- *Environments in which to eat food and drink beer:* these are often known as leisure or lifestyle experiences. Typical are restaurants or 'theme' restaurants where the family might go to eat, drink and play. A major issue for these establishments is the supply and preparation of food as well as drink. For a brewer, this significantly changes the basic business objectives — there are other aspects to consider apart from brewing. Again, there are some obvious implications for logistics.

• *Drinking beer at home:* another important development is the increase in the home consumption of beer and the fact that this is primarily bought from supermarkets, specialist shops, wholesalers or corner shops. The brewer is unlikely to have the option to own these outlets (although, of course, beer is bought from pubs and bars for home consumption), but there are very different business, marketing, packaging and logistics implications in competing in this environment.

These represent an overview of some of the alternative business choices a brewer might have. Before attempting to design a competitive strategy and identify possible functional strategies, a company must be clear about which business it is in and what it wants to achieve within this business — a strategy based on set objectives.

In addition to a company's corporate or business strategy, the other element that is crucial is the *competitive strategy* that the company plans to adopt. Competitive strategy has a major influence on the development of logistics strategy and in the way the physical structure of the operation may be configured. There are a number of important factors, but the key ones include the extent of globalization, the type of competitive positioning adopted and the degree to which the supply chain is an integrated one. These factors were discussed in Chapter 2, and some of the major implications for logistics were discussed.

As indicated in Chapter 2, a company should adopt a competitive strategy by competing as a service or cost leader, or where possible as both of these. A service leader is a company that is trying to gain an advantage over its competitors by providing a number of key service elements to differentiate it and give it a service advantage. A cost leader is a company that is trying to utilize its resources by offering the product at the lowest possible cost, thus gaining a productivity advantage. Either of these extremes, or a combination of both, will necessitate a very different logistics structure.

The move towards integration within whole supply chains has been relatively slow; indeed, most companies still have fairly limited integration within their own organizations. Full external integration is quite unusual, but many companies have moved to functional integration, with some achieving an element of full internal integration. The extent of integration will have a big impact on the logistics structure of a company. A company with limited integration will hold stocks in many parts of its operation. A highly integrated company will hold very limited stocks, with the emphasis on the steady flow of product throughout the physical system.

LOGISTICS DESIGN STRATEGY

On completion of this initial phase of the business planning process it should be possible to identify corporate strategy and objectives, and to determine a specific competitive strategy. The next task is to prepare appropriate functional strategic plans. The remainder of this chapter will concentrate on the functional strategy for logistics.

There are several important issues concerning the development of a suitable logistics strategy. The first is the need to link the logistics or distribution plan directly with the corporate plan. This is best achieved by ensuring that logistics is an integral part of the corporate plan and that factors related to these functions are used as inputs in the overall planning process.

The second point concerns the extent or coverage of the logistics strategic plan. This will clearly vary from one company to another. It may well just be a ' distribution' functional plan. It is most likely that it will be necessary to incorporate elements from other functions (marketing, production, etc) to represent the fully integrated nature of logistics or the supply chain.

The third, and in many ways most important, issue is whether or not a company has a structured logistics plan at all. Many still don't, so a first and major step may be to ensure that such a plan is developed, based of course on the company's business and competitive strategic plans. To achieve this, a logistics planning framework, as outlined in Figure 6.4, can be used.

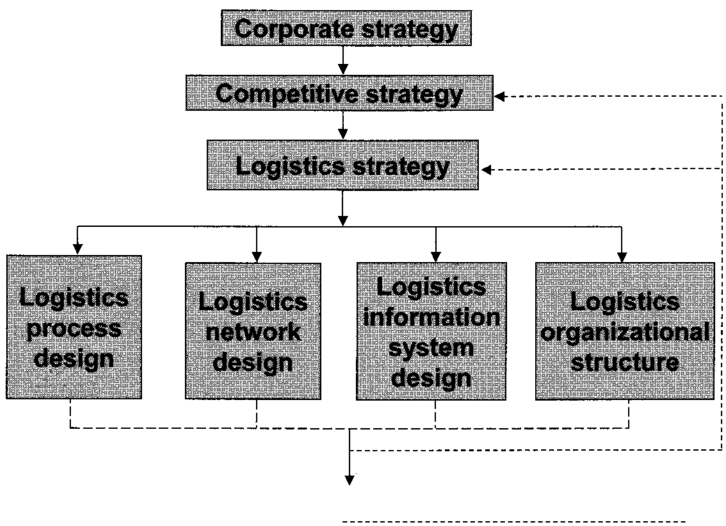


Figure 6.4 A framework for logistics network design

As can be seen from the figure, there are four key design elements that need to be considered. Traditionally, logistics planning and design have evolved around the structure of the logistics network, such as depot numbers and location, but it is now recognized that, as well as these physical logistics elements, there are other factors that also need to be considered. These are the design of logistics processes, logistics information systems and logistics organizational structure.

Logistics *process design is* concerned with ensuring that business methods are aligned and organized so that they operate across the traditional company functions and become supply-chain-oriented. Thus, they should be streamlined and should not be affected or delayed because they cross functional boundaries. A typical logistics process is order fulfilment, designed to ensure that customers' order requirements are satisfied with the minimum of time and the maximum of accuracy. The process should be designed as a seamless operation from the receipt of the order to the delivery of the goods and not as a series of different operations that occur each time a different internal function is involved – sales department, credit control, stock control, warehouse, transport. Other logistics processes that might be considered are information management, new product introduction, returns or spare part provision. Processes might need to be differentiated for variations in customer type, customer service requirements, product group, etc. Logistics process design is considered in more detail in Chapter 7.

Logistics *network design* refers to the more traditional elements of logistics strategy. These include aspects related to the physical flow of the product through a company's operation, such as the manufacturing location from which a product should be sourced, the inventory that should be held, the number and location of depots, the use of stockless depots and final product delivery. One key to the determination of an appropriate physical design is the use of trade-offs between logistics components and between the different company functions. Typical trade-offs were described at the beginning of Chapter 2. A detailed approach to physical design is provided in Chapter 8.

Logistics *information system design* should include all of those information-related factors that are vital to support the processes and the physical structure of the operation. As well as these, however, it is important to recognize that there are also enterprise-wide information systems (enterprise resource planning or ERP systems) , which may have a direct influence on logistics process and network design. Typical information systems that may support logistics process and network design might be electronic point of sale (EPOS), electronic data interchange (EDI) between companies, warehouse management systems, vehicle routeing and scheduling and many more. These are outlined in Chapter 29.

The final design element is that of the logistics *organizational structure*. It is the experience of many companies that an inadequate organizational structure can lead to substantial problems. These include issues such as sub-optimization whereby functions tend to concentrate on their own operation in isolation from the rest of the company, or even worse examples where different functions and their managers compete against one another and develop antagonistic attitudes, often styled as a ' blame culture'. These types of attitude work against the company but are also detrimental to customers and customer service. Organizational issues are further discussed in Chapter 9.

Each one of these different factors needs to be planned in association with the others. It is inappropriate to concentrate on any one without understanding and taking into account the influence of the others. Although Figure 6.4 indicates that process design should be the first factor to be considered, this is not necessarily the case. For different companies it may be any one of the other factors that plays the most dominant role. For example, a company that has introduced an enterprise-wide information system may find that this has a primary influence on how logistics strategy is formulated. Equally, a company may feel that it is necessary to put a workable logistics organizational structure in place before it attempts to redesign its logistics processes and physical operations.

The different tools and techniques for undertaking logistics design are described in the next few chapters. Before considering these, the remainder of this chapter looks at some associated factors that also have an influence on how a logistics operation is designed.

PRODUCT CHARACTERISTICS

One of the major factors to be considered when planning for logistics is, perhaps not surprisingly, the product itself. The product is, in fact, perceived to be an amalgam of its physical nature, its price, its package and the way in which it is supplied. For the logistics planner, the physical characteristics of the product and package are seen to be of great significance. This is because, in distribution and logistics, we are directly concerned with physical flow – movement and storage. The physical characteristics of a product, any specific packaging requirements and the type of unit load are all-important factors in the trade-off with other elements of distribution when seeking least-cost systems at given service levels. This potential for trade-off should continually be borne in mind.

There is a variety of product characteristics that have a direct, and often important, impact on the development and operation of a distribution system. This impact can affect both the structure of the system and the cost of the system. There are four main categories: volume to weight ratio; value to weight ratio; substitutability; and high-risk products.

Volume to *weight* ratio

Volume and weight characteristics are commonly associated, and their influence on logistics costs can be significant. A low ratio of volume to weight in a product (such as sheet steel, books, etc) generally means an efficient utilization of the main components of distribution. Thus, a low-volume/high-weight product will fully utilize the weight-constrained capacity of a road transport vehicle. Also, a low-volume/high-weight product will best utilize the handling cost component of storage (most other storage costs are not significantly affected by low volume to weight ratios).

The converse, a high volume to weight ratio, tends to be less efficient for distribu tion. Typical products include paper tissues, crisps, disposable nappies, etc. These products use up a lot of space, and are costly for both transportation and storage, because most companies measure their logistics costs on a weight basis (cost per tonne) rather than a volume basis (cost per cubic metre). In Europe, for example, there is a noticeable increase in the use of draw-bar trailer outfits in an attempt to increase vehicle capacity and so decrease the transportation costs of moving high-volume products.

Thus, overall distribution costs tend to be greater for high-volume as against high-weight products. This effect is shown in Figure 6.5. It can be seen that the total costs of movement and storage tend to increase as the volume to weight ratio increases.

Value to *weight* ratio

Product value is also important to the planning of a logistics strategy. This is because high-value products are more able to absorb the associated distribution costs. It is often essential for low-value products to have an inexpensive distribution system, as otherwise the effect on the total cost of the product might make it non-viable in terms of its price in the marketplace.

Once again, it is useful to assess the value effect in terms of a weight ratio: the value to weight ratio. Low value to weight ratio products (eg ore, sand, etc) incur relatively high transport unit costs compared with high value to weight products (eg photographic equipment, computer equipment, etc). Storage and inventory holding unit costs of low value to weight ratio products tend to be low

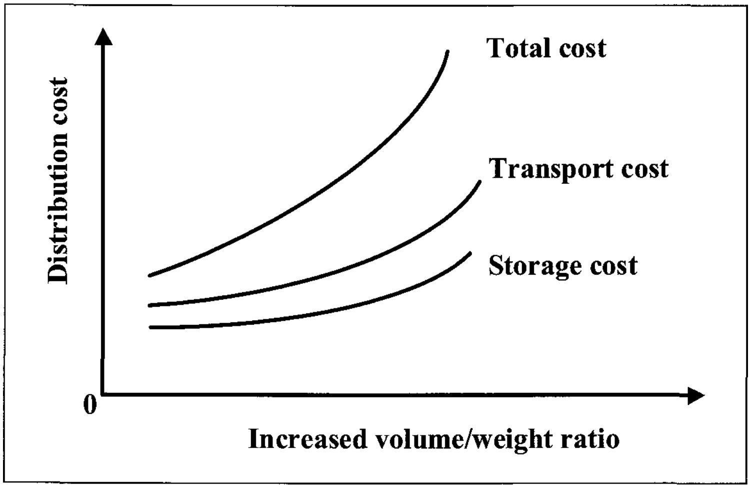


Figure 6.5 Effect of product volume to weight ratio on logistics costs

in comparison with high-value products because the capital tied up in inventory is lower.

Figure 6.6 shows that there is a trade-off effect as value to weight ratios increase.

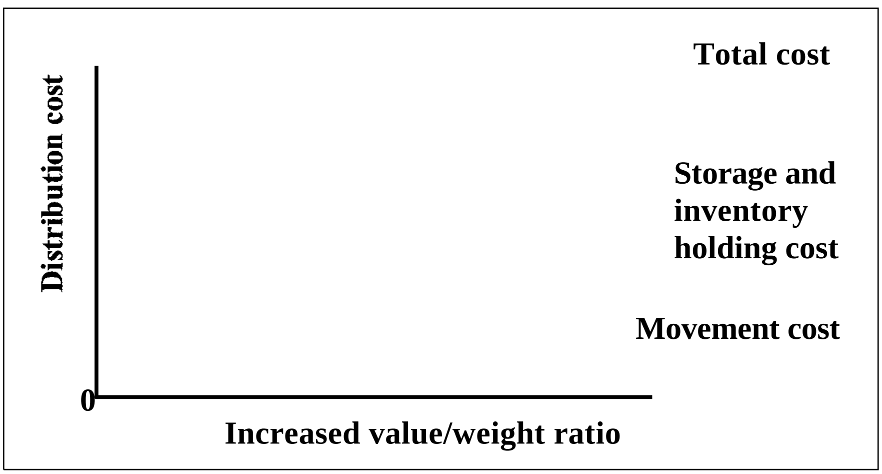


Figure 6.6 Effect of product value to weight ratio on logistics costs

Substitutability

The degree to which a product can be substituted by another will also affect the choice of distribution system. When customers readily substitute a product with a different brand or type of goods, then it is important that the distribution system is designed to avoid stock-outs or to react to replenish stocks in a timely fashion. Typical examples are many food products, where the customer is likely to choose an alternative brand if the need is immediate and the first-choice name is not available.

In a distribution system, this can be catered for either through high stock levels or through a high-performance transport mode. Both options are high-cost. High stock levels will decrease the likelihood of a stock-out, but will raise average stock levels and, thus, costs. The provision of a faster and more dependable transport function will reduce acquisition time and length of stock-out, but this increase in service will be at a higher transport cost.

High-risk products

The characteristics of some products present a degree of risk associated with their distribution (perishability, fragility, hazard/danger, contamination potential, and extreme value). The need to minimize this risk (sometimes a legal obligation) means that a special distribution system design must be used. As with any form of specialization, there will be a cost incurred. Examples of this effect include the following items:

- Hazardous goods may require special packaging, a limited unit load size, special labelling and isolation from other products. Regulations for the movement of hazardous goods differ between the different modes of transport.
- Fragile products require special packaging to take account of handling and transport shocks. Specialist distribution service providers now exist for some types of fragile goods.
- Perishable goods in many instances require special conditions and equipment for their distribution (eg refrigerated storage and transport facilities for frozen and chilled food).
- Time-constrained products - almost all foods are time-constrained now that ' best before' dates are so common - have implications for distribution information and control systems (eg first in first out). Some products have fixed time or seasonal deadlines. Daily newspapers have a very limited lifespan, which allows for no delivery delays; fashion goods often have a fixed season;

agrochemicals such as fertilizers and insecticides have fixed time periods for usage; there are the classic seasonal examples of Easter eggs and Christmas crackers, which are time-constrained. There are significant implications for the choice of distribution system for many products such as these.

- Very high-value products – cigarettes, videos, etc – are attractive products that require especially secure means of distribution.

There are many and varied product characteristics that can impose important requirements and constraints on all manner of logistics operations. They also affect the interrelationships between the different logistics functions, providing quite complex alternatives that need to be carefully assessed according to the implications on service and on cost.

THE PRODUCT LIFE CYCLE

One marketing concept that concerns the product and is also very relevant to distribution and logistics is that of the product life cycle (PLC). The principle behind the PLC is that of the staged development of a product. This starts with the introduction of the product into the market and follows (for successful products) with the steady growth of the product as it becomes established. The life cycle continues with the accelerated growth of the product as competitors introduce similar products, which stimulate total demand, and ends as the demand for the product runs into decline. The PLC concept is illustrated in Figure 6.7.

It is important that the performance of a logistics operation is able to reflect the life cycle of a product. This can be differentiated as follows:

- *Introductory stage:* need for a high response to demand with a logistics structure that gives stock availability and quick replenishment, and can react to sudden demand increases. Initial retail stock-holdings are likely to be low, to avoid overstocking of products that do not fulfil their expected demand, so there is a need for speedy information and physical logistics systems probably from a centralized stock-holding base using a fast mode of transport.
- *Growth stage:* here, sales are more predictable. The requirements for distribution are now for a better-balanced, more cost-effective system. The trade-off between service and cost can be realized.
- *Maturity stage:* where the introduction of competitive products and substitutes will increase price and service competition. An effective logistics operation becomes vital in order to maintain market share, especially for key customers.

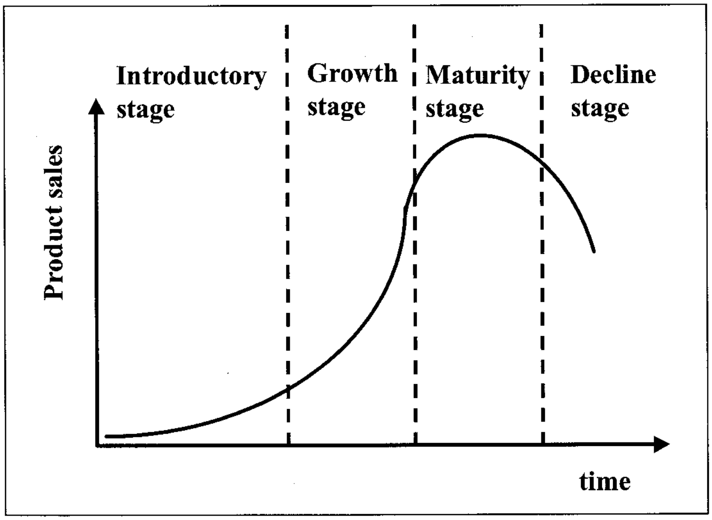


Figure 6.7 Standard product life cycle curve showing growth, maturity and decline

- *Decline stage:* the product is becoming obsolete. Here, the logistics system needs to support the existing business but at minimum risk and cost.

There is a clear requirement to take into account the PLC concept when planning for logistics. A different emphasis needs to be placed on certain aspects of the logistics system according to the stage of a product's life. For operations where there are many products at varying stages of their PLC, this will not be crucial. In some instances, however, there will be a need to plan for a logistics operation that is suitably dynamic and flexible.

PACKAGING

In discussing the product, it is important to be aware of other relevant physical characteristics that can influence any decisions regarding the choice of logistics operation. In terms of the physical nature of a product, it is not generally presented to the logistics function in its primary form, but in the form of a package or unit load. These two elements are thus relevant to any discussion concerned with the relationship of the product and logistics.

The packaging of a product is broadly determined for product promotion and product protection, the latter being the function that is particularly pertinent to logistics. There are also some other factors that need to be considered when designing packaging for logistics purposes. In addition to product protection, packages should be easy to handle, convenient to store, readily identifiable, secure and of a shape that makes best use of space - usually cubic rather than cylindrical.

Once again, there are trade-offs that exist between these factors. These trade-offs will concern the product and the logistics operation itself. It is important to appreciate that, for those involved in logistics, the package is the product that is stored and moved and so, where possible, should be given the characteristics that help rather than hinder the logistics process.

Packaging is very much a part of the total logistics function, and the design and use of packaging has implications for other functions such as production, marketing and quality control, as well as for overall logistics costs and performance.

UNIT LOADS

The idea of a unit load for logistics was developed from the realization of the high costs involved in the storage and movement of products - particularly in the inefficient manual handling of many small packages. The result of this has been the unit load concept, where the use of a unit load enables goods and packages to be grouped together and then handled and moved more effectively using mechanical equipment. Two familiar examples are the wooden pallet and the large shipping container, both of which, in their different ways, have revolutionized physical distribution and logistics. From the product point of view it is possible to introduce unit load systems to alter the characteristics of a product and thus make more effective logistics possible. One classic example has been the development of the roll-cage pallet that is in common use in the grocery industry. Although the cages are expensive units, the trade-off, in terms of time saving and security, is such that overall distribution costs decrease significantly.

Much of distribution and logistics is structured around the concept of load unitization, and the choice of unit load - type and size - is fundamental to the effectiveness and economics of a logistics operation. Choosing the most appropriate type and size of unit load minimizes the frequency of material movement, enables standard storage and handling equipment to be used with optimum equipment utilization, minimizes vehicle load/unload times, and improves product protection, security and stocktaking.

SUMMARY

This chapter has described the key elements of a logistics design strategy and has introduced a specific planning framework for logistics. The importance of understanding and taking account of a company's corporate and competitive strategies has been emphasized. The detailed application of these different steps in logistics design is described in the next few chapters.

The chapter began with an outline of some of the main pressures exerted on companies such that they need to consider the replanning of their overall strategies. These covered a number of different internal and external aspects. A strategic planning overview was defined to incorporate a review of:

- the external environment to the company;
- internal factors;
- the development of a corporate strategy;
- the development of a competitive strategy;
- the development of functional strategic plans.

A framework for a logistics design strategy was proposed. This incorporated the four key aspects of logistics design:

1. process design;
2. network design;
3. information system design;
4. organizational structure.

Some of the major factors that need to be considered when planning for logistics were also considered. These included the product type, the product life cycle, packaging and unit loads.

7

Logistics processes

INTRODUCTION

As discussed in Chapter 6, one of the key elements of planning for logistics is concerned with the design of appropriate logistics processes. These processes are the methods used to ensure that the business operates effectively so that all the major objectives are achieved. The aim is for a streamlined operation that works across the various functional boundaries existing within any company. Thus, processes need to be supply-chain-oriented. One of the main problems with logistics processes is that they are very often tied in with a number of different functional elements of the business and so it is difficult for them to operate efficiently. The results of this are usually seen to be either additional costs within the logistics system or lower levels of customer service. In many operations, both of these effects occur.

This chapter will consider the importance of logistics processes and the need to move away from functional and towards cross-functional process development. The main reasons for adopting more streamlined processes are discussed. Some of the key logistics processes are described, and the 'process triangle' is introduced as a means of categorizing the different processes. A broad approach to process design is outlined, and the main steps in this approach are discussed. Finally, some key tools and techniques are described. These can be used for logistics process redesign.

THE IMPORTANCE OF LOGISTICS PROCESSES

The reason that the concept of logistics processes has been highlighted in recent years is a development of the move away from the functional view of logistics. Although functional excellence is important – if you are running a fleet of vehicles, it is still important to ensure that it operates cost-effectively and fulfils all the necessary requirements – the idea of trade-offs within logistics is now an accepted aspect of sound logistics planning. Some parts of an operation may sacrifice their efficiency to the greater good of the operation as a whole. Following on from this, there is the perspective of the supply chain where logistics is viewed not just across internal company functions but also across the broader expanse of different companies. The chief beneficiary of this has been the final customer. The aim of any supply chain is to ensure that cross-company and cross-supply-chain activities are directed at achieving customer satisfaction for the end user. Thus, processes need to be developed to make this happen. They need to be able to span internal functions and company boundaries to provide the type and level of customer service required.

Unhappily this is not the case within many companies. Processes have generally been derived to enable each separate function within an organization to undertake its particular role, but they are not streamlined to act across all company functions as a united whole. Thus, an effective process should be designed as a seamless operation rather than as a series of different elements. The order fulfilment process provides a good example of a typical logistics process. The aim of order fulfilment should be to ensure that a customer's order is received, checked, selected and delivered according to the customer's requirements, with no disruption and with complete accuracy. The process within many companies does not always work like this! As well as the possibility of error or delay within functions, there is also the possibility of error and delay between the different functions. Typical functional errors might be:

- incorrect transcription of the original order requirements;
- incorrect notification of availability;
- incorrect selection or picking of the order;
- damage to the goods;
- late delivery;
- delivery to an incorrect address;
- invoicing to the incorrect address.

In addition, there might also be errors and delays associated across the functional boundaries. Examples might include:

- Order taking may be delayed because another function has to check stock availability.
- Stock may appear to be available but is actually pre-allocated to another customer.
- Order details maybe incorrectly transcribed when moved from one information system to another.
- Credit control may delay the progress of the order – but the customer may not be informed.
- Different goods may be picked because the original requirement is out of stock so the 'next best' is selected. The customer may not be informed of this.
- Goods may not be delivered as part orders due to some product unavailability, when partial delivery may be better than no delivery.
- Goods may be physically delivered via an incorrect channel – to the customer's cost (next-day rather than the normal three-day service).

It is usually quite easy to identify problems that occur within individual functions and then put into place control measures to overcome these problems. It can be much more difficult to identify problems that occur between functions. Firstly, there is usually an unclear line of demarcation between functions, which makes it no easy matter to determine that there is a problem, let alone what the problem is. Secondly, it is very difficult to determine what the cause of the problem is – not least because of the associated 'blame' culture that often exists between functions, so that one will traditionally blame the other regardless of the true issues.

To avoid problems such as these, some companies now seek to redesign their key logistics processes. There are three essential elements. Properly designed processes should be *customer facing,* that is, they should aim specifically to satisfy customer demands and expectations. They should also be *cross functional* or indeed where possible they should be supply-chain-oriented in that they cross not just company functions but also the boundary between companies. For most companies, the aim of achieving cross-functional processes is a big and sufficient challenge. Finally, they should be *time-based* in that they need to reflect the importance of time as a key element in the logistics offering.

KEY LOGISTICS PROCESSES

What then are the key logistics processes? These will, as expected, vary between different companies, different sectors and different industries. Typical examples are:

- *Order fulfilment* — probably the most common that is quoted. Order fulfilment is concerned with the ability to turn a customer's specified requirements into an actual delivered order. Thus, it embraces many of the traditional functions usually recognized as being a part of the logistics operation. Order fulfilment will involve the information elements of receiving and documenting an order through to the physical means of selecting and delivering the goods. For some ' make-to-order' manufacturing operations, this will also have an impact on the production process itself. Some companies maintain the divide between the order-taking component (which is information-based) and the order-delivery component (which is both information-based and physical). This is a reasonable first step in process redesign, but ultimately there should ideally be a seamless process for the operation as a whole.
- *New product introduction.* This is an area where many companies find they have problems. There are many logistics issues related to the introduction of new products into the marketplace. Very often existing, standard logistics structures and processes are insufficient to enable a satisfactory launch of a new product. One of the main problems is the inability to respond sufficiently quickly. Standard processes are designed to deal with known products. The consequence of introducing new products using existing processes is usually one of two possibilities. The first is that the product takes off very quickly and very well and there is insufficient ability in the supply chain to ratchet up supply to the required levels. The alternative is that demand is lower than initially expected and so there is an oversupply of stock, which eventually leads to products being sold off at discount rates or to obsolescence.
- *New product development.* In this example the idea is to design the product so that it can reach the market as quickly as possible from the initial design plan through to availability. The aim is to link the development of the product with the logistical requirements so that all secondary developments (of which there are normally very many) can be identified and re-engineered in the shortest possible time. The automotive industry has led the way in setting up processes to cut significantly the time that is required to bring a product to market from initial design.

- *Product returns.* There is a growing requirement in many businesses to provide an effective process for the return of products. This may be for returns that come back through the existing distribution network or through a new one that is specifically set up. It may also be for product returns that will be reworked or repackaged to go into stock, product returns for subsequent disposal, or packaging returns that may be reused or scrapped. In the light of developments in environmental legislation, this is a very important area for process design or redesign.
- *The provision of spares.* For many companies the supply of a product or series of products is inextricably linked to the subsequent provision of spare parts to support the continuous use of the initial products. For many logistics operations, neither the physical structure nor the associated processes are really capable of providing a suitable support mechanism for spare parts as well as for original equipment. This then is another example of the need for the development of processes specifically designed to undertake a particular task.
- *Information management.* Advances in information technology have enabled a vast amount of detailed data and information to be available and manipulated very easily. This has led some companies to recognize the need to devise suitable processes to ensure that data are collected, collated and used in a positive and organized way. For logistics, this means detailed information can be made available for individual customers, concerning not just their product preferences but also any customer service requirements that are distribution-specific (delivery time preference, order size preference, invoicing requirements, etc). This enables a much more positive, proactive approach to be adopted when considering particular customer relationships.

There are other associated processes that could also be relevant, such as:

- supplier integration;
- quality;
- strategic management;
- maintenance;
- human resource management;
- environmental management.

A number of different concepts have been proposed to try to help differentiate the type and importance of the various processes that might be relevant to any given company as it tries to position itself with its customers. Perhaps the most useful of these is known as the process triangle. This is shown in Figure 7.1. The process triangle is based on three different process categories. These can be used to help identify those particular processes that need to be highlighted for specific development. The processes are as follows:

1. *Basic processes:* those processes that are not really recognized as essential to a business but are nevertheless a prerequisite.
2. *Benchmark processes:* those processes that are seen to be important to the customer and must be of at least an acceptable standard even to begin to compete satisfactorily in a given market.
3. *Competitive processes:* those processes that are of direct significance to the competitive area. Good practice and excellence in these processes will provide a competitive edge and ensure that the company is active and successful through its logistics operations.

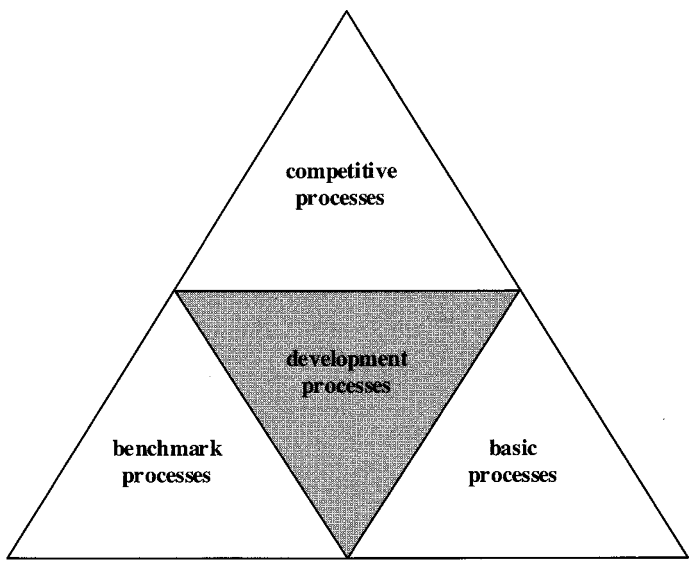


Figure 7.1 The process triangle

An assessment of what is required in these three areas and then the identification of what is missing — the 'gap' — will enable the development processes to be identified. These are the processes on which further work is necessary to ensure that the company will achieve or maintain a suitable competitive position.

It would be difficult for any company to develop a suitable process to cover all possible contingencies. Thus, it is useful to understand some of the main methods of differentiating between the various factors that are fundamental to most logistics operations. Processes can then be developed to suit different requirements. Typical differentiating factors will include:

- *market segmentation:* by sector — engineering, automotive, chemicals, etc;
- *customer types:* may vary between, for example, industrial and consumer, or international, national and local;
- *product groups:* broken down according to a variety of categories, dependent on the industry — household, industrial, consumer, or hardware, software, spares, etc;
- *customer service requirements:* same day, next day, normal, special, etc;
- *order type:* made to order, off the shelf, postponement (partial production);
- *channel type:* direct, via depot, via wholesaler.

APPROACH

A broad approach to process design is outlined in Figure 7.2.

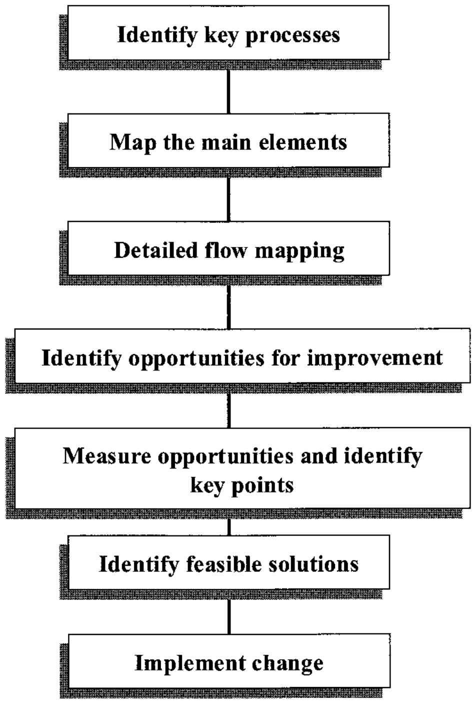


Figure 7.2 Approach to process design or redesign

The first step is to *identify the key processes* for design or redesign. This can be undertaken in a variety of different ways, but it is important to include representatives of all the main functions from within the company. Typically, some type of brainstorming exercise will provide the initial ideas, linked closely with a customer service study similar to that described in Chapter 3. As usual, it is imperative to get a clear view of customer service requirements, and these can only be truly identified through close contact with the customer. Any opportunity to benchmark against key competitors will also be advantageous.

The next stage is to *map out the main elements* of each process to be redesigned. The objective is to identify the key steps in each process and clarify which departments and people are involved. Key outcomes are to provide an understanding of what the process is all about, what it is trying to achieve and what some of the main problems are, and perhaps to provide an indication of some of the potential improvements that might be introduced.

Allied to this initial mapping approach is the next stage, which is to undertake a much more *detailed flow mapping* exercise. Here, the work flow is identified in detail as it progresses through each relevant department. Each crucial part of the process is identified, together with the specified amount of time taken to complete each of these parts. Any problems are identified and noted. As already indicated, the order fulfilment process is likely to be one of the key processes that needs to be mapped. The complicated nature of this process in most companies indicates that the mapping exercise itself is likely to take a lot of time and effort. In general, the specific opportunities that should be identified are those with a high potential for positive change, and those that are either very high in cost or very high in terms of the time taken to complete that respective part of the process, or of course all of these. Additionally, it may be possible to identify some parts of the process that are entirely superfluous. This is not uncommon with many processes that have been allowed to develop over time without any specific replanning.

Once the detailed flow mapping has been completed and *opportunities for improvement* have been identified, it is useful to set up a specific team to undertake the remaining stages of the process redevelopment. This team should be one that has the full backing of senior management and should also be representative of the main departments to be affected by the redesign. The team should be in a position to complete any additional or more detailed mapping or measurement, as necessary. It should *identify and measure the effects of any feasible solutions* and then get overall agreement for any changes it feels should be put into practice.

The final stage, once agreement for change has been reached, is to *implement any change*. This may be undertaken on a pilot basis at first to test the effectiveness of the redesigned process. Subsequently, measures should be put in place to monitor the process continually into the future.

TOOLS AND TECHNIQUES

There are a number of different tools and techniques that can be used to help with logistics process redesign. These range from ones that provide assistance with the initial categorization of key process objectives to those that offer a detailed assessment of the processes themselves and thus can be used to identify opportunities for improvement. Some of these techniques have been adopted in manufacturing under the umbrella known as 'Six Sigma' (see Chapter 10). Some of the main alternatives are:

- *Pareto analysis*. Sometimes known as the 80/20 rule, this is a crucial method used in logistics for identifying the major elements of any business or operation. By identifying these main elements it is possible to ensure that, for analytical purposes, any assessment is based specifically on the key aspects and is not taken up with the peripheral detail. A typical Pareto curve is shown in Figure 7.3. In this example, which is common to most companies, 20 per cent of the product lines or SKUs (stock keeping units) are responsible for 80 per cent of the sales in value of the company's products. This type of relationship holds true for many relationships in logistics and distribution – the most important customers, the most important suppliers, etc. Thus, it is possible to identify a limited number of key elements that are representative of the main business and to concentrate any major analysis on this important 20 per cent. Another useful result of Pareto analysis is to identify the items (customers, products or whatever) that make up the final 50 per cent of the 'tail' of the curve. These are often uneconomic to the company and should be considered for rationalization or elimination. In Figure 7.3, 'A' class products represent 20 per cent of the range of products, but account for 80 per cent of sales, 'B' class products represent 30 per cent of the range of products, but account for 15 per cent of sales, and 'C' class products represent 50 per cent of the range of products, but account for just 5 per cent of sales.
- *Market or customer segmentation*. One of the main objectives of the design of suitable logistics processes is to ensure that they are 'customer-facing' and to align them in such a way that all customers' needs are met. Clearly, not all customers are the same and therefore not all customer requirements are the same. It is important to be able to identify different types of customers and different types of market and to adopt the appropriate service requirements to take account of these differences. Through the use of suitable customer service studies (as described in Chapter 3) it should be possible to categorize companies according to different types of service requirement. Suitable processes can

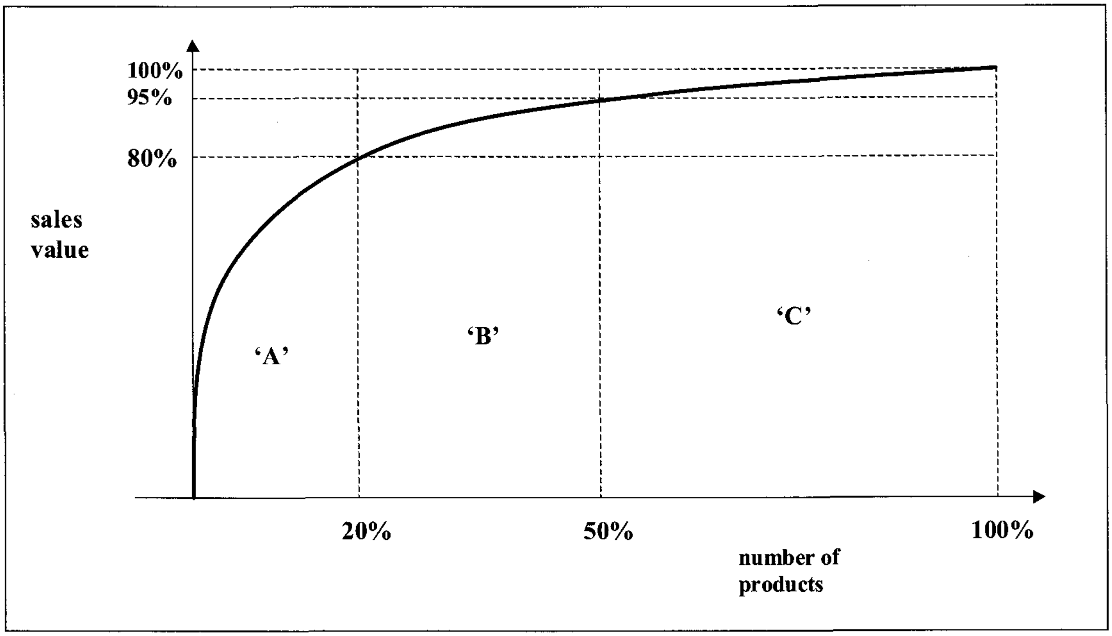


Figure 7.3 A typical Pareto curve showing that 20 per cent of products represent 80 per cent of sales value

then be based around the different categories of customer or segments of the market.

- *Customer service studies.* As already described in Chapter 3, a customer service study should be used as the basis for identifying key service requirements on which to design suitable logistics processes.
- *Relationship mapping.* This is used at an early stage of logistics process design to identify the main departments within a company (or across the broader supply chain if this is possible) that are specifically involved in a particular process. An example is given in Figure 7.4. As well as identifying these key departments, so that they can be brought into the design process, this will help to pinpoint the major relationships and will highlight the complexity within any particular process, thus indicating its need for redesign.
- *Process charts.* These can be represented in a variety of different guises, whether by straightforward flowcharts or by a matrix, as shown in Figure 7.5. The flowchart approach can be based on traditional flowcharting techniques. This is useful because standard shapes are used to represent different types of

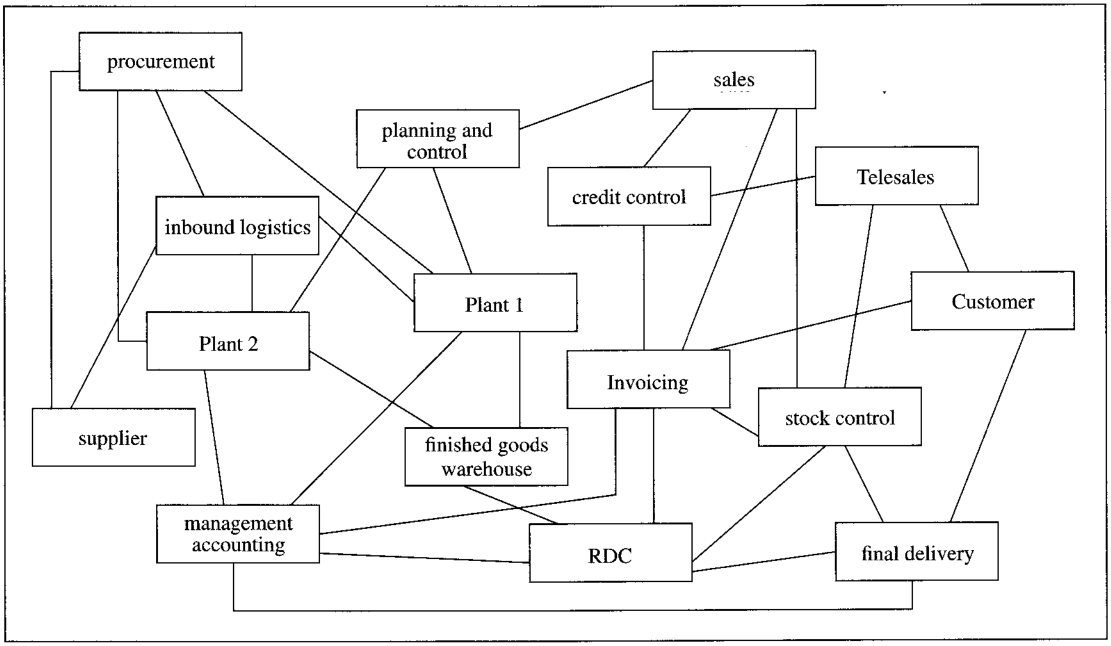


Figure 7.4 Relationship mapping: used to identify key departments and their interrelationships

activity (storage, movement, action, etc), and the importance of flows can be highlighted in terms of the number of movements along a flow. The matrix chart provides a more systematic way of representation and can be beneficial where time is to be represented.

- *Value/time analysis*. This type of analysis can be used to identify where in a process value is actually added to the product. The aim is to highlight those parts of the operation that provide a cost but add no value. Traditionally, for most manufactured products, value is added when a process changes the nature of the product (such as production, which alters the physical attributes, or transport, which alters the physical location). Value is not added, but waste occurs through the passing of time, when the product is stored (as work-in-progress or as finished goods stock in a depot). Figure 7.6 provides an example of a value/time analysis. This is not an easy type of analysis to undertake, especially for the early downstream activities when it becomes difficult to isolate the true time and costs attributable to partially manufactured products.

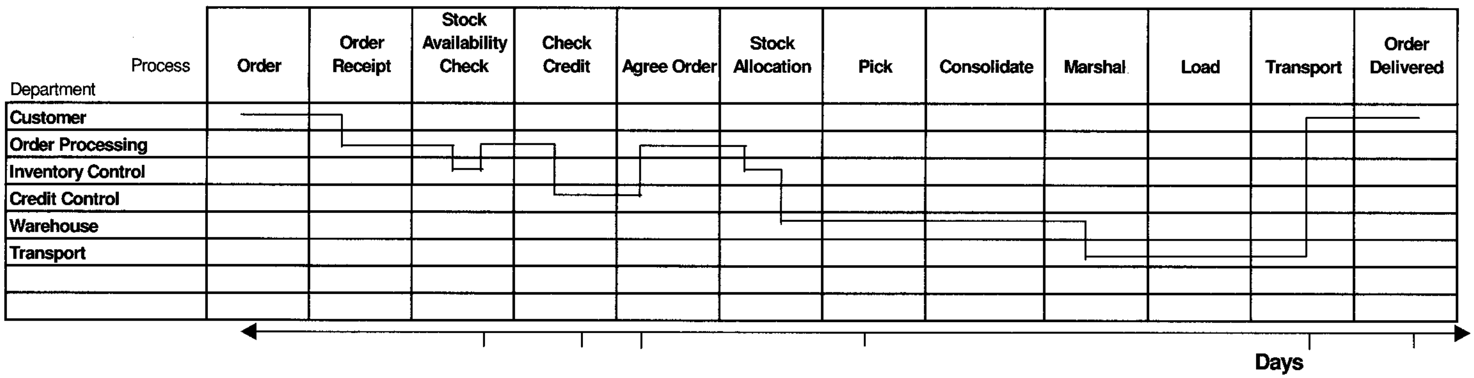


Figure 7.5 A matrix process chart

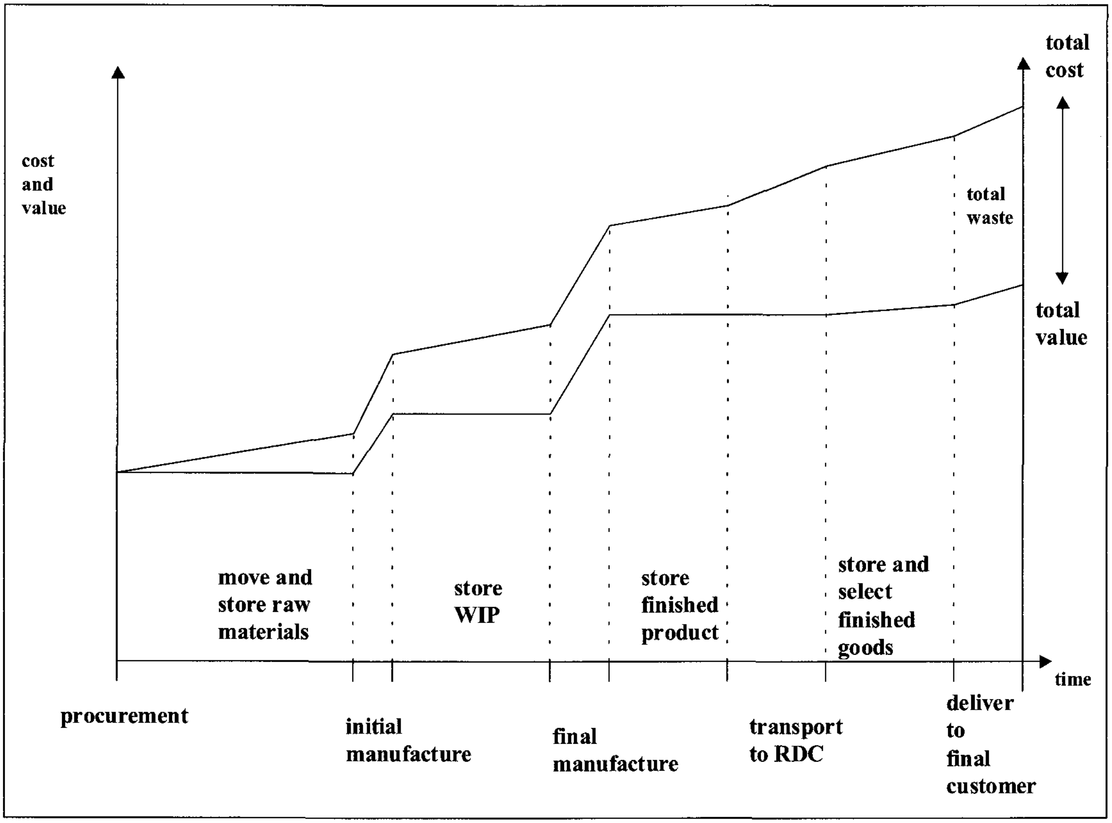


Figure 7.6 Value/time analysis

- *Time-based process mapping*. This is another method of identifying and eliminating wasted time in a process. The idea is to understand and record a process in detail and to be able to identify what is active or useful time and what is wasted time. The output from such an exercise is the opportunity to engineer the wasted time out of the process so that service is improved and cost is reduced through a reduction in the overall time taken to complete the process. The simple steps are:

  Map the process by 'walking' through the actual operation and recording the key steps and the associated time taken.

  Identify and differentiate between what is value adding (eg necessary) and what is non-value adding (eg unnecessary) and record this.

  Calculate the relative time spent on the different activities and identify the most appropriate for improvement.

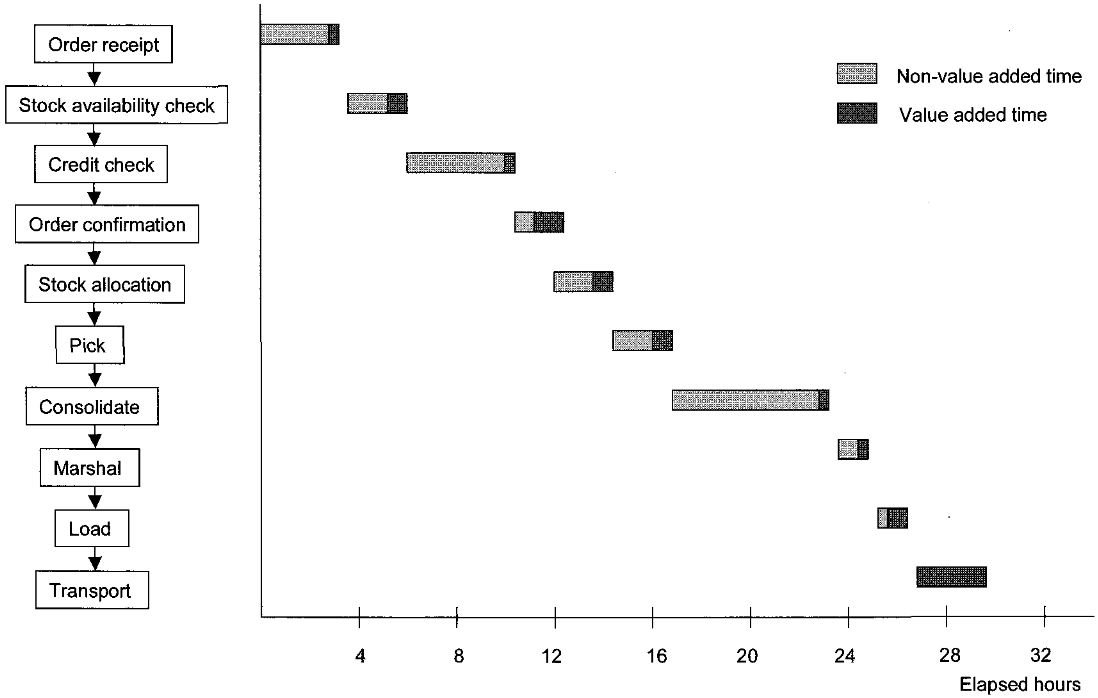


Figure 7.7 A time-based map illustrating the order to dispatch process broken down into value and non-value added time

Analyse the causes of the problem and assess any opportunities for change.
Develop solutions and implement.
An example of a time-based process map is given in Figure 7.7, and a method of helping to identify the causes of non-value added time is shown in Figure 7.8.

SUMMARY

In this chapter the importance of logistics processes has been reviewed. The need to move away from functional and towards cross-functional process development has been highlighted. The main reasons for adopting more streamlined processes were discussed. Some of the key logistics processes were described, the main examples being:

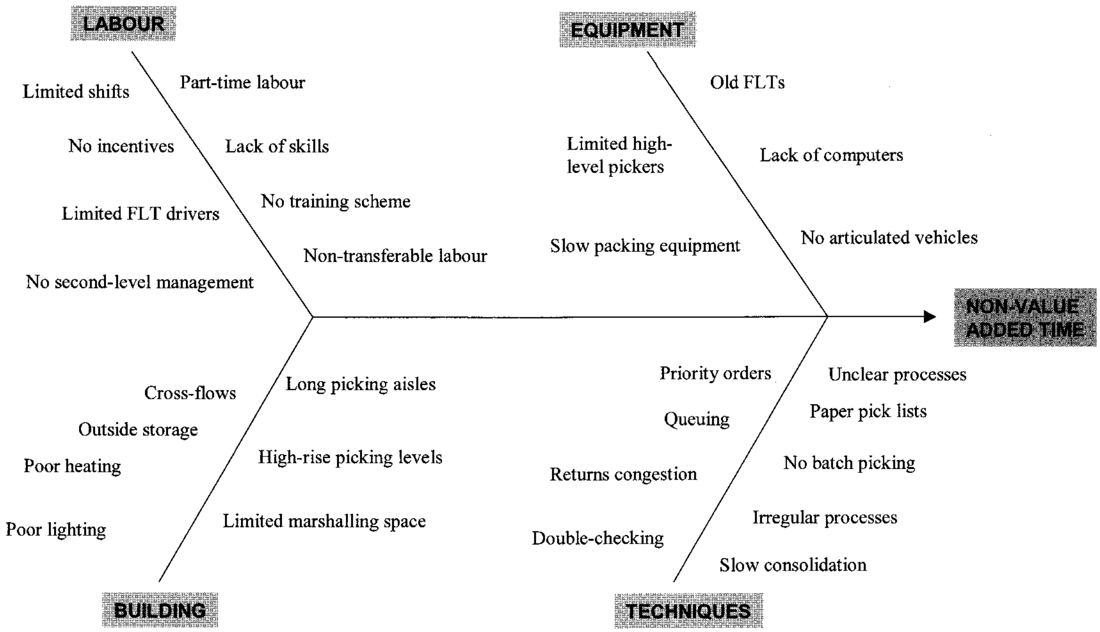


Figure 7.8 Finding the cause of non-value added time using an Ishikawa diagram

- order fulfilment;
- new product introduction;
- new product development;
- product returns;
- the provision of spares;
- information management.

The process triangle was used as a means of categorizing the different processes.

A broad approach to process design was outlined, and the main steps in this approach were described. Finally, some of the key tools and techniques for logistics process redesign were described.

8

Logistics network planning

INTRODUCTION

In this chapter a particular approach to logistics network planning is developed and described. The main content follows on from, and links very closely with, the planning framework that was proposed in Chapter 6. As well as considering the key flows and cost relationships, various aspects associated with depot/distribution centre (DC) and facilities location are reviewed. There are both theoretical concepts and practical considerations to be taken into account. Some of the major points for discussion are:

- the role of DCs and warehouses;
- distribution cost factors and relationships;
- a methodology for planning a physical distribution structure;
- an overview of different modelling techniques;
- qualitative assessment;
- DC site considerations.

The question of the number, size and location of facilities in a company's distribution system is a complex one. There are many different elements that go to make up the distribution mix, and it is necessary to take into account all of these when considering the question of network structure or facilities location. Prior to the

DC location decision, a lot of work must be undertaken. This is necessary to help to understand the key requirements of the company and to collect and collate sufficient data that represent a numerical picture of the distribution structure so that appropriate analysis can be carried out to test potential options for improvement.

Before trying to determine the most appropriate number and location of DCs, it is also necessary to ensure that there is an efficient flow of products from source to final destination. This assessment of the different patterns of product flows is known as sourcing analysis.

The complexity of sourcing and location decisions has led to the development of some quite sophisticated mathematical models that attempt to find the optimum flows and the optimum number of DCs to serve a system. The detailed mathematical principles used as the basis for these models will not be covered, but consideration will be given to the relationships involved, and the approaches that can be undertaken when making location decisions.

It is worth while to begin the discussion by concentrating on the most practical aspects of importance to an individual company. The main point to appreciate is that the vast majority of location studies are undertaken when the company already has a number of DCs and associated delivery areas. Thus, location studies are rarely based upon the premise that the 'best' results can be applied at the end of the day. Generally, it is necessary for a compromise to be reached between what is ' best' and what is currently in existence. The very high cost of DCs and vehicle fleets is the main reason for this, as well as the high cost and great disruption involved in making any changes to existing systems.

Despite this, it is very important for companies to know how their distribution networks might be improved. Although some networks are planned from the beginning of a company's operation, this is a rare occurrence. The majority of systems are unplanned; they just evolve very much as the company evolves. This may be a steady growth (or decline), or may be in short steps or large leaps as mergers and takeovers occur. Perhaps the most common reason why logistics networks are out of balance is that of inertia, because of the great amount of work and effort required to make changes.

It needs a forward-looking management or a particularly significant change for a company to undertake a large-scale study of this nature. The recent realization of the importance of logistics to most companies, and the need to cut costs and improve efficiency, have provided sufficient impetus for a number of companies to review their logistics and distribution structure with a particular emphasis on the use and location of DCs and warehouses.

THE ROLE OF DISTRIBUTION CENTRES AND WAREHOUSES

There are a number of reasons why DCs and warehouses are required. These vary in importance depending on the nature of a company's business. In general, the main reasons are:

- To hold the inventory that is produced from long production runs. Long production runs reduce production costs by minimizing the time spent for machine set-up and changeover, enabling 'lean' manufacturing.
- To hold inventory and decouple demand requirements from production capabilities. This helps to smooth the flow of products in the supply chain and assists in operational efficiency, enabling an 'agile' response to customer demands. Note that many supply chains have strategic inventory located at several different points, whereas this buffer only needs to be held at what is known as the decoupling point: the point at which discrete product orders are received.
- To hold inventory to enable large seasonal demands to be catered for more economically.
- To hold inventory to help provide good customer service.
- To enable cost trade-offs with the transport system by allowing full vehicle loads to be used.
- To facilitate order assembly.

These reasons emphasize the importance of the facilities location decision, and also give an indication of the complex nature of that decision. It is possible to summarize the main reason for developing a logistics network as 'the need to provide an effective service to the customer, whilst minimizing the cost of that service'. Service and cost factors are thus of paramount importance when determining the number, size and location of facilities.

For the best possible customer service, a DC would have to be provided right next to the customer, and it would have to hold adequate stocks of all the goods the customer might require. This would obviously be a very expensive solution.

At the other extreme, the cheapest solution would be to have just one DC (or central warehouse) and to send out a large truck to each customer whenever his or her orders were sufficient to fill the vehicle so that an economic full load could be delivered. This would be a cheap alternative for the supplier, but as deliveries might then only be made to a customer once or maybe twice a year, the supplier might soon lose the customer's business.

There is obviously a suitable compromise somewhere between these extremes. This will usually consist of the provision of a number of DCs on a regional or area basis, and the use of large primary (line-haul) vehicles to service these, with smaller vehicles delivering the orders to customers. For certain operations, of course, even these simple relationships will vary because of the need for very high levels of customer service or the very high value of products.

In addition, it should be noted that there are a number of different types of DC, each of which might be considered in the planning of a suitable physical distribution structure. These might include:

- finished goods DCs/warehouses — these hold the stock from factories;
- distribution centres, which might be central, regional (RDC), national (NDC) or local DCs— all of these will hold stock to a greater or lesser extent;
- trans-shipment sites or stockless, transit or cross-docking DCs — by and large, these do not hold stock, but act as intermediate points in the distribution operation for the transfer of goods and picked orders to customers;
- seasonal stock-holding sites;
- overflow sites.

Logistics network and DC location strategies are aimed at establishing the most appropriate blend of storage and transport at a given customer service level. The interrelationship of the different distribution elements and their associated costs thus provide the basis for decision making.

COST RELATIONSHIPS

To plan an efficient logistics structure, it is necessary to be aware of the interaction between the different distribution costs, specifically as to how they vary with respect to the different site alternatives (number, size, type and location), and what the overall logistics cost will be. This is best done by comparative analysis of the major alternative configurations. Before this can be achieved, the detailed make-up of the individual distribution cost elements must be understood.

Many companies have cost information based on their conventional accounting systems, but almost always these costs are too general to allow for any detailed break-down into the integral parts that reflect the company's distribution structure.

Without this information, and the understanding that goes with it, it is impossible to measure the effectiveness or otherwise of the existing operation. It is also impossible to gain the necessary insight into the distribution operation to allow for successful planning and management. The component parts of a distribution system necessarily interact with one another to form the system as a whole. Within this system, it is possible to trade off one element with another, and so gain an overall improvement in the cost-effectiveness of the total system. An appreciation of the make-up and relationship of these key costs is thus a vital link to successful distribution planning and operations.

The major cost relationships are outlined in this section, starting with *storage and warehousing* costs. The major cost breakdown is between building, building services, labour, equipment and management/supervision. The relationship of these costs will, of course, vary under different circumstances — industry, product type, volume throughput, regional location, age of building, handling system, etc. In general, the direct labour cost is likely to be the greatest element, with the building cost likely to fluctuate from very high (new building, prime location) to very low (old building, peppercorn (low) rent, low rates or local taxes). See Chapter 14 for more detailed discussion.

With respect to the cost relationship of warehousing with other parts of the distribution system, the importance of storage and warehousing costs will be dependent on such factors as the size of the DC and the number of DCs within the distribution network as a whole.

The effect of site size is illustrated by the economies of scale experienced if larger DCs are operated. It has been established that the cost of operation of a site and the amount of stock required to support a DC tend to be higher (per unit) for a small site than for a large one. This is because larger DCs can often achieve better space and equipment utilization and can benefit from spreading overhead costs over the higher throughput. With stock-holding, the larger a site, the less buffer and safety stock is required. It should be noted that, eventually, diseconomies of scale could occur, because very large DCs can be adversely affected by such conditions as excessive internal travel distances, problems of management, etc.

The effect of a different number of warehouses or DCs in a given distribution network can be seen by developing the economies of scale argument. If a distribution network is changed from one site to two sites, then the overall DC/storage costs will increase. The change is likely to be from a single large site to two medium-sized sites. This will not, therefore, double the costs, because the change is not to two large DCs. It will certainly increase costs, however, because there will be a need for more stock coverage, more storage space, more management, etc. In simple terms, this can be described by a graph, illustrated in Figure 8.1.

Thus, as the number of DCs in a distribution network increases, then the total storage (DC) cost will also increase.

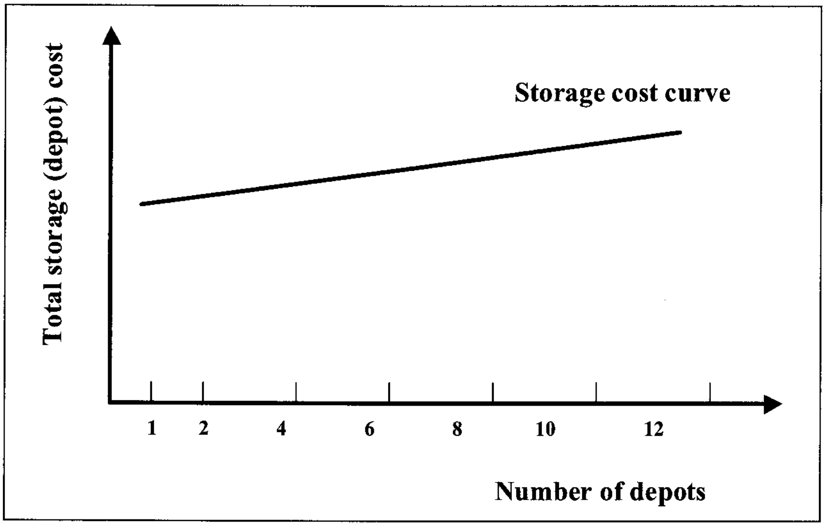


Figure 8.1 Relationship between number of depots (ie storage capacity) and total storage cost

One point that should be appreciated is that some care must be taken over any generalization of this nature. In practice, it will be found that each individual site may differ in its cost structure from the other sites in a system for a variety of practical reasons. These may include, for example, high (or low) rent and rates according to the locality of the DC (eg very high in cities) or high (or low) labour costs.

The two most important categories of *transport costs* are primary (trunking/line-haul) and secondary (final) delivery. These are affected differently according to the number of DCs in a distribution network.

Delivery transport is concerned with the delivering of orders from the DC to the customer. This can be carried out by a company using its own fleet of vehicles or by a third-party carrier. Whichever alternative is used, the cost of delivery is essentially dependent on the distance that has to be travelled. Delivery distance can be divided into two types: 1) 'drop' distance, which is the distance travelled once a drop or delivery zone has been reached; and 2) 'stem' distance, which is the distance to and from a delivery zone. Whilst the 'drop' distance remains the same whatever the distance from the supplying DC, the 'stem' distance varies according to the number of DCs in the system. The greater the number of sites, the less the stem distance. This can be described by a graph, as shown in Figure 8.2.

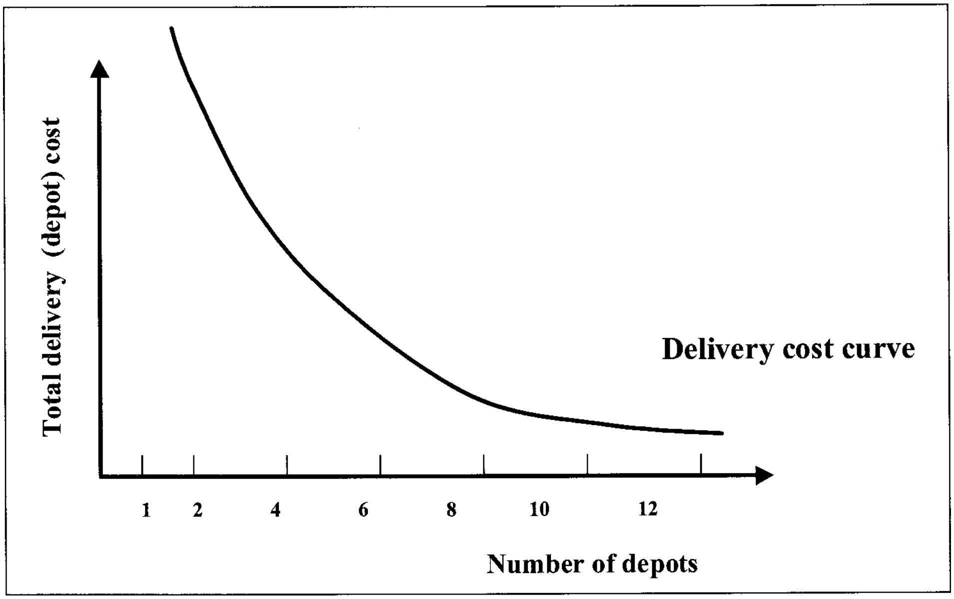


Figure 8.2 Relationship between the number of depots and total delivery costs

The *primary transport* element is the supply of products in bulk (ie in full pallet loads) to the DCs from the central finished goods warehouse or production point. Once again, the number of sites affects the overall cost of this type of transport. In this instance, the effect is not a particularly large one, but it does result in an increase in primary transport costs as the number of DCs increases. The effect is greatest where there is a smaller number of sites, as the graph of Figure 8.3 indicates.

If the costs for both primary and delivery transport are taken as *a combined transport cost* then the total transport costs can be related to the different number of DCs in a distribution network. The overall effect of combining the two transport costs is that total transport costs will reduce, the greater the number of sites that there are in the system. The effect can be seen in the graph of Figure 8.4.

Another important cost that needs to be included is the cost of holding inventory. The main elements of *inventory holding* are considered in detail in Chapter 12. The key costs can be broken down into four main areas:

1. *Capital cost* — the cost of the physical stock. This is the financing charge, which is the current cost of capital to a company or the opportunity cost of tying up capital that might otherwise be producing a return if invested elsewhere.

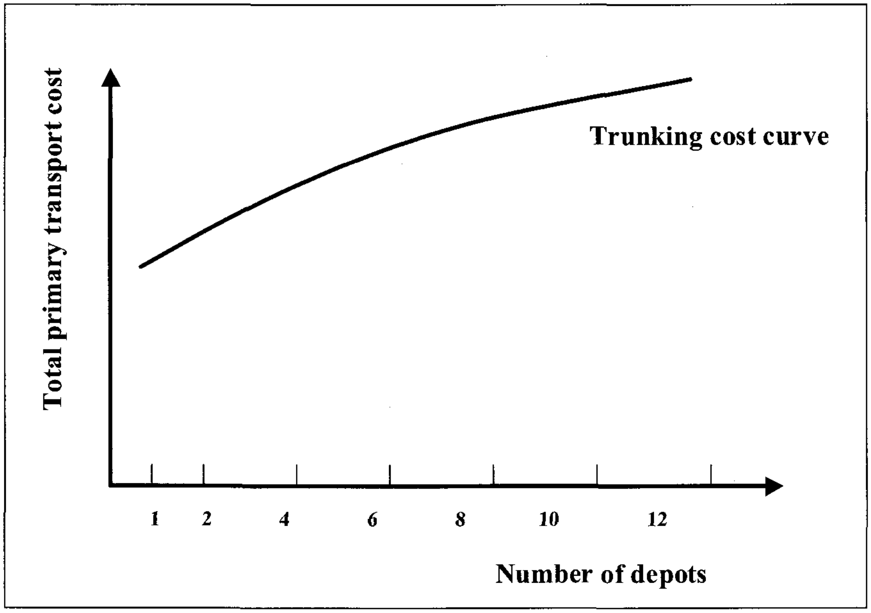


Figure 8.3 Primary transport costs in relation to the number of depots

2. *Service cost* — that is, stock management and insurance.
3. *Risk costs* — which occur through pilferage, deterioration of stock, damage and stock obsolescence.
4. *Storage costs* — here considered separately (as storage and warehousing costs: see earlier in this section).

These first three costs, when taken together and measured against the number of DCs in a system, can be represented as shown in Figure 8.5.

The final cost element for consideration is that of *information system costs*. These costs may represent a variety of information or communication requirements ranging from order processing to load assembly lists. In recent years, there has been a significant move from manual systems towards the use of computerized information systems to provide these requirements. These costs are less easy to represent graphically because of the fast rate of change of information systems and because costs can vary considerably dependent on the level of technology introduced. These costs can be broadly represented as shown in the graph of Figure 8.6.

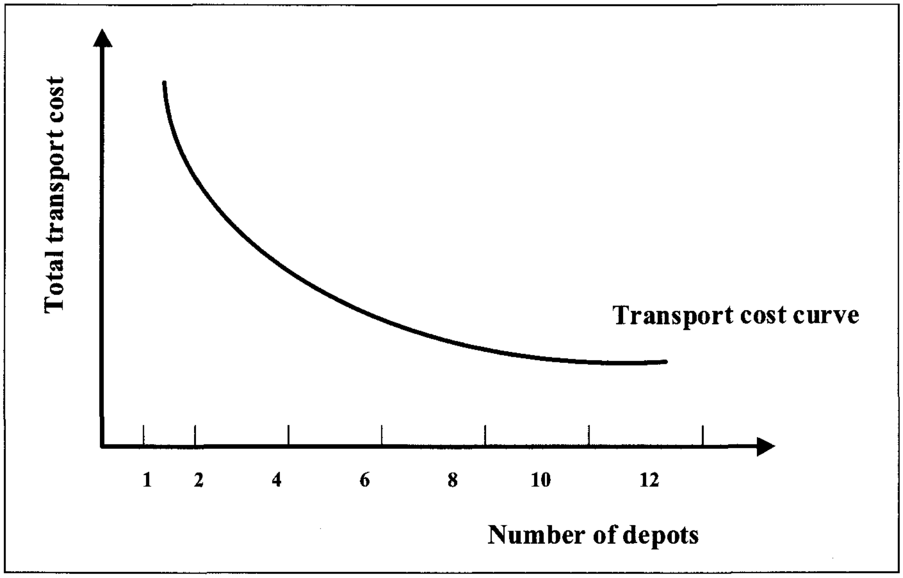


Figure 8.4 Combined transport costs (delivery and primary) in relation to the number of depots

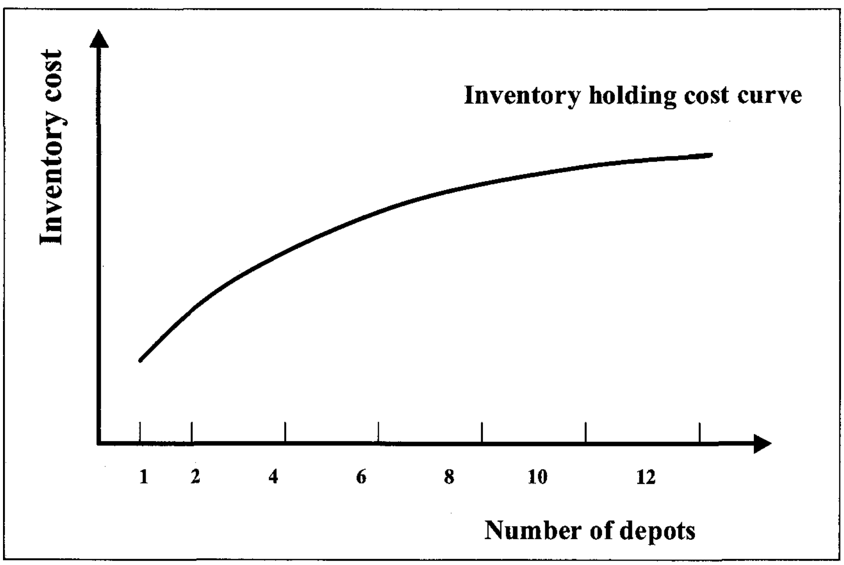


Figure 8.5 Inventory holding costs in relation to the number of depots

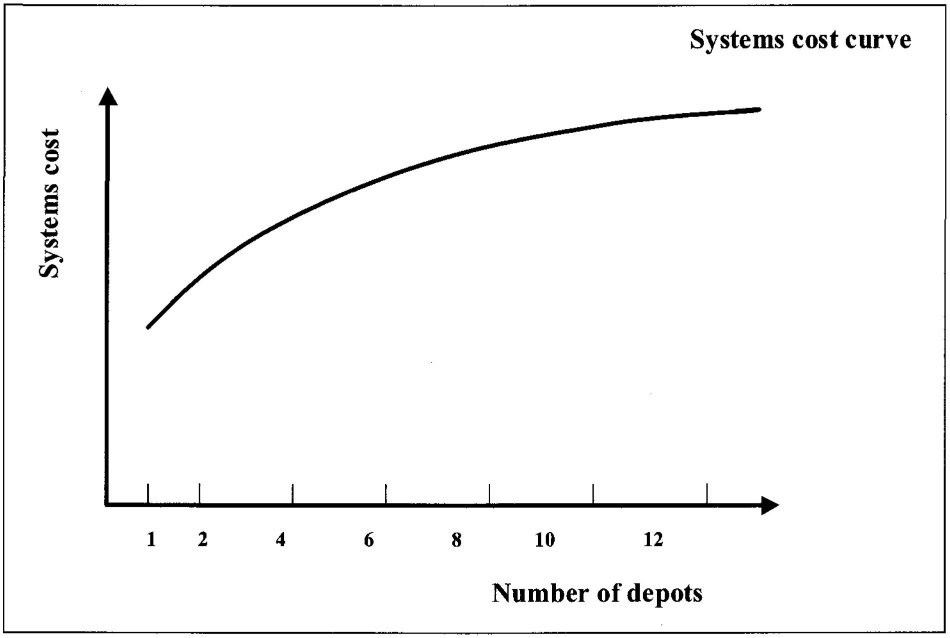


Figure 8.6 Information system costs in relation to the number of depots

By its very nature logistics operates in a dynamic and ever-changing environment. This makes the planning of a logistics structure a difficult process. By the same token, it is not an easy matter to appreciate how any changes to one of the major elements within such a structure will affect the system as a whole. One way of overcoming this problem is to adopt a 'total' view of the system, to try to understand and measure the system as a whole as well as in relation to the constituent parts of the system.

Total logistics cost analysis allows this approach to be developed on a practical basis. The various costs of the different elements within the system can be built together. This provides a fair representation, not just of the total logistics cost, but also of the ways in which any change to the system will affect both the total system and the elements within the system.

The total cost approach can be represented in a graphical format by building up a picture from the graphs used to illustrate the cost elements in the earlier section of this chapter. This is illustrated in Figure 8.7 and demonstrates how the individual distribution and logistics cost elements can be built up to give the total logistics cost. It shows, for example, the effect of a different number of DCs and the related costs on the total distribution cost.

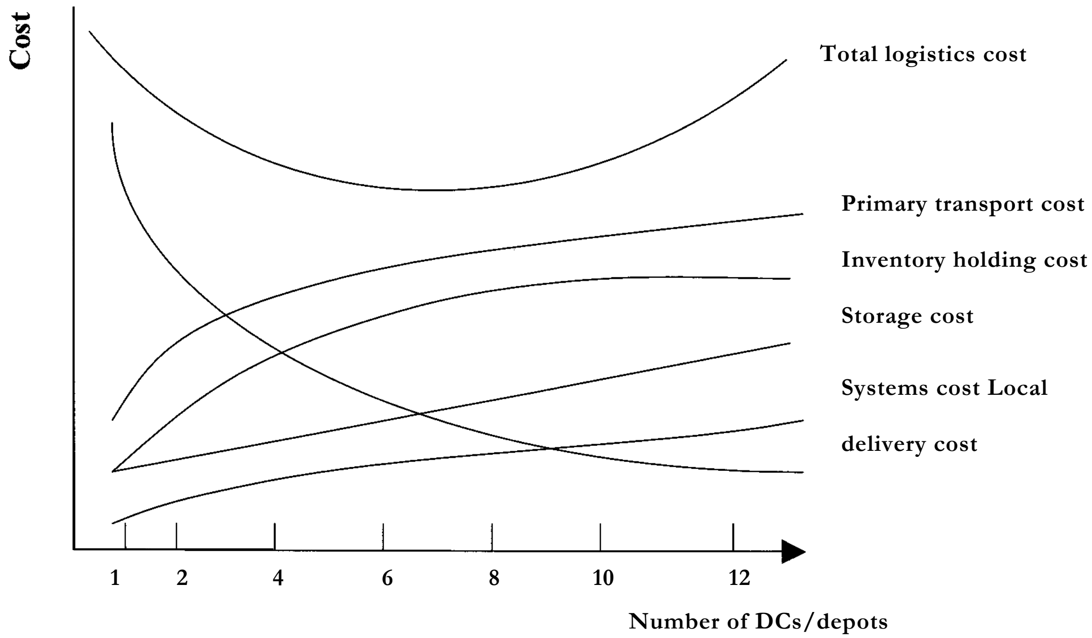


Figure 8.7 The relationship between total and functional logistics costs as the number of depots in a network changes

For facilities location planning, for example, the overall cost effect of using a different number of sites can be explained by such a graph. The top line on the graph shows the overall logistics cost in relation to the different number of DCs in the network. It is obtained by adding together the individual cost curves of the key distribution elements that correspond to each number of sites. For just a single DC, for example, there is a large local delivery cost to add to the much smaller costs of primary transport, inventory, storage and system costs.

It can be seen from the graph that the least expensive overall logistics cost occurs at around the 6-to-8 DC number (in this example). The minimum point on the overall logistics cost curve represents this lowest-cost solution. The results, in practice, will depend on a number of factors – product type, geographic area of demand, service level required, etc.

These relationships are the key to the planning of logistics strategy and structures. As will be discussed later in this chapter, models have been developed that allow this type of detailed quantitative analysis to be carried out so that least-cost solutions can be identified and implemented.

Trade-off analysis

The concept of trade-off analysis is a key feature of this total cost approach to logistics planning. It has been shown that any change in one of the major elements within a logistics system is likely to have a significant effect on the costs of both the total system and the other elements. By the same token, it is often possible to create total cost savings by making savings in one element, which creates additional costs in another but produces an overall cost benefit. This can be seen in Figure 8.8.

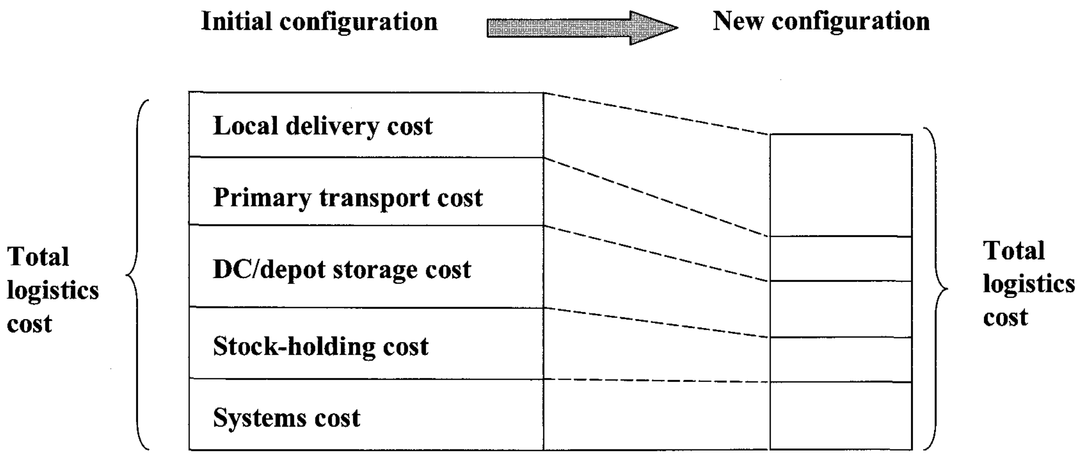


Figure 8.8 Trade-off analysis showing that a change in configuration can lead to a reduction in total logistics cost whilst some cost elements increase and others reduce

In this example, a DC rationalization policy has been adopted whereby the number of sites in a logistics system has been reduced. Although this has led to an increase in local delivery costs, savings in some of the other main elements of distribution have produced overall cost benefits.

The cost and service trade-offs within any logistics structure will, of course, vary from one company to another depending on the role the company plays within the supply chain as a whole. In the main, however, the following major costs and their associated trade-offs may need to be considered and assessed:

- *Production costs.* These will vary according to the type of production process or system used and the type of product manufactured. Make-to-stock or make-to-order will also be relevant. Factories may be 'focused' on one or two specific types of product or may make a large range of different products. Different distribution structures may be required to support different types of product. The effect on primary transport costs will be very relevant.

- *Packaging costs*. These are mainly concerned with the trade-off between the type of packaging and the handling and transport costs. The type of load unitization will also be important.
- *Information systems costs*. These cover a wide area from order receipt to management information systems. The type of DC network will affect many of these costs.
- *Lost sales costs*. These might occur because of inadequate customer service, and are very relevant in the context of the proximity of the DC to the customer, together with the reliability and speed of service.
- *Inventory costs*. These include the cost of capital tied up in inventory as well as the cost of obsolescence, etc. They have a fundamental relationship with the DC network in terms of the number of stock-holding points and the hierarchy of stock-holding according to DC type.
- *Transport costs*. The number and location of sites within the distribution structure, and the associated throughputs significantly affect transport costs. Both primary transport and final delivery costs are affected by DC numbers and location.
- *Warehousing costs*. These costs vary according to the type of storage and handling systems used, together with the volume and throughput at the site. The size and type of site will thus be important, as will the location.

A PLANNED APPROACH OR METHODOLOGY

An approach to logistics and distribution strategy planning is outlined in Figure 8. 9. This approach describes the practical steps that need to be taken to derive a physical distribution strategy from a corporate business plan, as described in Chapter 6. This type of approach requires the collection, collation and analysis of a great deal of data. It is thus quantitative, although a degree of qualitative assessment may also be necessary. Each key step is described in the remainder of this chapter.

Some initial points to note are:

- Great care should be taken to define the precise overall problem. It is likely to be concerned with the use and location of DCs within a distribution network,

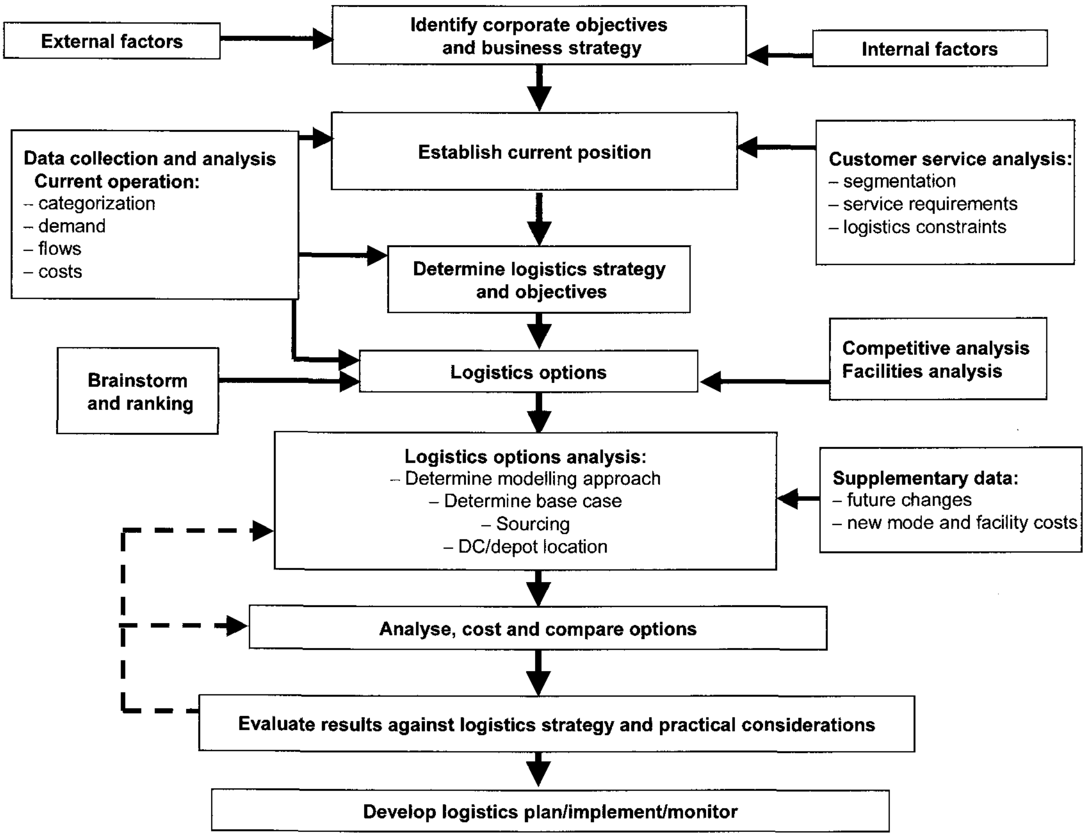


Figure 8.9 An approach to logistics and distribution strategy planning

but it is vital to have clear limits and boundaries. These might include, for example, whether all production facilities must be retained, whether product sourcing can be relocated or whether there are existing sites that cannot be closed down.

- The planning horizon into the future needs to be determined.
- All relevant cost relationships need to be identified and understood.
- The relevant product flows for different patterns of demand and supply need to be established. Important aspects will include the type of products, the origin of these products (factories, etc), the destination of products (shops, hospitals, factories, etc) and the amount and type of product going through the system (throughputs, etc).

- The identification of all relevant data and information requires consideration. There are always problems in finding and obtaining the data and information required. It may be necessary to make compromises over the data that are available. Data collection is always the largest part of a study. Data should be collected in the format in which they will be finally used in the analysis.
- A sourcing or 'flow' model is likely to be an important link in the process of moving from a corporate to a logistics plan.
- Both cost and service elements are vital inputs to the logistics planning process.
- Essential to the development of a suitable logistics plan is the need to carry out some fairly detailed quantitative analysis.
- Additional planning tools and models may also be used as an add-on to this planning process, but they are normally used as a second stage. They include, for example, inventory models (to determine stock levels and stock location) and vehicle routeing and scheduling models (to determine fleet size and vehicle mix).
- Once a suitable logistics strategy has been identified, it is essential to undertake the dual process of evaluating this strategy against the preferred business strategy and ensuring that due account has been taken of any practical considerations.

INITIAL ANALYSIS AND OPTION DEFINITION

External factors

Any number of external factors may be relevant in a logistics-based study, and these will of course vary according to the industry, the company, the marketplace, etc. Some of the factors that may be relevant will include:

- transport mode availability;
- infrastructure changes (eg new roads, rail links, etc);
- regulatory changes (transport legislation, customs regulations, etc);
- information technology (EDI, EPOS, etc);
- technology changes (new vehicle design, unit load technology, etc);
- environmental impacts;
- industry trends.

Examples of these factors were described in Chapter 6.

Internal factors

The importance of the many internal factors will certainly vary from industry to industry. It is generally possible to categorize these in two ways: firstly, qualitative or descriptive factors that relate directly to the operation under review; and secondly, quantitative facts and figures. Both qualitative and quantitative information are used to help 'describe' the business in an operational context. These factors will be developed in much greater detail to represent the inputs into the modelling process for costs, product flows and customer service requirements.

Establish current position

This major element of the study is aimed at producing a mathematical description of the main existing material and product flows and costs of the logistics operation. In addition, the respective service level requirements should also be identified. The resultant model is then used as the basis for testing any options that are subsequently identified for analysis. This is a very detailed and necessarily time-consuming process but is essential to the study as a whole. Data accuracy is crucial because it provides the basis against which all alternative solutions are measured.

The complicated nature of the data requirements is illustrated in the network diagram of Figure 8.10, where an example of some of the typical major flows and costs is given.

Costs and product flow: data collection

This section summarizes the data that will be used as the basis for determining the current situation and for the subsequent logistics modelling and analysis that will underpin the entire strategy planning process.

Several important decisions concerning data collection should be made very early in the data collection process. These decisions will affect key areas such as the type of data to be collected, various data categories that need to be determined and suitable time periods. These include:

- *The unit of measure:* this should be suitably representative of the whole logistics operation that is being assessed. This is often not easy to determine, as there may be several different descriptive measures that are used within a company — pallets for bulk stock, cartons for picking, and roll cages for transport. In some industries a common unit is standard — in the brewing industry, for example, the barrel is a universal measure.

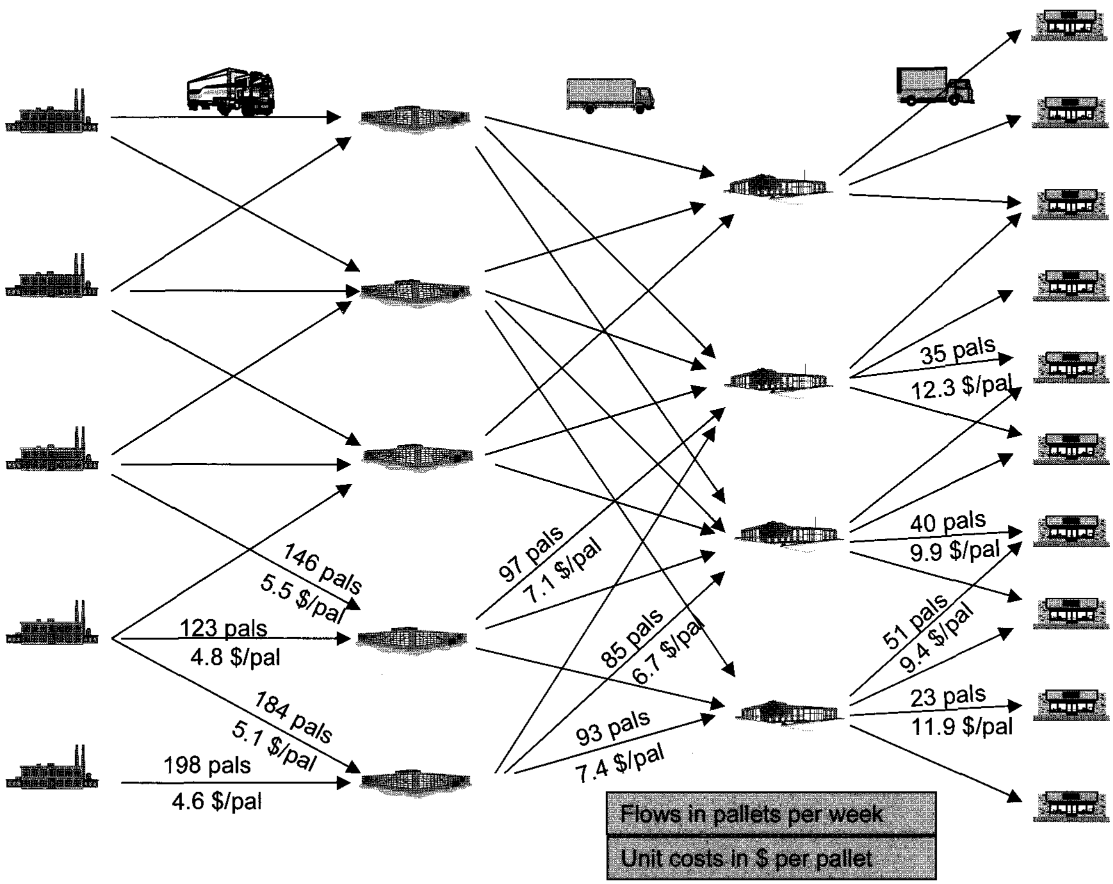


Figure 8.10 Logistics network flow diagram, showing some examples of major flows and costs

- *Product groups:* it is not possible to model each individual product, so products must be categorized into suitable groups that reflect similar logistics characteristics — eg sector (cosmetics, personal care, cleaners), format (powder, liquid, hazardous), pack type (box, bottle).
- *Customer classification:* to differentiate between demand for products for any different service level requirements.
- *Time periods:* generally a financial year is most suitable, but data collection time periods will vary if, for example, seasonality needs to be determined (several years needed for this) or if product life cycles are limited.

Typical examples of descriptive data include:

- product groups;
- own and bought-in sourcing locations;
- number and type of sites and facilities;
- major transport modes;
- handling systems used;
- unit load types;
- own versus third-party operations;
- main customer groups;
- customer service levels;
- logistics information systems.

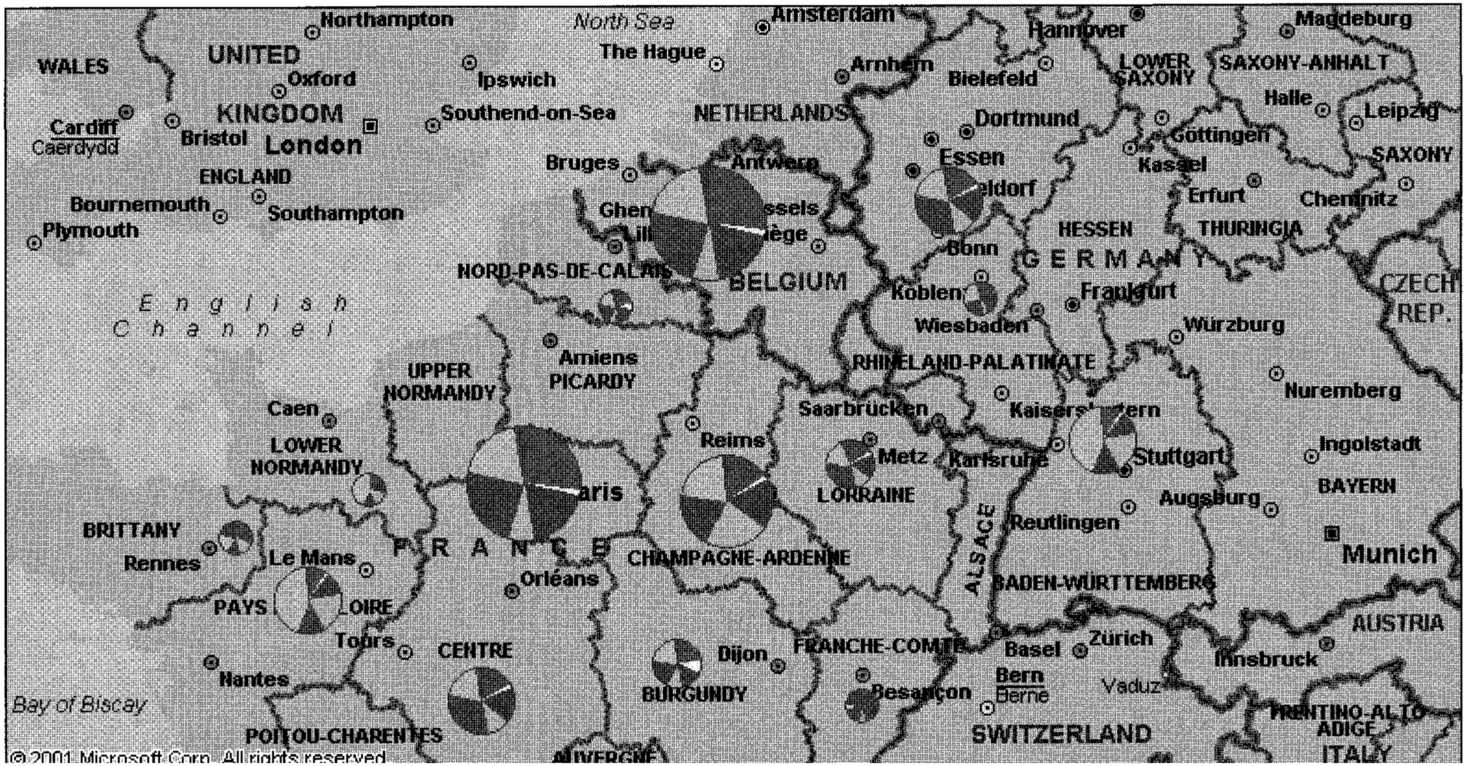
Examples of quantitative data are:

- major product flows;
- transport modal split for the major flows;
- demand by region, by major product group, by customer type, etc;
- market segmentation;
- customer service goals and achievements;
- carrier analysis;
- inventory holding profile;
- product profile;
- customer profile;
- planned future expansion requirements.

As well as preparing numerical tables of data, it is also a good idea to make visual representations. This can be essential in helping to understand the implications of the data in terms of the demand for different product groups in different geographical areas and the subsequent recommendations for DC location. There are many software packages that provide this functionality. Figure 8.11 is an example of this.

It is advisable to collect initial data in the format that can be used for the subsequent logistics strategy modelling exercise. This will usually include the following key variables and key data requirements:

- *Variables:* - location and capacity of each plant, DC or trans-
  shipment depot;



Manufacturer of laundry, household cleaning and personal care products

Figure 8.11 Map showing a representation of the demand for di geographic areas

- cost functions for storage, primary transport and local delivery;
- demand locations and amounts.

• *Data:*
  - customer location and demand;
  - DC location and throughput;
  - primary transport costs (fixed and variable);
  - local delivery costs (fixed and variable);
  - inventory holding costs.

Quantitative data may not always be readily available, so descriptive information or alternative data may have to suffice. For example, it may be recognized that customers can be broadly profiled in terms of, say, national accounts, key accounts, dealers, distributors and specialist users. It may not be possible to make precise quantitative comparisons in terms of tonnage distributed per annum to each grouping, but some type of value analysis may be available.

The quantitative data derived are crucial to the analytical process carried out and thus to the final conclusions and recommendations made. Although collection is extremely time-consuming, it is important that data are correct and that they do adequately reflect the real flows and costs within the business.

Customer service analysis

Customer service requirements provide a key input to any logistics network planning study. It is essential to understand what customer service levels need to be achieved because these will have a vital impact on the type of logistics structure that should be developed. As discussed in Chapter 2, there is a vast difference between offering a low-cost service solution compared to a value added (high-cost) solution, and the chosen approach must be reflected in the logistics structure that is chosen. A detailed approach to determining customer service requirements is given in Chapter 3.

Logistics objectives and options

An assessment of corporate objectives and business strategy together with the most relevant external and internal factors should allow for clear logistics objectives to be determined. From these, and from the analysis of the current situation and customer service requirements, it should be possible to generate a long list of alternative options that would be worth considering for analysis. For any strategic review, it is also important to enable any innovative alternatives to be considered within the planning process, because the length of planning time horizon is likely to be one that takes the logistics evaluation outside the scope of the existing operation. This can be undertaken through the use of techniques such as lateral thinking and brainstorming sessions.

With approaches such as these, it is usually possible to develop a long list of options (some of which may, initially, appear to be less than ideal) and then by fairly simple assessment determine which of them, or which combination, may be feasible in the context of the planning horizon. A short list of alternatives can then be drawn up for quantitative evaluation in the modelling process.

LOGISTICS MODELLING

Modelling complete logistics structures

Many modelling techniques used in logistics concentrate on the detailed representa tion of specific parts of the logistics operation, eg production optimization, DC location and vehicle routeing. These methods, however, have the potential risk of optimizing only part of a logistics operation when greater economies or benefits could come from changes to other parts of the operation or from a complete restructuring of the operation.

The problem with such multifaceted optimization is that suitable techniques do not exist to consider simultaneously all the possible alternatives. The combinatorial problem of considering all products, made at all sites, shipped via all modes, to all customers, via all DCs is simply prohibitive. If the techniques did exist, solutions would require uneconomic run times on large computers.

A similar situation exists in the specialist area of production planning known as MRPII, where the technique of rough-cut capacity planning was introduced. Instead of trying to produce initial plans at a most detailed level, a rough-cut plan considers the overall requirement for key resources.

The consideration for logistics planning can be described as trying to establish the 'economic footprint'. The economies of scale of production, the customer service requirement and the logistics cost are all considered to give an optimum factory size and radius of operation, hence the economic footprint. A brewery with canning lines has large economies of scale and a product with sufficient shelf life to give a medium to large economic footprint. A bakery has much lower economies of scale and a product with a short product life and thus has a smaller footprint.

A means of 'rough-cut modelling' for the whole of a logistics operation is to use sourcing models. Costs of raw materials, production rates and capacities, together with approximate logistic costs across a geographical area, are used to calculate the trade-off between the major elements.

Sourcing models

With multiple products from multiple sources it is only too easy to assume that the lowest-cost solution is to source each market from the closest available plant with available capacity. In some situations this is true, but if plants have significant changeover (set-up) times it *may* be more cost-effective to have long production runs, high inventory and high transport costs. Thus, the first step in rationalizing a logistics system is to investigate optimal sourcing patterns. One definitive pattern may not be sufficient, as sourcing could change according to market conditions, product price, raw material costs and transport costs.

Linear programming is a mathematical technique that finds the minimum cost or maximum revenue solution to a product sourcing problem. All available sources are described with capacities, changeover penalties and raw material costs. Approximate logistics costs from sources to markets are defined as linear cost functions. Under any given demand scenario the technique is able to identify the optimum solution for the sourcing of products. Most spreadsheet packages have an optimization feature that allows this type of analysis to be undertaken. A typical sourcing model equation operates under the following constraints:

- the availability of each plant for production and changeover;
- that customer demand should be met;
- the least-cost solution is required.

The objective of a typical sourcing model equation is to minimize the following, given the run rate of each product at each plant:

- raw material cost;
- material handling cost;
- production variable cost;
- logistics cost from plant to customer.

Distribution centre location modelling

The output from a sourcing study is the optimized major product flows from source points to final customer. The next stage is to take these flows and to develop the most cost-effective logistics solution in terms of the most appropriate number, type and location of DCs, transport mode, etc. Thus, the overall trade-offs of the supply chain are considered and assessed during the sourcing study, and a preliminary sourcing allocation is made. The detailed logistics of modes, rates and site structure can now be considered using a DC location study.

Cost trade-off analysis can be used as the basis for the planning and reassessing of logistics and distribution systems. Clearly, this approach is a time-consuming and often daunting task, not least because of the difficulty in obtaining the appropriate data and information from within a company's accounting system, but also because of the somewhat complicated models that have to be used.

Mathematical programming uses a number of well-known mathematical techniques (such as linear programming) that are particularly applicable to solving the DC location type of problem. They are prescriptive, using a logical step-by-step procedure to reach the optimal or 'best' solution. The main drawbacks with these techniques are that linear relationships are not always adequate (if linear programming is used) and some solutions can be 'local' optimums, that is, they are not the best from the overall point of view.

Heuristics is a Greek-based word, used to describe the method of solution that is derived on a 'rule-of-thumb' principle. Heuristic methods are determined by using experience and common sense to reject unlikely solutions from the outset. In this way, problems can be reduced to a more manageable size in terms of the number of alternatives that need to be tested. This type of approach is often very valid for DC location problems, because there are always a number of locations that are totally inappropriate.

Simulation is a widely used operational research technique, which is capable of representing complex problems and cost relationships. It is not an optimizing technique, so does not produce the 'best' answer, but it is descriptive of the different relationships and is used to evaluate any alternatives. The inability to produce optimal solutions has previously been seen as a drawback, but in fact a carefully derived simulation model, used with the practical expertise of a distribution specialist, is likely to result in realistic and acceptable solutions that can be readily implemented. Simulation models allow for various 'what if' questions to be asked to test alternative strategies.

In a practical context, there are also different practical approaches that can be used. The most straightforward is map-based, whereby the network is represented spatially on a map. Clustering techniques are used to reduce the complexity of the problem: that is, all customers in close geographic proximity are clustered together. This approach is relatively quick and is made much easier because it is very visual, allowing for alternative configurations to be identified. The next level of sophistication is to use a spreadsheet-based approach. This allows for a much better level of analysis, enabling the quantification of the problem and potential solutions in fairly quick time. Spreadsheets can also be used to provide maps of the output.

The most common approach to determining DC location solutions is to use a logistics strategy simulation or optimization model. A variety of software has been developed. The common technique is to simulate the cost of operation for a particular configuration. A variety of heuristic techniques such as hill climbing or centre of gravity is used to suggest potential site locations. As indicated, these methods are essentially 'what if' simulation systems, which will always give best results in the hands of an experienced user. Recent innovations have included the use of high-resolution colour graphics to give a detailed representation of the geography and logistics involved.

The main steps necessary in a DC location model are outlined in Figure 8.12. Two essential stages of logistics simulation are model validation and option testing. The validation exercise involves taking a known situation, reproducing flows and customer service to test whether the costs are predicted with reasonable accuracy. It is essential to ensure that the model or method of analysis is truly representative of the system being investigated. There is a consequent requirement during the modelling process to check and test the appropriateness of the model

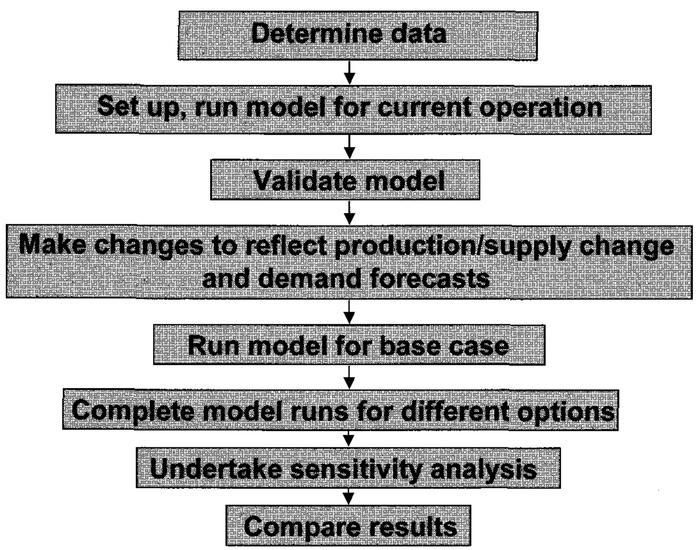


Figure 8.12 Logistics modelling: the main steps for a DC location study

and the results produced. When agreement has been achieved or variances have been understood, then a variety of alternative options can be tested. Often the simulation of a future scenario will involve the synthesis of new databases of customer location and demand.

An additional stage in the modelling process when sourcing models have been used is to rerun the allocation with the logistics costs as modified in the logistics simulation. This should not lead to major changes if the original cost estimates are realistic and robust solutions are obtained.

MATCHING LOGISTICS STRATEGY TO BUSINESS STRATEGY

Having modelled the logistics options and selected one or more that perform well when measured against service and cost, then the impact of these on the total business strategy must be assessed. Three main areas where this will impact are:

1. *Capital costs.* If increased factory storage, new DCs, new equipment or new vehicles are required, then capital or leasing arrangements will be needed. In certain situations capital constraints can exclude otherwise attractive options. In other cases an increase in working capital (eg stock-holding) may exclude an option.
2. *Operating costs.* The minimum operating cost is frequently the main criterion for selection between options. In some situations increased operating costs can be accepted in the light of future flexibility.
3. *Customer service.* Although options should have been developed against customer service targets, the selected short list must be examined for the customer service level achieved. The balance of the mix might have changed in an effort to reduce costs. Stock held close to the customer might need to be increased to improve service reliability.

One means of matching logistics strategy to business strategy is to undertake some associated qualitative analysis. There are several reasons for doing this but the key ones are to back up the quantitative analysis and to use it in place of quantitative analysis where it is impossible to derive good quantitative measures. A series of key assessment criteria can be developed and used to help in the comparison of the different strategic options identified. These can then be weighted according to their importance in the decision-making process, and scored according to how

	weighting	score	total
	%	1 to 5	
Service/marketing	25%		
Service – reliability	8%	4	32%
Service – response/speed	4%	4	16%
Complete order delivery	1%	5	5%
Market presence (ie stock-holding)	1%	1	1%
Product quality	3%	3	9%
Company image	4%	1	4%
Flexibility of service	4%	1	4%
Total	25%		71%
Others	25%		
Flexibility (for subsequent change)	3%	5	15%
Ease of management/control	4%	2	8%
Change from current – physical	1%	1	1%
Change from current – personnel	1%	2	2%
Risk (financial)	4%	4	16%
Risk (customer service)	4%	3	12%
Risk (loss of business)	5%	5	25%
Management of change	3%	4	12%
Total	25%		91%
Overall total			162%
large positive impact	5		
no impact/no change	3		
large negative impact	1		

Figure 8.13 Example of part of a qualitative assessment used for a European study

each particular option is thought to perform. As well as the more obvious cost indicators, there are other criteria that may also be important. Figure 8.13 gives a partial example of this. The other 50 per cent (not shown) would be represented by cost factors.

SITE SEARCH AND CONSIDERATIONS

After a suitable series of site locations has been determined through the modelling process, there are various practical considerations that should be taken into account when deciding on a particular site.

Without initially having the benefit of detailed layout plans, some assessment should be made about the general *size and configuration of the site,* and its consequent ability to enable a sensible layout of the building and other ancillary structures and site roads. Finally, consideration should be given to the extent to which the site should also be able to accommodate future anticipated expansion.

An estimate will be needed of the number, type and size of vehicles using the proposed site, including some measure of future expansion, in order to check that *suitable access* can be provided on to the site. This should clearly take account of the traffic characteristics for different operations, in terms of vehicle size and numbers coming on to the site, and also in terms of access for employees, whether on foot, by car or by public transport. In this context, the external roadway system and access need to be considered as well as the likely internal site roadways. Any future plans for development of the road and rail network in the vicinity of the site that could possibly affect the ease of site access should be explored. Generally, goods will arrive and leave by road transport so that local links to the motorway network or other major roads are of significance.

Any site development will require planning permission, but checks should also be made about *local development plans* for the area, the adjacent land and the general environment. This is to ensure that there is nothing that would adversely affect the site operation in terms of future plans for expansion. This might relate to physical growth, the extension of working times or shifts, site access, the availability of suitable labour and the overall operating environment, especially as it might affect potential customers.

Certain *site details* relating to the features of a potential site should be considered. These can influence the position of any proposed buildings, and also influence such aspects as construction costs, site security and site operation. In general the site should be suitable in terms of soil conditions (load-bearing), slope and drainage. Such factors may exert a significant influence on construction costs in terms of piling, excavation, backfilling and similar civil engineering factors. The necessary services should be available, or planned, and accessible — power, water, sewage and telephone links.

The adjacent properties to the proposed site can also influence such considerations as site security (eg if open space is adjacent) or the feasibility of working outside 'normal' day hours (eg if housing is adjacent).

Financial considerations are also important. The cost of site acquisition and rental or other ownership costs should be established, as should the probable levels of commitment for rates (local taxes), insurance and any other services or site-related charges. On the other side of the cost equation, there may be investment or other government grants that apply, which could influence the overall cost picture.

When occupying a site and either putting up new buildings or taking over existing buildings or facilities, there will be legislation and *local regulations and planning requirements* to be considered and met. When considering the site, some typical constraints are a requirement for a minimum number of employee car parking spaces, an upper limit on the height of any building to be put up on the site and limits to the type of building to be constructed.

SUMMARY

The approach to logistics strategy planning outlined here must of course flex to suit particular industries and business situations. The important theme is the use of a formalized framework that takes into account business issues as well as more detailed logistics issues and combines the conceptual and quantitative evaluation techniques that are available. The basic methodology can be followed in any organization.

The various roles of DCs and warehouses were discussed, and once again the influence of the different elements within logistics was noted.

The basic cost relationships have been described. These relationships have been brought together to produce a total logistics cost. It has been shown that trade-off analysis can be used to help optimize the cost-effectiveness of distribution systems, even where this may mean that individual cost elements are increased.

A formal planned approach for developing a physical distribution strategy was described. The major discussion points have been the need to determine appropriate product flows and the planning of DC and facilities location. A number of different aspects have been covered, and it has been emphasized that the problem is a complex one, involving a great deal of data manipulation and the need for quite sophisticated modelling techniques.

In the final section, a number of factors were put forward for consideration when a practical search for a site takes place. These factors are all influential in ensuring the effective operation of a DC.

Based on articles written and work undertaken by Alan Rushton and Richard Saw, Cranfield School of Management.

9

Logistics management and organization

INTRODUCTION

This chapter is concerned with the way in which logistics and distribution are organized within the company. The importance of the integration of the logistics function into the business as a whole has been emphasized at various times throughout this book. In addition to the need for integration in a business sense is the need for the organizational structure to reflect a similar form of integration. Thus, the organizational structure and the human resource or 'people' aspects are considered in this chapter.

There are several factors covered, the first being a Srief summary of those aspects, discussed in Chapter 2, dealing with the relationship of logistics and distribution with other corporate functions. Allied to this, a number of different organizational structures are discussed. These include traditional structures as well as those that provide more emphasis on logistics and those that allow for a process-oriented, cross-functional integrated approach to the organization.

The role of the logistics and distribution manager is considered —both with respect to his or her position within the company and also with respect to key functional responsibilities. A more 'grass-roots' view of logistics is taken, with a discussion on the payment schemes used within the distribution and logistics environment.

Finally, some key points are made concerning the selection of temporary staff and assets.

RELATIONSHIPS WITH OTHER CORPORATE FUNCTIONS

In the first two chapters, logistics and the supply chain were considered in the context of business and the economy as a whole. In particular, the interfaces with other corporate functions were discussed, the major ones being with production, marketing and finance. There are many occasions when the importance of these corporate relationships has been emphasized, not least because of the move to a cross-functional, process-oriented view of the supply chain. This importance is particularly valid where the planning of corporate strategy is concerned. The need to adopt such a view was discussed in Chapter 6.

There are two key points that bear re-emphasis at this stage. First is the fact that logistics is, for many companies, such an integral part of the corporate being. Because of this, the second major point becomes apparent - the need for logistics planning and strategy to be recognized and used as a vital ingredient in the corporate plan.

The first point - that logistics is such an important element within a company's total business structure - can be illustrated using the interrelationships of logistics with other functions:

With production	Production scheduling Production control Plant warehouse design Raw material stocks etc
With marketing	Customer service Packaging Distribution centre location Inventory levels Order processing etc
With finance	Stock-holding Stock control Equipment financing Distribution cost control etc

The need to include the planning of logistics and distribution into the overall corporate plan is thus self-evident. The business planning process was previously shown in Figure 6.2. Even within this strategic framework it can be seen that distribution and logistics factors should provide a vital input. Within the strategic planning process, such elements as market analysis and policy determination cannot be derived without an understanding of customer service requirements and channel choice alternatives. With any policy assessment exercise and in any subsequent determination of competitive strategy, knowledge of key logistics elements is essential. Any factors related to the procurement, storage and movement of goods must, of necessity, be relevant to the determination of a company's business plan.

The reason that companies fail to take sufficient account of the logistics input to corporate planning is probably due to the dynamic nature of the logistics environment and operation. Logistics is seen to be very much about doing and providing. As such, it can be viewed and treated as a short-term factor, with little direct relevance to long-term planning.

Logistics is a function with both long- and short-term horizons. Its very dynamism tends to mould the one into the other, making it difficult at the operational level to distinguish between the two. In addition, the consequence of inappropriate planning is often seen as a short-term operational problem. In effect, the size and extent of financial and physical investment makes it imperative that the differentiation between the long and the short term is made and that, where necessary, the relevant elements of distribution and logistics are included in the overall business plan.

LOGISTICS ORGANIZATIONAL STRUCTURES

Associated with the failure to include relevant logistics factors within the corporate business plan is the need to recognize that the logistics function may also require a specific organizational structure. For many years, logistics was barely recognized as a discrete function within the organizational structure of many companies. Although recently the importance of distribution and logistics has become much more apparent to a broad range of companies, a number have failed to adapt their basic organizational structures to reflect this changing view.

Such companies have traditionally allocated the various physical distribution functions amongst several associated company functions. This failure to represent distribution and logistics positively within the organizational structure is thus often a result of historical arrangement rather than a specific desire to ignore the requirement for a positive logistics management structure. Clearly, some positive

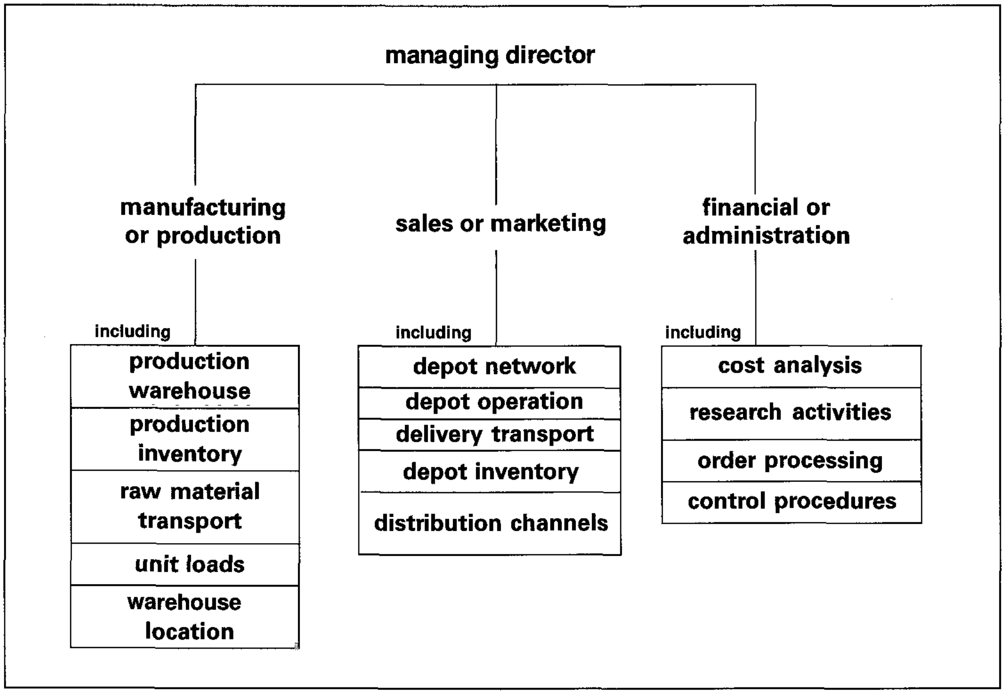


Figure 9.1 Traditional organizational structure showing key logistics functions

organizational structure is essential if the logistics function is to be planned and operated effectively.

A typical structure, showing logistics and physical distribution functions based on traditional lines, is illustrated in Figure 9.1. The problem with this type of organizational structure is that lines of communication are unclear. Thus, it is often impossible to optimize the efficiency of the different logistics sub-functions, let alone create an overall logistics system that is both effective and efficient.

Several of the more forward-looking logistics-oriented companies have seen the need for some formal organizational change to represent the recognition now being given to the distribution and logistics activity. This new functional approach emphasizes the need for logistics to be planned, operated and controlled as one overall activity. The precise structure will obviously differ from one company to another. A typical structure might be as illustrated in Figure 9.2. This type of structure allows logistics to be managed as a function in its own right, although the need for close liaison with other company functions remains vital.

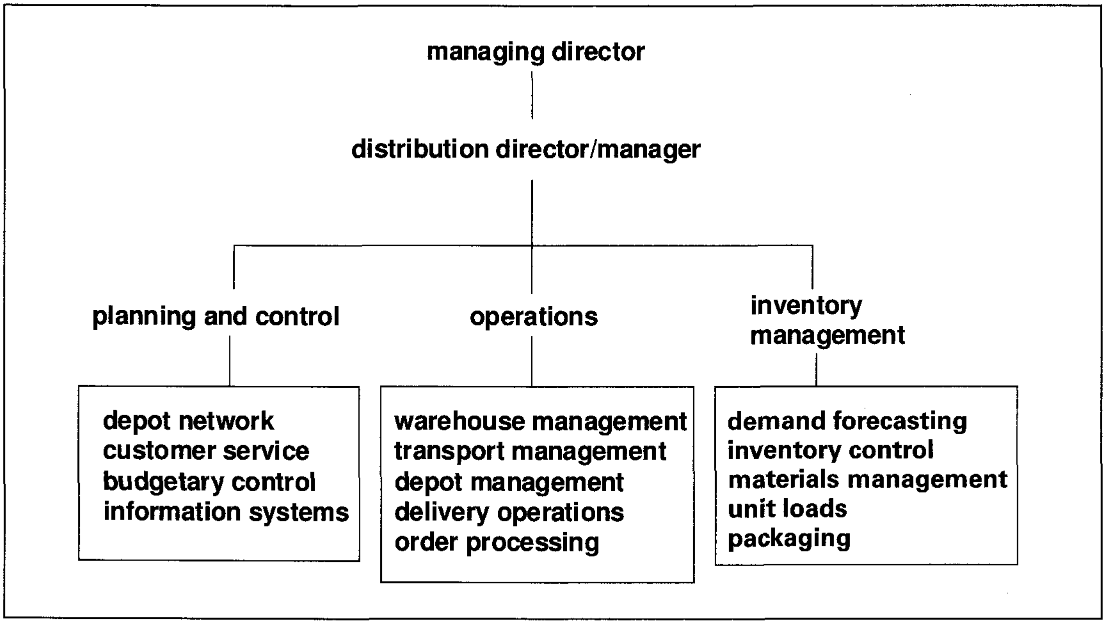


Figure 9.2 Functional structure showing logistics activities linked together

ORGANIZATIONAL INTEGRATION

One important feature that has evolved with the refocusing towards supply chain integration is the need to rethink the way in which logistics operations are organized. This has led to a change in thinking in organizational terms away from functional structures and towards process-oriented structures. This is in many ways a reflection of the key changes that have been outlined in previous chapters:

- the emphasis on the customer, and the need to ensure that internal processes support the requirement to achieve customer satisfaction;
- the concentration on time compression throughout the whole supply chain, and the need to identify and manage suitable trade-offs;
- the move to globalization and the requirement to plan and manage the logistics network as a complete system.

Traditional organizational structures do not really lend themselves to this new way of thinking. They are essentially functional and inwardly focused, with

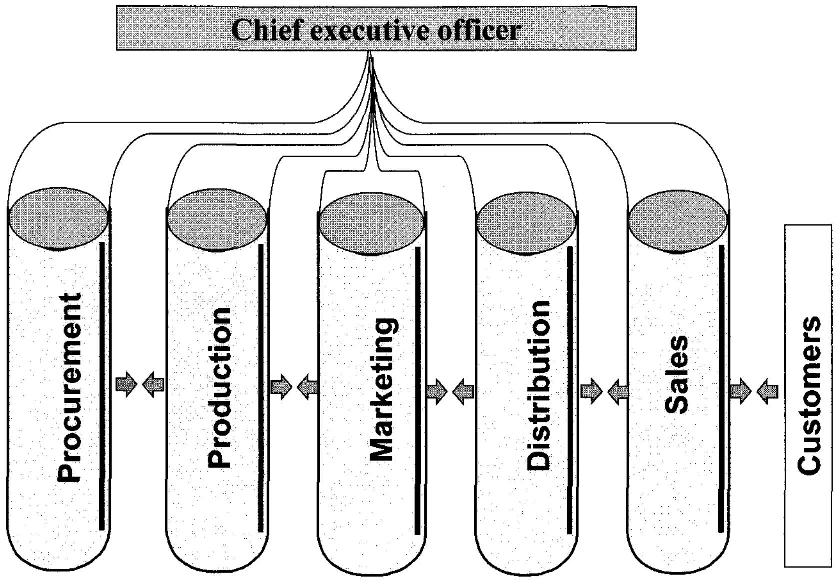


Figure 9.3 Traditional silo-based functional organizational structure

several directors of functional activities reporting to a chief executive officer (see Figure 9.3). There is a tendency for these functional boundaries to create barriers to integration — with the power barons at the head of each function fighting to protect their own power base, rather than serving the overall company objectives.

Thus, there has been a move away from these silo-based functional structures towards more process-oriented organizations. These are based on key business processes, such as those described in Chapter 7. They attempt to reflect the need to support, in particular, the customer-focused approach that many companies are trying to achieve. These new structures try to increase the visibility of market demand and enable an integrated supply chain response. An example of such an approach is shown in Figure 9.4.

This type of structure is known as mission management and is based on the concept of the management of systems or flows. This is undoubtedly relevant to logistics and distribution, which are concerned with material flow and the associated information flow often from raw material through various processes, storage and movement to the final customer.

Clearly the potential problems lie in the inability to manage and co-ordinate across functional boundaries. However, where good management practices have been followed, and in the appropriate operational context, organizational structures

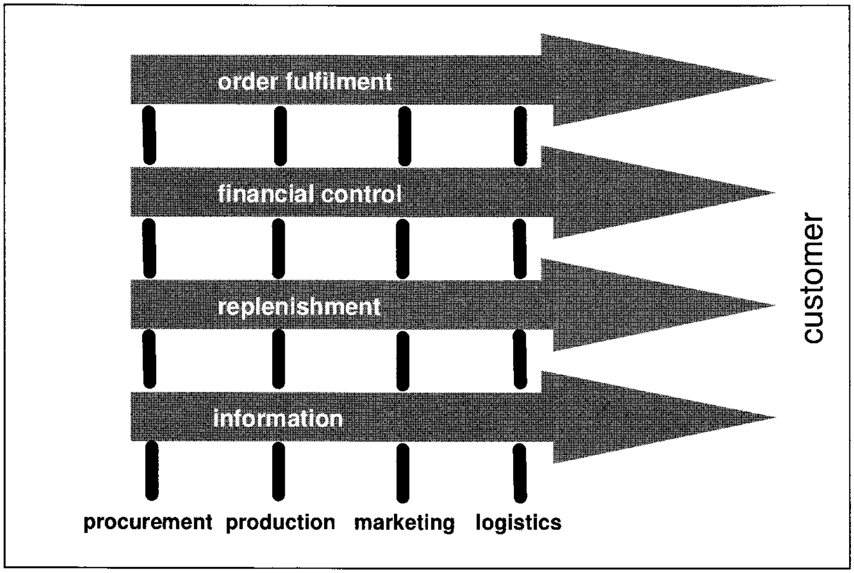


Figure 9.4 A customer-facing, process-driven organizational structure

such as these have been made to work very effectively. They are particularly relevant for customer-service-oriented businesses. Some of the larger chemical companies, for example, adopt this type of management structure to provide co-ordination and control throughout the supply process of particular products.

Mission management is cross-functional, and as such can pose problems in a traditionally functional organization. For many companies, this type of mission management structure has not been an easy alternative, with traditional managers loath to make such a dramatic change to an approach that they have been familiar with for many years. Because of this, a further development, matrix management, has evolved. Here, the product or flow is planned and managed by a 'flow' or logistics manager, whilst the traditional functions provide the necessary inputs as they are required.

For some companies, a mixed or matrix approach seems to have been the most successful. This accepts that there is a need, at the *planning* level, to reorganize on a process basis, which crosses traditional boundaries, but recognizes that it is important to retain specialists at an *operational* level to ensure the efficient running of operational functions such as transport and warehousing. The different emphasis in these two approaches is demonstrated by comparing Figures 9.5 and 9.6.

As well as changes to process-oriented management structures, there have been broader supply chain initiatives, in particular the need to rethink buyer–supplier

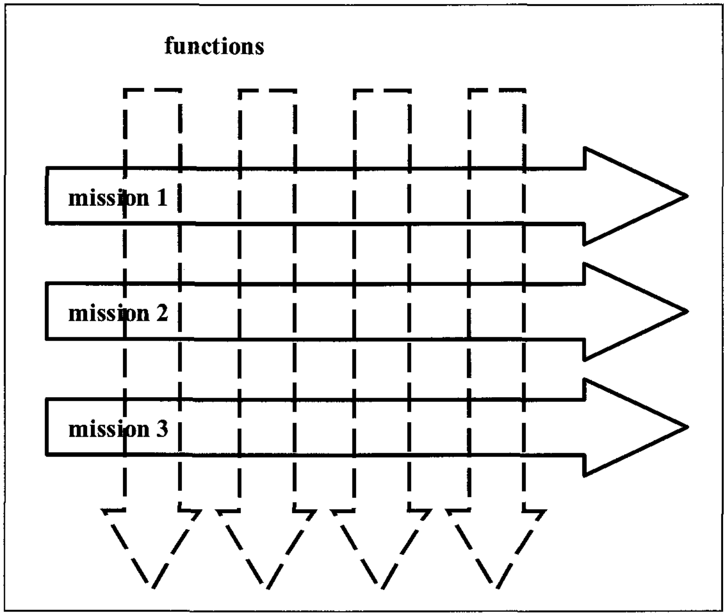


Figure 9.5 Mission management, which acts directly across traditional functional boundaries

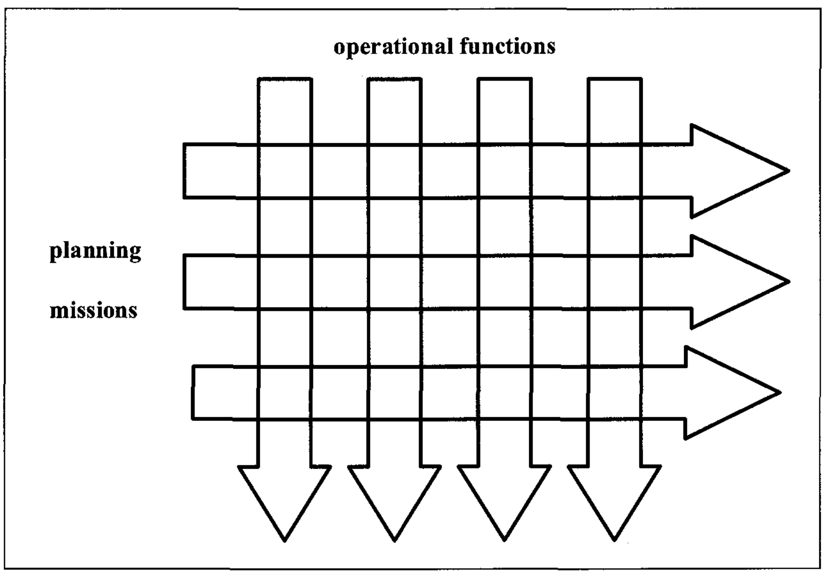
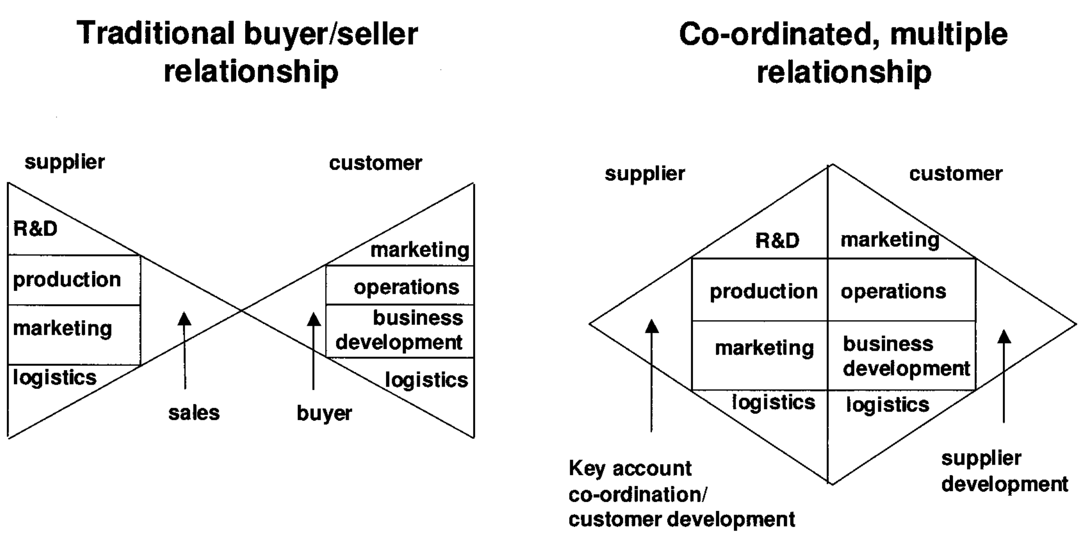


Figure 9.6 Matrix management, which emphasizes both planning and operational elements

relationships. A major aim is to move away from the traditional combative arrange ments towards the building of stronger and more positive partnerships that reflect the need for companies, within a supply chain, to work together to achieve commercial success. This involves the development of a structure where the link is not merely with the traditional sales/buyer, but also includes co-ordination and co-operation with other relevant groups across company boundaries. This might include research and development, marketing, distribution and any other functions that, with a suitable link, can benefit from such a partnership approach. Figure 9.7 demonstrates the change in approach from a traditional single point (' bow-tie') to a co-ordinated multiple approach ('diamond').

THE ROLE OF THE LOGISTICS OR DISTRIBUTION MANAGER

The role of the logistics or distribution manager can vary considerably from one company to another, dependent on the internal organizational structure, the channel



Source: Christopher and Peck (2003)

Figure 9.7 Buyer/seller relationships: a single versus a multiple linked approach type (own account, third party, etc), the industry or product, and the customer profile. Factors such as these will certainly affect the extent of the operational role and to a lesser extent the nature of the planning role.

In an earlier section of this chapter, the need for companies to include the planning of logistics and distribution in the overall corporate strategy was emphasized. It is useful here to consider the part that the logistics or distribution manager can play in the planning process. M A McGinnis and B J LaLonde (1983) have discussed this question. They take three main themes: the contribution that the logistics/ distribution manager can make to corporate strategic planning; the advantages of this contribution; and the preparation that the manager can make to increase the effectiveness of his or her input.

The main points are as follows:

1. *Contribution to corporate strategic planning:*
   - an understanding of the functional interfaces;
   - an understanding of distribution's activities;
   - familiarity with the external environment as it relates to distribution;
   - insights regarding competitor distribution strategies;
   - familiarity with customer distribution needs;
   - familiarity with channels of distribution;
   - distribution data.
2. *Advantages of contributing to corporate plan:*
   - understanding of impact of corporate strategy on distribution activities;
   - increased physical distribution responsiveness;
   - increased sensitivity to the distribution environment;
   - identifying distribution opportunities;
   - improving communications.
3. *Preparation for strategic planning:*
   - know the company;
   - develop a broader perspective of distribution;
   - know the distribution environment;
   - develop rapport/liaison with others;
   - know customer needs;
   - improve communication skills.

Logistics-related planning activities are thus a vital input in the overall business strategy. The more specific activities were outlined in the early chapters of this book. They involve a medium- to long-term planning horizon and will include aspects such as the number of facilities, their size and location, transport networks, fleet size and mix of vehicles, stock levels, information systems, etc.

As already indicated, the operational role for managers can vary significantly according to the size and nature of the business, the product, the channel type and the customer profile, amongst other factors. Also, there are a number of different job titles and job functions that exist. These range from the distribution or logistics manager, who might have overall responsibility for an entire distribution network including central distribution centres, regional distribution centres, primary transport (line-haul) and delivery vehicles, stock location and control, computer systems, etc, to a shift manager or supervisor who might, for example, be concerned with the detailed performance and control of an order picking operation on a night shift.

Traditionally, the three main operational areas of responsibility are related to:

1. *transport* - primary transport (line-haul), delivery operations, vehicle routeing and scheduling, vehicle procurement, etc;
2. *warehousing* - goods inward, bulk storage, order picking, marshalling, materials handling equipment, etc; and
3. *information* - stock location, stock control, order processing, budgeting, monitoring and control, etc.

For many logistics managers, these areas may be expanded to cover other aspects such as procurement, inbound logistics, inventory levels, forecasting, telesales, production planning, reverse logistics, packaging, etc.

In addition to these broad functional areas, there is a staff role concerning the management of human resources, union negotiation, health and safety, and the linkage to other corporate interfaces such as production, supply, marketing, sales and finance.

Over and above all of these aspects of the operational role, and probably common to all types of distribution organizations, is the responsibility for, and the need to control, the balance between the service to the customer and the cost of providing this service.

From the point of view of supply chain planning, the key roles for a logistics manager with a broad remit might be summarized as:

- to lead the design, creation, configuration and parameter setting of the entire supply chain;
- to create the framework and the dialogue that determine the performance targets along the whole chain;
- to drive the systems and monitor and report the entire logistics operational performance against agreed targets;
- to review how problems can be solved and performance improved.

PAYMENT SCHEMES

One relatively neglected area in the literature on logistics and distribution concerns the payment mechanisms and incentive schemes that are used within the industry. Having looked at the broad roles and responsibilities of the logistics manager and director, it is interesting to gain a better understanding of the grass-roots position related to the type of payment systems that are commonly used.

There are a number of different types of payment mechanism. These can be broadly divided into the three main systems of daywork, piecework and payment by results. These three systems are illustrated in Figure 9.8. Daywork is a method of payment based entirely on the hours attended at work; piecework is payment entirely related to the amount of work undertaken; and payment by results is a mixture of these, providing a basic wage plus a bonus based on work undertaken.

The main payment systems can be summarized as follows:

- *daywork* (also known as graded hours, fixed day, etc) — based entirely on the hours worked;
- *measured daywork* — basic attendance wage plus bonus for achieving a given level of work performance;
- *stepped measured daywork* (stabilized incentive scheme, premium payment plan) — introduces 'steps' in the measured daywork scheme, so providing additional incentive;
- *merit-rated bonus scheme* (incentive bonus scheme) — a bonus scheme on top of a basic wage, but not productivity-related;
- *piecework* — payment related entirely to the amount of work completed;
- *payment by results* — in its purest form this is piecework, but usually it is a results-based payment on top of a basic wage;
- *commission* — a piecework or payment-by-results scheme, but based on effort and achievement (eg sales, cost savings); a common type of management bonus scheme;
- *group or plant-wide schemes* — collective bonus schemes based on collective performance, which can be related to costs versus sales, increased output or improved efficiency;
- *fringe benefits* — various non-performance-related add-ons covering such items as holiday pay, Christmas bonus, subsidized canteen, clothing allowance, etc; eventually, these types of benefit become taken for granted;
- *profit sharing scheme* — related to the company profit, and aimed at fostering employee interest in the company;

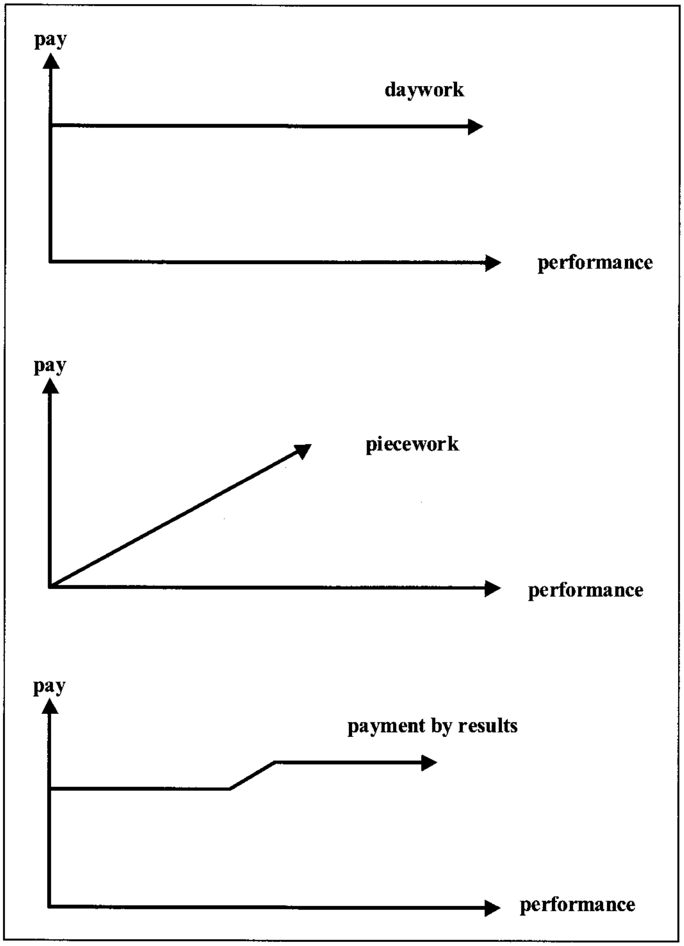


Figure 9.8 The main types of payment mechanism, showing the relationship between performance and pay

- *share schemes* – usually limited to managers and directors, though there are some notable company-wide share schemes;
- *team working* – rewards for small groups, usually used for management teams;
- *annualized hours* – systems that are formally organized for working time on the basis of a number of hours per year rather than hours per week; they have become recognized as useful schemes where there is a distinct seasonal or peak nature to the work and thus are matched to the needs of the business to meet customer requirements and are popular in warehouse operations.

For motivational financial schemes it is important to distinguish between schemes that provide an incentive, reward or bonus, because they can have a varying impact on workforces. The main differences are:

- *Incentives*. These stimulate better performance in the future because they are payments for the achievement of previously set and agreed targets. Incentives tend to have the most direct impact on employee behaviour and motivation because the conditions of payment are known in advance.
- *Rewards*. These recognize good performance in the past. They are likely to have a less direct impact on behaviour and motivation due to the level of uncertainty of the amount of the pay-out.
- *Bonuses*. These are rewards linked to performance but paid out in a lump sum.

Clearly, the applicability of these methods of payment varies considerably from one type of distribution company to another, and from one type of distribution job to another. Productivity-related incentive schemes are only valid in operations that will benefit from schemes of this nature, ie where increased worker effort will mean an increase in output. For many distribution operations, the need for accurate, timely order picking may far outweigh the number of picks made per picker per hour. Additionally, it is likely to be both dangerous and illegal to propose a driver incentive scheme that gives additional payment for the speed with which the work is completed.

It is worth emphasizing two particular aspects related to payment schemes, and to show how these vary according to the type of scheme operated. The first is the relationship between different schemes and financial incentives. This is illustrated in Figure 9.9. In contrast, Figure 9.10 shows the extent of supervision required for the different schemes. One is the direct converse of the other, indicating the high levels of supervision required for payment schemes that offer strong financial incentives.

The relevance of these different schemes for distribution is best summarized according to the mainbreakdown of distribution personnel – drivers and warehouse staff.

Drivers are most likely to be paid on hours worked or hours guaranteed – some form of daywork. There may also be a special rate for the job, based on work experience or driving qualifications. In terms of incentive, a form of 'job and finish' might be operated, giving extra leisure rather than extra cash as the incentive. Financial bonuses might be offered as a form of payment by results based on such things as miles/kilometres run, cases delivered, etc. Once again it must

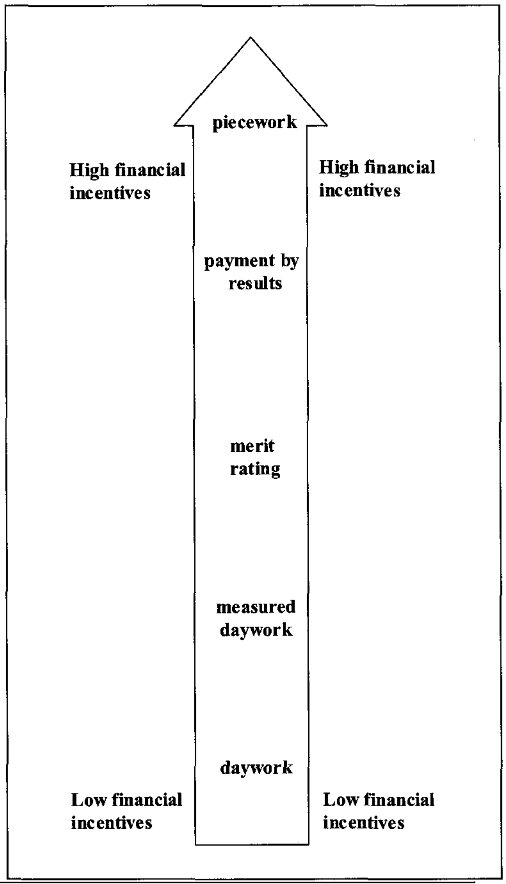


Figure 9.9 Hierarchy of payment schemes in relation to financial incentives

be emphasized that any bonus payments are prohibited if they endanger road safety.

Warehouse staff are also likely to receive remuneration based on hours worked or guaranteed. In the more controlled environment of a warehouse, daywork is likely to be measured. Additionally, there are likely to be different rates according to different job functions (fork-lift truck drivers, pickers, etc). Merit-rated bonuses based perhaps on attendance might be offered, and certainly productivity-related bonuses are likely to be very common, based on cases picked, pallets moved, etc. Measured performance schemes are operated based on work study standards for specific tasks. In addition, as already indicated, many companies are now introducing annualized hours because it can lead to a much more efficient use of the labour force.

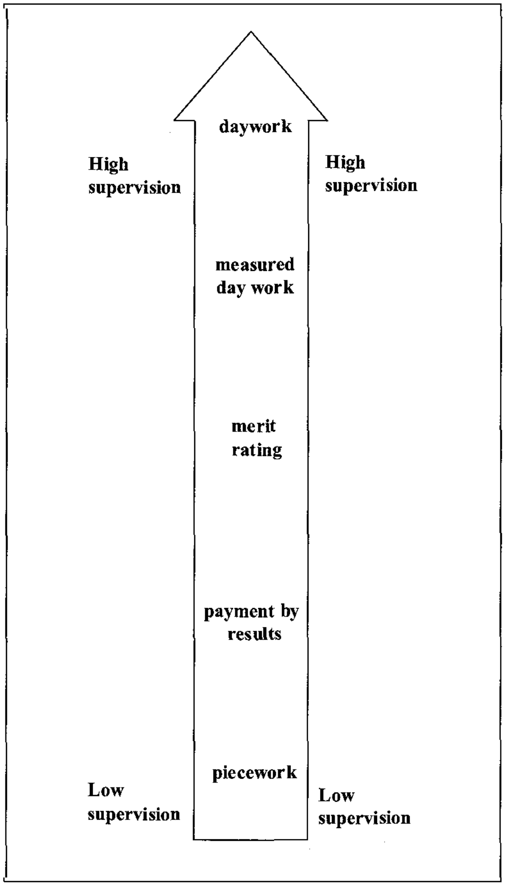


Figure 9.10 The extent of supervision required for different payment schemes

THE SELECTION OF TEMPORARY STAFF AND ASSETS

Most distribution operations today can ill afford to waste money on human or physical assets that are not fully utilized. The days of the spare vehicle or driver are a distant memory. However, the realities of business are that operational requirements regularly swing between peaks and troughs, often on a daily basis. This inevitably means that warehouse staff, vehicles, drivers or hired transport will be required at some stage to deal with the peaks. Indeed, if an operation never has any requirements for temporary assets, then that is usually a sign that the operation has too many assets in the first place. The objective must be to utilize the operation's core assets to the maximum and to use hired assets for the peaks. Other situations also lead to short-term hiring, such as staff holidays or bouts of illness as well as vehicle or handling equipment breakdown. Advanced planning to deal with these temporary situations will avoid problems when they occur. The following section concentrates on temporary drivers, but the approaches proposed will also apply to warehouse operatives.

Hiring temporary staff

Temporary drivers attract a great deal of criticism for various reasons, but very often many of the situations they are held accountable for are not of their making. Too often, harassed managers telephone a temporary staff agency late in the day and request a driver without having invested the time in the necessary preparatory work. Many simply look for the cheapest price and then complain when things go wrong. The following is a checklist that will help avoid disappointment:

1. Set aside time to investigate the temporary staff agencies in your area. Don't just select the cheapest. In the UK, for example, many reputable agencies will be members of the Federation of Recruitment and Employment Services (FRES).
2. Check with other companies in the area about which the best agencies are and why.
3. Key points to be established with any potential agency are:
   - How are drivers selected?
   - How often are driving licences checked?
   - Are the drivers examined to establish their level of understanding of relevant legislation?
   - Are drivers' employment histories and references checked?
   - Are drivers full-time employees of the agency?
   - Does the agency have all the relevant insurances such as employer's and public liability cover? What insurance do they have to cover damage caused by their drivers' negligence? If you have an excess on your motor insurance policy, this last point could be significant.
   - What training does the agency provide for its employees?
   - Does the *agency* have 24-hour telephone cover?
   - How will the agency provide information about the hours of work the driver has completed before undertaking your work? When was the last weekly or daily rest period? How many driving hours have already been used?

   Any agencies that cannot give satisfactory answers to any of the above questions should be avoided.

4. Having selected an agency, try to establish a good working relationship with them. Invite them to your premises so that they can gain a better understanding about the specific needs of your business. If the agency is of the right calibre, they should suggest this themselves.
5. Agree rates of payment for a given period. This will ensure that rates are negotiated at leisure and not under pressure.
6. Tell the agency exactly what is expected from any driver that they send. Each driver should be to a standard that has been agreed. Ensure that any who do not meet this standard are rejected. Sometimes this is difficult to achieve if the alternative is letting a customer down, but in this case agree penalty clauses in advance. This allows them to be invoked retrospectively if such a situation arises. A financial penalty is usually very effective. A percentage reduction in the fee for that driver could be effective, especially if it has been agreed in advance.
7. Supply the agency with all relevant health and safety information in advance to allow them time to brief their drivers. Include any specific rules about your premises such as smoking policies or protective clothing required.
8. If your delivery drivers have regular delivery points, try to compile a library of direction sheets to hand out to temporary drivers. This could save a lot of time and trouble.
9. If security is important, then insist that temporary drivers are provided with identity cards that display the driver's photo on them. Obtain the name of the driver being assigned to your work and ensure that your staff are made aware of whom to expect.
10. In large operations, some agency staff will become almost permanent fixtures due to their continued presence covering for holidays and sickness. Make an effort to include the agency in any information bulletins that are circulated to drivers. This will be especially important in the case of health and safety information or quality management information.

The above list has concentrated on temporary drivers but may be easily adapted to cover other temporary staff. With warehouse staff, fork-lift training certificates will be important.

Hiring temporary vehicles

Hiring vehicles and trailers to cover short-term needs is always easier if the hire company has advance warning of your requirements. Unfortunately, many short-term requirements are needed to deal with the unforeseen such as breakdowns.

However, if business peaks, such as Christmas or harvest times, occur regularly every year, then it is worth establishing what extra vehicles are needed in advance and communicating this to the chosen hire company in good time.

Another way of dealing with short-term peaks is to use the services of a third-party haulier. Spot hire rates are likely to be higher than rates negotiated on the basis of a long-term relationship. When establishing such a relationship, check the following:

- What are the conditions of carriage?
- Ask to see a copy of the haulier's operator's licence.
- What levels of goods-in-transit insurance does the company have?
- Do the haulier's vehicles look well presented and maintained?
- Do the drivers wear uniforms and are they generally well presented?

The cheapest is not always the best. Poorly maintained vehicles may break down. Remember that these hauliers will be representing your company to your customers. If a good working relationship is established with reputable hauliers, they are more likely to put themselves out to ensure that a good service is provided.

SUMMARY

In this chapter, various organizational aspects of logistics and distribution have been considered. The first section concentrated on the relationship with other corporate functions and concluded that there is a need to include the planning of logistics and distribution within the overall corporate/business plan, and that this should be reflected in the upper echelons of the organizational structure of a company.

The next section discussed the basic organizational structures that are used in logistics. These included:

- traditional structure;
- functional structure;
- mission management;
- matrix management.

The need to reflect the development of process-driven operations by adopting cross-functional organizational structures was emphasized.

The role of the logistics and distribution manager was assessed with regard to his or her input into the planning process and with respect to his or her operational role.

The different types of distribution staff payment and incentive schemes were outlined. The applicability and relevance of these various schemes to distribution and logistics were discussed — especially regarding drivers and warehouse staff. The implications for staff of financial incentives and the degree of supervision required for the range of schemes were noted.

Finally, some key points were raised concerning the selection of temporary staff and assets.

10

Manufacturing and materials management

INTRODUCTION

As noted earlier, materials management is an important and integral part of logistics management. This chapter aims to give the reader an overview of some of the most common forms of manufacturing planning and control techniques. It is not intended to examine these systems in great depth but rather to explain the basic principles of the various approaches and explain some of the terminology.

The following approaches will be covered:

- just-in-time;
- manufacturing resource planning (MRPII), incorporating material requirements planning (MRP);
- flexible fulfilment or, as it has come to be known, postponement.

Before we look at these planning and control systems in detail, it is worth explaining a few terms that are often used when production scheduling and control systems are discussed.

Push and pull systems

A 'push' system of manufacturing is one where goods are produced against the expectation of demand. In other words, goods are not produced specifically to order but are produced against a forecast demand. Demand forecasting has to be carried out where raw material suppliers' lead times for delivery have to be considered. If there is a one-month lead time for a given raw material then it will be necessary to estimate what the level of production will be in one month's time to satisfy forecast demand for the product. These forecasts are usually based on historical sales information. The difficulty arises when either there is a higher level of demand than expected and sales are lost, or there is a lower level of demand and finished product stocks grow too large. Lost revenue from missed sales opportunities is the result on the one hand, and higher inventory carrying costs or product obsolescence costs are the result on the other. MRPII (incorporating MRP) is a 'push' system.

A 'pull' system of manufacturing is one where goods are only produced against known customer orders. This is because only actual orders from customers are being produced on the production line. None of the goods are being made to keep as finished product stocks that may be sold at a later date. Therefore firm customer orders are 'pulling' all the materials through the process from the material suppliers and culminating in the delivery to the final customer. Just-in-time is a ' pull' system.

Dependent and independent demand

Dependent demand is created by the demand for the constituent parts of the finished product. In other words, because it is planned to make a given finished product, this decision triggers the demand for all the constituent parts of that product. In this situation there is no uncertainty and activities may be planned accordingly. Therefore, when the production scheduling activity is taking place, the quantity and required delivery dates of the constituent parts are known to the schedulers.

Independent demand is quite the opposite. In this situation the schedulers do not have a clear view of customer demand and are therefore forced to forecast demand in the best way they can. The demand for spare parts for products sold in the past is a good example of this type of demand. This is a very difficult situation, which is full of uncertainty. The schedulers must try to ensure goods and services are available when the customers require them. Almost by definition in this situation there will always be a state of imbalance between supplies of the goods and services and the demand for those same goods and services.

Cellular manufacturing

The use of work cells is frequently used in lean manufacturing environments. A work cell is more than a single machine location but smaller than a manufacturing department. A small group of workers are brought together in one part of the factory to produce a certain product or range of products. In their cell they will have all the machines, resources and materials available to produce these products. Production workers in the cell produce the product in a mini production line ideally passing the product progressively from one worker to the next. This system speeds up processing time, while quality, co-ordination, communication and teamwork between workers are all improved by this technique. The travel distance and travel time in the factory are also reduced by this system of cellular working.

JUST-IN-TIME

'JIT aims to meet demand instantaneously, with perfect quality and no waste' (Bicheno, 1991). Strictly speaking, this is not so much a clearly defined system of materials management but more a set of management philosophies that work together to create the desired effect.

This approach was first developed in Japan by Toyota, the automobile manufacturer, in the 1970s. In its early days it was known as the 'Toyota manufacturing system' or 'Toyoterism'. The label 'just-in-time' was applied later.

One of the central ideas of this system is the elimination of waste ('muda' in Japanese) from the manufacturing process. In this context, 'waste' does not refer simply to reworking or scrapping sub-standard products. Waste within the just-in-time environment means waste in all its manifestations. It seeks to reduce what is known as 'the seven wastes':

1. overproduction;
2. waiting;
3. transporting;
4. inappropriate processing;
5. unnecessary inventory;
6. unnecessary motions;
7. defects.

Elimination of wasted time

Because only customers' orders are being produced and the speed of the production process is known, it is possible to synchronize deliveries of raw materials to the end of the production line (or to the precise point on the production line in some cases) with little time to spare before use. The whole purpose of this exercise is to reduce the working capital used in the overall manufacturing system. In turn this produces a better return on capital employed. The other benefits are that there is little or no requirement for factory space to be used for storage and a reduced requirement for labour to manage the stock. This is the origin of the name 'just-in-time'.

Movement through the manufacturing process

If materials move through the system in a straight line it is reasonable to suppose that the minimum distance has been covered. In many manufacturing systems this is not always possible. In fact it has been identified in some manufacturing processes that components and sub-assemblies are moved around the factory in a very erratic pattern before they all come together in the finished product. Attempting to minimize the overall distance that materials have to travel through the system helps avoid wasted travelling time and effort.

Kanban

The word 'Kanban' (the signal) refers to a system of cards (other methods such as marked squares on the floor or balls are used in some cases), which is used to organize the progress of materials through the manufacturing process. It may be easier to understand the system if squares marked on the floor of the factory are imagined. The squares contain work-in-progress required by the next step in the manufacturing process. The squares become empty as the materials are used. The next batch of materials may only move into a square when the square is empty. This approach is replicated as materials move progressively from one step to the next. Thus no build-up of goods occurs, and materials move through the system in an orderly fashion.

The problem is that goods will have to move through the system at the speed of the slowest element in the chain. However, large online work-in-progress stocks will be eliminated. This too contributes to the reduction of working capital being used by the system.

Right first time

Quality problems in the form of scrapped or reworked products are waste of the first order. The Japanese developed several strategies to counter this problem. In one case they built their factory with no area to store scrap on the principle that having an area for scrap encouraged its production. Quality circles were created, where workers were allocated time specifically given over to discussing quality issues and their elimination, the target being zero defects. The philosophy of Kai zen, or continuous improvement, was engendered as a working culture in these organizations with support at the very top. Systems of quality management such as total quality management (TQM) and ISO 9000 seek to achieve the same ends.

The causes of scrapped or reworked production may not originate in the factory itself and may be caused by sub-standard raw materials being supplied to the process. Increasingly, suppliers' performance is critically appraised and measured in defective parts per million or in some other way. Working in a positive environment with suppliers to eliminate problems quickly is the preferred approach. Involving suppliers in new product development helps eliminate potential problems before they are translated into the production process.

Many companies have now adopted Six Sigma as a formal process improvement technique. Literally, this aims to control a process to the point of ± six sigma (ie standard deviations), which equates to 3.4 defects per million. The processes in this technique normally consist of DMAIC (define, measure, analyse, improve and control).

Finished product stocks

These stocks only contain goods produced to a specific customer order. This too contributes to a reduction in working capital.

Because of the needs of brevity it has only been possible to skim the surface of the JIT philosophy. Subjects such as the reduction of set-up and changeover times, team working and empowerment, total productive maintenance, levelled production schedules and many more are arguably no less important.

MANUFACTURING RESOURCE PLANNING (MRPII)

Although MRP pre-dates MRPII, it is easier to see MRP in the context of MRPII rather than the other way round.

As the name implies, manufacturing resource planning deals with more than simply production scheduling. Whilst the basic material requirements planning system is incorporated into MRPII, the wider system brings other activities into the picture. The objective is to harmonize and control more of the activities within the production plant. Areas outside an MRP system but included in an MRPII system usually are:

- maintenance management;
- cost accounting;
- stock management;
- sales orders;
- procurement;
- personnel levels.

MRPII requires considerable computing power to operate because of the inclusion of virtually all the activities within a production plant. Implementation of such a sophisticated computer-based system is an enormous task and should not be undertaken lightly.

MATERIAL REQUIREMENTS PLANNING (MRP)

This principle of production scheduling is based on the premise that if one knows what product needs to be produced then one should also know how many constituent parts are required in order to make the product. A useful analogy is the preparation of a meal. Let us say that the meal in question is a traditional cooked breakfast. Depending on taste you may choose two rashers of bacon, a fried egg, some mushrooms, tomatoes and toast. Whilst describing the contents of the breakfast, we have also prepared a list of the constituent parts. If we needed more than one single breakfast then we would simply multiply the quantities of ingredients by the number of breakfasts required. We now have our 'bill of requirements'. This would allow us to go shopping for the ingredients and also allow us to purchase accurately only the ingredients required to avoid wastage through having too many ingredients or disappointment through not having enough ingredients to meet the demand. The success of this system relies on us knowing how many breakfasts are required and how many diners actually turn up for the meal. In other words, success relies on matching the forecast with actual demand.

If we were building a complex piece of machinery rather than our meal then we could apply the same principles. The numbers of different machines could be broken down into the numbers of sub-assemblies required, which in turn could be further broken down into components. Orders could be placed with suppliers for the required quantities and delivery times agreed. These orders would be made in the light of any existing stock of parts already available for use. This sounds very simple but in practice is an enormously complicated process. It usually requires the assistance of a computer package because of the number of transactions required in a short space of time for the schedule to be of any use. In fact the whole system was developed as computer software for scheduling production.

The situation is further complicated when orders are cancelled at short notice or increased without warning. The adjustments will need to be made quickly to avoid failing to meet customer requirements or conversely being left with an excessive amount of component stock.

THE MRP SYSTEM

The following is a simple explanation of the basic structure of an MRP system.

The master production schedule (MPS)

The MPS is a list of all the products or services to be supplied within a specific period of time. This period of time must be sufficiently long to allow for the ordering and delivery of required sub-assemblies and parts, as well as allowing sufficient time for manufacturing the product in question. The schedule may be made up of forecast demand and actual known demand, ie customers' orders. It also lists all the required outputs from the system and when the goods and services are required through the use of a 'due date'. Therefore the contents of the schedule will dictate the contents of the bill of requirements.

The bill of requirements

This is also referred to as the bill of materials (BOM). As explained earlier, this will list all the sub-assemblies, components and parts required in total to produce all the goods listed in the master schedule. It will also show the different levels at which these constituent parts are put together in order to produce the finished goods.

For example, the finished product may contain two sub-assemblies that together complete the product (see Figure 10.1). The finished product is said to be at level O. These assemblies will be numbered sub-assembly 1 and sub-assembly 2. Together these sub-assemblies are said to be at level 1. Both sub-assemblies are made up of one component and one further sub-assembly each. This level is described as

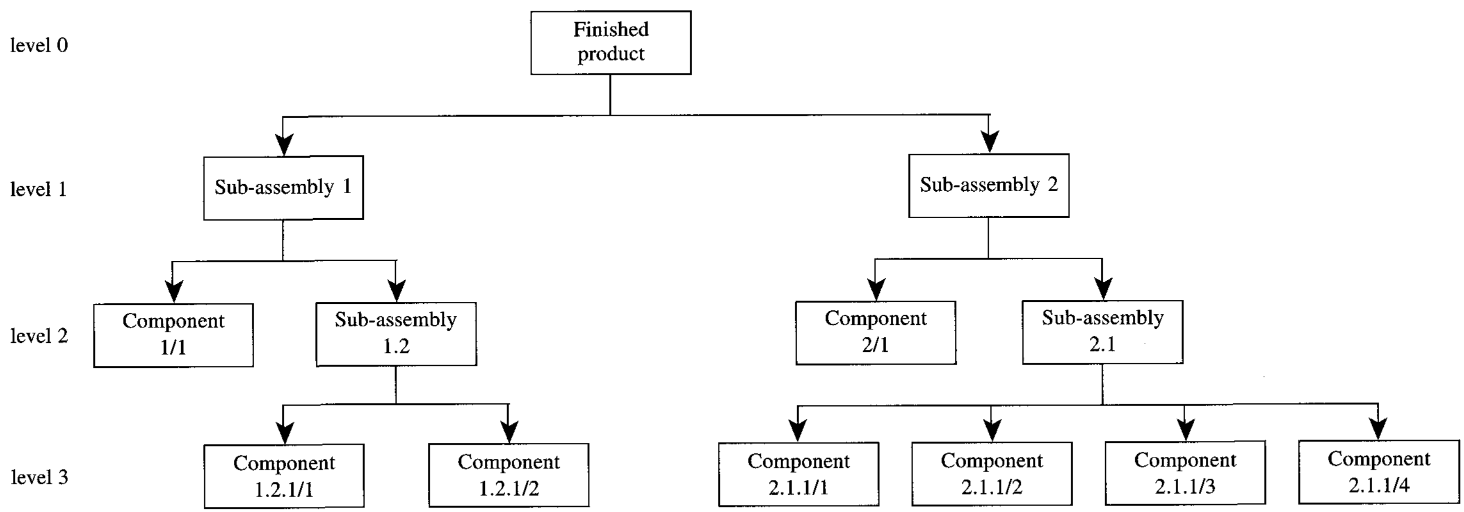


Figure 10.1 A bill of requirements for one product

level 2. Owing to the fact that the two major sub-assemblies at level 1 themselves contain one further sub-assembly each at level 2 then a further level is created at level 3. At level 3 it can be seen that one of the sub-assemblies at level 2 contains two components and the other contains four components.

This process (sometimes referred to as netting) is continued until all the constituent parts are broken down and listed at different levels. It can be quickly seen that, if the bill of requirements for each product is viewed from the opposite direction to the finished product, ie the highest-level number first, then one is looking at a sequence for assembly. The components are put together to form sub -assemblies, which in turn are put together to form the finished product.

This bill of requirements, having detailed all the required parts and sub-assemblies, will allow the MRP program to create the required orders to be placed with suppliers. One important thing to remember is that it also lists in detail the order and timing when these parts are required.

Noting the level of detail in the bill of requirements for just one product described above, it may be easier to understand the level of complexity involved in scheduling many different products that may contain many more components. It will also underline the complexity involved in changing the master schedule due to cancellations or additional orders. For anything more than a very basic schedule, a customized computer program will be required to deal with the large number of transactions required to effect the most straightforward of changes to the schedule.

Opening stock

The master schedule and the bill of requirements together form the framework of what is required and when it is required, but two other factors must be fed into the computer program at the same time. The first of these will be the current level of unallocated stocks of parts, components and sub-assemblies available for immediate use. There will be in total larger stocks on hand but these will already have been allocated to production via the system and are therefore unavailable. This information will, of course, modify any orders for raw materials placed on suppliers.

Opening capacity

The final fundamental factor required by the MRP program is the current level of available unallocated production capacity for not only the finished product but any components or sub-assemblies that are manufactured in-house.

All of the above information - the master schedule, the bill of requirements, the opening stock and the opening capacity - will be fed into the MRP computer program. The program will then produce as required the following:

- a list of purchase requirements, which will list what needs to be purchased and when;
- a manufacturing schedule, which will list what will be made and when it will be made;
- the closing stock of parts, components and sub-assemblies after the master schedule has been completed;
- the closing capacity available after the master schedule has been completed;
- a list of anticipated shortfalls in production - these may be due to shortages of parts or capacity.

The whole MRP process is iterative and therefore must be repeated periodically. This may be done on what is known as a 'regenerative' basis or a 'net change' basis.

The 'regenerative' basis involves assuming that no previous MRP calculation has taken place. Therefore known or forecast demand is used to create a new bill of requirements, with available parts of stock and available production capacity being allocated disregarding any previous calculations. For the purposes of this approach, all parts and capacity are assumed to be unallocated, as existing orders and work-in-progress will be covered by the new master schedule. This approach tends to be used where demand and therefore output are fairly consistent. This method also has the advantage of not perpetuating any previous computation errors as each new calculation starts from fresh current data.

The 'net change' approach concentrates on changing only those parts of the production plan that have changed rather than recalculating the whole plan. Thus, if changes are made to the master schedule then only those parts of the plan that are affected will be changed. This method tends to be used more in situations where demand is more volatile and so changes are more frequently needed.

FLEXIBLE FULFILMENT (POSTPONEMENT)

Flexible fulfilment is a method of manufacturing that attempts to delay the final definition of a product to the last possible stage in the supply chain - hence the popular description of 'postponement' for this system.

The advantages gained from this method can be dramatic, especially where companies trade on a global scale. Consider the problems raised by the different voltages available around the world for the use of portable electrical goods. If the manufacturer supplies goods around the globe, then stocks of finished products might have to be kept for each different type of power supply, very likely in or close to the particular market in question. This will increase inventory carrying and, especially in the electronics business, the possibility of product obsolescence. However, if it were possible to have a number of different power supply packs that all fitted the same product then it would be necessary to have only one 'global' product, which could be quickly adapted by changing the power module alone to suit the market concerned. This would mean that there would no longer be country- or market-specific products, and products could be transported and sold anywhere in the world at short notice.

This method has considerable implications for product design in that products need to be designed so that any variations dictated by markets can be adapted by changing modules only. Different keyboards for laptop computers are required to allow for the different alphabets to be found around the world. Manufacturing a laptop with a keyboard that is not easily substituted for another creates large inventories of language- or alphabet-specific stocks ha those countries. Postponement means that the bulk of the laptop is produced and shipped around the world, but the final definition of the product only takes place when the alphabet-specific keyboard is attached.

Other examples of postponement can be seen when promotions of a product such as 'Buy product A and get product B free' occur. The attachment of product A to product B creates a third product, C. This product can be produced by wrapping the two products, A and B, together in some form of outer. This operation can be undertaken in the distribution centre prior to final delivery, which will avoid the necessity of forecasting and shipping stocks from further up the supply chain. The product C could almost be made to order via the wrapping process. If the promotion goes well then only increased levels of products A and B need be shipped.

THE EFFECTS ON DISTRIBUTION ACTIVITIES

These developments in manufacturing planning and control systems have had a significant impact in the management of traditional distribution activities. In the case of flexible fulfilment, where final modifications to products are taking place in distribution centres, this has caused traditional distribution managers and companies to redefine their role and approach. Distribution companies have had to start offering these services as part of their portfolio of services. Distribution managers have had to create the working environment for these activities to take place as well as providing a suitably trained workforce to deal with the new requirements.

The effects on distribution systems of just-in-time (JIT) deliveries have led to more frequent deliveries of smaller quantities to stringent delivery timetables. This has had effects on vehicle fleets and scheduling as well as developments in linked information systems between manufacturer, supplier and transport provider. Without these developments, JIT would be virtually impossible.

Distribution requirements planning (DRP) systems were developed as a logical extension of MRP systems. The principles have simply been extended into a forward distribution planning system.

SUMMARY

This chapter has provided an overview of materials management in the production area as a part of supply chain management. Explanations of the following were included:

- push and pull systems;
- cellular manufacturing;
- dependent and independent demand;
- the philosophy of just-in-time, including a description of the 'seven wastes', Kanban, and a 'right first time' approach to quality management;
- manufacturing resource planning (MRPII) and material requirements planning (MRP);
- flexible fulfilment, which has come to be known as postponement.

Finally, the effects of these manufacturing planning and control systems on distribution activities were briefly discussed.

Part 3

Procurement and inventory decisions

11

Basic inventory planning and management

INTRODUCTION

Decisions regarding the amount of inventory that a company should hold and its location within a company's logistics network are crucial in order to meet customer service requirements and expectations. But there is, potentially, a large cost associated with holding inventory. It is vital to get the balance of cost and service right. This chapter sets out to explore the basic concepts behind the inventory holding decision.

In the first part of the chapter, the main reasons for holding stocks are considered. The many different types of inventory are then described. These include raw material stocks through the supply chain to finished goods stocks. The implications of inventory holding policy on other logistics functions are highlighted, with particular emphasis on the need to provide the balance between cost and service that was indicated above. The need to avoid the sub-optimization of logistics resources is also discussed.

The two main inventory replenishment systems are described. These are the periodic review and the fixed point reorder systems. Also outlined are the impacts that end-user demand changes have on requirements further up the supply chain. The means of identifying reorder quantities using the EOQ method is described, and it will be noted that it is important to take other factors into account when determining order quantities in this way.

Two methods of demand forecasting are discussed, moving average and exponential smoothing. It will also be shown that demand can be broken down into trend, seasonal and random factors.

THE NEED TO HOLD STOCKS

There are a number of reasons why a company might choose or need to hold stocks of different products. In planning any distribution system, it is essential to be aware of these reasons, and to be sure that the consequences are adequate but not excessively high stock levels. The most important reason for holding stock is to provide a buffer between supply and demand. This is because it is almost impossible to synchronize or balance the precise requirements of demand with the vagaries of supply. These and other important reasons are summarized, as follows:

- *To keep down productions costs.* Often it is costly to set up machines, so production runs need to be as long as possible to achieve low unit costs. It is essential, however, to balance these costs with the costs of holding stock.
- *To accommodate variations in demand.* The demand for a product is never wholly regular so it will vary in the short term, by season, etc. To avoid stock-outs, therefore, some level of safety stock must be held.
- *To take account of variable supply (lead) times.* Additional safety stock is held to cover any delivery delays from suppliers.
- *Buying costs.* There is an administrative cost associated with raising an order, and to minimize this cost it is necessary to hold additional inventory. It is essential to balance these elements of administration and stock-holding, and for this the economic order quantity (EOQ) is used.
- *To take advantage of quantity discounts.* Some products are offered at a cheaper unit cost if they are bought in bulk.
- *To account for seasonal fluctuations.* These may be for demand reasons whereby products are popular at peak times only. To cater for this whilst maintaining an even level of production, stocks need to be built up through the rest of the year. Supply variations may also occur because goods are produced only at a certain time of the year. This often applies to primary food production where, for example, large stocks result at harvest time.

- *To allow for price fluctuations/speculation.* The price of primary products can fluctuate for a variety of reasons, so some companies buy in large quantities to cater for this.
- *To help the production and distribution operations run more smoothly*. Here, stock is held to 'decouple' the two different activities.
- *To provide customers with immediate service.* It is essential in some highly competitive markets for companies to provide goods as soon as they are required (ex-stock).
- *To minimize production delays caused by lack of spare parts.* This is important not just for regular maintenance, but especially for breakdowns of expensive plant and machinery. Thus, spares are held to minimize plant shutdowns.
- *Work-in-progress.* This facilitates the production process by providing semi-finished stocks between different processes.

TYPES OF STOCK-HOLDING/INVENTORY

There are a number of different stock types that can be found in company supply chains. These are generally held at strategic positions throughout the company logistics network and in particular at the interfaces with suppliers or customers. The main categories are:

- *raw material, component and packaging stocks* – generally used to feed into a production or manufacturing process;
- *in-process stocks* – sometimes known as work-in-progress (WIP), these consist of part-finished stock that is built up between different manufacturing processes;
- *finished products* – stocks that are held at the end of the production line normally in a finished goods warehouse and sometimes known as finished goods inventory (FGI);
- *pipeline stocks* – probably the most common type of stock-holding, these are held in the distribution chain for eventual transfer to the final customer;
- *general stores* – containing a mixture of products used to support a given operation, for example a large manufacturing plant;
- *spare parts – a* special category because of the nature of the stock, which provides a crucial back-up to a manufacturer's machinery or plant where any breakdown might be critical, and also held by service and maintenance companies for supply to their customers to support service contracts. Service industries, such as utilities, hospitals and maintenance, repair and overhaul (MRO)

providers, invest in spare parts inventory to support their service offer. They have two main stock categories:

– consumables (nuts, bolts, etc);
– rotables and repairables (parts that require periodic maintenance or are repairable).

Within the above categories, stock can again be broken down into other major classifications:

- *Working stock*. This is likely to be the major element of stock within a distribution depot's stock-holding, and it should reflect the actual demand for the product.
- *Cycle stock*. This refers to the major production stock within a production warehouse, and it reflects the batch sizes or production run lengths of the manufacturing process. This flow of inward supply and outward demand for a product in a warehouse is often depicted as a classic 'saw-tooth' and is shown in Figure 11.1. The sharp rise in stock level represents the delivery of an order, and the steady decline in stock level represents the regular demand for the product over time (although this would in reality be more irregular than that depicted in the figure).

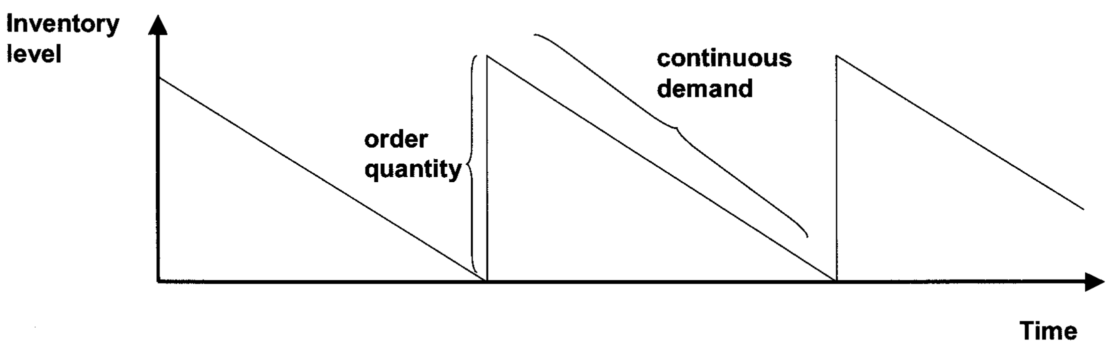


Figure 11.1 Inventory level showing input (order quantity) and output (continuous demand)

- *Safety stock*. This is the stock that is used to cover the unpredictable daily or weekly fluctuations in demand. It is sometimes known as 'buffer' stock, as it creates a buffer to take account of this unpredictability. This is depicted in Figure 11.2.

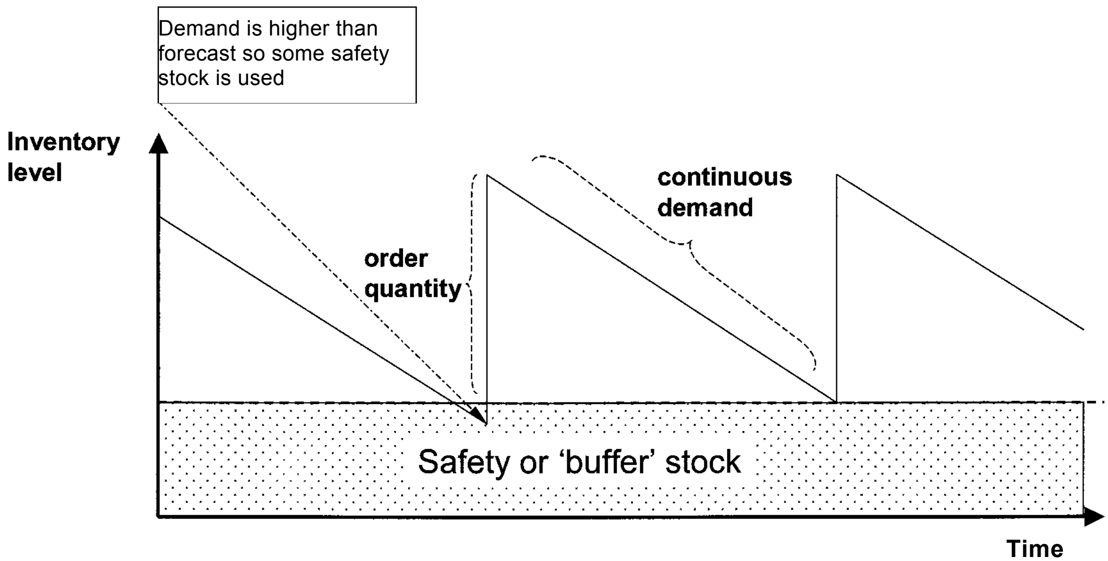


Figure 11.2 Inventory level with safety stock in place

- *Speculative stock*. This can be raw materials that are 'bought forward' for financial or supply reasons, or finished stock that is pre-planned to prepare for expected future increases in demand.
- *Seasonal stock*. This is product that is stockpiled to allow for expected large increases in demand. Typically, this would include inventory built up prior to the Christmas demand peak.

THE IMPLICATIONS FOR OTHER LOGISTICS FUNCTIONS

There are many ways in which the need to hold stock affects other logistics functions and vice versa. It is essential for effective planning that the various costs associated with inventory are minimized in relation to other logistics costs. As already discussed in previous chapters, it requires a process of balance between these functions to avoid any sub-optimization and to create a cost-effective total solution. With this in mind, it is useful to review those areas where this balance may be needed.

The *number of distribution centres* (DCs) in a distribution system significantly affects the overall cost of that system. The reasons given for having a large number of DCs are generally the perceived need to have a 'local presence' within a market and the need to provide a given level of service to customers. A distribution system that does have many sites will require high stock levels, specifically with respect to the amount of safety stock held. In addition, a large number of sites is likely to mean fairly small delivery areas, reflecting poor stock turn and higher unit costs in the warehouse.

Many companies have, in recent years, undertaken DC rationalization exercises whereby they have cut significantly the number of sites within their distribution network. This particularly applies to retail and to manufacturing companies. Although this leads to an increase in local transport costs because delivery distances are greater, there are large savings to be made in inventory reduction – specifically in safety stock reduction.

A simple rule of thumb exists for estimating these savings, known as the 'square root law' (Sussams, 1986). Basically, the law states that the total safety stock-holding in a distribution system is proportional to the square root of the number of depot locations. The law thus gives a broad indication of prospective inventory savings from any DC reduction project. For example, a site reduction from, say, 10 to 5 can lead to inventory savings of 29 per cent, as indicated in the following calculation:

$$\text{Inventory reduction} = 1 - \left\{ \frac{\sqrt{5}}{\sqrt{10}} \right.$$

$$= 1 - \left\{ \frac{2.24}{3.16} \right. \times 100$$

$$= 29\%$$

Another major factor to be considered is the effect that an excess of inventory can have on *the size and operation of a DC*. This might be for a number of reasons, such as obsolete stock, dead stock, unnecessary storage of slow-moving lines, etc. This may mean that a DC is larger than necessary, that extra outside storage is required or that the site operation is hindered through a shortage of working space.

One means of tackling these problems is to be more aware of the range of products held. This can be achieved by using Pareto analysis (or ABC analysis). Pareto's law provides the '80/20 rule', which states that there is an 80/20 relationship for products in many conditions. For example, it is often found that approximately 20 per cent of storage lines represent 80 per cent of the throughput in a warehouse. See Chapter 7 for a more detailed discussion of this.

Using Pareto analysis, it is possible to categorize product lines on the basis of:

'A' lines = fast movers (20 per cent)
'B' lines = medium movers (30 per cent)
'C' lines = slow movers (C+D 50 per cent)
'D' lines = obsolete/dead stock

Policy decisions can then be made, for example: 'A' lines should be held at all DCs and have a 98 per cent availability; 'B' lines should be held at all DCs but only at 90 per cent availability; 'C' lines should be held only at a limited number of DCs and at 85 per cent availability; and 'D' lines should be scrapped.

Clearly this policy will differ according to product type, industry type, service level requirements, etc. The essential point is to be aware of the appropriate stock-holding costs and recover the costs accordingly.

There are several ways in which stock-holding policy and practice can affect *a transport operation*. One that has already been indicated concerns the number of DCs in a distribution system. Whereas inventory savings can be made by reducing site numbers, this will be associated with an increase in local delivery costs because delivery distance will increase as DC catchment areas become larger. It is generally true, however, that any increase in transport cost will be more than offset by inventory and warehouse cost savings.

One other area where inventory policy can influence transport is in the provision of backloads for return journeys by primary (line-haul) vehicles and sometimes by delivery vehicles. Empty return journeys are a recognized cost that transport managers are always keen to minimize. It may be possible to arrange for raw materials or bought-in goods to be collected by own vehicles rather than delivered by a supplier's vehicles.

A company's stock-holding policy may also affect *the distribution structure* that the company adopts. There are three main patterns:

1. direct systems;
2. echelon systems; and
3. mixed or flexible systems.

Direct systems have a centralized inventory from which customers are supplied directly. These direct systems are of two main types — either supplying full vehicle loads, or specialist services such as mail order.

Echelon systems involve the flow of products through a series of locations from the point of origin to the final destination. The essential point is that inventory is stored at several points in the distribution chain. There may be several links or levels within these structures, perhaps from production warehouses through a central stock-holding point to regional and/or local DCs. Typical examples include some of the manufacturers of FMCG products.

Mixed systems are the most common. They link together the direct and the echelon systems for different products, the key element being the demand characteristics of these products (order size, fast-/slow-moving, substitutability, etc).

INVENTORY COSTS

Inventory costs are one of the major logistics costs for a large number of manufacturing and retail companies, and they can represent a significant element of the total cost of logistics. As has been discussed in several previous chapters, there are many major cost trade-offs that can be made with all the other key logistics components. It is important to be able to understand what the key cost relationships are within a company. To do this, an awareness of the major elements of inventory cost is essential.

There are four principal elements of inventory *holding cost*. They are:

1. *Capital cost:* the cost of the physical stock. This is the financing charge that is the current cost of capital to a company or the opportunity cost of tying up capital that might otherwise be producing a better return if invested elsewhere. This is almost always the largest of the different elements of inventory cost.
2. *Service cost:* the cost of stock management and insurance.
3. *Storage cost:* the cost of space, handling and associated warehousing costs involved with the actual storage of the product.
4. *Risk cost:* this occurs as a consequence of pilferage, deterioration of stock, damage and stock obsolescence. With the reduction in product life cycles and the fast rate of development and introduction of new products, this has become a very important aspect of inventory cost. It is one that is frequently underestimated by companies. It is particularly relevant to high-tech industries, the fashion industry, and fresh food and drink.

Another important cost that needs to be understood is the reorder or the set-up cost for an individual product. The *reorder cost* refers to the cost of actually placing an order with a company for the product in question. This cost applies regardless of the size of the order. It includes the cost of raising and communicating an order, as well as the costs of delivery and order receipt. The *set-up cost* refers to the additional cost that may be incurred if the goods are produced specifically for the company. Here, the larger the order, the longer the production run and the lower the production unit cost of the items in question. Of course, orders for large amounts of a product will result in the need for it to be stored somewhere - at a cost! This is yet another classic logistics trade-off decision that needs to be made. The means of assessing appropriate order quantities are discussed in the section ' The economic order quantity' in this chapter.

The final inventory-related cost is the *shortage cost* - the cost of not satisfying a customer's order. This cost is notoriously difficult to measure. It is used to try to reflect the penalty of not holding sufficient stock of a product, which may lead to lost profit due to lost sales, loss of future sales, loss of reputation and the cost of the urgent delivery of unsatisfied orders.

INVENTORY REPLENISHMENT SYSTEMS

The aim of an effective inventory replenishment system is to maintain a suitable balance between the cost of holding stock and the particular service requirement for customers. The need for this balance can be illustrated by considering the disadvantages of low stock levels (which should provide very low costs) and high stock levels (which should provide a very high service).

The disadvantages of *low stock levels* are that customers' orders cannot be immediately fulfilled, which may lead to the loss of both existing and future business, and that goods have to be ordered very frequently, which may lead to heavy ordering costs and heavy handling and delivery costs.

High stock levels have a major disadvantage because capital is tied up that might be better invested elsewhere. Also, there is the risk of product deterioration (eg food and drink) and of products becoming outdated, superseded or obsolete if they are stored for long periods of time (eg computers, mobile phones and fashion goods). A final disadvantage, previously discussed, is the expense of providing additional storage space.

Inventory replenishment systems are designed to minimize the effects of these high/low stock level disadvantages by identifying the most appropriate amount of inventory that should be held for the different products stocked. There is a variety of systems, but the two major ones are the periodic review (or fixed interval) system and the fixed point (or continuous) reorder system.

The *periodic review system* works on the premise that the stock level of the product is examined at regular intervals and, depending on the quantity in stock, a replenishment order is placed. The size of the order is selected to bring the stock

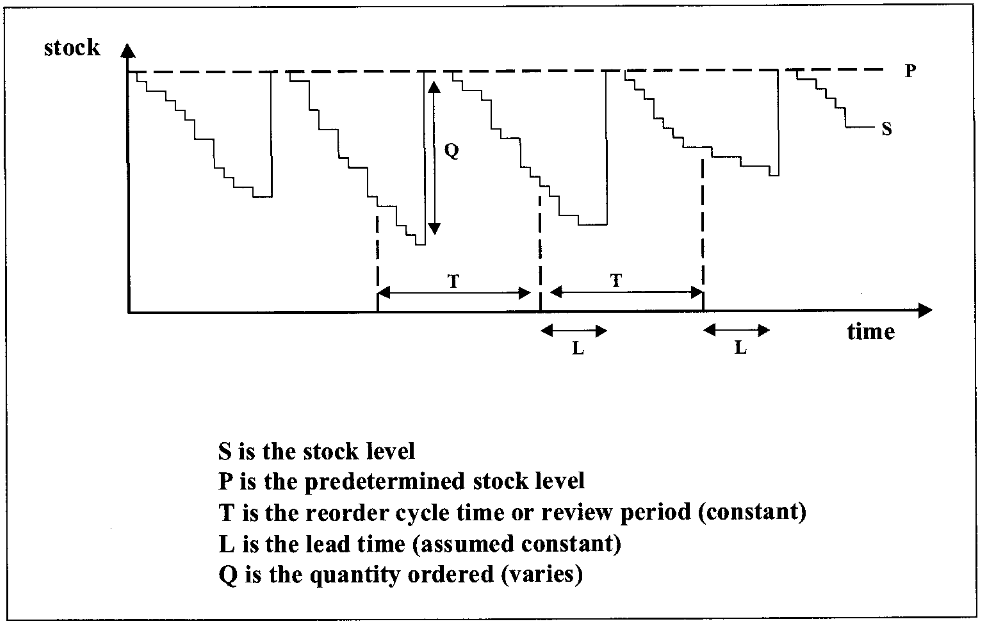


Figure 11.3 Periodic review

to a predetermined level. Thus, the order size will vary each time a new order is placed. The system is illustrated in Figure 11.3.

In Figure 11.3, the change in stock level can be seen by the pattern represented by the line S. T represents the reorder cycle time, which is the regular interval at which stock is reviewed — say at the beginning of every month. An order is placed at a quantity (Q) that will bring the inventory for this product back to the predetermined stock level (P). Note that the quantity ordered includes an allowance for the time it takes for the product to be delivered from the supplier (this is the lead time, L). With this method, the quantity ordered is different each time an order is placed.

For the *fixed point reorder system,* a specific stock level is determined, at which point a replenishment order will be placed. The same quantity of the product is reordered when that stock level is reached. Thus, for this system it is the time when the order is placed that varies. This is illustrated in Figure 11.4.

In Figure 11.4, the change in stock level can be seen by the pattern represented by the line S. When the stock level reaches the fixed point reorder level (B), a replenishment order is placed. This is for a fixed order quantity (Q). L represents the lead time for the order, and the figure shows that when the order arrives the

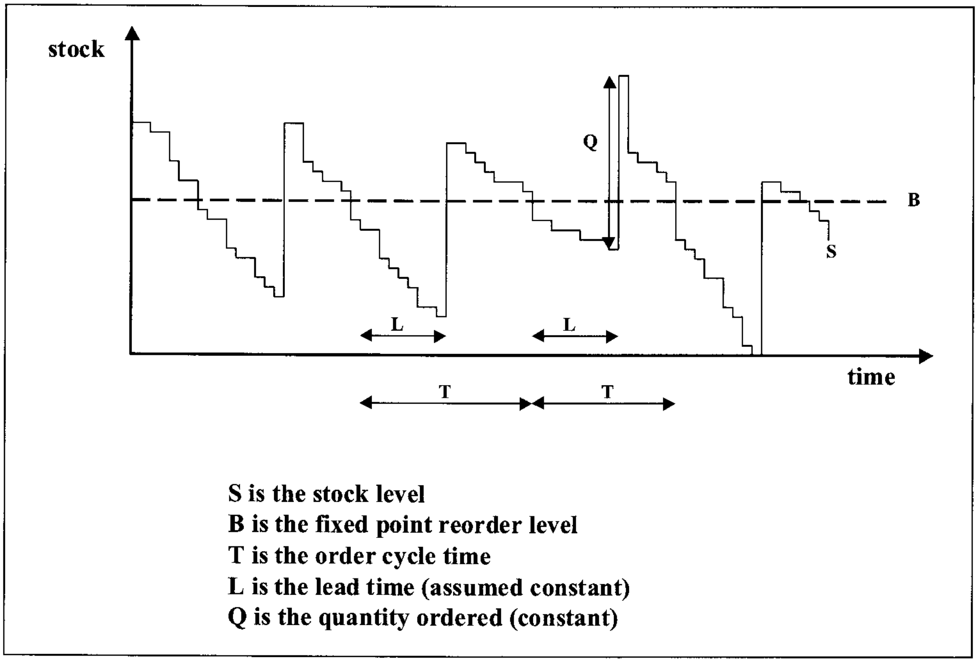


Figure 11.4 Fixed point reorder system

stock level is increased by the set quantity that has been ordered. T represents the time period between orders, the length of which varies from one cycle to another for this system.

These systems, and variations of them, have been used for many years. Apart from the vagaries of lead time reliability they generally work quite well. They do have one significant drawback, however, which is that they can create unnecessarily high or low stock levels, especially when demand occurs in discrete chunks. This applies, in particular, to multi-echelon distribution systems where the demand at each level is aggregated at the next level up the supply chain. Thus, small changes in demand for finished products are amplified as they move back through the supply chain. This is because each part of the chain is acting independently of the others. The result is a surge in demand up the supply chain as each inventory location individually adjusts to the demand increases. This is known as the 'bull whip' or Forrester effect. It is illustrated in Figure 11.5.

An example of this might occur where an unexpectedly hot day causes an increase in demand for cold soft drinks. This will lead to additional orders from a variety of outlets — supermarkets, pubs, corner shops, vending machines, etc.

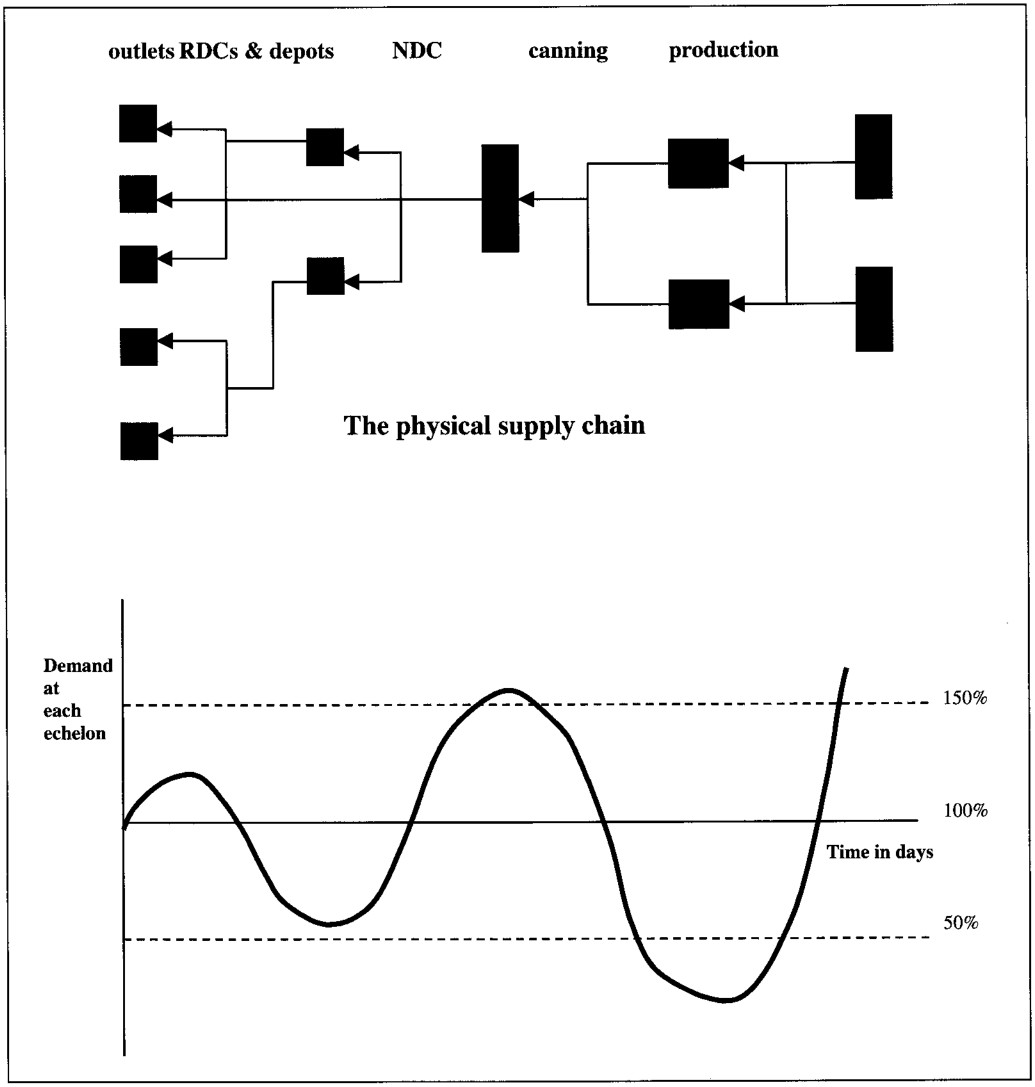


Figure 11.5 The 'bull whip' or Forrester effect

As these requirements move up the supply chain through the different channels of distribution, they will be converted into additional orders of various sizes and at different order frequencies. They might be for weekly mixed pallet loads from cash-and-carry outlets, twice-weekly full pallet loads from grocery regional DCs and daily vehicle loads for manufacturers' national DCs. The consequence at the canning factory and point of production for the drink will be for a massive increase in demand for the product and a very confusing picture of what the true requirements are. This is echoed back into raw material and packaging supply.

Thus, it can be very difficult to forecast demand based only on the immediate next or lower level of demand. Accurate forecasts need to reflect the requirements at all levels, which is often very difficult because companies have traditionally been loath to share information with their suppliers. This is one of the reasons for the move towards more open information systems that provide a clearer vision of stock-holding and demand throughout the supply chain. These are discussed in Chapter 12.

THE ECONOMIC ORDER QUANTITY

The two reorder systems described in the previous section require either fixed or variable quantities of different products to be ordered. The next question that needs to be addressed is how much product should be reordered. To answer this question is not easy, and there are many different views as to the best means of arriving at an answer. The traditional method of calculating the appropriate quantity is known as the economic order quantity (EOQ) method.

The EOQ method is an attempt to estimate the best order quantity by balancing the conflicting costs of holding stock and of placing replenishment orders. This is illustrated in Figure 11.6.

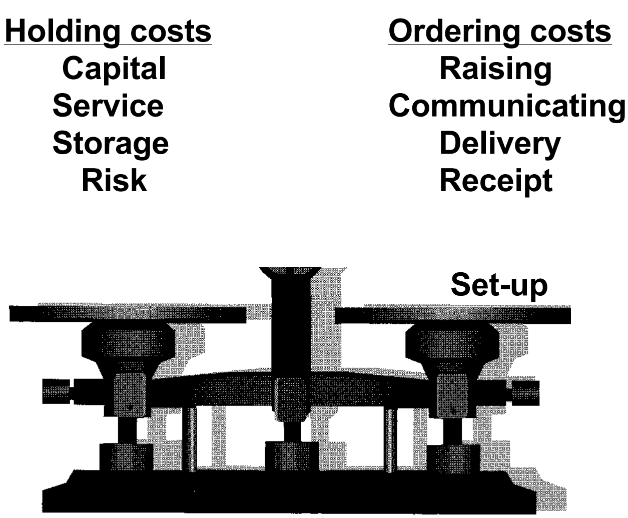


Figure 11.6 The EOQ balance

The effect of order quantity on stock-holding costs is that, the larger the order quantity for a given item, the longer will be the average time in stock and the greater will be the storage costs. On the other hand, the placing of a large number of small-quantity orders produces a low average stock, but a much higher cost in terms of the number of orders that need to be placed and the associated administration and delivery costs. These two different effects are illustrated in Figure 11.7. The large order quantity gives a much higher average stock level (Q1) than the small order quantity (Q2). The small order quantity necessitates many more orders being placed than with the large order quantity.

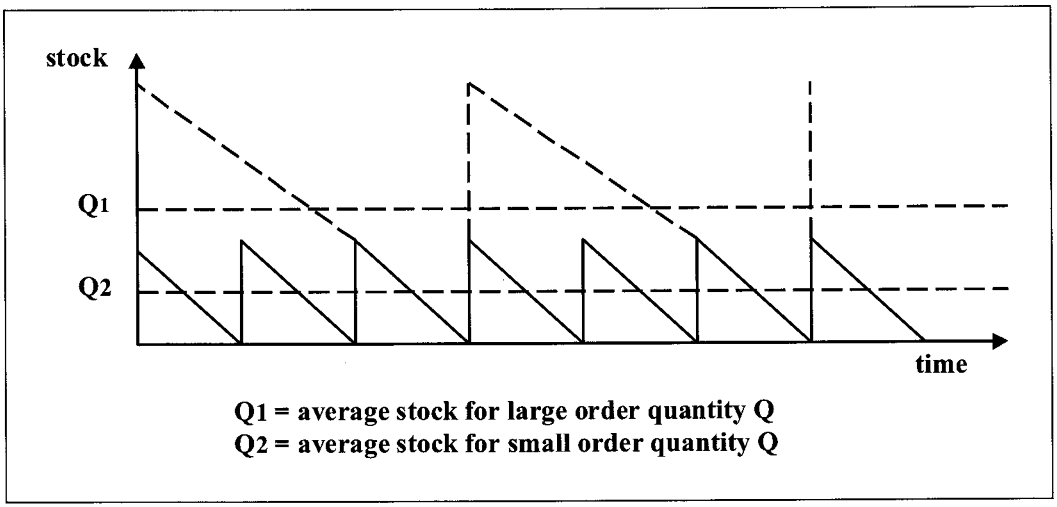


Figure 11.7 Reorder quantities

The best approach is, once again, one of balance, and it is this balance that the EOQ method aims to provide. Figure 11.8 helps to illustrate how this balance is achieved between the cost of holding an item and the cost of its reordering. There is a specific quantity (or range of quantities) that gives the lowest total cost (Q_0 in the figure), and this is the economic order quantity for the product.

There is a simple formula that enables the EOQ to be calculated for individual stock keeping units (SKUs). This is shown in Figure 11.9, together with an example of how the formula can be applied. It should also be appreciated that the EOQ model is based on a number of assumptions that need to be taken into account

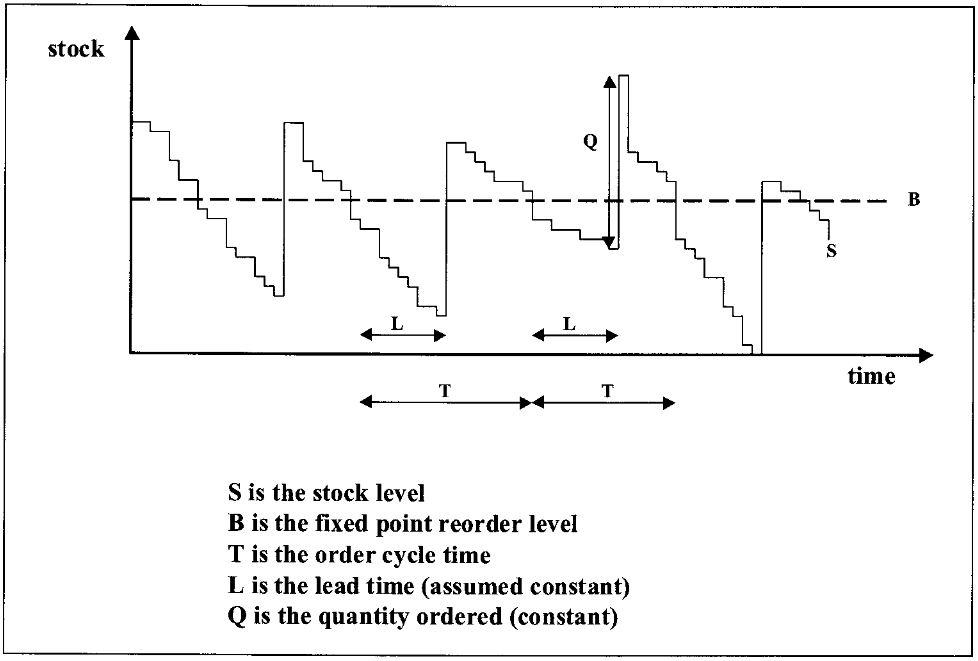


Figure 11.4 Fixed point reorder system

stock level is increased by the set quantity that has been ordered. T represents the time period between orders, the length of which varies from one cycle to another for this system.

These systems, and variations of them, have been used for many years. Apart from the vagaries of lead time reliability they generally work quite well. They do have one significant drawback, however, which is that they can create unnecessarily high or low stock levels, especially when demand occurs in discrete chunks. This applies, in particular, to multi-echelon distribution systems where the demand at each level is aggregated at the next level up the supply chain. Thus, small changes in demand for finished products are amplified as they move back through the supply chain. This is because each part of the chain is acting independently of the others. The result is a surge in demand up the supply chain as each inventory location individually adjusts to the demand increases. This is known as the 'bull whip' or Forrester effect. It is illustrated in Figure 11.5.

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Formula:

$$EOQ = \sqrt{\frac{2PD}{UF}}$$

P = Cost of placing an order
D = Annual demand in units
U = Cost of a unit of inventory
F = Annual stock-holding cost as a fraction of unit cost
UF = Cost of holding stock per unit per year

Example:

P = £75 = Cost of placing an order
D = 2,400 = Annual demand in units
U = £50 = Cost of a unit of inventory
F = 25% (1/4) = Annual stock-holding cost as a fraction of unit cost

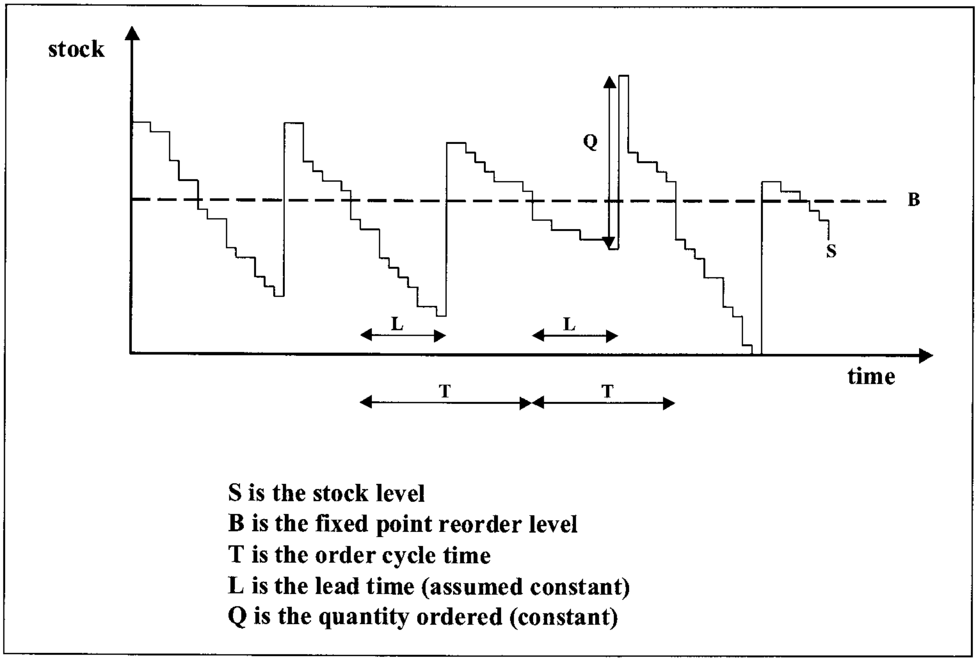
$$EOQ = \sqrt{\frac{2 \times 75 \times 2{,}400}{50 \times 0.25}}$$

$$EOQ = \sqrt{\frac{360{,}000}{12.5}}$$

EOQ = 170 units

Figure 11.9 The EOQ formula with worked example

- *New product lines*. These may be one-off items, or items that are expected to show a sharp increase in demand. There will be no historic data on which to base demand forecasts, so care must be taken to ensure that adequate stock levels are maintained.
- *Promotional lines*. National or local promotion (via TV, newspapers, special offers, etc) may suddenly create additional demand on a product, so stock levels must cater for this.
- *Test marketing*. This may apply to certain products, and may be for a given period of time or be in a given area only.
- *Basic lines*. Some companies feel that a certain number of their basic stock lines should always be available to the customer as a matter of marketing policy. To provide this service, higher stock levels must be maintained.
- *Range reviews*. A company may adopt a policy to rationalize, or slim down, its range of products – particularly if new lines are being introduced. To do this it may be necessary to reduce the reorder quantities for some products.



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These methods are used when historic demand data are very limited or for new products. They include brainstorming, scenario planning and Delphi studies.

- *Causal methods* - used where the demand for a product is dependent on a number of other factors. These factors maybe under the control of the company (promotions, price), under other control (competitors' plans, legislation) or external (seasonality, weather, the state of the economy). The main method used is regression analysis, where a line of 'best fit' is statistically derived to identify any correlation of the product demand with other key factors.
- *Projective methods* - these forecasting techniques use historic demand data to identify any trends in demand and project these into the future. They take no direct account of future events that may affect the level of demand. There are several different projective forecasting methods available, and it is important to select the most appropriate alternative for whatever demand is to be measured. Two of the most common methods of forecasting are described here. One of the most simple is the moving average, which takes an average of demand for a certain number of previous periods and uses this average as the forecast of demand for the next period. Another, more complicated, alternative is known as exponential smoothing. This gives recent weeks far more weighting in the forecast. Forecasting methods such as exponential smoothing give a much faster response to any change in demand trends than do methods such as the moving average. Figure 11.10 provides an example of these different approaches. The dotted line (C) represents actual demand, the dash-dot line (B) represents a forecast using the moving average method and the single line (A) represents a forecast using exponential smoothing. It can be seen that the single line (exponential smoothing) responds more quickly to the demand change than does the dash-dot line (moving average).

There are a number of ways in which the demand for a product can vary over time. These different elements of demand are illustrated in Figure 11.11. It can be seen from the graphs that the overall demand pattern can be divided into the following patterns:

- *A trend line* over several months or years. In the graph, the trend is upward until the end of year 4, and then downward.
- *A seasonal fluctuation.* This is roughly the same, year in, year out. In the graph, there is high demand in mid-year and low demand in the early part of the year.
- *Random fluctuations* that can occur at any time.

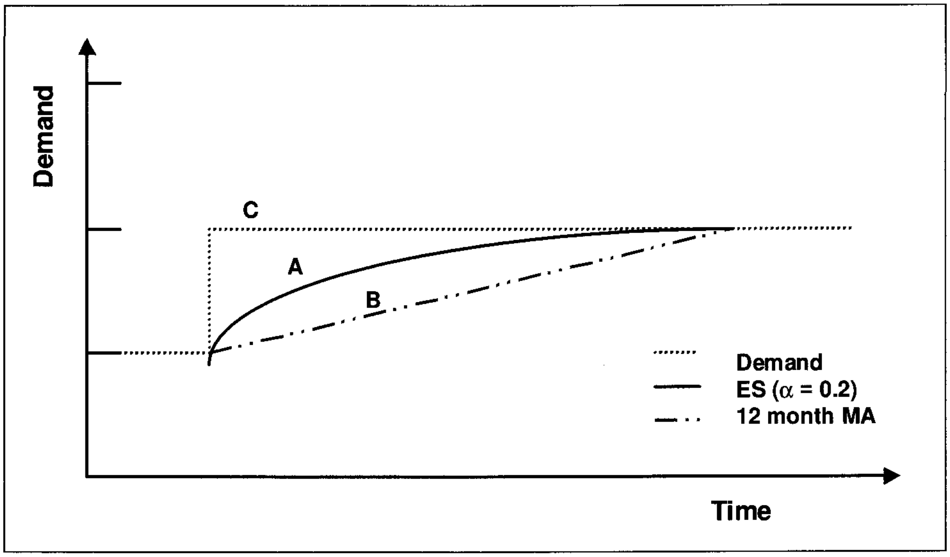


Figure 11.10 The moving average method (B) and the exponential smoothing method (A) of forecasting shown working in response to a step change in demand (C)

Each of these elements should be taken into account by a good stock control system:

- the trend, by a good forecasting system;
- seasonality, by making seasonal allowances;
- random, by providing sufficient buffer stock.

It is sensible to adopt a very methodical approach to demand forecasting. To achieve this, it is recommended that a number of key steps are used. These can be summarized as follows:

1. *Plan.* Ensure from the outset that there is a clear plan for identifying and using the most appropriate factors and methods of forecasting. Understand the key characteristics of the products in question and the data that are available. Consider the different quantitative and qualitative methods that can be used and select those that are relevant. If necessary and feasible, use a combination of different methods. Identify ways of double-checking that the eventual results are meaningful — it is unsafe merely to accept the results of a mechanical

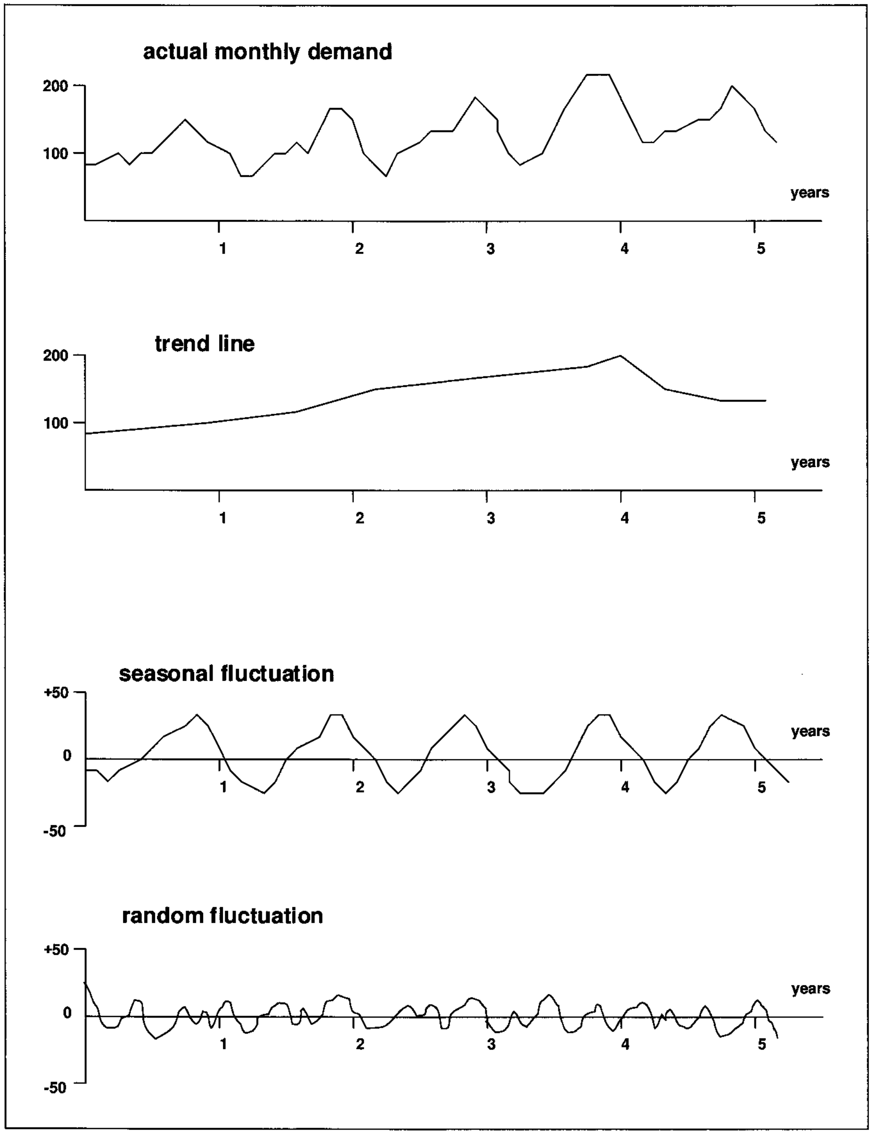


Figure 11.11 Elements of a demand pattern

analytical process. Forecasting at individual SKU level is a typical 'bottom-up' approach, so check results with suitable 'top-down' information.

2. *Check.* Take care to review the base data for accuracy and anomalies. Poor data that are analysed will produce poor and worthless results. Where necessary, ' clean' the data and take out any abnormalities.

3. *Categorize*. A typical range of company products can and do display very different characteristics. Thus, it is usually necessary to identify key differences at the outset and group products with similar characteristics together. It is likely to be valid to use different forecasting methods for these product groups. Use techniques such as Pareto analysis to help identify some of the major differences: high versus low demand, high versus low value, established products versus new products, etc.
4. *Metrics*. Use statistical techniques to aid the understanding of output and results (standard deviation, mean absolute deviation, etc). There may be a number of relevant issues that can impact on the interpretation of results: the size of the sample, the extent of the time periods available.
5. *Control*. Any forecasting system that is adopted needs to be carefully controlled and monitored because changes occur regularly: popular products go out of fashion and technical products become obsolete. Control should be by exception, with tracking systems incorporated to identify rogue products that do not fit the expected pattern of demand and to highlight any other major discrepancies and changes.

SUMMARY

This chapter has considered basic inventory planning and management, and a number of important factors have been outlined. In the first section, the reasons for holding stock were summarized. Following on from that, the main stock types were categorized as:

- raw materials, components and packaging;
- in-process stocks;
- finished products;
- pipeline stocks;
- general stores;
- spare parts.

A further breakdown of stock includes five major classifications:

1. working stock;
2. cycle stock;
3. safety stock;
4. speculative stock;
5. seasonal stock.

The implications of inventory holding policy on other logistics functions were highlighted, with particular emphasis on the need to provide a suitable balance between cost and service, and the need to avoid the sub-optimization of logistics resources.

The main inventory holding costs were introduced (capital, service, storage and risk), as well as other related costs, including those associated with placing an order, set-up costs for special production runs and shortage costs.

The two main inventory replenishment systems were explained - periodic review and fixed point reorder. The Forrester effect was described, demonstrating the impact on requirements further up the supply chain as end-user demand changes. The question of reorder quantity was then discussed and the EOQ method was outlined. The need to take other factors into account when determining order quantity was emphasized.

Several different approaches that can be used for forecasting were identified. These were judgemental, causal and projective. Two methods of projective demand forecasting were outlined, the moving average and exponential smoothing. It was shown that demand could be broken down into trend, seasonal and random factors. Finally, a five-step approach to demand forecasting was described.

12

Inventory and the supply chain

INTRODUCTION

In the previous chapter, the basic inventory planning and management techniques were described. This chapter provides a description of some of the more recent developments in inventory planning, particularly with respect to the way that inventory is viewed across the supply chain as a whole. In addition, the important relationship of inventory and time is discussed.

The chapter starts with a consideration of some of the problems associated with the traditional approaches to inventory planning. Inventory requirements are reviewed in relation to the different types of demand that can be found. The need for a company to hold inventory is explored with respect to the lead-time gap - the difference between the length of time it takes to complete an order and the amount of time a customer is prepared to wait for that order to be satisfied.

Different approaches to inventory reduction are considered, and some of the main methods of measuring inventory and its relationship with time are reviewed. Finally, various new approaches to inventory planning for both manufacturing and retailing are described.

PROBLEMS WITH TRADITIONAL APPROACHES TO INVENTORY PLANNING

Inventory planning has traditionally been applied in particular at the finished goods end of the supply chain. It is now an activity that is seen to have relevance for stock held at all stages within the supply chain. Companies are beginning to understand that the cost of excess or unnecessary stock held anywhere in their supply chain, whether they have direct responsibility for it or not, is still going to have an impact on their bottom-line costs. Thus, raw material and component stock-holding levels are seen to be relevant and to provide an opportunity for cost improvement. Some retailers have begun to ask their suppliers to take responsibility for the planning and management of the stock of products they supply.

Because of this changing approach to inventory responsibility, the traditional methods of inventory planning are now becoming less applicable for many companies. This applies to the economic order quantity (EOQ) concept that was discussed in the previous chapter. Although still a useful and valid tool in many circumstances, some of the main assumptions on which it is based are less realistic for companies that have adopted a more streamlined approach to their logistics and supply chain activities. For example:

- Demand is not as predictable as it may once have been.
- Lead times are not constant – they can vary for the same product at different order times.
- Costs can be variable. Order cost relationships have changed with the introduction of automatic and electronic data interchange (EDI) related ordering procedures.
- Production capacity can be at a premium; it may not always be feasible to supply a given product as and when required.
- Individual products are closely linked to others and need to be supplied with them, so that 'complete order fulfilment' is achieved.

Thus, the main assumptions that are the basis for the EOQ may not now hold true for a number of companies and their products. This can be linked to the introduction of continuous replenishment, which is now at the heart of many companies' supply policies. This means that orders are for much smaller quantities and are required much more frequently. The rules that once applied to inventory planning are undergoing a change. This is certainly true for many large companies, although the application of EOQ is still very relevant to many small and medium-sized enterprises.

DIFFERENT INVENTORY REQUIREMENTS

There are some important differences in the way inventory requirements are determined that are related to the type of demand for the products in question. The nature of this demand should have an influence on the approach adopted to manage the inventory. One important way of differentiating between demand types is that of dependent or independent demand. The type of demand will have an influence on the nature of the inventory management technique chosen.

Independent demand occurs where the demand for one particular product is not related to the demand for any other product. Consumer demand for a desktop computer is, for example, independent. Indeed, most consumer products are independent of the demand for other finished goods. This is an important distinction, because products with an independent demand necessitate the use of forecasting to help determine expected demand levels and associated inventory requirements. The EOQ approach is commonly used for products with independent demand.

Dependent demand occurs where the demand for a particular product is directly related to another product. In the case of the desktop computer, for example, the demand for the power leads or the connecting cables would be directly dependent on the number of computers stocked as finished goods. Dependent demand can be classified in two ways. It may be vertical, eg the chip actually required in the production of the computer, or it may be horizontal, eg the instructional manual that is packed with the computer as a finished product. Typically, most raw materials, components and sub-assemblies have their demand dependent on the demand for the finished product. Because of this dependence, there is a far more limited requirement for the forecasting of the demand for these elements, as the actual needs are directly related to the finished product requirements themselves. MRP and MRPII systems are used for these elements.

One feature that has become particularly relevant in recent years concerns the nature of the demand requirement. Is it a 'push' system or a 'pull' system? *A push system is* the more traditional approach where inventory replenishment is used to anticipate future demand requirements. *A pull system is* where the actual demand for a product is used to 'pull' the product through the system.

A push approach to inventory planning is usually based on a set plan that is predetermined according to certain rules of inventory reordering. This approach is a proactive one in the sense that it is planned on the basis of estimated, or fore-cast, demand for products from customers. The aim is to anticipate the extent and location of this demand and ensure that adequate stock is available in the right place at the right time. Typically, a push system is applicable for dependent demand and for cases where there are uncertainties in supply, source or production capacity limitations or the need to cater for seasonal demand. The EOQ method of inventory planning is based on the push approach. This was outlined in the previous chapter.

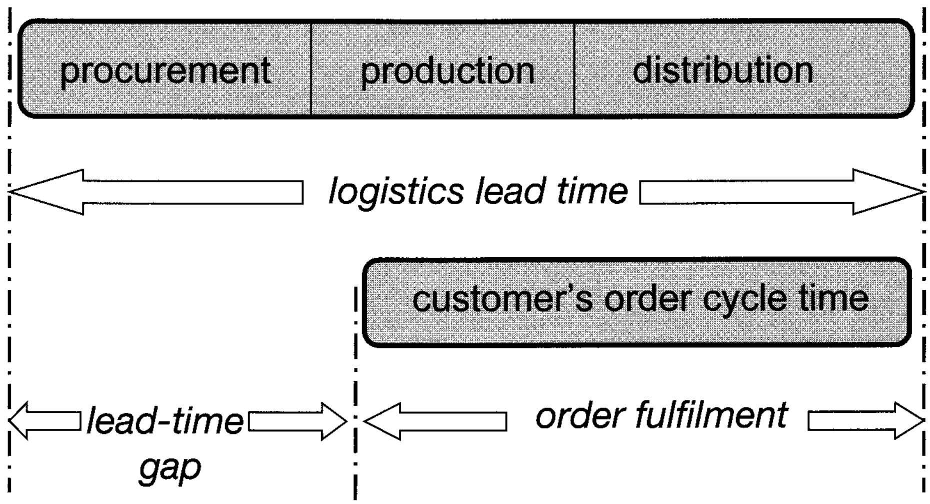
The pull approach is a reactive one where the emphasis is on responding directly to actual customer demand, which pulls the required product through the system. The idea of a pull system is that it can react very quickly to sudden changes in demand. The pull system is most useful where there is independent demand and where there is uncertainty of demand requirements or of order cycle time. The most common form of pull system is JIT, as the orders are placed only when working stock is at such a level that a replenishment order is triggered.

For many companies there is a need to adopt the concepts of both types of approach. Thus, hybrid systems are often used in practice.

THE LEAD-TIME GAP

One of the major reasons for the build-up of finished goods inventory is because of the long time that it takes to manufacture and deliver products. Ideally the customer would be prepared to wait the full amount of time that is required. If this were the case, there would be no need to hold any stock at all. This, of course, happens only rarely for special 'made-to-order' products. The vast majority of products are required either immediately, as for many consumer products at the point of sale in shops, or within a short timescale, as for industrial products and also for consumer products when the retailer orders them in the first instance from the manufacturer.

The total time it takes to complete the manufacture and supply of a product is often known as the *logistics lead time*. Customers are generally prepared to wait for a limited period of time before an order is delivered. This is the *customer's order cycle time*. The difference between the logistics lead time and the customer's order cycle time is often known as the *lead-time gap*. The concept of the lead-time gap is illustrated in Figure 12.1. It is the existence of this lead-time gap that necessitates inventory being held. The extent of the lead-time gap, measured in length of time, determines how much inventory must be held. The greater the lead-time gap, the greater the amount of inventory that must be held to satisfy customer requirements. Thus, the more this gap can be reduced, the less inventory will be required. Recently there has been a move towards identifying different approaches for reducing this gap. A number of these approaches are described in the next section.



Source: Cranfield University

Figure 12.1 The lead-time gap

INVENTORY AND TIME

High levels of inventory are used by many companies to hide a number of problems that occur throughout the supply chain. Companies may have sound and acceptable reasons for holding stock – as outlined in the previous chapter – but some may also use high levels of inventory to protect themselves from those problems that they are unable or unwilling to solve by more direct means. The implications of this are illustrated in Figure 12.2. This shows that there is significant waste in many logistics systems, made up of unnecessary inventory (the difference between A and B). This is used to cover up problems such as:

- unreliable suppliers;
- inaccurate forecasts;
- production problems;
- quality issues;
- unpredictably high demand.

There is of course a very real cost associated with these high inventory levels. This is caused by the amount of capital tied up in the value of the inventory itself, and also of course in the other associated costs. These include the costs of the storage

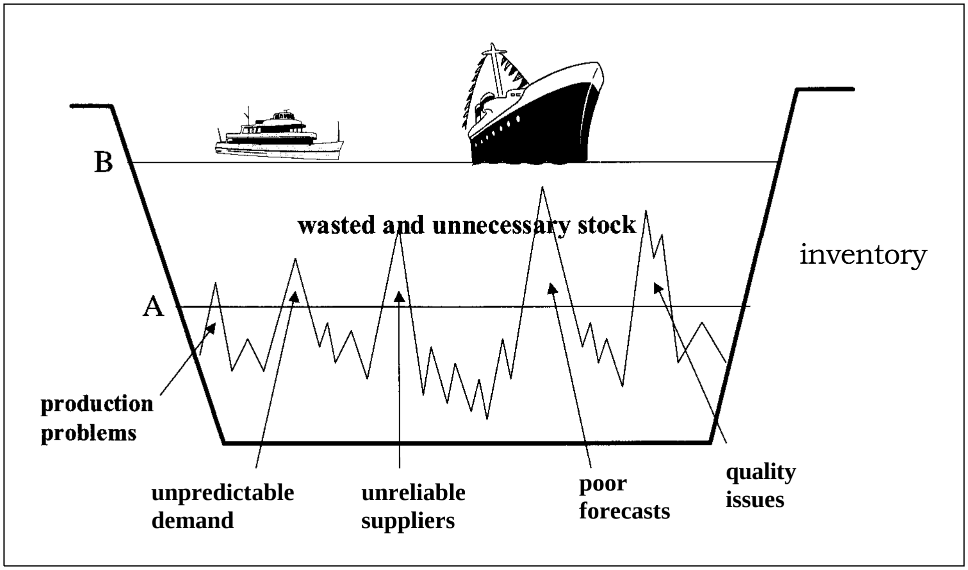


Figure 12.2 High inventory levels can hide other supply chain problems

facility and the cost of obsolescence when products become outdated and have to be sold at discount rates or even scrapped.

Finding a solution to these inventory-related problems can lead to a significant reduction in the requirement to hold stock. In Figure 12.2, their elimination would mean inventory coming down from level B to level A. How can inventories be lowered in this way? As well as confronting the particular problem areas directly, another approach is through what is known as *lead-time reduction.* This approach recognizes the importance of time within the inventory decision-making process. The aim of lead-time reduction is to reduce the amount of unnecessary time within the order-to-delivery process and thus reduce the need to hold so much inventory as cover for this time delay. This can be achieved in a number of different ways, as follows:

- *Manage the supply chain as one complete pipeline.* This will allow stock to be reduced at various stages in the total pipeline because it is clear that other stock exists to provide the necessary safety stock cover. The section on supply chain mapping in this chapter will explain this further.
- *Use information better.* If there is a clearer picture throughout the supply chain of what the true final demand for a product is, then it will be much easier to

provide more accurate forecasts of the likely demand at other points in the supply chain.

- *Achieve better visibility of stock throughout the supply chain for all participants.* This will allow for clearer and more confident planning of stock requirements at the various stock-holding points in the chain and thus reduce the need to hold safety stocks.
- *Concentrate on key processes.* Make sure that the greatest planning and monitoring effort is spent on the most important processes in the supply chain. These may well be those that are providing the biggest bottlenecks or hold-ups in the system. It will often be necessary to undertake specific analysis to identify these bottlenecks using flowcharts such as those described in Chapter 7.
- *Use just-in-time (JIT) techniques to speed up the flow of products through the supply chain.* These will reduce lead times and thus mean that less stock is required within the supply chain.
- *Use faster transport.* This is, of course, one of the classic trade-offs in logistics. Faster transport will almost certainly cost more, but there will be an associated reduction in the need to hold stock, and savings will be made accordingly. Ideally this will provide an overall cost reduction in the supply of that product as a whole. It is also likely to result in a faster and more responsive service level.
- *Develop supply chain partnerships.* It is important to understand the need to identify lead-time reduction opportunities that lie outside a company's own boundaries. The most spectacular savings in stock reductions occur where companies in the same supply chain can work together, share information and build up a trust that allows them to reduce stocks with confidence.

ANALYSING TIME AND INVENTORY

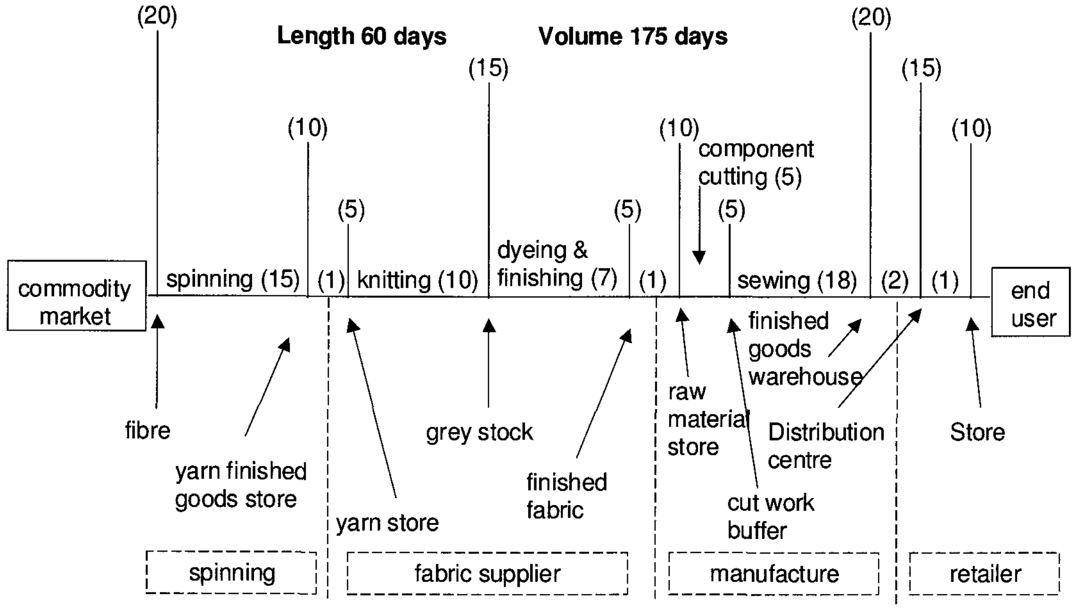
To help understand the relationship of time and inventory it is useful to be aware of the concept of activities that add value to the supply chain and those that do not add value. An activity that adds value is one that provides a positive benefit to the product or service being offered. This can be assessed in terms of whether the customer is prepared to pay for this activity. An activity that does not add value is one that can be eliminated from the supply chain process and will not materially affect the finished product as far as the final customer is concerned. The analysis of supply chain activities in terms of the extent to which they add value to a product has thus become an important factor in the assessment of supply chain efficiency. The aim is to identify and eliminate those activities that add cost but do not add value. The holding of inventory within a supply chain is one such activity, and many companies are now trying to eliminate unnecessary inventory from their supply chains.

One method of highlighting unnecessary inventory is through the use of *supply chain mapping*. This technique enables a company to map the amount of inventory it is holding in terms of the length of time that the stock is held. An example of this technique is provided in Figure 12.3. This is an example from the US clothing industry. It shows:

- *Value-adding time*, which is represented along the horizontal axis. This shows the total of the manufacturing and transport time for the whole supply chain process from the initial fibre raw material to the supply to the end user. It is value-adding because the product is changed either through a production process or through a movement process. It amounts to 60 days.
- *Non-value-adding time*, which is represented by the vertical lines that rise from the horizontal axis. These show the various occasions when the part-prepared or finished product is held as some form of inventory. This is adding no specific value to the product. This amounts to 115 days.
- The *total time* or pipeline time, which is the addition of the value-adding horizontal time and the non-value-adding vertical time. This therefore includes all the time that it takes through all the different manufacturing, storing and transport processes. This is a total time (or volume) of 175 days.

Note that in some instances transport is treated as non-value-adding (movement between production processes) and in others as value-adding (movement to the final customer).

The example clearly indicates the opportunities for reducing time within the supply chain by reducing unnecessary inventory. Some inventory will be required, but as illustrated by this particular example there is a lot that is not, for example there are 20 days of inventory in the finished goods warehouse and 15 in the distribution centre. With better visibility in the supply chain, there is scope for eliminating some of this. Very few companies undertake this type of analysis, and those that do are usually surprised by the results they get as large inventory levels are identified. It should also be noted that this type of analysis is particularly dramatic where a complete supply chain can be measured. Where a product moves from one company to another within a supply chain, then there is often evidence of large stock builds by both the supplier and buyer companies. This is due to a variety of factors, such as unreliable supply, a lack of confidence, uneven demand patterns and poor information on the real demand requirements for the finished product.



Source: Scott, C and Westbrook, R (1991)

Figure 12.3 An example of a supply chain map showing inventory mapped against time

INVENTORY PLANNING FOR MANUFACTURING

Recent developments in inventory planning are aimed at solving some of the problems encountered by the use of the more traditional approaches to stock replenishment. They are based on the concept of *materials requirements planning* (MRP), which is a computerized system for forecasting materials requirements based on a company's master production schedule and bill of material for each product. This has subsequently been developed into *manufacturing resource planning* (MRPII), which is a broader-based system, used to calculate the time-phased requirements for components and materials with respect to production schedules, taking into account replenishment lead times, etc. This approach enables inventory levels to be significantly reduced, and service levels, in terms of shorter production lead times, to be improved.

MRP systems are now quite well established, as are other related techniques such as 'just-in-time' (JIT) or Kanban systems. The obvious advantages of these systems to manufacturing have led to the further development of associated techniques for distribution - distribution requirements planning (DRP). DRP systems are designed to take forecast demand and reflect this through the distribution system on a time-phased requirements basis. DRP thus acts by pulling the product through the distribution system once demand has been identified. It is particularly useful for multi-echelon distribution structures to counter the problems of requirements occurring as large chunks of demand (the Forrester effect, described in Chapter 11).

The most recent systems adopt an even broader planning approach. These are time-phased and enable planning across a whole business and even across complete supply chains. They are known, respectively, as *enterprise resource planning* (ERP) and *supply chain planning* (SCP).

These systems are also discussed in Chapters 10 and 29.

The concept of *time compression is* an important approach in the planning of manufacturing inventory requirements, or perhaps it should be termed as the planned reduction in manufacturing and WIP inventory. The opportunities for such reductions have been illustrated in the above discussion on analysing time and inventory, where the use of supply chain mapping enables the identification of feasible time and inventory savings. Time compression techniques provide the means for achieving these improvements. A typical approach includes:

- the need to take a complete supply chain perspective when planning;
- the need to undertake appropriate analysis;
- the identification of unnecessary inventory and unnecessary steps in key processes;
- working towards customer service requirements as well as cost minimization when planning for production;
- designing products to be compatible with supply chain requirements;
- designing production processes to be compatible with supply chain requirements.

Time compression is a relatively simple exercise to undertake. Supply chain mapping can be used as the starting point to help identify the major opportunities for time and inventory saving. The next stage is then to 'walk the process', taking care to follow and record every detailed step in the process. Each activity is then measured according to the total time, including both 'value added' time and ' wasted time' (see Figure 12.4). The process is then reassessed or re-engineered to

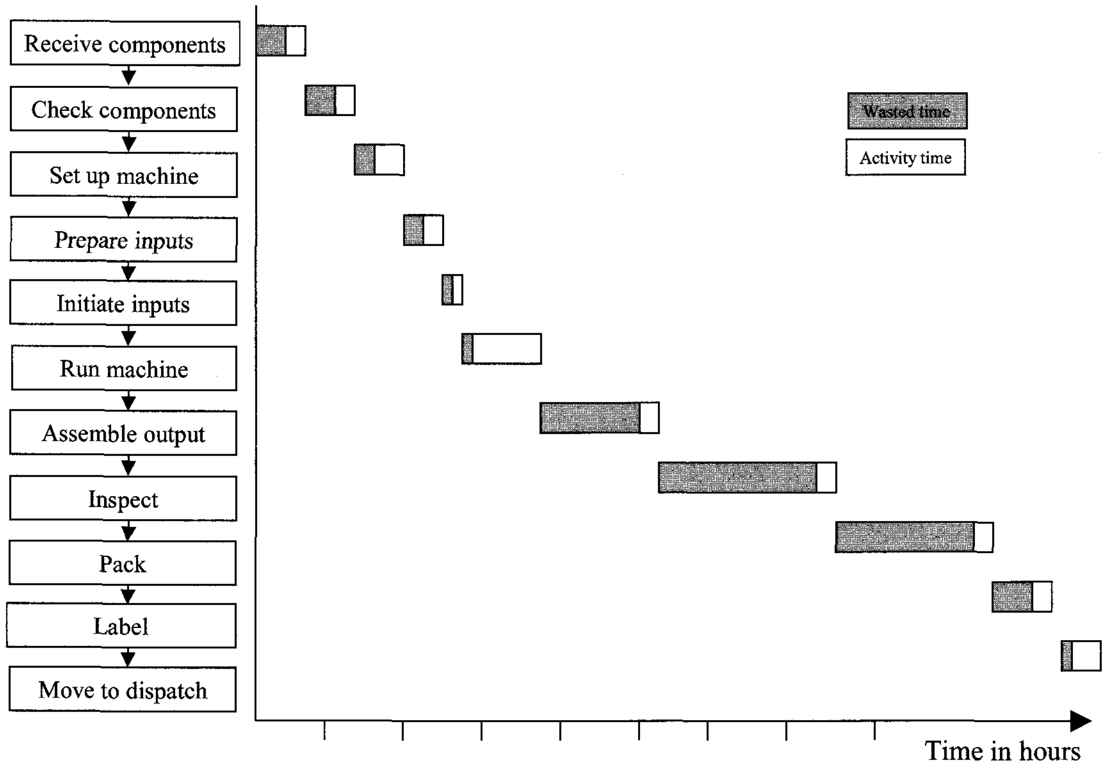


Figure 12.4 Time-based process mapping

eliminate as much wasted time as is possible. Time, and thus inventory, is taken out of the system and in this way overall cost is reduced. Time compression is a technique that provides a means to identifying and improving processes that can lead to a number of potential benefits. It is a way of creating a 'virtuous circle' of improvement, as illustrated in Figure 12.5.

INVENTORY PLANNING FOR RETAILING

In recent years, power within most supply chains for consumer products has lain very firmly in the hands of retailers rather than manufacturers. This has applied to all but the strongest brand names. If anything, this power has continued to increase even further, and so far the development of internet and home shopping has had little if any impact in changing this. Many retailers have tended to outsource their

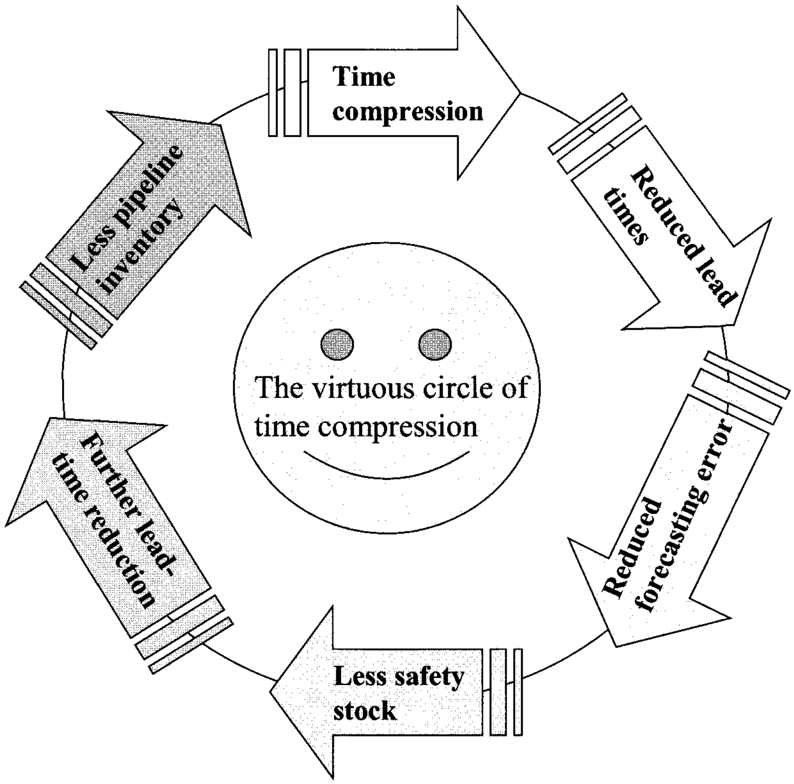


Figure 12.5 The virtuous circle of time compression

distribution and logistics activities but, although this continues to be the case, retailers are now taking a much closer interest in the impact an effective logistics operation can have on their overall service offering and consequent company profit -ability. This applies to distribution and also particularly to inventory management policy and practice.

Inventory management at distribution centre (DC) level for both retail national distribution centres (NDCs) and retail regional distribution centres (RDCs) poses similar problems to those experienced by manufacturers. At the retail store, however, inventory requirements can be quite different, depending on the product availability strategy and the merchandising policies that are used. New types of inventory management systems have been developed in recent years to cater specifically for these different requirements. Some of these approaches have significant similarities, but the overall aim is to promote the greater visibility of information within the supply chain, to enable inventory to be reduced and to enhance customer service in terms of product availability. The main planning techniques are:

Vendor-managed inventory (VMI). This is where the manufacturer is given the responsibility for monitoring and controlling inventory levels at the retailer's DC and in some instances at the retail store level as well. Specific inventory targets are agreed, and it is the responsibility of the manufacturer to ensure that suitable inventory is always available. Such arrangements depend on accurate and timely information, and suitable computerized systems have only become available in recent years. The main advantage for retailers lies in the reduction of operating costs and also the delay in payment for the products in question. For manufacturers, it is suggested that running a VMI system for a retailer provides the opportunity to develop a much closer, and hopefully more binding, relationship with the retailer as well as giving a much better visibility of real demand. This can make the planning of production much easier and can lead to significant reductions in inventory holding right through the supply chain.

Continuous replenishment (CRP). The aim with CRP is to develop free-flowing order fulfilment and delivery systems, so that pipeline inventories can be substantially reduced. Such systems use up-to-the-minute point-of-sale information (via electronic point-of-sale – EPOS – systems) to identify real-time demand and to pull product through directly from the supplier, through the DC and on to the retail outlet. CRP systems are thus able to synchronize this flow of product by focusing on end-user requirements via the use of real-time demand, linked to flow-through distribution systems that allow for cross-docking, store-ready packaging and automated handling. Once again, pipeline inventory is kept to a minimum or completely eliminated.

Quick response (QR). A further development of the JIT approach is that of quick response (QR). Here the aim is to link the manufacturer more closely to the actual demand at the retail level. There are strong similarities with continuous replenishment systems, but with QR the emphasis is on time compression and the opportunity for the manufacturer to redesign production operations to allow for a 'little and often' approach to resupply. Short production changeovers and small batch sizes enable the manufacturer to respond to changes in demand in a very short timescale. *A* classic example is the Benetton operation. This demonstrates most of the key characteristics of a QR system. It has allowed the company to offer an extremely responsive supply to its retail outlets to reflect the fast-changing nature of the fashion industry. Figure 12.6 provides more information.

Efficient consumer response (ECR) is another concept that uses the most recent advances in information technology to allow a streamlined approach to the supply of products to retail stores. ECR was originally set up and run in the USA with the

Background

- **Integrated manufacturer and retailer**
- **Knitwear, casuals, accessories**
- **80 million garments a year**
- **All with a pre-placed order**
- **From 7,000 licensed Benetton stores**
- In 110 countries

Distribution

- **Distribution via automated central warehouse in Italy Automated and linked to factories**
- **Cartons bar-coded and electronically sorted**
- **15,000 cartons shipped per day**
- **50% air freight, 50% rail/sea/road**

Ordering

- **For each of two main fashion seasons:**
- **Store managers adjust product mix for local requirements**
- **Each** store commits for **80% of orders seven months ahead, which are shipped on a 20-day order** cycle to **provide regular** new ` **collections'**
- **Remaining 20% by quick response in seven days**
- **Orders transmitted by EDI direct from shops to factory (via regional agents)**

Logistics efficiency

Provides:

- **Fastest order cycle times in the industry**
- No excess **work** in **progress**
- No **`pipeline' inventory build-ups**
- Little **residual end-of-season stock** for `clearance'
- Extremely **high** customer service to stores
- Extremely **responsive product provision**

Figure 12.6 The Benetton Group: initial quick response system

aim of improving service and reducing costs in the grocery industry by focusing on the efficiency of the supply chain as a whole rather than on individual components in individual companies. The goal of ECR is therefore to develop a customer-driven system that works across the supply chain. One original definition is still very applicable today: 'A seamless flow of information and products involving manufacturers and retailers working together in joint planning and demand forecasting. Both sides might take on functions traditionally handled by the other if they can do it better and at a lower cost. It will drive changes in business process, organization structure and information systems' (*Financial Times,* 1996). ECR combines a number of different concepts and strategies. The basic tenets of ECR are:

- a heavy use of EDI for exchanging information with suppliers;
- an extremely efficient supply chain using cross-docking and direct store deliveries, thus keeping inventory holding to a minimum;

- the use of sales-based ordering, notably through continuous replenishment programmes (CRP);
- much greater co-operation with suppliers, using where appropriate co-managed inventory (CMI) or full vendor-managed inventory (VMI).

There are four key strategies in the use of ECR. These are the areas that companies believe should improve significantly:

1. *replenishment* - to get the right product into store at the right time, etc;
2. *store assortment* - ensuring the right mix of products in the store to maximize consumer satisfaction;
3. *promotion* - to link trade promotions with retail availability;
4. *new product introduction* - streamlining all processes to get new products to the consumer more quickly.

In general, the greatest benefits are to be found with the improvement in the first two of these - speedier replenishment and better store assortment. Overall, benefits can be found in both cost reduction and service improvement. The main benefits are:

- Automated systems reduce labour and administrative costs.
- Sharing information leads to more timely deliveries and falling inventory levels at the store.
- Cross-docking reduces inventory levels at the DC.
- Concentrating on fewer suppliers reduces transaction and administration costs.
- Offering the right products to the right customers increases volume sales and economies of scale.
- Customer needs are more fully addressed.
- The ability to tailor the products and services on offer in the store allows a company to take account of local preferences.
- Rapid replenishment can reduce stock-outs, and this means that customers seeking a particular product or brand will not leave empty-handed.

A common approach for the implementation of ECR by a retailer is to focus on the consumer and then to develop a particular IT strategy and capability. This is likely to include the use of EDI, EPOS, computer ordering, computer routeing, etc. It is important to create a climate for change and to re-engineer existing business practices, as they are unlikely to be adequate for the successful implementation of ECR. The next requirement is to develop a responsive replenishment strategy jointly with key suppliers for key products. Finally, a workable flow-through distribution operation must be planned and implemented. A typical flow-through operation is likely to involve:

- *Pre-distribution identification.* Vendors pick, sort and pre-label final orders using bar codes.
- *Automated cross-docking.* This will require conveyors, diversion lines and bar-code readers.
- *A disciplined appointment scheduling procedure.* Inbound receipt scheduling will need to match available labour and minimize vehicle waiting.
- *New facility design.* This should ideally include shipping doors around the circumference of the building. The use of conveyors will eliminate put-away and picking.
- *Floor-ready merchandise.* Suppliers should provide tags and labelling to reduce DC and retail store work and handling.

In fact, many cross-docking operations in an ECR environment can work well with much less automation than indicated above. Clearly, this becomes problematic for very large-scale operations. The major tenet for any quick response system is that the product should be continually moving.

Category management (CM) has been developed to provide greater support for product and inventory control and management. It is essentially a means of categorizing products into 'families' that have very similar characteristics in terms of their selling profile. Thus, SKUs from very different product groups may be categorized together and their inventory holding planned in the same way because they have the same order or usage patterns. Typical examples of these categories are:

- *Vital and expensive:* products that require close control and monitoring. Supply sources need to be reliable, and delivery performance must be consistently good. A continuous stock review policy should be applied to products in this category.
- *Desirable and expensive:* inventory should be held at minimum levels and a continuous stock review policy should be applied.
- *Vital and inexpensive:* these should be stocked at maximum levels, and a reliable source of supply should be substantiated. Delivery performance should be carefully monitored. A weekly periodic stock review policy should be used.
- *Desirable and cheap:* hold maximum stock levels and use a monthly periodic stock review policy. Keep order frequency to a minimum number of times per year.

- *Common usage spares:* hold stocks at reasonable levels and use a monthly periodic stock review policy.

Note that this approach emphasizes the important factor that product requirements can be very different and therefore that companies that adopt a 'one size fits all' approach to inventory planning are likely to suffer either high-cost or low-availability issues for some of their portfolio of products.

Collaborative planning, forecasting and replenishment (CPFR) combines multiple trading partners in the planning and fulfilment of customer demand. Sales and marketing best practice (eg category management) is linked to supply chain planning and operational processes to increase product availability at the same time as minimizing inventory and logistics costs. A general framework is used to help the retailer/buyer and manufacturer/seller to work together to satisfy the demand of the customer. As Figure 12.7 demonstrates, there are four main areas for collaboration:

- *Strategy and planning:* identifying and agreeing the overall rules for the collaboration, including product mix and placement, and event plans.
- *Demand and supply management:* forecasting of consumer demand at the point of sale and replenishment requirements.
- *Execution:* the placing of orders, delivery shipments, restocking of products on shelves, etc. These are all of the events in the 'order to cash' cycle.
- *Analysis:* monitoring of exception orders, calculating KPIs and assessing continuous improvement opportunities.

SUMMARY

This chapter has considered the broader role of inventory within the supply chain as a whole. Some of the drawbacks of the traditional approaches to inventory planning have been discussed. The need to differentiate between demand types was highlighted, the major types being independent demand and dependent demand. Also important is the nature of the demand requirement. A push system is the more traditional approach, where inventory replenishment is used to anticipate future demand requirements. A pull system is where the actual demand for a product is used to 'pull' the product through the system.

The relationship between inventory and time was also reviewed. Two important elements were described: the lead-time gap and the opportunity for lead-time reduction. In addition, the technique of supply chain mapping was outlined, and

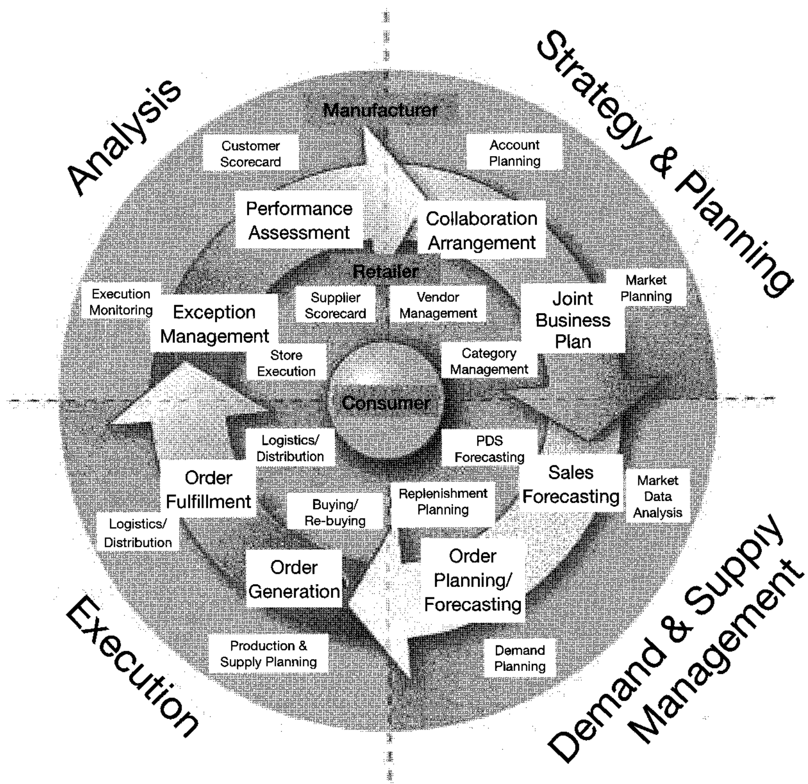


Figure 12.7 CPFR model

it was shown how this could help in the analysis of inventory in the supply chain, and show how value-adding and non-value-adding time could be identified.

Recent developments in inventory planning for manufacturing were reviewed. These included:

- materials requirement planning;
- distribution requirements planning;
- time compression.

Developments in inventory planning for retailing covered:

- vendor-managed inventory;
- continuous replenishment;

- quick response;
- efficient consumer response;
- category management;
- collaborative planning, forecasting and replenishment.

The importance of new information systems to support these techniques was seen to be fundamental to their continued development and implementation.

13

Purchasing and supply

INTRODUCTION

Purchasing and supply, also known as procurement, are amongst the key links in the supply chain and as such can have a significant influence on the overall success of the organization. Ensuring that there are sufficient supplies of raw materials at the right price, of the required quality, in the right place and at the right time is obviously crucial to any manufacturing plant. So important is this process that over the years many organizations have developed large departments to deal with the sheer weight of supplier transactions.

Recently, however, many companies have been reducing the number of suppliers they deal with in order to reduce the cost of these transactions.

In addition to supplier reduction programmes, many companies have tried to move away from the traditional adversarial relationship with suppliers and towards a more partnership-based approach. This style of relationship recognizes that both parties need to make a profit to survive but that there may be areas where, through co-operation, real cost may be removed from the supply chain.

Of course, procurement is not just about raw materials. The following may also need to be acquired:

- utilities - gas, water, electricity and telephones;
- fuel - diesel, petrol and heating fuel;

- capital assets - machinery, vehicles and buildings;
- corporate travel and hotels;
- stationery;
- consultancy;
- outsourced services - distribution contracts, IT services, etc;
- IT equipment - hardware, software and support.

Very large sums of money are involved in the above areas of purchasing, with different emphasis placed on different elements depending on the business of the organization concerned. For a transport company, fuel may represent as much as 35 per cent of the total operating budget, but for a manufacturing plant the major cost may be in the plant running costs. These costs need to be carefully managed, but the first step is to determine some purchasing objectives.

Managing suppliers is another crucial aspect of procurement. 'How many suppliers should we have?', 'How will we assess their performance?' and 'Should we make or buy this component?' are all key questions that need to be answered if a procurement strategy is to work to the benefit of the business.

Procurement is a very large subject area. The objective in this chapter is only to highlight the key areas.

SETTING THE PROCUREMENT OBJECTIVES

When setting procurement objectives, consideration should be given to the following:

- ensuring the supply of raw materials and other supplies;
- vendor-managed inventory (VMI);
- the quality of supplies;
- product specification;
- the price;
- the origin of the supplies;
- the method of supply, eg JIT-style deliveries;
- the mode of transport used;
- a hierarchy of importance, eg key raw materials would have precedence over office stationery;
- whether to make yourself or buy from a supplier.

Ensuring the supply of raw materials

Clearly, without an assured flow of raw materials into a manufacturing plant serious problems will ensue. These could take the form of plant stoppages, which will be enormously expensive. If expensive plant, machinery and labour are standing idle then costs may be incurred at an alarming rate. Not only will cost be incurred, but customers may be let down, as goods are not available for delivery at the appropriate time.

With this in mind, procurement management can adopt several policies to ensure that supplies are always in the right place at the right time:

- The manufacturer could purchase the supplying company. This used to be common in vertically integrated organizations.
- Sufficient safety stocks may be held at the manufacturing plant to cover such eventualities. These stocks would attract inventory carrying costs, but the alternative may justify this investment.
- A manufacturer may insist on the co-location of the supplier next to or close to the plant itself.
- Where commodities such as wheat or crude oil are concerned, then options to buy certain quantities may be negotiated in advance.
- A manufacturer may develop very close relationships with suppliers, for example by a system of quality-assured suppliers or vendor-managed inventory.

Vendor-managed inventory

Where VMI is used, the vendor takes responsibility for the inventory held in the client's premises. The vendor monitors inventory levels and organizes replenishment. Ownership of the inventory passes to the client when the inventory is utilized. For VMI to be effective, the management of information is crucial. Vendor and client have linked computer systems, often using electronic data interchange (EDI). This allows the vendor to monitor inventory levels and for purchase orders and invoices to be effectively transmitted between the partners.

The main advantage of VMI is that the overall level of inventory in the client's warehouse can be reduced. The vendor is able to schedule deliveries efficiently, as it has better visibility of the client's requirements, and it can incorporate these requirements at an early stage into its production schedules. For the process to work, there need to be high levels of trust between the two partners. This is often derived from the cultural compatibility of the companies involved. The partners' IT systems also need to be compatible.

Where the client retains an element of involvement in managing the vendor's inventory, this is referred to as co-managed inventory (CMI).

The quality of supplies

Ensuring that the goods and services purchased are of the right quality is important in that sub-standard supplies cause waste and a variety of problems:

- If the goods are unusable then their presence has created a shortage in the required quantity, which in JIT environments may be crucial.
- Sub-standard goods will need to be stored awaiting collection. This could be a problem if storage at the receipt stage is restricted.
- They will incur transaction costs, as paperwork and time will be involved in rectifying the error.
- They will undermine confidence in the supplier and the supply process.

Insisting on suppliers having quality management systems in place can help avoid these problems, as can extrinsic audits of suppliers' premises. These audits may be carried out by the company's quality auditors. Supplier assessment programmes will help highlight the main offenders.

Product specification

An important method of avoiding purchasing sub-standard supplies is the development of product specifications. If vendors are given very clear and precise instructions about what is being ordered, this will go a long way to avoiding costly misunderstandings. This is especially true where there are many different options associated with components of a product. For example, when purchasing a car the same model may be offered for sale with different types of engine, gearbox, paintwork and interior trim. It is important that the choices made are clearly communicated in writing to the vendor in the form of a request for quotation (RFQ) . Product specifications should also be included in the purchase order when it is issued to the supplier.

The price

This is the area that most people associate with the purchasing process. The price will be dictated by certain factors:

- The relative negotiating skills of the purchasing and selling team.
- The quality of the goods in question.
- Detailed knowledge of the product being purchased. For example, when multiple retailers purchase commodities such as flour they will have familiarized themselves with the costs of wheat and production before entering any negotiation.
- How much of the product is generally available for purchase. In other words, if the product is scarce then prices tend to be higher as purchasers pay higher and higher prices for the goods. The opposite is true when the product is plentiful.
- The distance the goods have to travel from their point of origin to the delivery point. Associated with this is the mode of transport used. The cost of transporting the raw materials may represent a large part of the purchase price.
- If the goods are being purchased by a buying group, then prices should be lower. A buying group is a number of companies grouped together in order to pool their buying power.

If the product specification can be defined precisely, then prices can be assessed on a like-for-like basis between suppliers.

The origin of the supplies

In recent years many large organizations have decided to source their supplies offshore. The logic for this trend is that, in some parts of the world, such as China and India, the costs of labour and production are very low. Companies can therefore potentially gain a significant competitive advantage by offshore sourcing. However, a number of factors need to be taken into account. If the goods have to travel halfway around the globe then not only will the transport costs be high but the lead times to delivery may be unacceptably long. In addition, pipeline inventory will be increased if sea transport is used. This can have the effect of impeding market responsiveness due to the long replenishment lead times. There are inherent problems with regard to dealing with different country's cultures. Further to this, the documentation associated with international sourcing is diverse and complicated. Dealing with different cultures and international documentation requires specialist knowledge and expertise.

It is also the case that not all parts of the world enjoy political stability. If supplies are interrupted for unspecified periods of time by political strife then a company could be in dire trouble if it does not have an alternative source of raw materials. Important decisions must be made with these factors in mind.

The method of supply

Smaller, more frequent deliveries typify a JIT system of supply. Inventory carrying of raw materials maybe measured in hours only, and deliveries may even be made directly to the production line itself. As more and more companies seek to reduce inventory carrying costs then these types of arrangement have become more common.

The process of receiving goods in a warehouse can be significantly speeded up if suppliers provide the goods in the right quantities, at the allotted time, correctly labelled and bar-coded where necessary. How the raw materials are to be supplied needs to be determined and then discussed in advance with suppliers because they may not be able to meet the necessary criteria. It will be no good insisting on bar-coded products if a supplier is unable to comply and, if a supplier cannot comply, a buyer's receiving operation may be severely compromised.

The mode of transport used by suppliers

Many transport and delivery requirements need to be discussed prior to agreeing to deal with a supplier. In the past, company procurement managers have in some instances been guilty of making spot purchases of goods on the basis of price alone only to discover that the consequential cost of handling has been unreasonably high. Typical questions that need to be answered include:

- Will the goods be shipped by road, sea, rail or air?
- What sort of unitization is used?
- Will the goods be on pallets?
- What size are the pallets?
- Will the goods be stuffed loose inside containers and require considerable time and labour cost to unload?
- Should a railway siding be built to accommodate rail traffic?

The hierarchy of importance

> In our visits to firms, it never ceases to amaze us how most purchasing departments still treat a critical microchip in the firm's key product much the same as a paperclip purchase.
>
> (Jack Berry, Arthur D Little Inc)

This quotation says it all really. It is vital that appropriate amounts of time and effort are spent on the purchases that most matter to the organization. Therefore procurement management must ensure that purchasing is segmented accordingly. Products need to be classified according to their criticality to the business and the value of annual purchases. The four categories usually used are:

1. routine purchases;
2. commodities;
3. critical items;
4. strategic items.

Figure 13.1 demonstrates how purchases may be easily categorized by assessing how critical an item may be to the organization and by calculating the annual value of purchases. A strategic item is one that is both very critical to the business and has a high annual purchase value. At the other end of the scale, a routine purchase is one that has a low annual purchase value and is not critical to the business.

Once purchases have been categorized in this way, the process by which they are to be purchased may be decided upon. Buying processes include:

- online catalogues;
- tendering;
- a system of approved suppliers;
- strategic partnerships.

Figure13.2 shows how the appropriate buying process may be matched with the purchase categorization described in Figure 13.1.

Online catalogues available to employees will allow them to purchase routine items quickly and easily. This speeds up the process and limits the cost of these transactions (see the Texas Instruments example below).

The tendering process for high annual purchase value commodities will be appropriate where obtaining the best price is important.

A network of approved suppliers and a formal system for approving suppliers are most appropriate where items are critical to the business but have a low annual purchase value. Suppliers will have been able to satisfy the purchasing department that they are able to meet certain criteria satisfactorily on a consistent basis. The criteria used may include delivery reliability, quality of goods supplied and value for money.

Strategic partnership (see the section on partnerships later in this chapter) will be most appropriate where the purchase has high annual value and is critical to

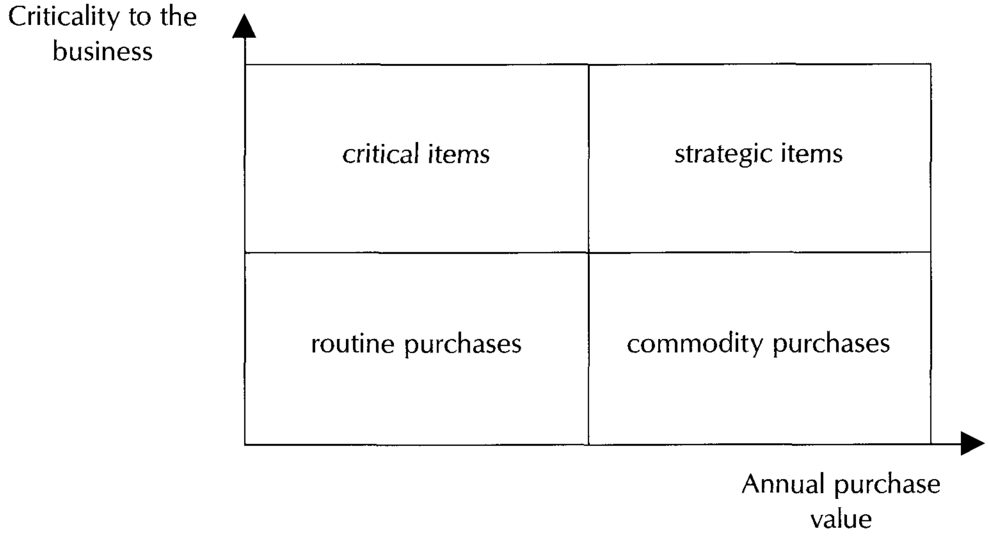


Figure 13.1 Purchase categorization

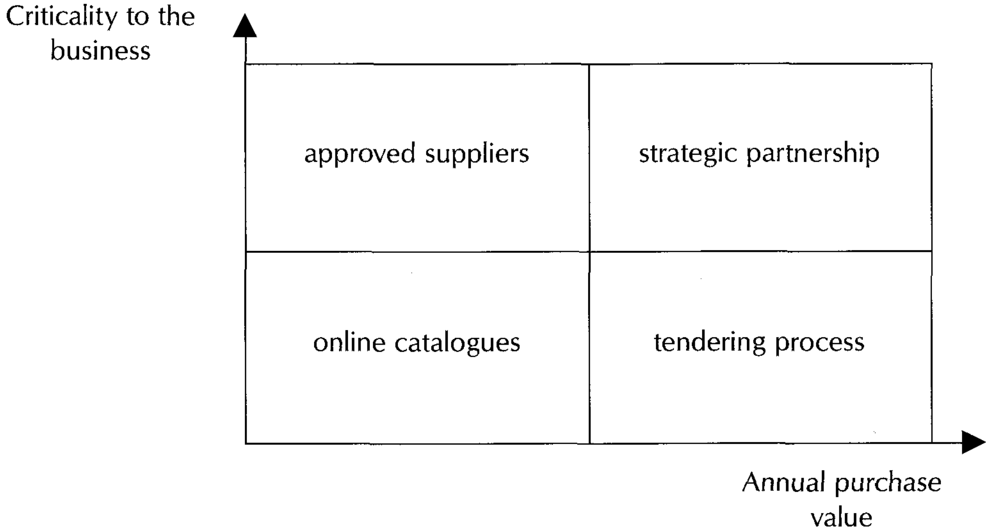


Figure 13.2 Appropriate buying processes

the business. In these cases, it is in the interest of both purchaser and vendor to develop a strong working relationship.

A practical example demonstrates this:

> Texas Instruments were able to save in excess of $30 million by redesigning their procurement process. In some cases they were able to reduce the transaction costs associated with line items from $250 for a manually processed order to less than $5. These kinds of saving were achieved by using the following approach:
>
> - Each division of the company had its own procurement system. This was changed so that the buying power of the whole company could be exploited.
> - The supplier base of 34,000 was significantly reduced.
> - Business processes were carefully examined and unnecessary steps or procedures eliminated. This saved both time and money.
> - The newly streamlined processes then formed the basis of their computerized paperless procurement model.
> - EDI links were established with suppliers internationally.
> - Online catalogues of items were made accessible to employees. This system, known as Express Buy, allowed employees to select the everyday items they needed with speed and ease, the terms and conditions of these purchases having already been negotiated by the buying team.
> - Savings were generated in labour costs and inventory carrying, buying power was consolidated on a global scale, and the need to expedite critical parts orders was reduced.
>
> These kinds of improvements and savings were not generated overnight. Texas Instruments started this process back in the 1980s but they had a clear idea about what they were seeking to achieve.

Make or buy?

The decision to make goods or provide a service as opposed to buying it in is one that is rarely straightforward. It is not always simply a question of cost. Other issues such as the company's reputation or production capacity may be included in the mix. The following is a list of some of the factors often considered:

- *Cost*. If the goods or services are to be provided in-house, then it is not simply the direct costs involved that need to be considered but the wider costs, such as the opportunity cost of the capital employed. In other words, could the capital tied up in this exercise produce a better return if invested in another activity? If the activity is to be provided by a supplier, then the costs associated with managing the supplier and the transaction costs (eg for processing invoices) should be included in the analysis.
- *Ensuring supply*. As mentioned above, if goods or services are not available when required then significant extra costs may be incurred. The reliability of the supplier and the quality of its offering is another crucial part of the decision-making process.
- *Production capacity*. Some parts of an operation may be provided by subcontractors because a company does not have sufficient capacity within its operation to do the job itself. This may be a very sensible approach to take in certain circumstances. A vehicle fleet, for example, should be kept working full time. Therefore, it is better to have sufficient vehicles to achieve this end and subcontract any further work created by short-term increases in demand. Of course, the opposite is true in that if a production plant has spare capacity then it may be correct to use it rather than have it stand idle.
- *Competitive advantage*. There may be certain products, components or processes that the company wishes to keep secret and so it will not allow any other company to gain information about them. A revolutionary new product may fit this situation.

MANAGING THE SUPPLIERS

The following areas should be considered when managing suppliers:

- who the suppliers will be;
- how many suppliers there will be;
- how suppliers will be managed — adversarial or partnership approach.

Who the suppliers will be

Choosing your suppliers will involve all the elements already discussed, but there are one or two further points that have to be considered. Of course, this only applies in a situation where there is a choice. There are certain situations where no choice exists at all and one is forced to deal with a monopoly situation.

If a partnership approach is desired then suppliers need to be able to respond to this type of situation. They must also be companies that are sufficiently well established. Company accounts are public information and easily obtained. A check should be made to establish that a company is financially stable. It would be very unfortunate to spend time developing a partnership only to see a new partner going into liquidation.

Another consideration is whether or not a supplier wishes to become closely involved with a major customer. It will be necessary to share information, and the supplier may also deal with competitors. This could place a supplier in a difficult position and it may decline the offer of closer ties. Another fear may be that the customer could become so close that it gets taken over.

How many suppliers there will be

This will obviously vary from industry to industry. The high costs associated with transactions are driving companies into supplier reduction programmes. The suppliers who remain will hopefully be the ones who perform best on supplier appraisals. They will also be the ones who have been prepared to share information and get involved in EDI to reduce the cost of purchasing and who have the geographical coverage to match the client company. Increasingly, global companies are seeking to do business with global suppliers.

A partnership or adversarial approach

In a traditional adversarial relationship between buyer and seller each party sees itself as being in competition with the other. The inevitable result of this kind of relationship is that one or other party inevitably 'wins' in any negotiation. This is often referred to as a 'win—lose' situation. Who and why one party is successful in this sort of relationship has much to do with the relative power that resides in one camp or the other. For example, a vendor with a rare product that is absolutely crucial to the process of the buyer would tend to be in a more powerful position. This would be especially true if the item on sale could not be substituted by another. The problem with this type of association is that, because both parties are secretive and defensive, inefficiencies in the supply chain are the result. These usually take the form of excess buffer stocks held by both parties, stock-outs and a lower level of customer service.

The idea of seeing a supplier as a partner makes a great deal of sense from a logistics point of view. The Toyota organization, like many other Japanese companies, has long seen its suppliers as co-makers of the product. The Japanese system of keiretsu epitomizes the approach. A network of suppliers is intimately bound to the client company in a complex web of interdependence. This type of association should be seen as a 'win—win' situation in which both parties gain more from the relationship than from the adversarial style.

It is worth introducing a word of caution at this point. Toyota reduced its supplier base to such an extent and was so reliant on JIT deliveries that when a fire occurred at the premises of one of its suppliers it was forced to stop its production lines in Japan for a week. At the time, Toyota owned 22.6 per cent of the supplier, Aisin Seiki, a manufacturer of vital brake components. The fire occurred early in 1997 and brought Toyota to a standstill. This was not an isolated incident either, because in 1995, after the Hanshin earthquake in western Japan, car manufacturers were cut off from some of their suppliers by the disaster. By contrast, Honda does not have such a closely knit keiretsu and has a policy of dual supply for all raw materials as a hedge against just such a situation.

These are extreme examples and should in no way inhibit companies from building closer ties for mutual benefit. As with all partnerships, the partner has to be selected with care, as not all suppliers will either wish to engage in this sort of relationship or be suitable. In practice it is usually the partner with the more power that dictates the terms of the partnership. It is very difficult for a small company to approach a larger company with a view to instigating such a partnership. A lack of equality in the partnership will lead to the more dominant partner dictating terms regarding many aspects of the relationship. This phenomenon has led some commentators to question whether a true partnership can ever exist between two commercial parties when one partner holds most of the power. Nevertheless clear advantages have been documented where two companies work more on a collaborative basis than an adversarial one.

Some prerequisites for a successful partnership will include:

- compatible cultures;
- high levels of trust already in place;
- compatible computer systems to aid the electronic sharing of information;
- the financial stability of both parties;
- a willing attitude to exploring the advantages of partnership.

In a partnership, members of equivalent departments in both organizations will meet regularly to discuss areas of mutual interest. For example, new product development people from both organizations will sit down together to see how products may be produced in such a way as to avoid causing problems for each other. In a similar way, logistics personnel will associate more freely. Traditionally, in the old adversarial way, only buyer and seller would meet.

Through this closer liaison, information sharing occurs for mutual benefit. Real benefits have been achieved by linking together computer information systems. In this way, a retailer with an electronic point-of-sale (EPOS) system can provide the supplier with real-time data about the current level of demand for a given product. This kind of information can lead to real reductions of inventory carrying in the supply chain and a reduction in stock-outs. As the relationship matures then initiatives such as VMI may be introduced. Ordering and invoicing may be carried out via EDI, thus reducing transaction costs by the removal of expensive paper-based systems.

COLLABORATIVE PLANNING, FORECASTING AND REPLENISHMENT

As the name implies, collaborative planning, forecasting and replenishment (CPFR) is a collaborative business process where two companies work closely together to improve the efficiency of their supply chains. The client and the supplier will link their computer systems to the extent that the supplier has visibility of the inventory held by the client as well as the latest sales and forecasts for the line items involved. Information regarding promotional activity will also be shared with the supplier.

Despite the compelling logic for adopting such an approach to efficient replenishment, take-up has been slow. Some of the reasons for this relate to the difficulties in aligning the two parties' IT systems as well as their business processes. Fears about the security of sensitive market information have also hampered progress. A further reason has been the practical difficulties of agreeing how to share the overall benefits, particularly where higher costs may be incurred by one party in the supply chain. However, some large organizations such as Procter & Gamble have found success using this process.

A survey of 21 companies in the USA reported the following benefits of CPFR:

- improved relationship with trading partners (57 per cent);
- increased service levels (38 per cent);
- reduced stock outages (38 per cent);
- increased sales (38 per cent);
- decreased inventory (29 per cent);
- forecast accuracy (29 per cent);

- improved internal communications (24 per cent);
- better asset utilization (14 per cent).

(*Source:* Sliwa, 2002)

FACTORY GATE PRICING

This is sometimes also referred to as purchasing on an 'ex works' basis. This is very often one area associated with the buying process that is overlooked, although in recent years it has been more widely discussed. The cost of transporting the goods to the buyer's facilities may hide some extra cost that the buying company could avoid. Often companies show a remarkable lack of interest in this area, preferring to see it as somebody else's problem. The reality is that some costs could be eliminated and a higher level of control over the inbound supplies may be achieved.

If raw materials are being sourced from a variety of locations, whether it is on a national, continental or global scale, then there may be a possibility of removing some of the associated transport costs by employing a third party to co-ordinate this process. Large freight-forwarding companies may be able to pool one company's transport requirements with others so that a better price is obtained.

Another way of removing cost from the inbound side of a business is to use the vehicles delivering finished goods to collect from suppliers. This will allow a company to buy raw materials at ex-works prices and utilize its delivery fleet more effectively as well. It may be possible to have the same organization that handles final deliveries co-ordinating inbound raw material transport needs as well.

E-PROCUREMENT

Procurement professionals have seen the benefits of the widespread use of the internet and IT systems in general. The internet has opened up a global marketplace for both consumers and professional buyers alike. Web-based companies such as eBay have created a vast auction site that connects buyers and sellers all over the world. Some industries have created industry-specific portals that facilitate the connection of suppliers and buyers. The internet can be used not only for the purchase of certain goods but the delivery as well. For example, software, music and films may all be delivered in this way.

Other manifestations of e-procurement include:

- online auctions where pre-qualified bidders compete to win contracts or buy assets;
- sending and receiving of documents such as purchase orders, bills of lading, RFQ, invoices and delivery confirmations;
- the use of online catalogues.

The portals may also be used earlier in the process for facilitating collaborative product design.

SUMMARY

This chapter has highlighted the crucial role played by procurement as part of the supply chain. The key areas covered were:

- the setting of procurement objectives with regard to ensuring supply, establishing a hierarchy of importance, quality, product specifications, price, origin of goods, method of delivery and mode of transport used;
- a practical example of how Texas Instruments saved $30 million by redesigning their procurement process;
- how to manage suppliers with regard to the number of suppliers and who they will be, make or buy decisions, and whether to adopt an adversarial or a partnership approach;
- a brief description of vendor-managed inventory (VMI), e-procurement, and collaborative planning, forecasting and replenishment (CPFR);
- factory gate pricing and co-ordinating inbound and outbound transport needs in order to reduce overall supply chain costs.

Part 4

Warehousing and storage

14

Principles of warehousing

INTRODUCTION

Warehouses are crucial components of most modern supply chains. They are likely to be involved in various stages of the sourcing, production and distribution of goods, from the handling of raw materials and work-in-progress through to finished products. As the dispatch point serving the next customer in the chain, they are critical to the provision of high customer service levels.

Warehouses are an integral part of the supply chains in which they operate, and therefore recent trends, such as increasing market volatility, product range proliferation and shortening customer lead times, all have an impact on the roles that warehouses are required to perform. Warehouses need to be designed and operated in line with the specific requirements of the supply chain as a whole. They are therefore justified where they are part of the least-cost supply chain that can be designed to meet the service levels that need to be provided to the customers. Owing to the nature of the facilities, staff and equipment required, warehouses are often one of the most costly elements of the supply chain and therefore their successful management is critical in terms of both cost and service.

The nature of warehouses within supply chains may vary tremendously, and there are many different types of classification that can be adopted, for example:

- *by the stage in the supply chain:* materials, work-in-progress or finished goods;
- *by geographic area:* for example, a parts warehouse may serve the whole world, a regional warehouse may serve a number of countries, a national warehouse may serve just one country, or a local warehouse may serve a specific region of a country;
- *by product type:* for example, small parts, large assemblies (eg car bodies), frozen food, perishables, security items and hazardous goods;
- *by function:* for example, inventory holding or sortation (eg as a 'hub' of a parcel carrier);
- *by ownership:* owned by the user (eg the manufacturer or retailer) or by a third-party logistics company;
- *by company usage:* for example, a dedicated warehouse for one company, or a shared-user warehouse handling the supply chains for a number of companies;
- *by area:* ranging from 100 square metres or less to well over 100,000 square metres;
- *by height:* ranging from warehouses about 3 metres high through to 'high-bay' warehouses that may be over 45 metres in height;
- *by equipment:* from a largely manual operation to a highly automated warehouse.

THE ROLE OF WAREHOUSES

The prime objective of most warehouses is to facilitate the movement of goods through the supply chain to the end consumer. There are many techniques used to reduce the need to hold inventory, such as flexible manufacturing systems, supply chain visibility and express delivery, and many of these have been encompassed in a range of supply chain initiatives, for example just-in-time (JIT), efficient consumer response (ECR) and collaborative planning, forecasting and replenishment (CPFR). However, as part of this movement, it is often necessary to hold inventory, particularly where the following two conditions apply:

- *The demand for the product is continual.* In some industries, such as fashion, a particular style may be manufactured on a one-off basis. Under these circumstances, the goods can be 'pushed' through the supply chain to the stores where they are sold, and there is therefore no need to hold inventory. However, most goods are offered for sale on a continual basis and therefore they need to be 'pulled' through the supply chain based on customer demand.

- *The supply lead time is greater than the demand lead time.* Where goods are 'pulled' through the supply chain, this can only be achieved without inventory where the supply can take place within the lead time offered to the customer. For example, if goods are offered to customers on a next-day-delivery lead time, it is often the case that materials cannot be sourced, goods manufactured and transport undertaken within this timescale. In this situation, the goods must be supplied from inventory.

In addition, some warehouses have a specific objective of stocking goods and material against particular contingencies that it is hoped will never occur. Examples include some major spare parts such as steam turbine rotors for a power station, or emergency/disaster relief supplies. It must be said though that, when such items are required, speed is still of the essence.

There is in fact a wide range of reasons for holding inventory, including:

- to provide a buffer to smooth variations between supply and demand;
- to enable economies of long production runs in manufacturing;
- to provide a buffer between different manufacturing operations;
- to enable procurement savings through large purchases;
- to allow cost trade-offs with the transport system (eg the use of full container loads);
- to cover for seasonal fluctuations and peaks, eg the Christmas build-up;
- to provide a wide range of different products, from different suppliers, in one location;
- to cover for planned or breakdown production shutdowns.

Where inventory is required, then the decision needs to be taken as to the optimum point in the supply chain to hold it. This may be related to the 'decoupling point' concept explained in Chapter 8, whereby strategic inventory is held to enable 'lean' manufacturing or supply to be undertaken upstream in the supply chain, whilst an 'agile' response may be given to volatile downstream marketplaces. Holding inventory upstream enables the form and location of goods to be postponed as long as possible, thus reducing inventories, whilst holding the inventory downstream is often necessary to be able to respond rapidly to customer demands.

The combination of global supply chains (which tend to have long lead times) and increasingly volatile markets has resulted in substantial strategic inventory holdings becoming necessary. This trend has been further compounded by product range proliferation, resulting in inventories of many different product lines being required. Thus, although great steps have been taken to improve supply chain management, particularly as regards the minimization of inventory, overall inventory levels have tended to remain fairly static in recent years, in such countries as the United Kingdom and the United States, in comparison to the levels of economic activity.

The holding of inventory is just one of a variety of roles that a warehouse may perform. Thus, with the increasing emphasis on the movement of goods through the supply chain, many of the roles may be related to this aspect as well as to inventory holding. The following list highlights some of the common roles performed:

- *Inventory holding point*. This is commonly associated with the decoupling point concept and, as explained above, may involve the holding of substantial strategic inventory. Other reasons may include the holding of critical parts in case of breakdown or acting as a repository (eg for archive records or personal effects).
- *Consolidation centre*. Customers often order a number of product lines rather than just one, and would normally prefer these to be delivered together. The warehouse may perform the function of bringing these together, either from its own inventory holdings or from elsewhere in the supply chain.
- *Cross-dock centre*. If goods are brought from elsewhere in the supply chain (eg directly from manufacturers or from other warehouses) specifically to fulfil a customer order, then they are likely to be cross-docked. This means that the goods are transferred directly from the incoming vehicle to the outgoing vehicle via the goods-in and -out bays, without being placed into storage.
- *Sortation centre*. This is basically a cross-dock centre, but this term tends to be used for parcel carrier depots, where goods are brought to the warehouse specifically for the purposes of sorting the goods to a specific region or customer. A similar operation occurs in the case of fashion goods being 'pushed' out to stores, whereby goods are brought to a warehouse solely for the purpose of sorting into vehicle loads.
- *Assembly facility*. This is often useful in postponing production as far as possible down the supply chain in order to minimize inventories. The warehouse may thus be used as the final assembly point for the product, involving activities such as kitting, testing, cutting and labelling.
- *Trans-shipment point*. These are particularly common to serve outlying regions of a country. In a typical scenario, orders would be picked at a national distribution centre and transported to a 'stockless' trans-shipment depot, where the goods are sorted to smaller vehicle loads for immediate delivery to customers. These trans-shipment depots may be small warehouses that are used just for sortation purposes, or this operation may even be performed on a concreted area by

using draw-bar trailers carrying swap-bodies that have already been loaded for the local delivery vehicle route. The local vehicles would just pick up each swap-body and deliver directly to the customers.
- *Returned goods centre*. The handling of returned goods is becoming increasingly important. This is being driven both by environmental legislation (eg on packaging and on the recovery of materials from electrical/electronic items) and by the growing use of internet shopping (which tends to be associated with higher percentages of returned goods than in the case of store shopping).

Warehouses often fulfil a mix of these different roles, and it is important to be clear as to the precise roles being performed. There is now a wide range of names given to warehouses, and many of these names reflect the different roles that they perform. Some of these names include: supplier consolidation centre, JIT sequencing centre, customer service centre, fulfilment factory and e-fulfilment centre.

STRATEGIC ISSUES AFFECTING WAREHOUSING

Since warehouses operate as an integral component of the supply chain, the wider business context must be taken into account when making key decisions about these facilities. The areas that should be considered are very wide-ranging and include the following:

- *Market/industry trends*. Almost all industries have seen dramatic changes in their marketplaces, as well as in the technology available to them. For example, the food retail industry has witnessed such developments as factory gate pricing, cross-docking of perishables and other items, store-ready presentations, and home shopping. All of these developments have involved substantial changes to warehouse design and operations, and thus any warehouse that is built without the latest trends in mind may be unsuitable by the time it comes into operation.
- *Corporate objectives*. Different companies often have quite different objectives, in terms of their market positioning (eg service commitment to customers), staff policies (eg working environment), and shareholder expectations (eg which may affect acceptable payback periods for capital investments). Again, any warehouse needs to fit with the particular objectives of the company.
- *Business plan*. The business plan will include factors such as new markets and the sales projections, as well as the degree of certainty of the projections. These will affect design features such as the expansion potential that needs to be

incorporated into the warehouse and the degree of flexibility that should be allowed for. In the case of the latter, it may be necessary to undertake scenario planning for how the warehouse facilities can accommodate possible variations in the business plan.

- *Supply chain strategy*. Each warehouse will be one component in the overall supply chain strategy and therefore needs to be designed accordingly. This strategy will determine factors such as the roles, location and size of each warehouse. The size may be determined in terms of both the throughput capacity and the inventory capacity that will be required.
- *Other related strategies*. The business plan will need to be implemented through various departmental strategies, as well as that of the supply chain. Many of these will affect the warehouse design, as they will determine factors such as incoming batch sizes from production or from suppliers, customer order characteristics, available information technology, and financial restrictions.
- *Customer service levels*. A number of the strategies previously described, particularly those of marketing and the supply chain, will determine the service levels that the warehouse needs to provide. It is these service levels that are key to how the warehouse should be designed and operated.
- *External factors*. There are likely to be constraints imposed by external factors, particularly in terms of regulation. A wide range of regulations may impact on warehouse design and operations, including laws in such areas as health and safety, manual handling, working hours, fire precautions, equipment, hazardous substances, food safety, and packaging waste, as well as possible local planning constraints (eg on building height and operating hours).

There is thus a wide range of factors that need to be taken into account prior to the detailed design of the warehouse.

WAREHOUSE OPERATIONS

Every warehouse should be designed to meet the specific requirements of the supply chain of which it is a part. Nevertheless, there are certain operations that are common to most warehouses. These tend to apply whether the warehouse is manual in nature with fairly basic equipment or whether it is highly automated with sophisticated storage and handling systems. For an inventory holding warehouse, typical warehouse functions and material flows are shown in Figure 14.1.

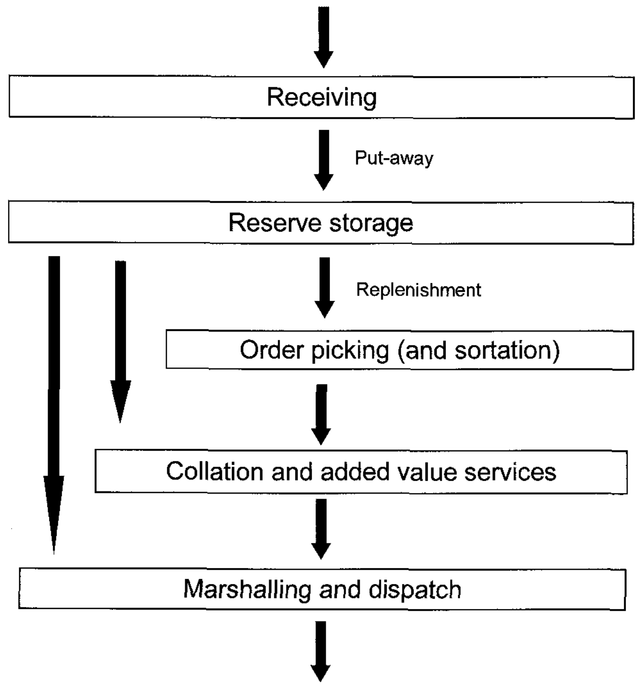


Figure 14.1 Typical warehouse functions in a stock-holding warehouse

These functions are as follows:

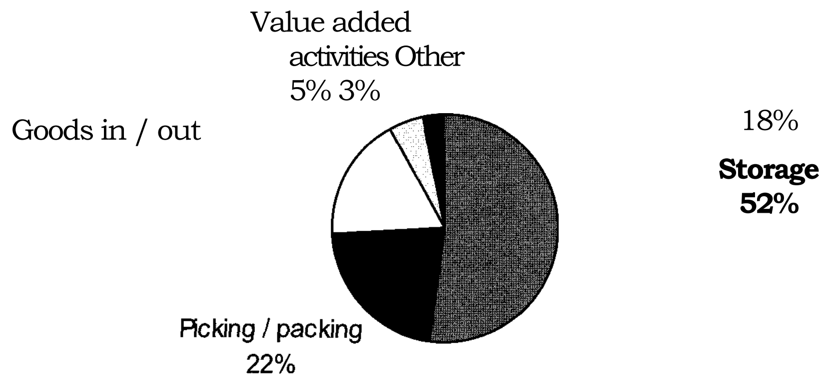
- *Receiving.* This involves the physical unloading of incoming transport, checking, and recording of receipts. It can also include such activities as unpacking and repackaging in a format suitable for the subsequent warehouse operations. Quality control checks may be undertaken as part of this activity. From here, the goods are then put away in the warehouse.
- *Reserve storage.* Goods are normally taken to the reserve or back-up storage area, which is the largest space user in many warehouses. This area holds the bulk of warehouse inventory in identifiable locations. When required, the goods are taken from reserve storage either directly to marshalling (if, for example, a full pallet is required by a customer) or to replenish a picking location.
- *Order picking.* Goods are selected from order picking stock in the required quantities and at the required time to meet customer orders. Picking often involves break-bulk operations, when goods are received from suppliers in, say, whole pallet quantities, but are ordered by customers in less than pallet quantities (eg cases or items). If only small quantities of a product are stored

in a warehouse, then the reserve and picking stock may be combined, and goods picked from this consolidated area. Accurate order picking is important for achieving high levels of customer service. It traditionally also takes a high proportion of the total warehouse staff complement and is therefore expensive. The good design and management of picking systems and operations are consequently vital to effective warehouse performance.

- *Sortation.* For small sizes of order, it is sometimes appropriate to batch a number of orders together and treat them as 'one' order for picking purposes. In this case, the picked batch will have to be sorted down to individual orders, ie secondary sortation, before dispatch.
- *Collation and added value services.* After picking, goods are brought together and consolidated as completed orders made ready for dispatch to customers. This can involve packing into dispatch outer cases and cartons, and stretch- and shrink-wrapping for load protection and stability. It may also involve final production postponement activities and value added services, such as kitting and labelling.
- *Marshalling and dispatch.* Goods are marshalled together to form vehicle loads in the dispatch area and are then loaded on to outbound vehicles for onward dispatch to the next 'node' in the supply chain - to an intermediate distribution centre, to a port or airport for the next transport leg, or directly to the final customer.

The typical split of floor areas used for these functions is shown in Figure 14.2. Reserve storage generally takes up the largest proportion of the warehouse area, and frequently uses a greater height section of the building (ie reserve storage being undertaken in 'high-bay' buildings and other activities in 'low-bay' buildings). Figures on picking and packing are shown together, as sometimes these activities are combined. These two activities typically take up a substantial floor area, as do the goods receiving, marshalling and dispatch activities. It is interesting that added value services often take up little space, but this is frequently because they are an integral part of the picking and packing activities (eg price ticketing may be undertaken at the same time as packing).

As mentioned earlier, the holding of inventory is not the only role of a warehouse. Some warehouses act as cross-dock or trans-shipment points and, in these situations, there is no reserve storage function. Such warehouses include parcel sortation centres, fashion garment sortation centres (where garments may be imported already destined for particular shops) and perishable goods centres (where perishable food items may be immediately sorted to their destinations). A simplified material flow is typical of such warehouses, as shown in Figure 14.3.



Source: King Sturge/Cranfield University survey, 2003, cited in Baker (2004)

Figure 14.2 Floor area usage

It should be noted that many warehouses combine both types of activity. For example, a regional distribution centre for a food retailer may pick some goods from inventory and combine these with cross-docked perishable items and then dispatch to the retail store in the same vehicle.

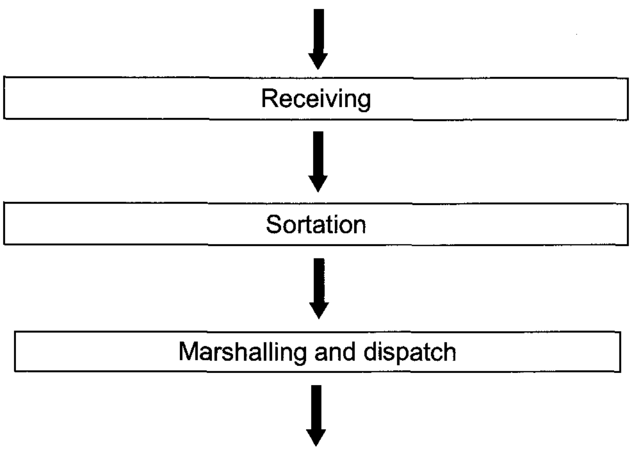


Figure 14.3 Typical warehouse functions in a cross-dock warehouse

The main functional areas of a cross-dock operation are as follows:

- *Receiving*. Goods may be received in a condition ready for immediate dispatch to the customer or may require labelling or some other form of activity.
- *Sortation*. The goods then need to be sorted to their destinations. This may be undertaken manually or by the use of high-speed sortation equipment. In the case of the latter, the incoming goods may be already bar-code-labelled by the sender so that they can be put directly on to the sortation machine and sorted into specific customer orders or destinations.
- *Marshalling and dispatch*. The goods are then marshalled into vehicle loads and loaded on to the vehicles. In the case of parcels, the warehouse may be equipped with boom conveyors that extend directly into the vehicles.

This section has indicated the principal activities found in warehouse operations. In addition there can be a range of subsidiary activities such as packaging material stores, sub-assembly areas, a truck battery-charging area, an equipment maintenance shop, offices and amenities, and in some cases services to support specific product environments such as chill or frozen goods stores.

COSTS

As noted in Chapter 1, warehousing typically accounts for about 22 per cent of logistics costs, whilst the carrying costs for the inventory within them account for a further 23 per cent. Together, these represent a very significant sum for many companies.

Past studies of 'conventional' warehouse operations - reach trucks and pallet racking with case picking at ground level - have indicated an average breakdown of annual costs, as follows:

- staff - up to 50 per cent, of which half is accounted for by the order picking staff;
- building (rent or equivalent) - 25 per cent;
- building services (maintenance, services, insurance, rates) - 15 per cent;
- equipment - 10 to 15 per cent.

From a cost point of view, the two key factors that emerge from these figures, on which designers and managers should put particular emphasis, are building space utilization and the design and management of order picking systems.

For automated warehouses, the equipment figure would normally be substantially higher, although it should be noted that most 'automated' warehouses still have manual operations for such activities as case picking and packing. In addition, information systems may represent a significant sum for both conventional and automated warehouses.

PACKAGING AND UNIT LOADS

Most goods that pass through a warehouse are packaged. This maybe, for example, to contain the product, protect or preserve it, improve its appearance, provide information, or facilitate storage and handling. Frequently, this packaging is at a number of different levels, such as directly enclosing the product (ie primary packaging), containing a number of primary packages (ie secondary packaging), or some form of outer packaging (normally to facilitate transport and handling).

The nature of packaging is very important for warehousing operations, particularly as customers may require the goods at any of these levels. Thus, some customer orders may be for individual items (eg in their primary packaging), for cases of goods (eg containing a number of items) or at some greater quantity (eg a full pallet load of goods). The warehouse operation must be designed so that any of the order quantities that are offered to customers can be picked and dispatched cost-effectively.

Most supply chains are structured around the unit load concept, whereby goods are transported, stored and handled in standard modules. Again, these may be at different levels, for example with goods being placed in plastic tote bins, which are placed on pallets, which in turn may be loaded in ISO containers for export shipping. The use of such unit loads enables transport, storage and handling systems to be designed around modules of common dimensions. In warehousing, some of the most frequently used unit loads are as follows:

- Small containers such as tote bins, made in galvanized steel or plastic, and used for small parts storage and handling.
- Wooden pallets made to standard sizes, although there are different standards, which can cause some problems with international movement. For example, the dominant pallet in continental Europe is the Europallet (1,200 millimetres by 800 millimetres), whilst the dominant UK pallet is slightly larger (1,200 millimetres by 1,000 millimetres), similar in size to that in the United States (48 inches by 40 inches). In addition to pallet size, other variables include the pallet construction: two-way or four-way fork entry, reversible or non-reversible

(double-sided or single-sided), open- or close-boarded. Some pallets are made from other materials, such as plastic and fibreboard. The wooden pallet is probably the most commonly used of all the unit load types.
- Cage and box pallets, often of metal construction, fitted with corner posts and sides to contain the products, and usually stackable by means of bell ends fitted on the bottoms of the corner posts.
- Roll-cage pallets, which consist of bases fitted with wheels and cage sides. These are widely used in distribution to retail stores.
- Dollies comprise bases fitted with wheels, on which plastic trays and tote bins may be stacked. Again, these are common in retail distribution.
- Intermediate bulk containers (IBCs) for solid particulate products (such as chemicals) and for liquids. There are rigid IBCs usually made of metal or plastic, collapsible IBCs made of canvas for ease of folding and return, and low-cost ' one-trip' IBCs made of fibreboard or similar. They are usually designed for top filling and bottom emptying, and are handled by standard fork-lift trucks. They can often be block-stacked.

The most significant unit load in warehousing is probably the wooden pallet, and storage/handling systems specifically designed for this type of load are examined in Chapter 15. Systems for non-palletized loads are then covered in Chapter 16.

SUMMARY

This chapter summarized the variety of different roles that warehouses may perform and highlighted some key strategic issues that impact on the design and management of warehouse systems. These must be taken into account if warehouses are to function effectively within the wider context of the supply chain. The typical activities that take place within inventory holding and non-inventory holding warehouses were described.

Warehouses are key components of many supply chains, and their roles and objectives should be determined by the overall context within which they operate. They should integrate closely with the other components in the supply chain. They are expensive and should be well designed and effectively managed, as the way they operate will have an immediate impact on both customer service and costs.

The concluding section of this chapter outlined the significance of packaging and unit loads in the supply chain, and summarized their use and benefits.

With acknowledgements to John Oxley, who wrote the 'Warehousing and storage' part of the previous editions of this handbook. Some of his contributions have been carried forward within Chapters 14 to 20 of this edition.

15

Storage and handling systems (palletized)

INTRODUCTION

The wooden pallet is the most common unit load used in warehouses. It is a convenient-sized load for moving goods around the warehouse and for the storage of goods. The goods often arrive already on pallets, but even where this is not the case, as occurs frequently with loose-loaded ISO containers, then the goods may be palletized at the goods receiving area ready for put-away to storage. The use of wooden pallets enables standard storage and handling equipment to be used, irrespective of the nature of the goods on the pallet. The exact nature of the equipment will be determined by such factors as the throughput levels, inventory holdings, and the requirements of the wider supply chain. The various types of storage and handling equipment available for palletized goods are explored in this chapter.

PALLET MOVEMENT

There is a wide range of equipment available for moving pallets around a warehouse, from simple manual aids to sophisticated computer-controlled equipment. Some of the most common types are as follows:

- *Hand pallet truck*. This is a truck with two forks that will fit into the slots of a pallet. The forks can be raised slightly by a simple pump action to lift a pallet off the floor. The truck can then be pulled manually and the pallet deposited at the required floor location in the warehouse. It is useful for infrequent movements over short distances.
- *Powered pallet truck*. This is similar to the above, except that it is battery-powered. The trucks may be pedestrian-controlled or may have a platform or a seat for the operator to stand or sit on.
- *Tugs and tractors*. For long horizontal movements, a tug may be used, towing a number of trailers. This reduces the number of journeys that need to be performed.
- *Conveyors*. There are a number of possible conveyor types, with the simplest being gravity roller conveyors. These conveyors comprise a series of rollers inclined at a slight angle. When the pallet is positioned on the conveyor, it rolls forward to an end stop (or to the pallet in front). Braking rollers may be fitted to slow the momentum of the pallet down the slope. For longer and more controlled movement, powered roller conveyors are used. Chain conveyors, comprising two parallel chains running in tracks, are often used for short transfers between roller conveyors and as a diversion mechanism from one conveyor to another. Turntables may be incorporated for 90-degree turns, and lift mechanisms may be used for vertical movement between conveyors at different levels. Further details of conveyors may be found in Chapter 16.
- *Automated guided vehicles (AGVs)*. These are electrically powered driverless trucks, controlled by computer (see Figure 15.1). They normally interface with other handling systems such as conveyors. Typical applications are for the transport of pallets from the goods receiving area to the reserve storage system, or from the latter to the marshalling area. Data may be transmitted to the AGVs by radio frequency signals, whilst guidance of the trucks may be by a variety of means. One method is an underfloor wire, which carries an alternating electrical current that induces a magnetic field around the wire. On-board sensors measure the field to detect any deviation from the prescribed path and, in this event, correcting signals are sent to the steering motor to bring the truck back on course. Other systems include magnets buried in the warehouse floor, optical guidance by strips or painted lines and, more recently, laser-guided systems. The vehicles have obstacle detectors on board so that they stop if they detect a person, truck or other obstacle in their path.

In general, the above types of equipment are used solely for horizontal movement. For placing pallets into storage positions, some form of lifting mechanism is

Figure 15.1 Automated guided vehicle (courtesy of Indumat)

required. These trucks are described in the following section. However, it should be noted that many of these lifting trucks are also commonly used for horizontal movement around the warehouse.

PALLET STACKING

The effective storage of goods in a warehouse normally involves the stacking of pallets, either one pallet on top of another or, more commonly, the placing of pallets into some form of racking. In order to achieve this, the truck must be capable of lifting a defined load. The capacity of a fork-lift truck is usually quoted as a maximum load when the load centre of gravity is at a specified distance (load centre) from the heel of the forks (see Figure 15.2).

If the load centre is longer than specified, the weight that can safely be carried must be reduced to avoid the risk of overturning. Manufacturers' technical

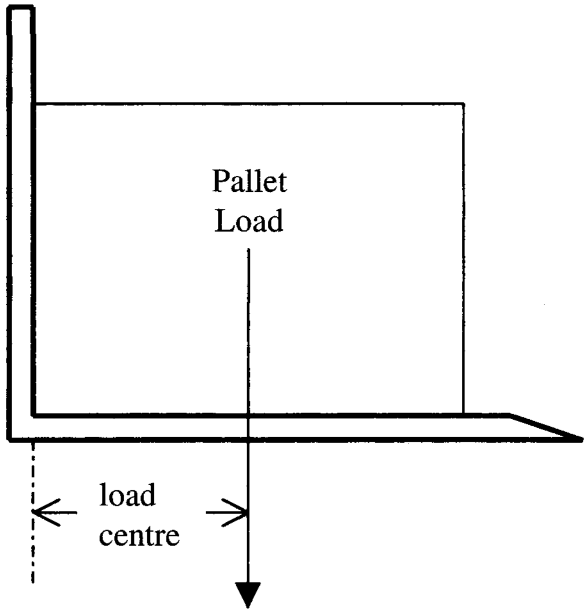


Figure 15.2 Fork-lift truck load centre

literature usually indicates the magnitude of the consequent 'derating'. Further derating (reduction in permitted load weight) applies to some trucks if the design load is raised above defined height limits, because as loads are raised truck stability decreases.

There are three basic fork-lift truck mast configurations, ie single-stage, two-stage (duplex) and three-stage (triplex). The more stages, the higher the mast can lift, and the lower the closed height of the mast.

With standard mast designs, when the forks begin to lift, the mast height immediately begins to extend. This can limit the use of the trucks for vehicle and ISO container loading and unloading. To overcome this, there are 'free lift' mast designs that allow some raising of the forks without any increase in mast height. Fork truck masts also incorporate a tilt facility, forward tilt of about 5 degrees for picking up and setting down loads, and about 12 degrees backward tilt during travel and lifting or lowering.

As with pallet movement equipment, there is a wide range of lifting trucks available. Some of the more common ones are discussed in the following sections.

Stacker trucks

These are fairly lightweight battery-powered trucks with maximum capacities up to about 2,000 kilograms. There are pedestrian, stand-on and ride-on versions. Pallets are put into or taken out of storage racking by the truck legs being driven into the space either under the bottom pallet (beam-supported) or straddling round the bottom pallet (which requires wide clearances between pallets). With some designs, when picking up pallets at floor level, the forks have to be lowered right down on to the outrigger legs, so perimeter-based pallets cannot be used, since they would be sprung apart as soon as the forks were raised. This problem is overcome if the lowest pallets are located on low beams with sufficient space underneath to accommodate the outrigger.

These trucks are usually limited to about a 6-metre lift, but they can operate in 90-degree turning aisles of only 2 metres or less.

Counterbalanced fork-lift trucks (CB trucks)

Counterbalanced fork-lift trucks carry the payload forward of the front wheels (see Figure 15.3), so there is always a turning moment tending to tip the truck forward. To balance this, a counterbalance weight is built into the rear of the machine – hence the name. Heavy components like engines and batteries are also positioned as far back as possible to help counter the overturning moment.

These machines are made with capacities ranging from 1,000 kilograms up to about 45,000 kilograms, the very large ones being typically for non-warehouse applications, such as container handling. Smaller trucks, 1,000–1,500 kilogram capacity, sometimes have three wheels rather than four, which makes them more manoeuvrable, and some smaller models are also made for pedestrian control.

Since the load is always in front of the front wheels, CB trucks are long, necessitating a wide turning area. They therefore need to operate in wide aisles (eg for putting pallets into or out of racking) of about 3.5 metres or more. Consequently, although CB trucks are very robust and fast, and are very good as 'yard trucks' and for vehicle loading and unloading, they are less appropriate for many activities inside the warehouse because of the space required for access aisles.

Whereas most trucks for use inside warehouse buildings have battery-powered electric motors, CB trucks can also be engine-driven – liquefied petroleum gas (LPG) or diesel. Battery power is clean, quiet and compact, gives high initial acceleration and is suitable for intermittent work. Technology such as regenerative braking and lowering extends the charge cycle of batteries by returning power to the battery during these activities. If continuous shift working is required, spare

Figure 15.3 Counterbalanced fork-lift truck (courtesy of Linde)

batteries will be needed, with one set in use whilst the other is being recharged. Battery changing and charging facilities are required for electric trucks.

LPG and diesel-powered trucks are robust and suitable for outdoor work. However, they are noisier than electric trucks, and the exhaust fume emissions make them less suitable for indoor work. LPG trucks are frequently used in goods receiving and dispatch areas, particularly where the warehouse doors may be open (eg to facilitate the side-unloading of vehicles).

Most fork-lift trucks have rear-wheel steering. However, there are some trucks that are articulated so that the truck body 'bends' in the middle during turning. These trucks are designed to operate in aisles of as little as 1.7–1.8 metres.

Note that certain mechanisms are available to facilitate the handling of pallets by fork-lift trucks. These include side shift, which enables the forks to be shifted laterally by about 75 millimetres at right angles to the direction of truck travel so as to facilitate the accurate positioning of loads, for example during loading pallets into ISO shipping containers. A further mechanism allows for the two forks to be spread into a total of four forks so that two pallets can be moved at a time.

This may be used for example for the rapid side-unloading of vehicles at goods receiving.

Reach trucks

Reach trucks (see Figure 15.4) are designed to be smaller and lighter than counterbalanced trucks and to operate in a smaller area. This is achieved by having a mast that can move forward or back in channels in the outrigger truck legs. When picking up or setting down a load, the truck is turned through 90 degrees to face the load location; the mast reaches forward, places or retrieves the load, and is retracted back into the area enclosed by the wheels. The truck travels with the mast in the retracted position. This virtually eliminates the need for a counterbalance weight, and reduces the truck length. Reach trucks are battery-powered. They are widely used in conventional, ie non-automated, warehouses.

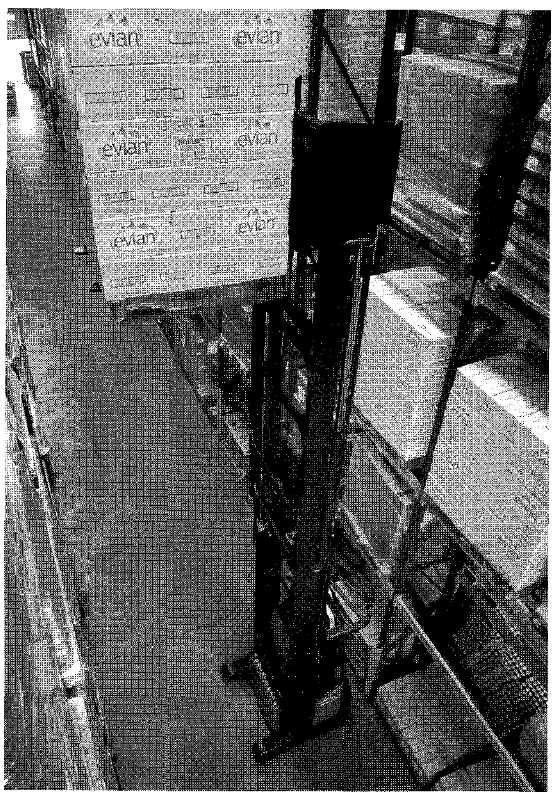


Figure 15.4 Reach truck (courtesy of Linde)

The typical range of capacities for reach trucks is 1,000 kilograms up to about 3, 500 kilograms, with a maximum lift height up to about 11 metres. Automatic height selection, or cameras at fork height, may be used to assist the driver when locating pallets at high level. Aisle widths for trucks placing standard pallets into storage are typically in the range 2.8 to 3 metres, which is considerably less than for standard counterbalanced trucks. Horizontal travel speeds are up to about 12 kilometres per hour.

In the United States, a more usual design has a static mast fixed back against the driver's compartment. The reach is achieved by the use of a pantograph (scissor) mechanism on the fork carriage, which moves the forks forward and back.

Other stacking equipment

There is a range of other specialist pallet stacking equipment for use with specific storage types. These include double-reach trucks, narrow-aisle trucks, and stacker cranes. Each of these is described with the appropriate storage system.

PALLETIZED STORAGE

There are many storage systems available for palletized goods, ranging from simple block stacking to advanced computer-controlled systems. As well as representing a range of technologies, these systems offer various compromises between the very dense storage of pallets with limited accessibility to each pallet and, at the other extreme, individual accessibility to every pallet but taking up a large amount of warehouse space. These alternative systems are described below.

Block stacking

In block stacking, pallets are placed directly on the floor and built up in stacks, one pallet on top of another (as in the foreground in Figure 15.5). No storage equipment is required. The maximum stable height of the stacks is typically not more than six times the shortest plan dimension of the pallet, eg maximum stack height 6 metres for 1,200- by 1,000-millimetre pallets. Rows of stacked pallets are laid out side by side. Typical clearances in a block stack would be 100 millimetres between each row of pallets and 50 millimetres between pallets in each row. When removing goods for use, free access is only to the pallets at the top and front of each row. Typically, block stacking is carried out by counterbalanced fork-lift trucks.

Figure 15.5 Block stacking in foreground, with adjustable pallet racking behind (courtesy of Redirack)

The pallet loads must be capable of carrying the superimposed pallets, and the top of each load should be flat enough to provide a stable base for the next pallet. If these conditions cannot be met, pallet converters or post pallets can be used, which carry the superimposed load directly to the next pallet below in the stack via corner posts or other means, and no weight is imposed on the 'payload'.

Any one row should contain only pallets of the same stock keeping unit (SKU), ie a particular product line (or sub-product line, eg by size or colour, if there are a number of variations of a line). This is necessary to avoid double-handling. Thus, rows should be emptied completely before being refilled in order to avoid trapping old stock at the backs of rows. In practice, more than one row is normally allocated to an SKU so that one row can be filled with new pallets arriving whilst another row is being emptied.

Note that any working store will always have some unoccupied locations. For block stacking, typically some 30 per cent of the individual pallet locations can be empty at any one time. For example, if three rows are used for a particular SKU, then one may be used for receiving goods (and will be on average half-full), one may be full with stock, and one may be used for dispatching goods (and thus be on average half-empty). In such a situation, only about two-thirds of the locations would be occupied by pallets. The effective utilization of the pallet positions is therefore often about 70 per cent. When designing for a random-location block-storage installation with capacity of P pallets, the number of pallet locations to be provided should be of the order of P/0.7. If a holding capacity for 1,000 pallets is required, then 1,000/0.7 = 1,430 (rounded) locations should be provided.

For safe fork-lift truck driving, the front-to-back depth of any row should not normally exceed six pallets in from the truck access aisle, which means blocks of a maximum 12 deep, back to back. In practice, layouts may well incorporate rows of different depths to accommodate SKUs with different inventory levels. Thus, in a four-high block store, for example, SKUs with typical inventory levels of 48 pallets and above may be stored in six-deep rows, whilst SKUs with 24-plus pallets may be stored in three-deep rows.

Block stacking is suitable for that part of the product range where there are few product lines, each with a high inventory level, and where very strict first in first out (FIFO) movement of inventory is not required. The advantages are good use of area (although not necessarily of building height), flexibility to change the layout of the blocks, and quick access to inventory for rapid throughput.

Drive-in and drive-through racking

Although this is a racked storage system, it is operationally similar to block storage. Again, there should only be one SKU in each row, and the effective utilization of the pallet positions is about 70 per cent. The racking structure supports the weight of the pallets, so this system is suitable for high-inventory SKUs, where strict FIFO movement is not required, but where the goods are not strong enough or of regular enough shape to carry superimposed loads. Since pallets are supported by the structure, the height of the installation is not limited by pallet strength or stability.

This system consists of vertical support frames, tied at the top, with cantilever pallet support beams at different heights. Fork trucks enter the racking between the vertical supports to access the pallets sitting on the cantilever beams (see Figure 15.6). If access is all from one end the racking is called 'drive-in', and if pallets are fed in at one end and removed at the other the term 'drive-through' is used. The latter requires careful attention to the management of the operations.

Access for the fork trucks within the racking is tight because the cantilever supports have to be narrower than the width of the pallets, and pallets have to be moved in and out of the racking in a raised position. This tends to limit the

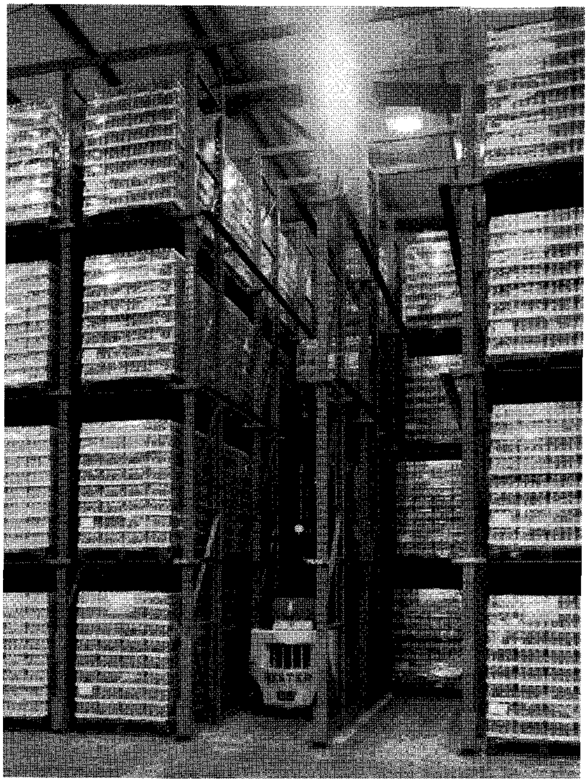


Figure 15.6 Drive-in racking (courtesy of Redirack)

speed of movement of pallets into and out of the racking, and driver strain can be a factor.

Since pallets are only supported along each side, pallet condition is important, and due to the narrow truck access the floor and the racking have to be built to tight tolerances to minimize the risk of the trucks colliding with the racking.

The suggested maximum height is 10 to 11 metres, with the front-to-back row depth of six pallets in from the fork truck access aisle, or 12 deep if back to back.

Push-back racking

Like drive-in racking, this gives high-density storage and can be built to any height up to the maximum lift height of the trucks accessing it. Pallets can be stored up to about four deep in the racking, on either side of the access aisle.

Each level in each vertical row of the racking (let us call it a lane) is fitted with inclined rails along which trolleys can move, the incline sloping down to the front of the racking. The trolleys 'nest' when empty. Incoming pallets are lowered on to the trolleys and pushed up the incline and into the racking by a fork-lift truck until the lane is full. As an outgoing pallet is withdrawn, the pallet behind moves down to replace it, until the lane is empty and can be refilled.

The basic operational difference between this system and block stacking or drive-in racking is the increased selectivity achieved. There should be no mix of SKUs in any one lane, but there can be between the lanes in any row. This system is thus suited to SKUs with lower levels of inventory, eg SKUs with eight-plus pallets in a four-deep system.

Adjustable pallet racking (APR) - reach truck operation

Adjustable pallet racking is probably the most widely used type of pallet racking, and offers free access to every pallet held. It can be built to match the lift height of any fork-lift truck. Counterbalanced fork-lift trucks may be used but, owing to the wide aisles required for turning, it is more normal to use reach trucks.

It consists of upright end frames and pairs of horizontal beams on which the pallets are located, and beam heights are adjustable to suit the height of the pallet loads being stored (see Figures 15.4 and 15.5). In theory, to optimize the use of vertical space, beam heights can be altered if pallet load heights change. In practice, this does not often occur because of the cost and disruption to the operation. Typically, two pallets of 1,000- by 1,200-millimetre dimension are stored per bay (ie between rack uprights), whilst three Europallets, with the 800-millimetre dimension facing the aisle, are stored in a single bay.

The conventional way of laying out APR is to have one row single deep against the wall at each end of the installation, with back-to-back rows in between. This gives every truck aisle access to two rows of racking, and minimizes the number of aisles required. Guidelines for the horizontal and vertical spacing of the racking components to enable safe access to the pallets are given by codes of practice issued by regional and national associations, such as the Federation Europeenne de la Manutention (FEM) for Europe and the Storage Equipment Manufacturers Association (SEMA) for the United Kingdom in particular.

APR is a flexible, versatile storage system, which gives excellent stock access. It is simple in concept and easily laid out, and damaged parts can be readily replaced. It can be suitable for fast-moving and slow-moving inventory. Typical utilizations for pallet positions in random-location APR can lie in the range 90 to 95 per cent, depending partly on the effectiveness of the warehouse management system handling the location information.

However, APR does not make good use of building volume. In a typical installation using reach trucks, each aisle (say 2.8 metres) is wider than the back-to-back pallets in the racking (2.1 metres, with ISO pallets positioned 1,000 millimetres deep into the racking). Hence, before allowing for any other space requirement such as transverse aisles, the building space utilization is well below 50 per cent, and this is important in the context of the building cost figures seen in the previous chapter.

Double-deep racking

If some loss of totally free access to stock can be accepted, although not nearly as severe as in block, drive-in or push-back storage, space utilization can be improved using double-deep racking. This supports pallets on pairs of beams as in APR, but improves space utilization by eliminating alternate access aisles, and using a 'double-reach' fork-lift truck, which can access not just one but two pallets deep into the racking. The concept is illustrated in Figure 15.7.

The price of this space saving is the requirement for double-deep reach trucks to access the stock, more costly than ordinary reach trucks, and some loss of selectivity

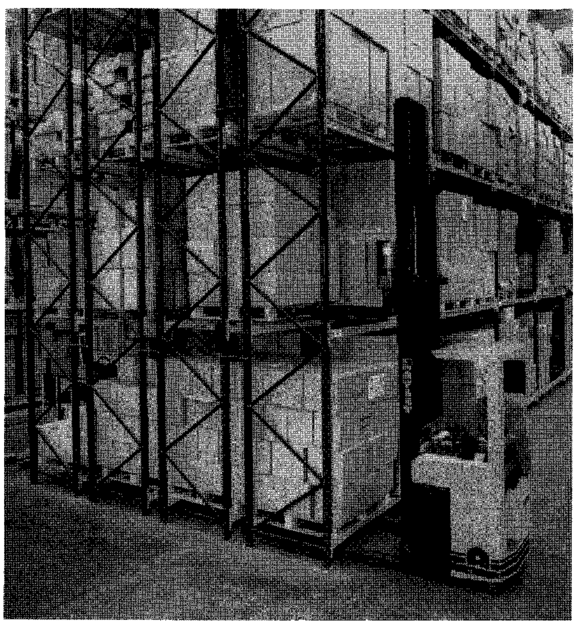


Figure 15.7 Double-deep racking (courtesy of Link 51)

since pallets are now stacked two deep into the racking, ie loss of absolute FIFO stock rotation. A minimum of at least four or five pallets per SKU is needed for double-deep racking to be suitable (ie to allow rotation of the two-deep lanes, whilst providing reasonable location utilization). Pallet position utilization in double-deep racking is typically of the order of 85 per cent, depending on the precise application. A practical requirement is that the bottom level of pallets in the racking normally has to be supported on a raised beam to allow the legs of a double-reach truck to fit under the racking structure when accessing the pallet furthest in from the aisle. In single-deep APR, the bottom pallet can sit directly on the floor.

Double-reach trucks may use a pantograph mechanism to achieve the additional reach or, on some lighter trucks, telescopic forks may be used. Double-reach machines are also used for side-loading pallets on to road vehicles, working only from one side of the vehicle.

Narrow-aisle racking

APR racking may be set out in much narrower aisles than those required by reach truck operations. High-rack stacker trucks, equipped with rotating or sliding pallet handling mechanisms, do not need to turn in an aisle to access pallet locations, and in APR can typically operate in aisles of 1.8 metres or less. They can also lift higher (up to about 14 metres) than reach trucks, and these two factors increase the space utilization. However, there are cost penalties in providing the required floor strength and flatness for working in high but narrow aisles, and the trucks are significantly more expensive than reach trucks. Nevertheless, narrow-aisle racking systems are very common in warehouses with large pallet reserve storage areas. A typical installation is shown in Figure 15.8.

Some narrow-aisle trucks have the operator at ground level, usually for pallet-in and pallet-out operations. Some form of automatic height selection is then necessary to assist the operator when locating or retrieving pallets at high level in narrow aisles. In other 'man-up' versions, the operator's cab rises with the forks, appropriate for high-level order picking operations (see also Figure 17.1).

The narrow-aisle trucks can be steered from one aisle to another, but they require guidance down the aisles (because of the tight tolerances involved). This is done either by fitting side wheels to the trucks, which engage with guide rails fixed to the racking on both sides of each aisle, or by using 'wire-in-floor' technology whereby magnetic sensors in the truck follow an electric cable buried in the floor (as described for automated guided vehicles).

Figure 15.8 Narrow-aisle racking (courtesy of Redirack)

Powered mobile racking

Powered mobile racking is effectively single-deep APR, with the racking (except the end or outer rows) mounted on electrically powered base frames, which move on rails set into the floor, as shown in Figure 15.9. Floor loadings are high. Typically only one fork truck access aisle is provided, and the rack sections are moved to open up access as required to any specific pallet location. Safety trips are fitted to each side of each mobile base frame to cut power in the event of any obstruction.

This type of system is expensive in equipment and floor costs, and it tends to be slow in operation. However, it gives very dense storage, and is suitable for the typically large number of product lines forming the 'Pareto tail' of a product range, where individual SKUs have low inventory and low throughput. It also finds use in cold-store applications where space costs are especially high, and where temperature variations are reduced by minimizing the air space in the

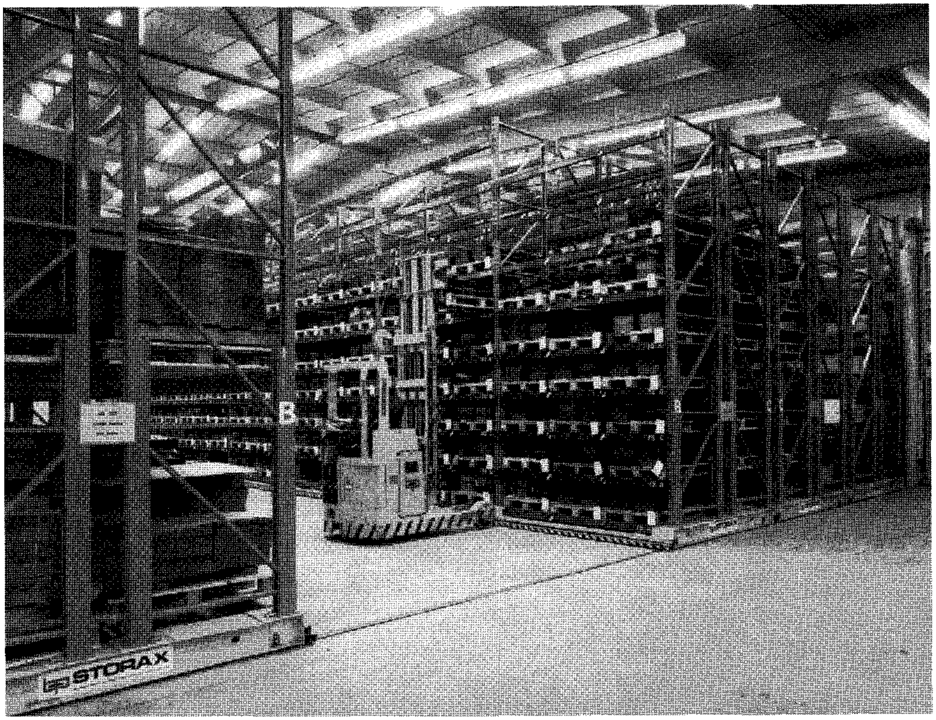


Figure 15.9 Powered mobile racking (courtesy of Redirack)

storage area. The pallet position utilization is likely to be similar to APR at 90 to 95 per cent.

Pallet live storage

Live storage systems are made up of inclined gravity roll conveyors, laid out side by side and at a number of vertical levels (see Figure 15.10). Pallets are fed in at the higher end and removed as required at the lower. Such a system imposes FIFO. The only accessible pallets are at the out-feed end, so any one lane should hold only pallets of the same SKU.

The incline of the conveyors is critical in these installations, and is perhaps best obtained by trial and error, by testing examples of the pallets that will be using the system. Braking devices and end stops are usually fitted to control the movement of pallets towards the discharge end.

Pallet live storage systems are suitable for very fast-moving product lines. They can provide effective order picking regimes, which automatically refill empty

Figure 15.10 Pallet live storage (courtesy of Jungheinrich)

locations, and also provide physical separation between picking and replenishment operations.

Pallet live storage is expensive, and pallet position utilization is not always high – say 70 per cent. Pallet type and condition are critical, and in some applications slave pallets, on which the pallets stand, may have to be used.

Automated storage *and retrieval systems* (AS/RSs)

Automated storage and retrieval systems comprise the following components:

- a storage medium, eg pallet racking;
- storage and retrieval machines that operate in the storage medium;
- in-feed and out-feed systems, eg fork-lift trucks, conveyors, AGVs;
- equipment control software.

A typical installation consists of high-bay pallet racking, with stacker cranes operating in the racking aisles to put pallets away to stock and to retrieve them as required. Installation heights of 45 metres or more can be achieved, and typical operating aisles for standard pallets can be about 1.5 metres. The equipment control software monitors the status of all the components of the system and, based on the warehouse inventory and movement requirements, plans the work to be carried out within the system and instructs the equipment accordingly. Because of the generally tight clearances in such installations and to prevent possible jams in the racking, a strict profile check for incoming pallets is adopted to ensure that loads have not slipped on the pallets during transit, and that packaging material has not come loose. Pallets outside the dimensional specification are rejected, and have to be rectified before being accepted into the system.

The stacker cranes that work within the AS/RS consist of a vertical mast or pair of masts supporting a unit load handling mechanism, which can be raised or lowered. The cranes travel on a floor-mounted rail running the length of each aisle, with an overhead guide rail. The unit load mechanism can pick up and put away pallets from and to either side of the racking aisle. The cranes are electrically powered, usually three phase 415 volts, supplied via suspended or reel-feed cable.

The amount of storage racking required depends on the designed inventory holding capacity of the installation. The overall rack dimensions are then determined by the height of the building (allowed by the local planning authority) and by the lift and travel characteristics of the cranes. This then determines the number of racking rows required and the number of crane aisles.

The number of cranes required is determined by the total amount of pallet movement that has to be carried out in a given period of time. If the number of cranes is significantly less than the number of aisles in the racking, a transfer facility can be incorporated into the design to enable the computer to instruct the movement of cranes between aisles as required. This operation may be undertaken in a transverse aisle equipped with one or more transfer cars on to which the cranes can be driven and moved between aisles (see Figure 15.11). An alternative method is to curve the rails at the end of the aisle so that the cranes can run down the transverse aisle. These have point mechanisms that the cranes can alter to proceed down the appropriate rack aisle. If the number of cranes required is close to the number of aisles in the racking, it is probably better to have one dedicated crane in each aisle, as this speeds up the operation and saves the space that would be occupied by the transverse aisle.

A frequently used term in automated warehousing is 'high-bay warehouse'. Generally this refers to a crane-accessed AS/RS that is higher than a conventional warehouse (ie the term may typically be used for such warehouses between about 15 and 45 metres in height). Other terms associated with this sort of installation

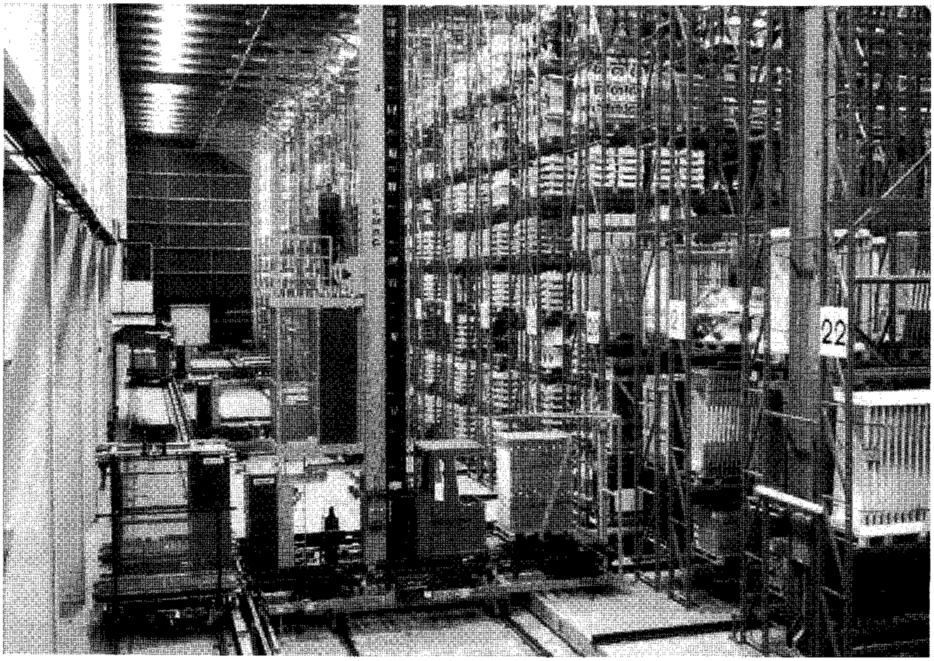


Figure 15.11 Stacker crane on a transfer car (courtesy of Siemens)

include 'roof on rack' and 'clad rack'. These both refer to the specific building technique in which the walls and roof are supported by the racking steelwork, so avoiding the need for a separate enclosing building. This reduces the cost of building. There can also be tax implications according to whether the building is classified as a fixed asset or as 'plant'.

There is a wide range of designs for AS/RSs but these may generally be classified as follows:

- *Single deep.* This has similar characteristics to those described for APR and narrow-aisle, in that there are two rows of pallet racking back to back between the aisles. The stacker cranes access one deep on either side.
- *Double deep.* Again, the characteristics are similar to double-deep conventional racking. In this case, there are four rows of pallet racking between the aisles, and the stacker cranes are specifically designed to reach two deep into the racks. Normally, they access one pallet at a time (as with double-deep reach trucks), but some AS/RSs have double-width aisles and can access two pallets at a time. The latter increases throughput rates but uses more space.

- *High-density systems.* There are various types of automated dense storage systems on the market. One system is the satellite crane, whereby each stacker crane has on-board a satellite that can move away from the crane in rails underneath the pallet lanes, and deposit a pallet into the racks or bring a pallet back to the crane. The pallet racks may be installed, for example 10 deep, so that the satellite can fill 10 pallets into a lane of racking. There would thus be 20 pallets back to back between the aisles. This is a very dense storage system, but operates on a last in first out (LIFO) basis for each lane of 10 pallets. Alternative systems include the use of flow racks, which may be gravity or powered, with stacker cranes putting in at one end and extracting pallets from the other, so as to maintain a FIFO system.

AS/RSs tend to make very good use of land area, because of their height and narrow aisles, and can be designed for high levels of throughput. However, they have a high capital cost and are therefore best suited to large installations that need to operate for most hours of the day (eg approaching seven-day-week, 24-hour operations). During non-working or off-peak hours, the equipment needs to be maintained. Also, during these periods, the AS/ RS can be set to work automatically on 'housekeeping' duties to reposition the pallets in the optimum locations (eg fast-moving SKUs may have had to be put away at the far end of the aisles during congested periods and can later be moved nearer the in-feed/out-feed end).

PALLETIZED STORAGE - COMPARISON OF SYSTEMS

A comparison of space utilization can be calculated for each type of storage system based on such factors as the handling equipment characteristics, available warehouse height and pallet dimensions. An example for pallets with base dimensions of 1,000 by 1,200 millimetres is shown in Table 15.1. This table gives the number of pallets high assumed for the example (obviously this will vary by application), the floor utilization (ie the percentage of floor area occupied by the pallets themselves within the storage module, excluding transverse aisles) and the number of pallet spaces that can be provided per square metre of floor area. In this example, it can be noted that, whilst block stacking offers very good floor area utilization, the height may be limited by the crushability and nature of the pallet loads. Similarly, narrow-aisle storage may provide more pallet spaces per square metre than double-deep storage because of the height that can be achieved. AS/RS can achieve much greater heights than conventional systems, so the increased land utilization can be very significant (even greater than that shown in the example).

Table 15.1 Space utilization examples

Storage Type	Assumed Height	Floor Utilization	Pallet Spaces per m^2
Block stack (four deep)	3 pallets	62%	1.5
APR (reach truck)	5 pallets	36%	1.5
Double deep	5 pallets	47%	2.0
Narrow-aisle	7 pallets	44%	2.6
AS/RS - single deep	10 pallets	48%	4.0

When considering the space utilization figures in Table 15.1, it should be noted that some storage methods are able to work at much greater location occupancy levels than other systems. For example, it was noted that block storage may require up to about one-third of the spaces to be empty so that the operation can work effectively, whilst APR may work effectively with only 5 to 10 per cent of the locations empty. The figures for pallet spaces per square metre in Table 15.2 therefore need to be adjusted by the relevant location utilization figures to give a more realistic comparison (as shown in Table 15.2).

Table 15.2 Space utilization examples (including location utilization)

Storage Type	Pallet Spaces per m^2	Location Utilization Factor	Pallets per m^2
Block stack (four deep)	1.5	70%	1.1
APR (reach truck)	1.5	95%	1.4
Double deep	2.0	85%	1.7
Narrow-aisle	2.6	95%	2.5
AS/RS - single deep	4.0	95%	3.8

In addition to space, there are other factors that need to be taken into account. One method is to draw up a storage attributes matrix, such as that shown in Table 15.3 (which represents a very subjective view by one author). This method helps to identify which storage systems are best able to meet the specific requirements of an individual warehouse operation.

Table 15.3 Palletized storage attributes matrix

Storage Type	Access to Each Pallet	FIFO	Low Rack Cost	Suitable for Ground Case Picking	Operating Speed
Block storage	1	1	5	1	4
Drive-in	1	1	2	1	3
Push-back	2	1	1	1	3
APR (with reach truck)	5	5	3	5	4
Double deep	2	1	3	2	3
Narrow-aisle	5	5	3	2	4-5
Powered mobile	5	5	1	1	1
Pallet live	1	5	1	5	5
AS/RS - single deep	5	5	3	1	5
AS/RS - double deep	2	1	3	1	5
AS/RS - high density	1	1	3	1	3

Key: scale from 5 (= favourable attribute) to 1 (= unfavourable attribute)

SUMMARY

This chapter has set out the basic storage and handling systems for palletized goods, and the essential characteristics of the different systems. A key aspect for determining the most appropriate system for a particular application is to select one whose characteristics most closely match the overall requirements of the warehouse within which it is to work. In most warehouses more than one system is used.

The basic objectives for determining the most appropriate storage and handling system for any application are likely to include:

- effective use of space — building height, building area and access aisles;
- good access to pallets for taking out and replenishing;
- high speed of throughput;
- low levels of damage;
- high levels of accuracy;

- integrity and security of inventory;
- personnel safety;
- minimum overall system cost.

There are often compromises to be made between these objectives. For example, storage systems that utilize building space most effectively often do not give particularly good access to the stock, and vice versa. On the other hand, where a system offers both excellent space utilization and individual access, as with powered mobile racking, then speed of throughput is compromised. Thus, a trade-off often has to be made between these factors when deciding on the use of any storage and handling system.

16

Storage and handling systems (non-palletized)

INTRODUCTION

Although pallets are very widely used in warehouse operations, there are many types of product that are not suitable for palletization, because they may be, for example, too small, too large or too long, or because they require lifting from the top. These products may include, for example:

- nuts and bolts;
- electronic items;
- paper reels;
- machinery;
- steel bars;
- carpets;
- drums;
- hanging garments.

This chapter examines the various storage and handling systems that may be applied to such items.

SMALL ITEM STORAGE SYSTEMS

There is a range of equipment designed for the storage of small items. Some of these are used in combination, and therefore standard sizes and modularity are important. Whatever system is used, it is important that there is a specified location, or locations, for every SKU.

Shelving - short and long span

Shelving is generally made from standard modular components that allow installations of different heights, vertical shelf spacing and shelf depths. The typical standard span width is 1 metre, but long span shelving is also available that facilitates the holding of longer items of stock. Subdividers can be used to provide even smaller locations where this is appropriate for the inventory being held.

Shelving can be accessed in various ways - from ground-floor level, from mezzanine levels or from fixed-path or free-path lifting equipment such as narrow-aisle picking trucks and picking cranes. A variant on this concept is cantilever shelving, which is supported from the back and sides, and gives completely clear access from the front and hence flexibility for holding items of different lengths.

Bins

Tote bins are made in a range of materials such as galvanized steel, polypropylene, wire mesh and fibreboard. They are made in modular sizes that are sub-multiples of standard dimensions, and this facilitates nesting and stacking, and the use of different sizes of tote within one installation.

A useful device for supporting tote bins is the louvre panel. It provides easy attachment and removal of totes, and also other attachments such as spigots for holding items such as gaskets, belts and other more awkward items.

Drawer units

Drawer units can be free-standing or incorporated into shelving modules or stores counters. Subdividers are used, which enable particularly good use of drawer space, and there is a range of other fittings suitable for such items as electronic components, machined items and other delicate components. Drawers give very good access to the stock and provide a clean and secure environment.

Mobile shelving

Just as for palletized stock, there are small item mobile storage systems with shelves mounted on moving platforms, which run along floor-mounted rails. Unlike palletized systems, however, these are not usually powered, but are manually moved by turning a large wheel at the end of each section of shelving. This system finds wide application in banks and insurance companies for holding documents required only infrequently.

Flow racks

Small items and cartons can also be held in live storage systems, sometimes referred to as flow racking, with the goods located on inclined roller conveyors, fed in at the high end and taken out as required at the lower end (see Figure 16.1). As with pallet live storage, this maintains FIFO for the products.

Figure 16.1 Flow racks (courtesy of Link 51)

Carousels

Carousels hold material on shelves, or in tote containers on shelves, supported and moved by chains, which are electric-motor-driven to bring specific product lines, as required, to an operator. The objective is to minimize operator movement when accessing inventory, so carousels find application in small items order picking. Carousel units can give fast rates of accession to stock, and are inherently secure. There are two types of carousel, horizontal and vertical.

In the horizontal carousel (see Figure 16.2), inventory is held in shelved cages or baskets, normally suspended from a motor-driven overhead chain conveyor loop, and for each stock accession the chain is driven forwards or backwards to bring the required goods to the operator by the shortest route.

In the vertical carousel (see Figure 16.3), inventory is held on shelves suspended between two motor-driven vertical chain loops. The shelves are moved up or down, taking the shortest route, to bring stocked items as required to the operator's static

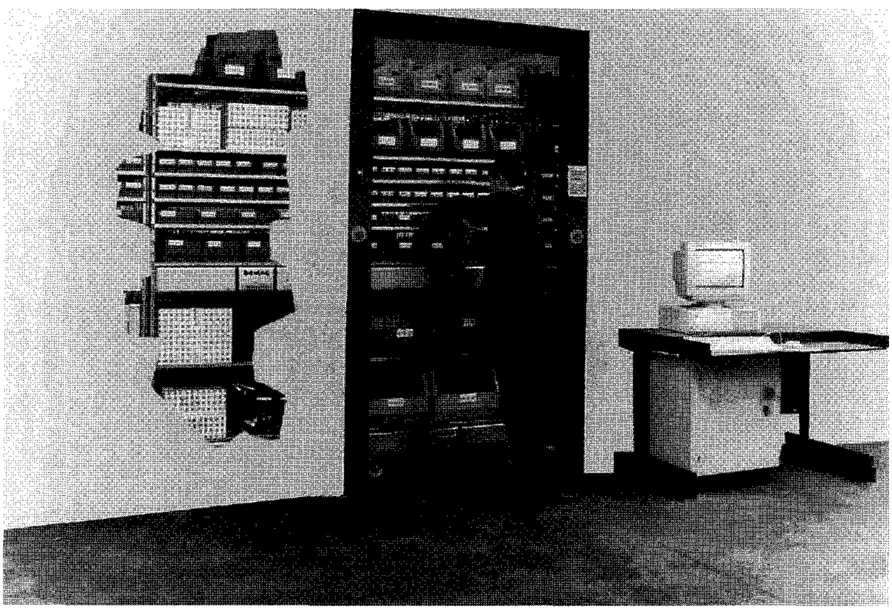


Figure 16.2 Horizontal carousel, including cutaway of storage modules (courtesy of Siemens)

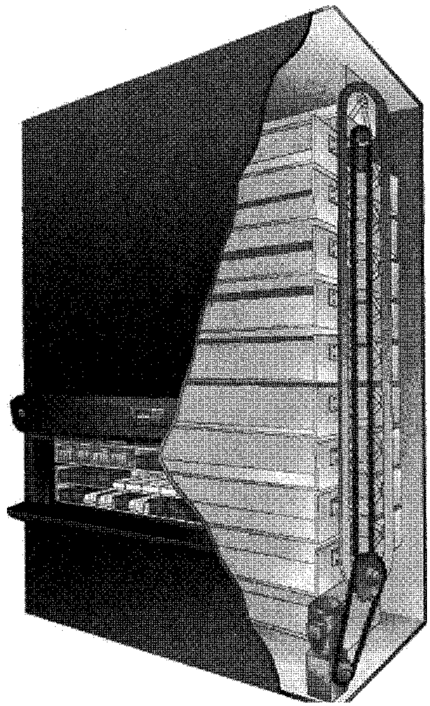


Figure 16.3 Cutaway drawing of a vertical carousel (courtesy of Kardex)

location. One advantage of the vertical carousel is that it can be built up to the roof height, so making good use of building space. A similar equipment type is the vertical lift system (or vertical storage/retrieval module), where trays are moved individually within the unit, rather than being rotated.

For carousel units, it is not generally practical to replenish stock at the same time as stock is being withdrawn, so a working pattern has to be established for these two aspects of the operation.

Miniload

Another mechanized small item storage system is the miniload (see Figure 16.4). A (computer-controlled) crane operates in a central aisle to bring goods out of, or put goods into, the storage medium, shelving or tote containers set out on either side of a central crane aisle. This is basically an AS/RS for small items. The cranes may be designed to transport more than one carton or tote bin at a time, in order to improve access rates. Thus, for example, a crane may pick up two tote bins from an

Figure 16.4 Miniload (courtesy of Swisslog)

in-feed conveyor, put one away and then put the other away in a nearby location, before proceeding to extract any tote bins required.

TRUCK ATTACHMENTS

For larger items, it may be possible to handle the goods by means of attachments fitted to fork-lift trucks. These attachments may be used for block-stacking the goods or they may be used in conjunction with accessories fitted to adjustable pallet racking. For example, channel supports are available for storing post pallets on APR. Similarly, drum and reel supports are also available.

It should be noted that all attachments have weight, and this must be taken into account when calculating the payload capacity of a truck where attachments are used. In addition, many attachments result in the load centre being moved further away from the heel of the forks, resulting in further 'deration' of the weight that can safely be carried by the truck.

Some common truck attachments are as follows:

- *Clamps.* Clamp attachments consist of shaped or flat side arms, sometimes also fitted with non-slip surfaces, used for handling loads such as washing machines, bales, drums, kegs and paper reels. They are powered by the truck hydraulic system, with the side arm pressure being adjustable to prevent crushing of the load.
- *Rotating head.* This device changes the orientation of a load. For example, reels of newsprint are usually stored with their axes vertical, but they are required to be presented to printing machines horizontally.
- *Load push-pull.* This device handles pallet-sized loads assembled on card or plastic skid sheets (sometimes referred to as 'slip-sheets'). A clamp fitted to a pantograph mechanism on the fork truck grips a lip on the skid sheet, enabling the load to be pulled on to a platen on the truck. Once there, it can be lifted, moved and positioned effectively as though it were a pallet load. This enables ' palletless' handling, including loading vehicles for dispatch to customers. An implication of this is that the customer also must have the attachment to be able to unload. The use of these sheets saves space in shipping containers, avoids the cost of one-way pallets, and overcomes restrictions on the import of wood (imposed due to the possible spread of pests and diseases).
- *Booms.* There are various boom attachments available for placing along the centre of items such as carpets and horizontal reels.
- *Multi forks.* These are frequently used where unit loads are made from the items themselves. For example, bricks may be strapped together leaving a number of slots within the lower layers for such attachments to fit into.
- *Drum tines.* These are horizontal bars that are used for lifting a number of horizontally oriented drums at once.

LONG LOADS

Items such as carpets, linoleum, wood and engineering material (eg bar, rod and tube) are not suitable for the standard types of storage system discussed so far, and require special storage and handling.

Storage methods include:

- *Block storage.* Wooden boards, for example, are often strapped into unit loads and block-stored in yards, with pieces of wood inserted between the loads so that they can be lifted from underneath.

- *Cantilever racking. This* type of racking comprises supporting bars set at various levels and cantilevered out from back frames. It is often used in engineering applications for long rigid items such as bar and tube stock.
- *'Toast-rack' storage.* This may be used for the vertical storage of metal plate or sheets of other material.
- *Pigeon-hole racking.* Other long loads that require some support along the length, such as rolls of carpet, can be stored in pigeon-hole racking.

The handling of long loads is generally undertaken by:

- *Side-loaders.* These have masts that reach at 90 degrees to the direction of truck travel (see Figure 16.5). Typical load lengths can be 6 to 7 metres, handled in narrow aisles between stacks. To access a load positioned along one side of an aisle, the truck must enter the aisle with the reach mechanism on the opposite side of the aisle. These trucks are long and typically require cross-aisles of some 7 metres to move between aisles. They are frequently used for outdoor operations such as timber yards.

Figure 16.5 Side-loader (courtesy of Linde)

- *Multi-directional trucks*. On a conventional reach truck, the front wheels always face forward, and steering is from the rear wheels. The multi-directional truck (see Figure 16.6) has an additional option of being able to turn the front wheels. A similar type of truck is the four-way truck, which can turn the front wheels through 90 degrees and lock them in this mode. These trucks can therefore act as side-loaders, but with narrower transverse aisles. This is especially useful in warehouses where part of the inventory range consists of long loads. For access to, say, cantilever storage, very wide rack and transverse aisles would be necessary if this option were not available.
- *Boom attachments*. These are used, for example, to access carpets from pigeon-hole storage. The booms are inserted by the truck into the centre of the roll to lift and position it.
- *AS/RS*. Stacker cranes may be used to move long loads into and out of cantilever racking.
- *Overhead cranes*. These are described in the following section.

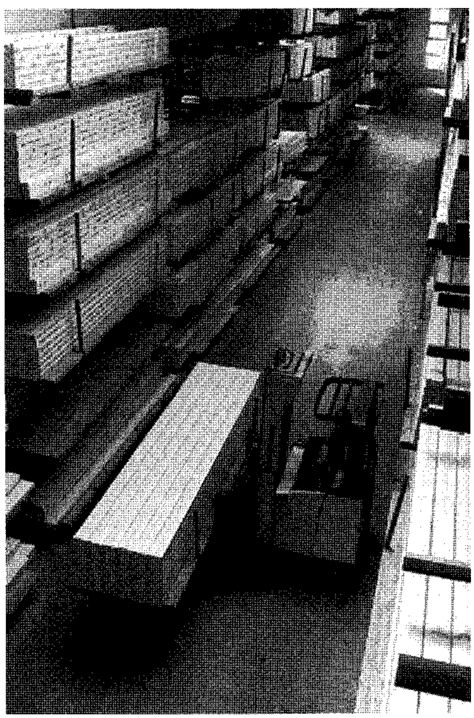


Figure 16.6 Multi-directional truck (courtesy of Jungheinrich)

CRANES

Cranes are used particularly for moving very heavy loads (such as metal bars) within a predetermined area, but may also be used for lighter loads, for example where items may be just too heavy in relation to manual handling guidelines.

Equipment types include:

- *Jib cranes. A* jib crane consists of a pivoted arm - the jib - either pillar-mounted or wall-mounted, with a hoist that can travel radially along the jib. The jib can be slewed about the pivot to position the payload within the arc defined by the radial jib.
- *Overhead travelling cranes.* These consist of a bridge made up of one or more beams, the bridge being fitted with end carriages that travel along a pair of parallel high-level rails. *A* trolley, incorporating a hoist, travels on rails on the bridge structure.
- *Gantry cranes.* The basic crane components are a bridge section carrying a transverse trolley and hoist mechanism, and supporting legs at each end of the bridge. The legs can run on ground rails or, for mobile gantry cranes, be supported on pneumatic wheels that allow free movement of the crane. They are therefore suitable for outdoor use.

Most cranes are electrically powered and are controlled by a fixed-wire push-button control box, by infrared, by radio or, in the case of the larger cranes, by operators in cabins fitted to the bridge.

A range of attachments may be used, including hooks, mechanical clamps and magnets.

CONVEYORS

Conveyor systems are used for moving material between fixed points, for holding material as short-term buffer (ie accumulation) and for sortation.

Both gravity and powered conveyors may be used for the movement of goods. Types of gravity conveyors include chutes, skate-wheel conveyors and roller conveyors. These types of gravity conveyors are normally used for moving goods short distances, for example chutes may be used for transferring goods down from a mezzanine floor whilst mobile skate-wheel conveyors may be used for vehicle loading and unloading. Powered conveyors are normally used for longer distances, and types include:

- *Roller conveyors*. These comprise a series of rollers and are frequently used for such unit loads as tote bins and pallets. In order to provide accumulation, the conveyors may be equipped with various features, such as rollers that have friction-clutches (ie that slip if the load is stopped by a 'pop-up' or end stop).
- *Belt conveyors*. Belt conveyors consist of a continuous belt running on supporting rollers and are generally used for lighter loads (eg cartons) than roller conveyors.
- *Slat conveyors*. These are fitted with horizontal cross-slats and can be used for heavy and awkward loads.
- *Chain conveyors*. These carry loads on chains running in tracks parallel to the direction of travel and may be used for heavy loads or as transfer mechanisms between sections of roller conveyor.
- *Overhead conveyors*. An overhead conveyor consists of a continuous chain running in an overhead track, with loads on carriers suspended from the chain. Applications include order picking in warehouses with a wide range of SKUs (eg mail order companies).

Conveyor systems may be suitable where some of the following characteristics apply:

- high throughput;
- fixed routes;
- continuous (or intermittent, but frequent) movements;
- uneven floors or split-level operations.

The possible disadvantages of conveyor systems include:

- high capital cost;
- obstruction to pedestrian and truck traffic;
- inflexibility for future change.

Conveyors are widely used for the movement of pallets, cartons, tote bins and other loads within warehouses, as well as being an integral part of order picking and packing operations. In the latter activities, conveyors may have a specific application as a means of sortation (eg to bring all goods together for a particular order ready for packing, or to sort to vehicle load), and this aspect is covered in Chapter 17.

AUTOMATED GUIDED VEHICLES

As well as being used for the movement of pallets (as described in Chapter 15), AGVs may be used for transporting large loads such as car bodies and paper reels. In the latter case, instead of being fitted with roller conveyors to move the load, they may have 'cradled' belt conveyors to hold the reels and to move the reels on to and off the AGV.

HANGING GARMENT SYSTEMS

These are specialist systems for storing and handling garments on hangers. It is possible for garments to be transported in a hanging condition all the way from garment manufacturers in source countries such as in the Far East through to shops in, for example, the United States or Europe. Road vehicles and ISO shipping containers can be fitted with hanging rails, and warehouses can employ hanging garment systems for storage and for sortation to the individual shops. These systems may be manual in nature or may be highly automated, with garments being put away to reserve storage rails and then order-picked to customer orders automatically under computer control. These activities are based on overhead conveyor systems, as described above, controlling the hanging garments either singly or in batches. The individual garments may be identified by, for example, bar codes, vision systems or radio frequency identification (RFID) tags and, based on this information, the garments may be sorted at the rate of several thousand per hour.

SUMMARY

This chapter has described some of the storage and handling systems that are available for non-palletized goods. These have included small parts systems, the use of fork-lift truck attachments, systems for long loads, and the use of conveyors, cranes and AGVs, as well as hanging garment systems.

Although there is a wide range of storage and handling systems covered in this chapter, the same objectives of achieving the required service and throughput requirements at the least overall cost apply as with palletized systems. The same trade-offs therefore need to be made between such factors as space, accessibility, speed, productivity, safety, accuracy and the minimization of damage.

17

Order picking and replenishment

INTRODUCTION

Order picking represents a key objective of most warehouses: to extract from inventory the particular goods required by customers and bring them together to form a single shipment — accurately, on time and in good condition. This activity is critical in that it directly impacts on customer service, as well as being very costly. Order picking typically accounts for about 50 per cent of the direct labour costs of a warehouse.

Customers may require goods in pallet, case or unit quantities. In the case of pallet quantities, goods can be extracted from the reserve storage areas and brought directly to the marshalling area by the types of equipment described earlier (eg by a reach truck or a combination of stacker crane and conveyor). This chapter is therefore chiefly concerned with case and unit picking operations. For example, a typical picking operation could involve picking case quantities of products held on pallets in dedicated pick locations, and then checking and collating the goods, ready for packing and dispatch.

In general, picking still tends to be largely a manual operation. However, there are many technology aids in terms of information systems and equipment that may be used to provide high levels of productivity and accuracy. Thus, whilst advanced 'automated warehouses' can often work effectively without direct operatives in the pallet reserve storage areas, the case and unit picking operations tend to be manually operated with technology assistance.

ORDER PICKING CONCEPTS

There are three main picking concepts that may be applied. These are:

- *Pick-to-order*. The simplest form of this is where one picker in one circuit of the picking area collects the items required for one order. This may be appropriate when one order will typically fill the capacity of the picking trolley or truck. An extension of this is when more than one order is picked per circuit, but each of the orders is accumulated into a separate container so that at the end of the picking circuit each order is discrete. Another form of pick-to-order is where pickers each pick part of a customer's order, for example where an order may fill several roll-cage pallets.
- *Batch picking*. For small orders it is not always economic to pick only one order per circuit. If it is not appropriate to pick multiple orders and to keep them separate during picking, a group of orders can be consolidated during order processing so that a picker assembles all the items required for that group of orders. At the conclusion of the picking circuit, the bulk-picked items are then sorted down to individual order level. This sortation may be undertaken either manually or using automated sortation equipment.
- *Pick-by-line or pick-to-zero*. Under this concept, the exact numbers of cases or items are presented for picking. For example, they may be brought forward from the reserve storage area or they may be specifically ordered from suppliers for cross-docking. In both cases, the unit load of one product line is picked to waiting customer orders (hence pick-by-line) and the picking continues until that line is exhausted (hence pick-to-zero).

There are a number of factors that need to be considered in determining which of the above concepts to use, for example the product range, the size of order, the picking equipment, and the size of unit load or container into which orders are being picked.

In some situations it may be appropriate to make use of a combination of two or more of the above picking regimes within one picking system. A typical warehouse order will require just one or two slow-moving products, but a large quantity of fast-moving popular products. In this situation the picking area may be laid out with popular products near the dispatch area to minimize movement, with the less popular products, which require fewer picking visits, further away. If pickto-order is used, the slow-moving products could add significantly to the distance travelled by the pickers. In this situation, the possibility of pick-to-order for the most popular products could be considered, with less popular slow-moving products for a group of orders batch-picked.

Zone picking

This approach is relevant where individual orders are beyond the capacity of one picker to collect in one picking circuit, and where for reasons of meeting dispatch times it is not feasible to pick sequentially until an order is complete. It is also used where there are different zones for products, for example where products are separated for reasons of security, hazard or temperature regime. With zone picking, stock is laid out in zones, each holding a specified part of the product range and staffed by dedicated pickers. Each incoming order is subdivided by zone, and picking then takes place simultaneously in all zones until order completion.

Another approach to this concept is to pass a receptacle (eg a tote bin on a conveyor) from one zone to another. A picker would just pick the items required for an order from that zone and then pass the receptacle to the next zone. This would continue until the order is complete.

Wave picking

Orders may be released in waves (for example, hourly or each morning and afternoon) in order to control the flow of goods in terms of replenishment, picking, packing, marshalling and dispatch. The timing of the waves is determined by the outgoing vehicle schedule, so that orders are released to allow enough time to meet this schedule. Note that orders may not be released at the same time to each zone. For example, some zones may require a long time for order picking whereas a small range of high-security items may be picked just before dispatch. The use of waves allows for close management control of operations such as sorting and marshalling, which may be limited in terms of how many orders can be handled at the same time.

ORDER PICKING EQUIPMENT

There is a wide range of order picking equipment types. Deciding the most appropriate for a given situation will depend on such factors as the types of product, product sizes and weights, product range (how many SKUs), the picking frequency by SKU, order size range including the number of SKUs per order, number of items per order, and order frequency.

Discussion of methods of picking is presented under three categories — picker to goods, goods to picker, and automated systems.

Picker to goods

This category involves the order picker travelling to the goods in order to pick them. As with all picking categories, consideration needs to be given as to what storage equipment the picker is picking from (eg shelving, flow racks or pallet locations), what equipment the picker is picking to (eg trolley or powered pallet truck) and what the picker is picking into or on to (eg wooden pallet or roll-cage pallet). The following is a list of common picking equipment types, based chiefly on what the picker is picking to:

- *Trolleys and roll-cage pallets.* With this method, the picker pushes the trolley (or roll-cage pallet) between shelving or pallet racking in order to access the goods. Generally pickers work from floor level, although in some cases trolley steps or warehouse ladders are used to access higher stock locations. In this case the slower or less popular product lines should be allocated to the less easily accessible positions. Depending on the type of goods handled and the order characteristics, such methods, despite their total reliance on pedestrian manual effort, can be very effective and achieve high rates of picking. The use of roll-cage pallets may form a common unit load for both picking and transport. The roll-cage pallets may therefore be moved directly to the marshalling area after picking ready for loading on to the vehicles.
- *Powered order picking trucks.* These are electrically powered trucks that have forks, often carrying two wooden pallets or three roll-cage pallets, on to which picked goods may be placed. It is common to use these for picking from ground-floor pallet locations, either the ground level of wide-aisle adjustable pallet racking or from pallets placed in a forward pick area. Some trucks are fitted with a step or elevating platform and are also suitable for picking from the pallets placed on the first beam level of racking.
- *Free-path high-level picking trucks.* For picking higher up from racking or shelving, high-level picking trucks incorporate a rising cab, which can lift the picker to the required levels. These typically operate in narrow-aisle environments, but some are also designed to operate in reach truck, or wider, aisles. Some narrow-aisle trucks can operate for both pallet put-away and retrieval as well as for order picking (see Figure 17.1). There are other specialist designs, for example trucks with two masts that raise a platform so that two pickers can operate at high levels and pick large items such as sofas. Picking rates for high-level picking are not as high as for lower-level picking.

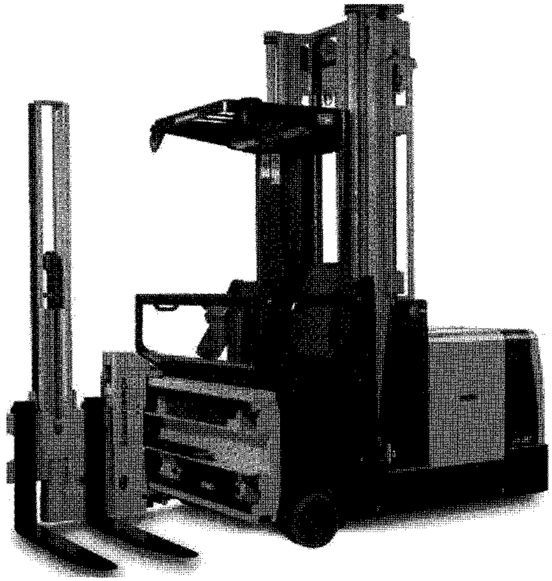


Figure 17.1 Free-path high-level combi-truck for order picking and pallet put-away/retrieval (courtesy of Jungheinrich)

- *Fixed-path high-level picking trucks.* Crane technology is also used for picking from narrow aisles, with pickers in crane-mounted rising cabs. Typical applications for this technology are in auto parts distribution centres holding large numbers of small-sized SKUs on shelving.
- *Pick cars.* A pick car operates up and down in a racking aisle, and is equipped with a rising cab linked by a hinged joint to an inclined conveyor, which moves up and down with the cab. The other end of this conveyor is hinged and connected to a trolley running on rails in the aisle. Picked items are placed on this conveyor, which feeds them down to a horizontal conveyor running along the bottom of the aisle, and beneath the pick car. At the end of the aisle the picked items are removed and packed or palletized, and collated to make up customer orders. The advantage of this system over other high-level truck systems is that the picker does not have to return to the end of the aisle every time a pallet is filled. However, there are relatively few examples of these installations.
- *Conveyors.* A number of picking operations make use of conveyors. For example, pedestrian pickers may select the required items from pallet locations, shelving

or flow racks and place them on to conveyors to be taken away for subsequent packing and collation into customer orders. Systems are often classified as 'pick-to-tote', whereby the goods are placed in plastic tote bins on the conveyor, or 'pick-to-belt', where the goods are placed directly on to the conveyor belt.

It is not uncommon for travel time (ie the time taken for a picker to move from one pick location to another) to take up 50 per cent or more of the picker's time. The next largest element is often the actual picking of the goods, and a third element is carrying out the information requirements (eg ticking a paper pick list, placing a label on the goods, and bar-code scanning activities).

Goods to picker

Various systems have evolved that are designed to reduce the very significant proportion of picker time spent travelling in picker-to-goods systems. Generally, goods-to-picker systems involve significant mechanization and can therefore be linked in to computer control to present pickers with the required goods in the appropriate sequence. These systems are generally suitable for small item picking.

These systems have been described in Chapters 15 and 16, but are listed here for reference:

- *Horizontal and vertical carousels*. It should be noted that goods are presented at the ideal picking height for the picker in the case of vertical carousels.
- *Miniloads*. These may be used for full carton picking or for presenting cartons, or tote bins, to a picker for the picking of individual units. The remaining goods are then returned to the miniload storage location.
- *Pallet AS/RS*. These systems may be used in a similar way, as described above, with pallets being presented to the picker. However, care has to be taken that throughput requirements can be met and that storage utilization is not adversely affected by the return of many part-empty pallets.

A hybrid system that may be used is that of a dynamic pick face. This is a 'goods-to-aisle' system, combined with a picker-to-goods method. Frequently, orders are not received at one time for the full range of goods held in a warehouse. Thus, pickers are travelling past many SKUs that are not required by any order at that time. The basis of a dynamic pick face is that only those goods that are required, for example in that picking wave, are placed in the picking aisles. This results in a condensed pick face and thus reduced travelling time. Miniload systems may be used to pick the required tote bins and bring them forward to a pick face ready for picking. The picking may then be undertaken manually, for example from the tote bins brought forward on to a conveyor. Dynamic pick faces are normally used for the slower-moving lines that are ordered infrequently, as the fast-moving lines tend to be required for every picking wave and are thus allocated permanent picking locations. Note that dynamic pick faces can be assembled using conventional means by, for example, reach trucks bringing pallets forward to the pick area.

Automated *systems*

The picking systems described so far all require a person to pick the individual items that make up an order. This is not surprising, considering the range of items that may need to be picked and the different ways in which they may rest in the picking locations. However, there are automated picking systems available that are suitable for certain applications. These include the following:

- *Layer pickers.* Cases are normally stacked on to pallets in layers. In some industries, such as fast-moving consumer goods, price differentials are offered to customers based on whether they order in pallet, layer or case quantities. In such cases, it may be beneficial to automate the picking of layer quantities. Typically, a pallet is brought forward from the reserve pallet store (eg by AS/RS and conveyor) to a layer picking machine. This machine would lift the top layer off (eg by suction pads) and place it on to a pallet that is being assembled for the customer order. The product pallet would be returned to the reserve store and another pallet would be brought forward and the process repeated until the customer pallet was filled with all the layers required. The layer picking machine often has three sections: one for the product pallet; one for the customer pallet being assembled; and one for empty wooden pallets that will form the next customer pallets.
- *Dispensers.* A dispenser normally comprises lines of vertical magazines, on one or both sides of a belt conveyor (see Figure 17.2). The magazines are loaded with SKUs, which need to be in regularly shaped packages for ease of movement down the magazines, and fairly small (eg pharmaceutical packs, cosmetics and beauty products). As the conveyor moves between the two lines, the required order quantities of the required SKUs are dispensed under computer control, all items for one order being dispensed on to the same section of conveyor. When the accumulated items reach the end of the conveyor, all the items for the order are together and fall off the conveyor into a carton ready to be taken away for packing. An alternative is to have empty cartons or tote bins already

Figure 17.2 Dispenser (courtesy of Knapp)

on the central conveyor belt, fed on at the upstream end. The picking operation is controlled and carried out by the machine, but there is often a heavy manual input required to keep the individual dispensers replenished as the stock is used up. These machines achieve very high item throughput rates.

- *Robotic applications.* The use of robots for the routine stacking and de-stacking of cases on to and off pallets is well established. Robots can be programmed to stack to prescribed patterns, to build up layers on a pallet, and to use different patterns on adjacent rows to assist pallet load stability. They are often used at the end of production lines for this purpose. As regards order picking, there are a number of products on the market. These include the picking of cases from pallets, and small item order picking. A typical application has computer-guided trucks fitted with robot arms, carrying a number of containers. The trucks move through a shelving installation containing, for example, pharmaceutical products, and items are picked and placed into the containers, each container being dedicated to a specific order. At the end of each picking circuit, the containers are automatically discharged into cases for dispatch. Other applications combine small robotic trucks with dispensing machines.

SORTATION

If goods have been batch-picked, then they will need to be sorted into the relevant customer orders. This may be undertaken manually (eg sorting to pigeon-hole or to roll-cage pallet) or by automated sortation equipment. Similarly, goods that have been zone-picked will need to be brought together into the relevant orders. This may be a much simpler operation (ie depending on the number of zones) but may still be undertaken either manually or with the assistance of some form of conveyorized sortation.

Sortation may occur immediately after picking so that items can be assembled into the appropriate orders ready for packing or dispatch. Where there is a separate packing operation, sortation may also occur after packing so that the packed goods can be assembled into vehicle loads.

Mechanized sortation can be undertaken as an integral part of conveyor systems. For example, a conveyor may sort to different packing stations by means of pop-up wheels that are raised when the required case goes past a conveyor spur. The wheels are then powered at that moment and the case is diverted down that spur.

High-speed sortation systems normally use a continuous loop conveyor moving between off-take chutes or conveyors set around both sides of the main conveyor. Items for sorting, or for routeing to order accumulation points, are fed on to the continuous conveyor, and as they arrive opposite the appropriate off-take point are automatically diverted to link up with other items for the same destination. These systems are computer-controlled and depend on some form of machine-readable coding system, such as bar codes, to identify individual items or groups of items as they move round the conveyor, so that they can be diverted down the correct off-take lines. Alternatively, there can be manual in-feed stations where goods are placed on to the conveyor and data concerning the SKU are fed in manually. Sortation systems give very high rates of sort/pick, and are used in some cross-docking applications. There are a number of such systems available including:

- *Sliding shoe sorters*. There are 'shoes' located at the edge of the conveyor. When the goods reach the appropriate destination point, the shoes slide across to divert the goods down that spur. These are suitable for cartons and tote bins of regular shape and reasonable rigidity. Typical operating rates are about 4,000 to 6,000 sorts per hour.
- *Tilt-tray sorters*. Tilting conveyors are usually laid out in horizontal carousel configuration, with a series of tilting trays or slats fitted to a conveying chain, and capable of tipping loads off to left or right to branch conveyors or to off-

take chutes. The slats can be tilted singly or in multiples according to sizes of load being handled. Tilting conveyors are used for high-speed sortation operations, such as parcel distribution, and for some cross-docking installations. The effectiveness and speed of these applications depend on information technology and coding systems such as bar codes. Each load is identified as it enters the system, which then instructs the conveyor to discharge the load to its designated destination. Sorting rates typically quoted are between 10,000 and 15,000 units per hour per installation, but the rate is dependent on the size of installation, the number of in-feed points and the number of destination off-take chutes or conveyors. These sorters are suitable for a wide range of products with non-stick bases, although normally the items conveyed should be of a similar weight.

- *Cross-belt sorters*. These comprise a series of mini-conveyor belts aligned at 90 degrees to the direction of travel (see Figure 17.3). The appropriate mini-conveyor belt starts up when the item reaches the required off-take destination point. This forms a positive movement and is therefore suitable for a wide range of items. Sort rates are similar to those of tilt-tray systems.

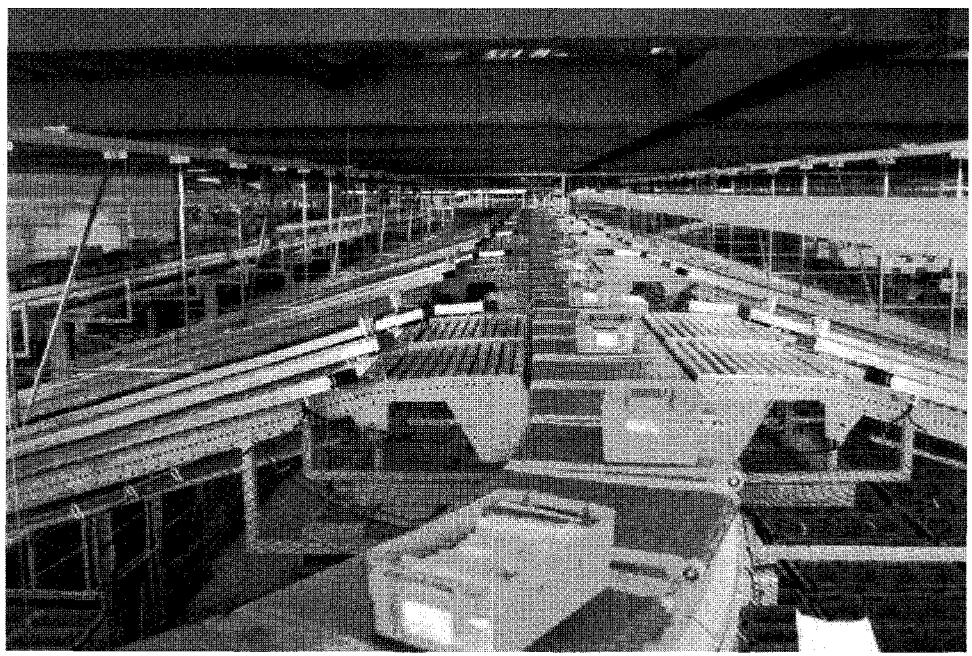


Figure 17.3 Cross-belt sorter (courtesy of Siemens)

LAYOUT AND SLOTTING

The layout of the picking area is critical to achieving high levels of productivity. One of the first decisions that needs to be taken is whether to have separate reserve inventory and picking locations for individual SKUs or to combine all the inventory into a single location. This will largely depend on the total amount of inventory for an SKU. For example, in the case of small electronic items the total inventory may fit in a small tote bin and therefore it would be sensible to have a single location, whereas there may be many pallets held of a particular retail food line and it would not be practicable to hold all of these pallets in picking positions.

The general principle is that picking stock should be concentrated into the smallest feasible area, so as to minimize travelling time between the SKUs. Reserve inventory therefore needs to be held separately in many instances. Where this is the case, a decision needs to be taken as to the amount of inventory to place in the pick location. This is a trade-off, as having small pick locations would reduce the pickers' travelling time (and pick location equipment costs), whilst having larger locations would reduce the replenishment effort to maintain product in the pick locations. One approach to minimizing the pickers' travelling time and, at the same time, reducing the replenishment workload is to use flow racks, so that a good depth of inventory can be held within a small picking face.

The separation of reserve and picking inventory may be vertical, eg pick from racking at ground-floor level with reserve stock on the higher racking levels, or horizontal, with reserve stock in one area and picking in another. In the latter instance, it is fairly common for picking activities to be conducted at multiple levels using mezzanine floors, so as to use the full height of the building.

The 'slotting' of inventory is a term used for identifying the individual SKUs that should be located in each location. In picking, a very common approach is to use the Pareto principle (ranked by units sold or, more normally for picking, ranked by the number of order lines for an SKU during a set period). In this way, the SKUs that are picked most frequently are located in the most convenient positions (sometimes called the 'golden zone'). This may be the area nearest the start and finish of the picking run, or locations at the ideal picking height (ie about waist height), or a combination of both. However, care must be taken not to cause congestion by concentrating most of the pick activity in just one small area. Other slotting approaches include location by weight (so that heavier items are placed at the bottom of dispatch loads) and location by store layout (so that items in roll-cage pallets can be easily placed on to shelves when they arrive at the stores).

INFORMATION IN ORDER PICKING

Accuracy and completeness of order fill, together with timeliness, are key factors in picking performance, and a good information and communication system is a prerequisite for meeting these objectives. This includes appropriate presentation of the correct and sufficient information to the order picking staff, ideally with minimum clerical effort required from them, with the facility for them to communicate back to the managing system in the event of mislocated stock or shortage.

The information required by pickers is the picking locations they have to visit and the sequence of the visits, the SKUs to be picked and the quantities, and the destination or order reference for the picked goods. The traditional way for pickers to receive picking instructions was by paper picking lists, which itemized the SKUs to be picked and the quantities, and left space for the picker to record differences between required and actual quantities. There are numerous alternative methods available, supported by varying levels of complexity in information systems:

- *Pick by label.* A gummed label is printed for each item to be picked, and the labels for one order are produced on a backing sheet in the sequence in which they are to be picked. The picker attaches the relevant gummed label to each item as it is picked, and any labels remaining at the end of the pick circuit show what shortages have occurred.
- *Bar codes.* These are widely used in warehousing. One use is to identify uniquely every storage and picking location in a warehouse, and of course to identify products and product information such as batch identification. In picking operations this can be used to verify pick locations and the items being picked.
- *Radio data terminals.* These can provide online communication between designated warehouse workstations and warehouse management computer packages, and as such have an application in order picking. The terminals may be truck-mounted, waist-mounted, or fitted to the wrists of the pickers. They are often combined with bar-code scanners. For example, a wrist-mounted radio data terminal may be attached to a bar-code scanner fitted as a ring on a finger so that pickers can move goods with both hands free.
- *Pick by light.* Normally, in these systems, every picking location is fitted with an LED (light-emitting diode) display panel, controlled by computer (see Figure 17. 4). A common application is for a plastic tote bin, representing a customer order, to be taken by conveyor to a specific zone of the warehouse. The bar code on the tote bin is read, and the appropriate LED panels illuminate, showing the

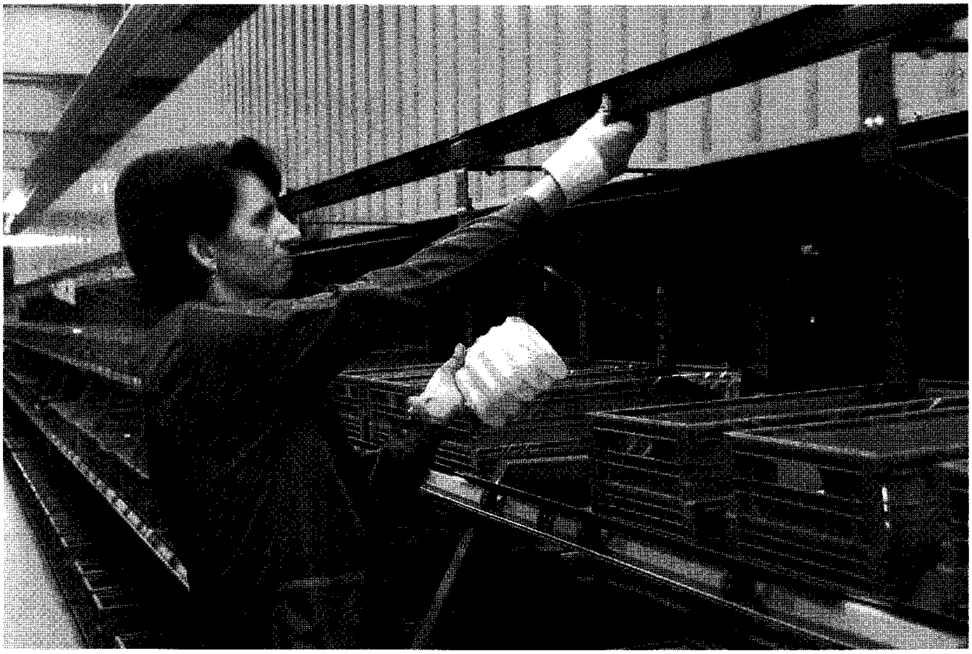


Figure 17.4 Pick by light (courtesy of Witron)

quantity of items to be picked for all SKUs required for that order. Having picked the items, the picker presses a cancel button and then uses the conveyor to pass the bin to the next zone. This process continues until order completion. This method can give high pick rates and very high levels of picking accuracy.

- *Put to light*. This is similar to pick by light, except that it is normally used in the sortation process. For example, a picker may undertake a batch-pick and then return to an area of pigeon-hole shelving, with each pigeon-hole representing a customer order. On scanning a particular product, LED panels illuminate, showing the number of items required for each customer order.
- *Voice technology*. With this technology, the picker can hear voice instructions from the computer through a headset. The picker then selects the required items and speaks through a microphone to confirm the pick. Frequently, a check digit located at each location needs to be repeated by the picker to ensure that the goods have been picked from the correct location. As with pick to light, this system completely frees the picker's hands and thus facilitates high pick rates.

E-FU LFI LM ENT

There has been a rapid growth in recent years in the use of the internet for ordering goods, both from the home and from businesses (eg individuals being able to order goods for their own office or department, rather than ordering through a centralized purchasing department that would consolidate such orders). The orders that result from internet ordering tend to have rather different characteristics, in that they are often small orders, with few order lines (ie a small number of product lines being ordered), few items per line, and often requiring individual units rather than whole cases. These characteristics increase the picking workload for a given throughput of goods. It is therefore important that the picking solutions adopted are well suited to the picking of large numbers of small orders at unit level.

For low-throughput operations, this may involve the use of multiple order picking using pigeon-hole trolleys, or trolleys containing a number of tote bins. By these means, a dozen or more orders can be picked at one time, with the picker sorting the orders to pigeon-hole or tote bin. An alternative is to batch-pick goods and bring them back to a manual sortation area, which may comprise a number of pigeon-hole shelves (each representing an order). The goods are then sorted to these pigeon-holes. This may be assisted by a put-to-light system as described above.

For high-throughput operations, zone picking may be conducted with tote bins (each representing an order or batch of orders) being circulated on conveyors to each zone that holds goods for that order (or orders). Goods are then picked into the appropriate tote bin for that order from pallets, shelving or flow racks, and directed to the packing area. Alternatively, a batch-pick can be conducted directly on to a conveyor, followed by automated high-speed sortation. Both of these methods can be supported by pick-to-light technology where appropriate. In addition, where there are large product ranges, dynamic pick faces can be used for medium- and slow-moving lines.

A particular characteristic of many internet operations is the high proportion of single-line orders (eg a consumer ordering just a digital camera). There is no need to sort these goods in the same way as for multiple-line orders that need to be brought together, and therefore single-line orders may be subject to a separate process, bypassing order sortation and being sent directly to packing.

PICKING PRODUCTIVITY

Perhaps the most common measure of picking performance is the pick rate, expressed as the number of 'picks' per person per hour. Some companies mean by this the number of items per hour, and some measure the number of SKUs or order lines per hour. This can lead to confusion, and it is important always to define the units.

Likewise, using such information to compare different operations can be misleading, since in very similar types of picking operation, and with the same units of measure, apparent performance levels can be surprisingly different. A survey of a number of warehouses in the same business sector, using the same technology and picking methods, produced figures for cases picked per person per hour varying between just over 300 to just under 100, with a mean value of about 170. Quite clearly there were other pertinent factors that influenced the figures. These included whether an incentive scheme was in operation, order characteristics such as the number of items per order line, the amount of 'back-picking' due to stock-outs at the pick face, and whether pickers carried out other functions such as replenishment.

Pick rate should not be the sole measure of performance, and other key indicators to be monitored include accuracy of pick, completeness of order fill, timeliness of meeting dispatch deadlines, returns and customer complaints, and stock damage during picking.

Other important issues that can impact on the effectiveness of order picking operations include:

- the way stock is laid out within the picking area;
- planning work to eliminate waiting time;
- balancing workloads across the various picking staff;
- ensuring timely replenishment of picking stock as it is used up;
- planning the interface between the picking and any subsequent packing operations;
- elimination of clerical work.

REPLENISHMENT

Picking stock availability is necessary to maintain high levels of order fill. The potential consequences of low availability at the picking face are reduced service levels in terms of incomplete orders, or extra cost because of the need for pickers to revisit picking locations they have already visited and found to be out of stock. Consequently, any order picking system must be backed up by an effective replenishment system. This may top up picking stock when trigger levels are reached, although with this type of system there is always the danger of the location being replenished too early (and thus the goods still in the pick face may need to be double-handled and put on top of the replenishment load) or, more seriously, the goods may arrive too late, with some pickers being unable to pick those goods. This uncertainty can be minimized by the use of real-time computer systems to issue replenishment instructions. A further method is to base the replenishments on the known order quantities for the next wave. Thus, there should be no pick face stock-outs occurring even when there is particularly heavy demand for an individual SKU.

In addition, flow rack storage is often used in pick face design so that, when one unit of stock is issued or one unit load is emptied, the next one rolls forward and is immediately available for use.

Particularly for very fast-moving materials, there is the potential for serious congestion at the picking face, and between the picking and replenishment operations. There are ways to alleviate this such as:

- incorporating multiple picking locations for fast-moving and popular product lines;
- laying out the pick area so that every other aisle is for picking, and the alternate aisles are for replenishment (eg using flow racks);
- carrying out the replenishment and picking operations at different times, either by using offset shifts or in some cases by staggered breaks with inventory being replenished during the pickers' lunch break.

SUMMARY

Order picking is a key activity in warehousing, having an immediate impact on customer service and accounting for a major part of warehouse costs and operating staff numbers. Consequently, picking systems should be designed and managed with particular care.

This chapter has reviewed the important principles for effective order picking, and presented an overview of the different equipment and picking methods available when designing a picking system. The importance of a good information and communication system was emphasized, as well as the need to support any picking system by effective picking stock replenishment.

18

Receiving and dispatch

INTRODUCTION

Both the receiving and the dispatch areas of a warehouse are critical to its successful operation. Receiving is important, as it forms the basis for all the subsequent activities of the warehouse. For example, goods need to be passed through receiving rapidly so that they are available for picking customer orders, and this must be carried out with a high degree of accuracy to ensure that the correct goods are received and located in their assigned locations. The dispatch activity is critical, as it is the customer-facing aspect of the warehouse and therefore it must operate effectively to ensure that all goods are dispatched to the customers on time. Operational failures in either of these areas will quickly result in service level failures, which may be damaging to the company and may be costly to rectify.

RECEIVING PROCESSES

The receipt of goods into a warehouse needs to be a carefully planned activity. In most large warehouses, incoming vehicle loads are booked in advance so that the appropriate resources can be allocated to the activity. On arrival, drivers report to the gatehouse, where staff check the vehicle documentation and direct the driver where to go, either directly to an unloading bay or to a parking area.

The vehicle, or container, doors may be sealed, particularly in the case of imported goods. Where this occurs, the seal number needs to be checked against that advised by the sender so that it can be ascertained whether the doors have been opened during transit (and hence there may be the possibility of loss).

On unloading, the goods are normally checked to ensure that they are the correct items and of the required quantity and quality. This may be undertaken by cross-checking against purchase orders, but this can be very time-consuming. An alternative method is for the sender to transmit an advance shipping notice (ASN) by EDI and for this to be related automatically to the appropriate purchase order. The goods can then be checked specifically against the ASN for that vehicle. For approved and trusted suppliers, it may be that the quantity and quality can be assumed to be correct as per the ASN, in which case the goods can be unloaded and transferred immediately to storage.

If goods are to be quarantined (eg stored until quality control results are available), then this can be undertaken by placing the goods into the normal reserve storage area and using the warehouse management system to ensure that the goods are not picked for any customer orders.

Some packages may require some form of processing, such as applying bar-code labels, palletizing (eg for goods received loose as cartons, as is common in the case of containerized shipments), re-palletizing (eg if the pallets are of the wrong type or of poor quality) or placing into tote bins (eg to be put away into miniload storage).

The unit loads then need to be checked, particularly if they are to be put away into an automated storage and retrieval system. For example, pallets may be weigh-checked on a conveyor and then passed through a dimension checking device, which would register any protrusions outside the permitted dimensions by means of photoelectric cells. Any pallets that do not conform (eg because the cartons have shifted in transit) are then sent to a reject spur on the conveyor for manual rectification.

When the goods are ready for placing into storage, they may be put away and the computer system advised of the location number or, more normally, the warehouse management system would identify the most appropriate location and issue a put-away instruction (eg on a paper put-away sheet or transmitted to a truck driver's radio data terminal).

A key objective in designing the receiving process is to enable the goods to be put away to the required location in the warehouse with the minimum handling and minimum delay possible. This often requires close co-ordination with suppliers, in terms of procurement agreements and the timing of deliveries.

DISPATCH PROCESSES

After order picking, the goods for a particular order need to be brought together and made ready for dispatch. This may involve added value activities, such as labelling, tagging, assembly, testing, and packing into cartons. Where production postponement is undertaken, these activities may be quite extensive.

The goods then need to be sorted to vehicle loads and placed in, or on to, unit loads ready for dispatch. This may be a conventional operation (eg loading into roll-cage pallets and then using a powered pallet truck to take the goods to the marshalling area) or it may be automated (eg using conveyor sortation and automatically loading tote bins on to dollies, ie wheeled platforms). In the case of goods being dispatched on pallets, then the whole pallet may be stretch-wrapped, or shrink-wrapped, so that the goods do not move during transit. The goods are then transported to the appropriate marshalling area, which will have been allocated based on the outgoing vehicle schedule. There may be one or more marshalling areas associated with each loading door. Particularly where large items are required for a customer order, the goods may in fact be brought together for a customer order for the first time directly in the marshalling area. The goods are then loaded on to the vehicle and secured.

Loading is often an activity that needs to take place within a short period of time (ie most of the vehicles may need to leave at about the same time of day). This can be alleviated by pre-loading drop trailers, or swap-bodies, during the hours leading up to the dispatch times. In this situation, the vehicle fleet is designed to have more articulated trailers than tractor units, and similarly more swap-bodies than vehicles. The extra trailers or swap-bodies can thus be pre-loaded whilst the vehicles are still delivering the previous loads.

If a customer plans to collect the goods, then the vehicle load will need to be assembled and held in the marshalling area, awaiting collection. Good co-ordination is necessary in such instances to avoid the load taking up valuable marshalling area space for longer than necessary.

In the case of temperature-controlled goods, it is important to consider how the dispatch activities are managed, particularly when loading vehicles that are compartmentalized and thus capable of transporting goods at different temperatures. For example, loading the vehicles at three different loading docks (eg at ambient, chill and frozen temperatures) may be very time-consuming, whilst loading at a single loading dock will require close control to ensure that the temperature chain is maintained.

CROSS-DOCKING

Cross-docking is an activity whereby goods are received at a warehouse and dispatched without putting them away into storage. The goods may thus be transferred directly from the receiving bay to the dispatch bay. This normally involves some form of sortation.

Goods for cross-docking need to arrive by a strict time schedule linked to the vehicle departure times. The outgoing vehicles may be taking a mix of cross-docked goods (eg fresh goods) and stocked goods (eg long-shelf-life items), and thus a great degree of co-ordination is required to ensure that the operation can occur smoothly. If sortation is required, then a pick-by-line technique may be used to pick individual products from incoming pallets and place them on outgoing customer pallets. This may be undertaken manually or by using automated sortation equipment.

There are a number of variations of cross-docking. For example, in some instances the goods may be pre-labelled for particular stores or customers, whereas in other situations the goods may just be sorted by product line, with or without a label being applied during the cross-docking operation.

Cross-docking has a number of advantages in that it facilitates the rapid flow of goods through the supply chain and can be used as a technique to reduce inventory levels. It is particularly common for fresh and short-shelf-life goods, as well as for goods that are pre-allocated and need to be 'pushed' out to stores, as in the fashion industry.

Whilst there can be substantial benefits from cross-docking, it may not be suitable in every situation, for example:

- Inventory at the warehouse may just be replaced by inventory held upstream in the supply chain to support the cross-docking activity on a just-in-time basis. A holistic view therefore needs to be taken to ensure that total inventory in the supply chain is reduced.
- Goods may be transported in less than pallet load quantities or less than vehicle load quantities, thus increasing transport costs.
- Considerable handling space may be required at the warehouse for the sortation activities.
- Close co-ordination is required with the suppliers (plus high levels of reliability), and this becomes increasingly complex with greater numbers of SKUs and suppliers.

For these reasons, it may not be beneficial to cross-dock in many situations, for example for thousands of SKUs from hundreds of suppliers. A total supply chain view thus needs to be taken, as with all logistics decisions, to identify when cross-docking may be advantageous.

EQUIPMENT

The equipment types required for unloading and loading tend to be similar in nature for both receiving and dispatch, and these are therefore described together. Common types of handling equipment include:

- *Boom conveyors.* Goods are frequently shipped in loose cartons in ISO containers to save on space in the container, to comply with wood regulations affecting pallets, and to save the cost of pallets that will not be returned. Similarly, packets are frequently transported loose to parcel carriers, as they will be individually sorted to destination on arrival at the parcel hub warehouse. In these instances, a boom conveyor may be used to extend into the vehicle or container. The warehouse staff then just need to lift the goods on to, or off, the conveyor, which transports the goods from, or to, the appropriate area of the warehouse.
- *Pallet trucks.* Where vehicles are unloaded or loaded from the end, then it is normal for a pallet truck (either hand or powered) to be used.
- *Fork-lift trucks.* For side-unloading (eg of curtain-sided vehicles), a counterbalanced fork-lift truck is normally used. These may be fitted with side-shifts so that the pallet can be accurately positioned on the vehicle. Another form of attachment that is often used is one that enables two pallets (side by side) to be lifted at a time. Fork-lift trucks may also be used for end-unloading and -loading, particularly if pallets are stacked two high on a vehicle. In this case, trucks with a maximum free lift are required, so that the truck mast does not rise whilst inside the vehicle. Another common use is for slip-sheets to be used to separate unit loads in a container, and special attachments can be fitted to unload and load these.
- *Automated systems.* There are automated systems available that can unload and load all the pallets on a vehicle simultaneously. These require special trailer units (eg fitted with rollers or tracks) and are therefore best suited to shuttle journeys, for example between a manufacturing plant and its associated distribution centre.

The loading bays themselves are normally equipped with a number of features, including:

- *Dock levellers*. These are normally permanently fitted at each bay and form a gentle slope up or down to match the bed heights of each vehicle. A truck, such as a powered pallet truck, can then be driven directly on to the vehicle for end-unloading or -loading. As vehicle bed heights may vary considerably, the dock leveller needs to be long enough to accommodate all vehicles that may be expected on that bay. The dock leveller is sunk into a pit and operated by a hydraulic ram.
- *Doors*. These often retract above the opening when in use. They are frequently fitted with windows so that warehouse staff can see whether there is a vehicle on the bay.
- *Dock shelters and seals*. Some form of weather protection is common to prevent draughts and dust from entering the warehouse around the vehicle.
- *Bumpers*. These are used to reduce the shock load exerted on the building structure when vehicles reverse up to the bay.
- *Lighting*. Lights on swivel arms are required to provide adequate illumination inside the vehicles, particularly at night.
- *Warning lights*. Red and green lights may be fitted to the outside and inside of the loading bay. These act as an indication to the driver as to whether the vehicle is ready to be driven away, thus reducing accidents of trucks being driven into the vehicle at the exact moment that the driver decides to pull away.
- *Vehicle restraints*. Some warehouses are fitted with an even more positive system in that the wheels of the vehicle are restrained until the warehouse staff decide that it is safe for the vehicle to be driven away.
- *Wheel guides and bollards*. These are used to assist the driver to park centrally on the loading bay.

A number of these features can be seen in the loading bays shown in Figure 18.1.

LAYOUTS

The receiving of goods on to the warehouse site begins at the gatehouse. The layout thus needs to include all the external areas within the perimeter fence, such as:

- *Vehicle roadways*. Roadway markings and signage are essential. The vehicle flow may be one-way around the site or two-way to and from the loading

Figure 18.1 Raised docks fitted with dock levellers (courtesy of Stertil)

bays. In the latter case, access still needs to be provided for emergency vehicles, such as fire tenders, to all sides of the building. In the case of one-way flows, a clockwise direction may be better for right-hand-drive vehicles to allow drivers to reverse a trailer on to a bay more easily, whereas anticlockwise is more suitable where left-hand-drive vehicles are the norm.

- *Parking areas.* Adequate vehicle, trailer and swap-body parking needs to be provided. Power points may be needed where temperature-controlled units are to be parked. The car park for staff and visitors should be separated from the heavy goods vehicle areas for safety reasons, as well as for security reasons (ie keeping cars away from direct access to the warehouse).
- *Ancillary areas.* Many such areas may be needed, for example fuel points, vehicle washing facilities, weighbridge, generators, empty unit load area, waste compactors, sprinkler tanks and fire assembly points. In addition, landscaping to shield the warehouse and vehicles from the local environment may be required.

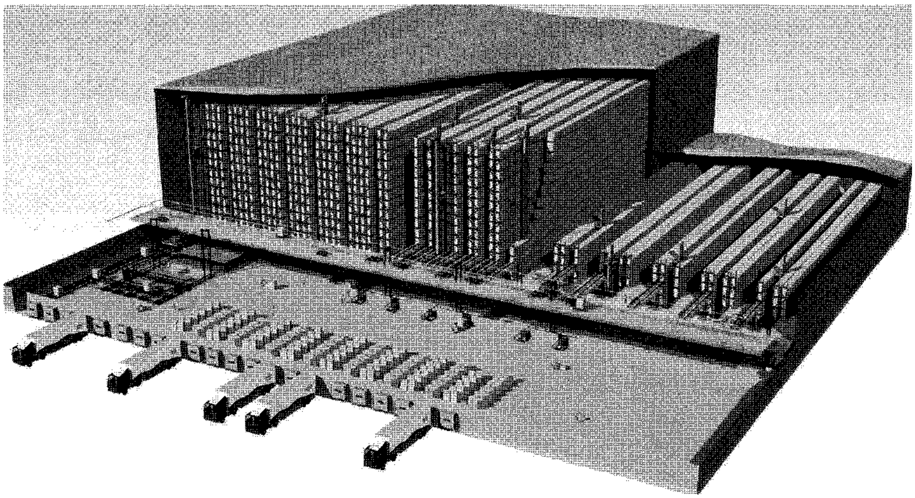


Figure 18.2 U-flow configuration, serving high-bay and low-bay operations (courtesy of Siemens)

The unloading and loading bays maybe at opposite ends of the building, to enable a through-flow of goods, or may be adjacent to each other on the same side of the building, to enable a U-flow (see Figure 18.2). Other options include an L-flow, or some mix of these.

A through-flow may offer a better flow of goods within the warehouse itself, although in practice, with goods moving from receiving to reserve storage and then to picking, sortation, packing and dispatch, it is not always the case that this flow is any better than a U-flow. Through-flow is often used when the number of unloading and loading bays required is too great to fit on one side of a building, as in a warehouse handling a rapid turnover of goods. A through-flow layout is also particularly suited to a cross-dock warehouse, such as a parcel sortation centre, where a long thin building may be appropriate, with incoming vehicles along one of the long sides and outgoing vehicles on the opposite side. However, in an inventory-holding warehouse, a U-flow may be more suitable for cross-docking, as the distance that the goods need to travel will be far less than with though-flow. A major benefit of U-flow is in situations where the receiving and dispatch activities occur at different times of the day. For example, in many warehouses, receiving occurs during the morning and dispatch in the afternoon and evening. In this situation, the doors, marshalling areas and equipment may be used for both receiving and dispatch activities. It is also easier to divert equipment and staff between the two activities as peaks and troughs arise, even when the two activities are occurring concurrently. A further advantage is that when the same vehicles are used for incoming and outgoing goods (as with back-hauling) then the vehicle can remain on the same dock for both activities.

The actual vehicle bays themselves may be:

- *Level intake.* This is where the warehouse floor is at the same level as the external roadway. It is suitable for the side-unloading of vehicles by lift truck. Vehicles may be unloaded outside (eg under a canopy) or brought into the building, although, with the latter option, care must be taken with fume extraction and maintaining the required temperature in the warehouse.
- *Raised dock.* With a raised dock, the warehouse floor is at the same level as the bed of the vehicle, so that a pallet truck or lift truck can drive directly on to the vehicle by means of a dock leveller. This is normal in the case of end-unloading (eg of box vans or containers). Raised docks are normally at 90 degrees to the building, but may also be set out in a 'saw tooth' or 'finger' configuration. In the latter instance, side-unloading may also be possible.

Normally a mix of level intake and raised docks is needed. For raised docks, it is often necessary to build a depressed driveway leading down to the docks. In this case, a gentle slope is required from the roadway level (ie less than 10 per cent), but the vehicle should be on the level at the loading bay, to facilitate truck movement on the vehicle and to avoid the top of the vehicle fouling the building. Frequently, level intake and raised docks are placed on the same side of the building, in which case they should be separated by a crash barrier (or by placing a transport office at this point to serve the same purpose).

Inside the warehouse, the space needed for all of the activities listed under receiving and dispatch processes should be estimated and laid out. This should not be underestimated, as quite frequently a total of 20 per cent to 30 per cent of the floor area needs to be allocated to these activities to facilitate the efficient flow of goods into and out of the warehouse. It should be noted that many of these activities require only a fairly low building height and can therefore take place in low-bay areas of the building. The height above the receiving and dispatch areas may, however, be used by introducing a mezzanine floor for other purposes, such as offices or packing activities, although care must be taken with regard to the restrictions that support columns may impose.

SUMMARY

In this chapter, the importance of the receiving and dispatch activities has been explained, and the main processes described. The concept of cross-docking has been explored, in terms both of the significant benefits that can be achieved and of the practical limitations to its application.

The various types of equipment that may be used for unloading and loading have been described, in terms both of handling equipment and of the loading bay areas themselves. Finally, the many factors that need to be considered with regard to the internal and external layouts have been discussed.

It should be noted that the receiving and dispatch areas of the warehouse represent the direct physical interfaces with the suppliers and customers. They therefore need to be designed as an integral part of both the upstream and the downstream elements of the supply chain.

19

Warehouse design

INTRODUCTION

The strategic issues affecting warehouse design have been covered in Chapter 14. These factors, particularly the business plan and the supply chain strategy, represent the starting point for warehouse design, as they define the warehouse's precise role, throughput requirements, inventory levels and customer service levels. From these types of requirement, the warehouse designer must select the appropriate equipment and operating methods, determine the internal and external layouts, calculate the equipment and staffing numbers, identify the supporting information systems, and present the capital and operating costs. The various steps involved in this design process are described below.

DESIGN PROCEDURE

The design of a warehouse and handling system involves a number of stages, starting with the definition of system requirements and constraints, and finishing with an evaluated preferred design. Although set out sequentially below, the design process is iterative and involves checking back against the system requirements as the design is developed, and assessing the interactions that necessarily occur throughout the process. The design process requires a range of skills and disciplines, including, for example, operations, construction, materials handling, information systems, personnel, finance and project management. The design process includes the following steps:

- Define business requirements and design constraints.
- Define and obtain data.
- Formulate a planning base.
- Define the operational principles.
- Evaluate equipment types.
- Prepare internal and external layouts.
- Draw up high-level procedures and information system requirements.
- Evaluate design flexibility.
- Calculate equipment quantities.
- Calculate staffing levels.
- Calculate capital and operating costs.
- Evaluate the design against system requirements and constraints.
- Finalize the preferred design.

Define business requirements and design constraints

The wider business requirements (see `Strategic issues affecting warehousing' in Chapter 14) set the context and the design requirements for a warehouse. These are likely to include, for example:

- required capacities, in terms of both storage and throughput;
- service levels to be achieved;
- specified activities, such as production postponement and added value services.

Relevant constraints can include:

- time, eg the facility to be up and running by a specified date;
- financial, eg the limit on capital expenditure available;
- technical, eg to be compatible with existing company technology.

Any design must also comply with local authority and legal requirements, which amongst other aspects can cover building height constraints, limitations on working times, and safety legislation including, specifically, manual handling and fork-truck codes of practice. Insurers also are likely to require measures relating particularly to fire prevention and control. The local fire officer will need to be satisfied about the measures for personnel safety and evacuation in the event of fire. Ideally, the local planning authority, local fire officer and insurer should be involved as early as possible in any design project. The impact of current, and likely future, environmental legislation also needs to be considered, with regard to such issues as packaging and product recovery.

A warehouse is a long-term asset, with the building often having a depreciation period of 20 to 25 years and the equipment about 5 to 10 years. There are ways of reducing the length of this commitment by leasing buildings, renting certain types of equipment, or outsourcing. However, the long-term nature of the asset still has to be considered very carefully, as leases are often for a lengthy period of time and logistics contractors negotiate contract periods so as to minimize their own exposure. There may be compromises in terms of the nature of equipment, or buy-back clauses, as a result of the agreements achieved.

In view of the long-term commitment that is normally associated with warehouse design, it is quite likely that a number of business scenarios can be envisaged within this period of time. In fact, it is almost certain that the original business plan will change. It is therefore important to undertake scenario planning so that the most likely future possibilities are identified and the warehouse (or the wider supply chain strategy) can be designed to accommodate these scenarios if and when required. This means incorporating flexibility as an integral part of the design.

Define and obtain data

The accuracy and completeness of the data on which any design is based will affect how well the final design meets the specified requirements. It is most unlikely that any design will be based on current levels of business, and it is important to establish anticipated growth and other changes to the business that the warehouse is to be designed to satisfy. Normally, data are collected for the base year (eg the most recent year of the current operation) and then projected forward in line with the business plan to the planning horizon. There may in fact be a number of planning horizons used. For example, a 1-year horizon may be used to calculate the initial staffing level, a 5-year horizon may be used for sizing the building and the design of fixed equipment, and a 10-year horizon may be considered for the purchase of land and for possible modular expansion of the building.

The data required for warehouse design include:

- *Products:*
  - — handling and other relevant characteristics, size, weight, temperature or other constraints;
  - — packaging and unit load(s);
  - inventory levels by SKU (maxima, average, minima and seasonal variations);
  - throughput levels by SKU (maxima, average, minima and seasonal variations), by relevant unit (eg case, pallet or cubic metre) and by value (to relate back to the business plan);
  - — forecast growth trends.
- *Order characteristics:*
  - service levels for time, and for completeness of order fill, plus order cut-off times;
  - order profile (eg lines per order and units per order line);
  - — order frequency (by season, week, day and time);
  - — number of order lines for each SKU (to identify pick frequency);
  - package and unit load details;
  - — special or priority order requirements.
- *Goods arrival and dispatch patterns:*
  - vehicle sizes, types (end- or side-load), frequencies and times;
  - — unit loads to be handled (including activities such as re-palletizing);
  - — consignment sizes;
  - own vehicles or third-party;
  - cross-docking profiles (eg quantities, timing and sortation requirements).
- *Warehouse operations:*
  - basic operations to be carried out;
  - ancillary requirements, eg packing and packaging store, returns, quality con trol, battery charging, offices, warehouse cleaning, maintenance workshop, services, stand-by generator, restaurant, locker rooms.
- *External area requirements:*
  - — security facilities, including gatehouse;
  - truck parking and manoeuvring areas, car parking;
  - — vehicle wash and fuelling points.
- *Site and building (if existing) details:*
  - — location, size, gradients, access;
  - adjacent activities and scope for expansion, constraints or obstructions;
  - services available.

- *Any existing facilities or equipment that may be used:* - size, condition, numbers.

Data are not always readily available, and data collection almost invariably takes considerable time. Potential sources include computer records, existing operational records, market forecasts, customers, drawings for site and buildings, equipment records and equipment suppliers, and input from relevant management and staff. Assumptions often have to be made based on informed opinion and experience, and these should be clearly highlighted.

Formulate a planning base

The relevant data need to be brought together as a structured planning base, so as to provide the foundation for the designer's proposals for appropriate operating methods and systems, equipment, layouts, staffing levels and costs. The data may be analysed and presented in various ways, including graphs and charts, tables, drawings, statistical analyses, and networks.

A useful way to present the data is as a warehouse flow diagram, as shown in Figure 19.1. In this diagram, a typical day in the life of the warehouse is presented in terms of flows and inventory quantities. It is a schematic diagram with the receiving area at the top and the dispatch area at the bottom. This does not represent the layout in any way, as no decision has been taken at this stage as to whether to have a through-flow or U-flow configuration. The flows are represented by the arrows, and are given in the most useful units for the operation under consideration. For example, they may be represented in pallet equivalents throughout, and some of these may be converted to other unit loads, as the design develops. The storage quantities are shown in the boxes, together with the number of SKUs that they represent.

A number of such warehouse flow diagrams may be constructed for the various planning horizons that are relevant to the design. Similarly, consideration needs to be given to whether to draw these at average, peak or some other level of activity in the planning year. The level used will depend on the precise purpose for which the flow diagram will be used. For example, the design of AS/RS equipment is likely to be based on peak flows, whilst staffing may be based on a figure such as average plus a specified percentage uplift (eg 10 per cent). This uplift will depend on the extent of seasonal, weekly and daily variations, and how these may be accommodated.

The flow diagram forces some initial consideration of warehouse zoning, in terms of whether to separate picking stock from reserve storage inventory (which is

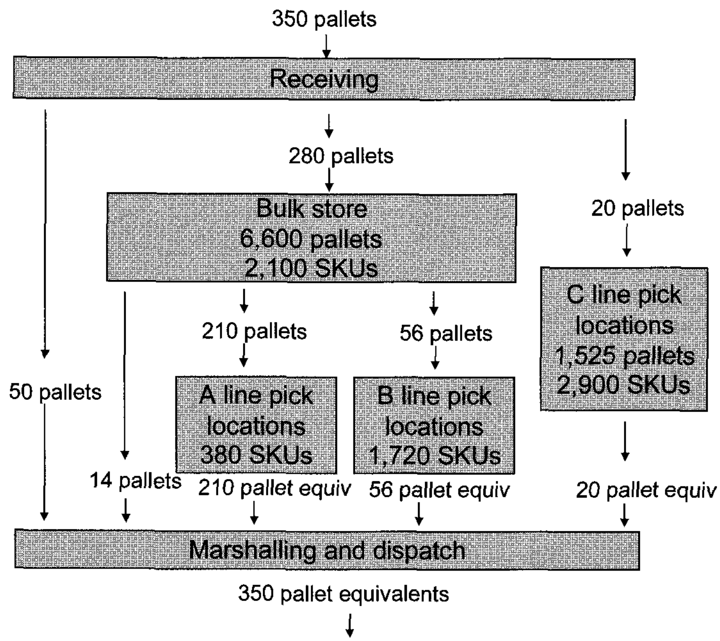


Figure 19.1 Warehouse flow diagram

likely to be the case if the volume of goods is too great to fit into one convenient size location). Also, the warehouse maybe divided by product groups, by temperature regime, by the degree of hazard, by the need for security, by size of items or by Pareto classification.

The Pareto classification is a very useful analytical tool to present inventory levels, sales quantities and picking accessions in descending order of magnitude across the whole range of SKUs. This technique is named after an Italian economist, and is also sometimes referred to as the 80/20 rule or A B C analysis. The results of this analysis often show that roughly 20 per cent of the inventory range accounts for about 80 per cent of the sales, and a significant proportion of the inventory and picking effort (although, of course, wide variations around these numbers may be found in individual companies). This analysis enables the designer to identify the really important SKUs in the product range and also to identify different characteristics for different sections of the product range and so devise solutions appropriate to the material being handled and stored. A simple example of this is shown in Figure 19.2. It should be noted that, where the sales Pareto is found to be approximately 80/20, then the inventory Pareto is likely to be less than this, often at about 60/20 (ie 60 per cent of the inventory may be accounted

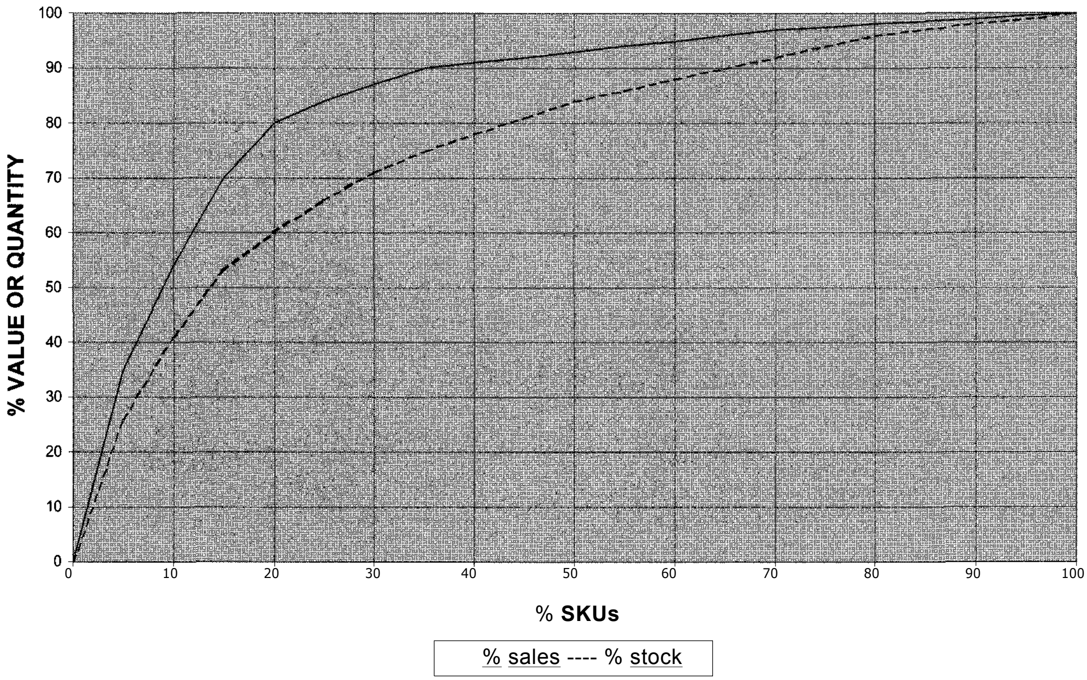


Figure 19.2 Pareto diagram, for throughput (sales) and inventory

for by the top-selling 20 per cent of SKUs). This is due to the inventory of the top-selling lines turning over more frequently than that of slow movers. Similarly, the picking accessions may represent a different characteristic, as, for example, greater quantities per order line may be ordered of the fast-moving lines.

The planning base should normally be presented to the steering group, representing (and often consisting of) the organization's executive, and agreed before detailed design commences. This is an important step, as this planning base is what the warehouse will be designed to achieve, and changes to requirements become more costly to incorporate as the design progresses.

Define the operational principles

The basic operations that will take place in a warehouse, and how they will be carried out, must be determined before it is possible to specify the equipment, space or staffing levels required for them. These may include vehicle unloading, quality assurance, storage, picking, production postponement, added value services, packing, cross-docking, sortation and vehicle loading. In addition to these fundamental considerations, there will be ancillary activities required to support the basic operations, which will require resources and space in their own right (such as those mentioned under 'Warehouse operations' and 'External area requirements' in the 'Define and obtain data' section above).

The time available for each activity is an important factor in determining how each should be performed. For example, if there is a late-evening cut-off time for orders and the service level is for next-day delivery, then the time window available for order picking may be limited to only a few hours. On the other hand, it may be possible to instruct suppliers to deliver goods to the warehouse earlier, so this activity could be scheduled for the morning in order to balance the workload over the day. An indicative time profile, for example as in Figure 19.3, could therefore be established.

At this stage, general operational methods may be identified for each activity. For example, if there are many small orders across a wide range of SKUs, then batch picking may be identified as the most likely picking concept. Similarly, for cross-docking, a pick-by-line concept may be adopted. Each activity should be examined to determine whether some general operational methods of this nature can be identified at this early stage.

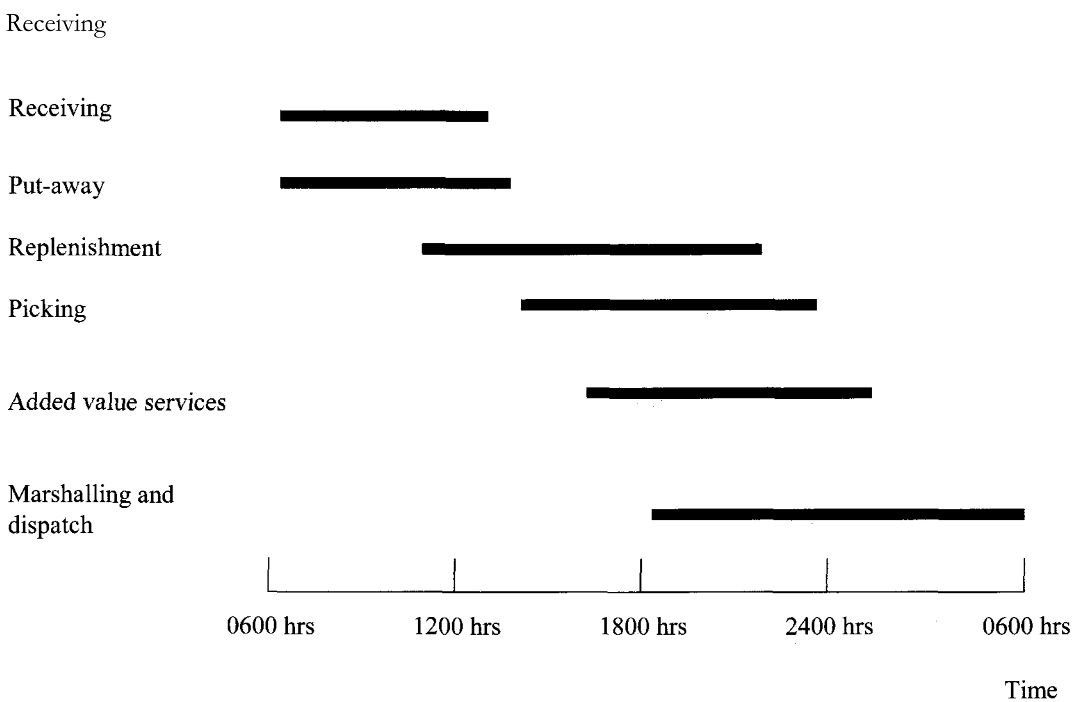


Figure 19.3 Time profile of warehouse operations

The choice of unit loads (eg pallets, stillages, roll-cage pallets, skid sheets, tote boxes and hanging garment rails) to be handled and stored in a warehouse is critical and should therefore be established early in the design process. Suppliers may impose the unit loads in which material arrives at a warehouse, and customers may specify dispatch unit loads, but the warehouse designer should use whatever freedom of choice exists to ensure the most appropriate unit loads for the processes being carried out. As an example, if roll-cage pallets are specified for dispatch to retail stores, then it may be advantageous to pick directly into these.

Evaluate equipment types

The basic types of equipment used in warehouses have been outlined in Chapters 15 to 18. Being able to specify the appropriate equipment for a particular application clearly requires an awareness of what is available and an understanding of the basic operating characteristics of the different equipment types.

To illustrate this point, consider a requirement for pallet storage of 1,000 different SKUs, with only a small amount of inventory associated with each SKU, say not more than two pallets, and fairly low throughput rates. Clearly block stacking, drive-in racking or even push-back racking would not be appropriate since it is not practical to mix different SKUs in any one storage row, and the use of any of these methods would result in either very poor use of space or unacceptable levels of double-handling. On the other hand, mobile racking or adjustable pallet racking could be considered. Mobile racking is expensive, but the good space utilization might reduce building costs. It provides random access to all pallets, and the inherently slow operation would not be a disadvantage with low throughput products. Adjustable pallet racking, however, would not give such good use of space, but is very much cheaper and gives random access to all pallets. It is also inherently more flexible in the event of future changes to stock or throughput profiles. This sort of argument should be used, selecting equipment with characteristics that most closely match the system requirements, for all warehouse operations.

It is important to proceed in a structured manner so that appropriate equipment types are not discarded without proper consideration. A narrowing down of options should therefore be carried out. It should be noted that the reasons for discarding equipment at each stage are just as important as the reasons for selecting equipment. A structured approach to equipment selection may comprise the following stages:

Initial automation assessment. Automated equipment may have distinct advantages in terms of good use of floor area (eg high-bay AS/RS), low running costs, security, accuracy and low damage levels. However, it may be possible to take a decision at an early stage as to whether to discard automation in certain situations, for example where land and staff costs are low or where the operation needs to be up and running very quickly. For example, in situations where a conventional warehouse may take one year to design and build, an automated warehouse may take up to 18 months. In addition, the full commissioning and refinement of the automated systems may take several more months.

- *Attribute assessment*. It may be possible to discard certain equipment types based on their attributes. For example, by referring to Table 15.3, it can be noted that only certain storage equipment types are suitable for strict first in first out, if this is a requirement of the operation.
- *Decision trees*. Clarity of thinking can be established by developing decision trees, as set out in Figure 19.4. The decisions may not be clear cut at each point for a particular operation, but this process can help to narrow down further the options available.

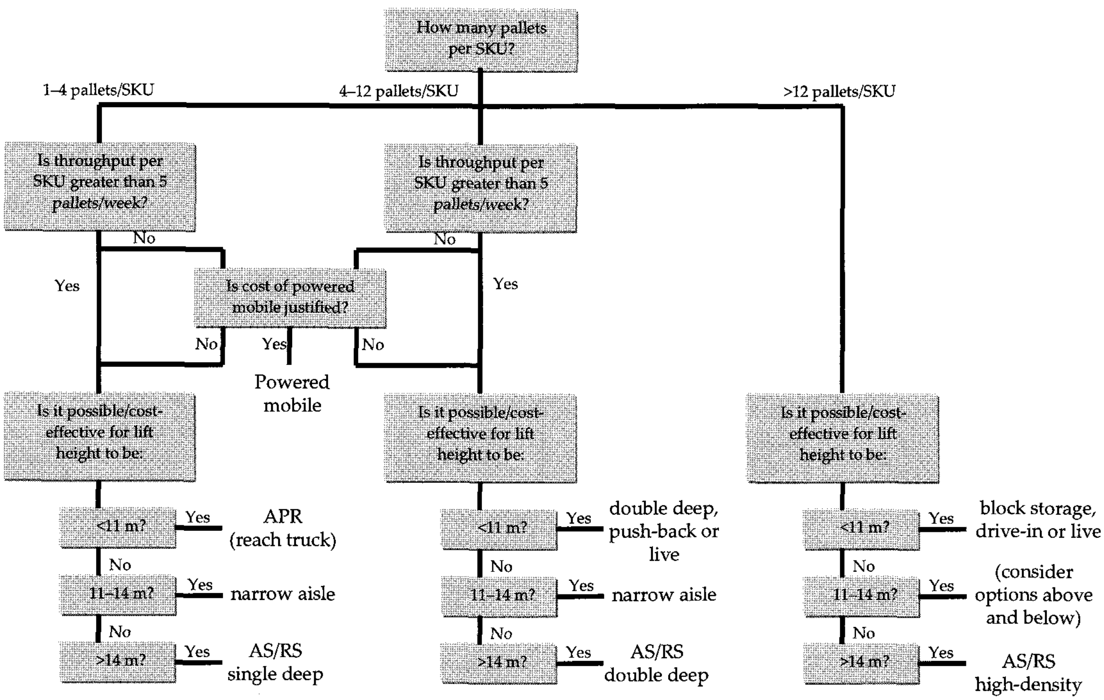


Figure 19.4 Decision tree to identify possible storage systems

- *Cost comparison*. At the end of this process, there maybe two or three equipment options left for a certain activity, and these can then be subjected to a cost evaluation. It is important to include all the relevant cost factors. For example, when choosing storage equipment, it is likely to be necessary to include costs for land, buildings, services, sprinklers, lift trucks, operators, maintenance and running costs, as well as the cost of the racks themselves. As some of these costs are capital and some are annual, a satisfactory method of comparison is needed, for example by using net present values or annualized costings (ie converting all capital costs to annual costs).
- *Equipment choice*. When the preferred equipment has been identified for each warehouse activity, then a final choice needs to be made, based on such factors as the overall equipment mix and the flexibility provided. Sensitivity analyses can be conducted to identify whether the preferred equipment is still the most appropriate choice under the different business scenarios that were identified.

Prepare internal and external layouts

The layout brings together all the components of the warehouse operation inside the building, and also the external site features.

Internal layout issues

The general principles for internal layout include:

- logical flow patterns with minimal cross-flows or backtracking of goods, based on analysis of movements, generally in a rectilinear layout;
- minimizing the amount of movement required for staff and for handling equipment;
- making the best use of building volume;
- good access to inventory (eg through adequate aisle widths);
- safe systems of work including the provision where possible of separate movement aisles and access doors for people and for mobile equipment, elimination of dead areas in which operators could be trapped, eg no aisles with closed ends, and provision of fire escapes.

A fundamental decision is whether to adopt a through-flow or U-flow configuration, and this depends on the factors described in Chapter 18. Another significant consideration is the height of the building, which may be determined partly by equipment choices and partly by any local planning constraints. As a general rule, the higher the building, the lower the capital cost per cubic metre of building space. For low-level activities, the use of mezzanine floors should be considered. Also relevant are the implications for moving the goods on to and off the floors (eg by conveyors, lifts or pallet access gates), as well as the possible interference to activities below resulting from the support columns.

Although the warehouse should be designed around the operational requirements, there is a significant interface at this stage with building design. For example, building spans, feasible floor slab dimensions, and fire officer requirements (eg fire walls) may all be important.

Other layout issues include:

- the use of raised or level docks for vehicle loading/unloading;
- the type of floor and floor flatness tolerances;
- the location of offices for good oversight of operations;
- provision of separate facilities for delivery and collection drivers;
- location of ancillary functions such as the packaging store;
- battery-charging facilities.

Finally, the likelihood of further expansion should be considered, with an internal layout that minimizes disruption if expansion has to be implemented.

External layout issues

The relevant factors that affect the site layout include:

- vehicle access to the site;
- security including barriers, gatehouses and separate access for cars and commercial vehicles;
- internal roads and directions of movement, and one-way or two-way circuits;
- manoeuvring and waiting areas for vehicles waiting to be called forward for loading/unloading;
- car parking;
- access for fire appliances;
- locating new buildings with potential future expansion in mind.

Draw up high-level procedures and information system requirements

Once the equipment and layout start to become clear, it is important to draw up the high-level procedures of how the operation will work. For example, if zone picking to plastic tote bins on conveyors is adopted, the process of issuing the pick instructions, confirming the pick, and conveyor sortation (eg the accumulation of multi-bin orders) needs to be established to ensure that it is in fact a good and workable solution.

In conjunction with this, the information system requirements should be estab lished. For example, in the above instance, it would be possible to use a variety of information systems, such as paper pick lists in the totes, reading an RFID tag on the tote and issuing instructions by radio data terminal to the picker, pick by light, or voice technology. This decision will form the basis of the specification for the warehouse management system and associated information and communications systems.

Evaluate design flexibility

The flexibility of the design to the range of business scenarios envisioned during the first stage should be fully evaluated. Even though this would have been considered at each stage, it is important to evaluate in detail to what extent the proposed design is flexible and can therefore meet the requirements of an agile supply chain.

The type of agility required may include the following facets:

- volume, eg to accommodate unexpected growth or sudden surges in demand;
- time, eg to enable rush orders to be picked and dispatched;
- quantity, eg to be able to switch to item rather than case picking;
- presentation, eg to present different unit loads to various clients;
- information, eg to provide specific information on customer labels.

This agility may be provided by a combination of measures, including:

- building, eg by designing for modular expansion of the building;
- equipment, eg by choosing versatile equipment;
- staff, eg by facilitating the addition of more staff to operations in peak periods;
- processes and systems, eg by developing processes and systems for a range of eventualities.

The agility provided should ideally be aimed at providing a wide range of flexibility, at minimal cost, in a short period of time, whilst meeting the required performance and service levels. Obviously, some compromises will have to made, but these need to be conscious decisions that are taken and agreed during the design process.

Calculate equipment quantities

Based on the warehouse flow diagrams and the equipment choices, it is normally relatively straightforward to calculate the equipment quantities.

For storage equipment, the number of unit loads (eg pallets) to be stored needs to be increased by the location utilization figures (see Chapter 15) for that type of equipment and operation, to give the number of unit load positions that should be provided.

Handling equipment requirements are based on material movements in the warehouse, including seasonal variations and short-term peak loads, and on operational data, typically from manufacturers' technical data plus operating experience. Shift working patterns will affect these calculations, and also determine whether spare batteries will be required for battery-powered trucks. The number of order picking trucks will depend not only on total warehouse throughput but also on order sizes and frequencies.

Data on goods received, including delivery window and times required for vehicle unloading, will dictate receiving dock facilities such as access doors and dock levellers, and the handling equipment for vehicle unloading. Similar considerations apply to dispatch. The provision of raised docks or level docks will depend on the types of vehicle accessing the warehouse - end-loading or side-loading. Space requirements for order collation and assembly should take account of the working patterns of order arrival at dispatch and the way in which vehicle schedules integrate with these internal work patterns.

Using inventory and throughput figures and equipment operating characteristics, the calculations of basic equipment requirements are generally straightforward when taken operation by operation. What is not easy to calculate, however, is the effect of all the mobile equipment and operating staff, working together, and interacting and interfacing, and sometimes getting in the way of one another, and causing queues and delays. This dynamic situation is nearer the real operational situation than is one based on merely calculating each operation in isolation. For this reason, computer-based dynamic simulation techniques may be used, to validate the 'static' calculations and to take account of potential interference between activities when running simultaneously.

Calculate staffing levels

The requirements for operating staff are closely linked to the mobile equipment requirements, and in many cases will 'fall out' of the equipment calculations. Quite clearly, staffing levels have to be established as part of the design and to enable a full costing of the warehouse to be made. Allowance needs to be made for absenteeism, sickness and holidays, as well as for shift rotas (eg for 24/7 working).

Calculate capital and operating costs

At this stage, the capital and operating costs can be determined. It is often useful to assemble these under the headings of:

- building, including land, construction (or leases or rents), local rates or taxes, services and building security and maintenance;
- equipment, including static and mobile equipment capital costs (or leasing or rental costs), and maintenance and running costs;
- staffing, including management, operatives, clerical staff and maintenance staff;
- information systems, including hardware, software and implementation costs.

It is also normal to add a contingency to capital costs for unforeseen events and for the detailed design of equipment (eg side-shifts and flashing lights on fork-lift trucks).

Under each of the above cost headings, the capital and operating costs should be calculated. These will represent the actual expenditure by the company on the warehouse. In addition, it is often useful to present these costs in a way that represents the timings of the cash outflows (eg net present value or annualized costings), both for the comparison of options and for the presentation of the business case.

Evaluate the design against system requirements and constraints

The original design objectives and constraints will have defined the commercial, financial and technical requirements to be met by the new warehouse, and these form the principal criteria for assessing the proposed design. The basic requirements for storage capacity, building size, site layout, staffing levels, and capital and operating costs can all be validated at this stage.

It is important not only to ensure that the design works well for 'the business plan', but also to identify how, and at what cost, the various other business scenarios would be accommodated. The use of simulation may well therefore be of benefit again at this stage.

Finalize the preferred design

As a design progresses, there will inevitably be a process of iteration, of checking back to the design requirements, and partial evaluation of ideas to assist the process of homing in on the final preferred design. The preferred design should then present the proposed operating processes and methods, services requirements, equipment specifications and requirements, staffing levels, capital and operating costs, and layout drawings. This is then normally put forward to the organization's executive body (eg the board of directors) for approval.

Once approval is received, then the actual project implementation can begin. This will involve many different strands of activity, all based on the agreed warehouse design, for example:

- *building:* site search, building design, tendering and selection of the construction company, detailed design, and construction, as well as ancillary specialisms such as sprinklers and security;
- *materials handling:* detailed design, tendering and supplier selection (or development with preferred supplier), manufacture, installation and commissioning;
- *information systems:* specification, selection, development and testing;
- *personnel:* job specifications, recruitment and training;
- *associated areas:* for example, transport.

All of these strands will need to be co-ordinated by a project management activity, which will involve implementation planning, a project network, and change management procedures and continuous control.

SUMMARY

This chapter sets out a general procedure for the design of a warehouse, starting from the definition of business requirements and any constraints on the design, and working through to an evaluated preferred design.

The key points of emphasis include:

- defining and agreeing the business requirements, and carrying out scenario planning;
- involving all relevant management and staff as early as possible in the design process, and external bodies such as the planning authority, local fire officer and insurance company;
- obtaining accurate and relevant data (usually very time-consuming) and validating the data;
- agreeing the planning base on which the design is to be based, including explaining and justifying any assumptions that have been used;
- evaluating the wide range of equipment options in a structured way;
- using the agreed planning base, for example in the form of warehouse flow diagrams, as a basis for calculating the equipment and staffing requirements and, hence, the capital and operating costs.

The time and effort to achieve a good and soundly based design are well spent when compared to the cost of setting up a warehouse facility. Making changes to achieve a good design when a project is still 'on the drawing board' is comparatively easy and inexpensive. Rectifying design errors or misconceptions once a facility has been built is either impossible or very expensive. Design flexibility should therefore be incorporated from the outset, as during the warehouse's life it will be expected to perform many tasks outside of 'the business plan'.

20

Warehouse management and information

INTRODUCTION

The management of a large warehouse is a very challenging position that requires a range of skill-sets. Warehouse management is now a high-level position in many companies, recognizing the high costs and investment involved in the facility, as well as the key role that warehouses play in the provision of high customer service levels. This chapter examines some of the key elements involved in warehouse management and then proceeds to explore the supporting information systems that are necessary for the successful operation of a large warehouse, whether it is automated or conventional in nature.

OPERATIONAL MANAGEMENT

The management of a large distribution centre is a complex task. There may be thousands of orders received in a day, across a range of thousands of SKUs, and all requiring consolidation by individual order, packing and dispatch in possibly hundreds of vehicles. The planning of such an operation needs to be undertaken at a number of levels. For example, in the long and medium term, capacity planning must be undertaken to ensure that growth can be accommodated and that seasonal peaks can be met at the required service levels. In the short term, detailed workload planning is required to ensure that the appropriate levels of equipment and staff are available, and that these are correctly balanced between the different warehouse zones.

As the requirements of the warehouse change, then the design steps detailed in the previous chapter will need to be revisited so that the appropriate equipment, staffing, processes and technology are brought in to match the new requirements. For ongoing operations, continuous process improvement is necessary, and methods such as Six Sigma and staff forums are becoming the norm in many warehouses.

PERFORMANCE MONITORING

The continuous measurement of performance is obviously essential to monitor process improvement. Warehouses need to operate within tight service and cost standards, and failure to meet these standards can mean the difference between a successful and unsuccessful business, particularly as warehouses are often the last link in the chain before delivery to the customer. The wider aspects of cost and performance monitoring in logistics are discussed in Chapter 27. In this current chapter, the more detailed requirements for monitoring in the warehouse are addressed.

Clearly the performance indicators appropriate to a particular warehouse will be specific to that operation, but typical measures will include those detailed in the following sections.

Service levels

Measures can include:

- percentage of orders completed on time;
- percentage completeness of order fill;
- accuracy of order fill;
- stock availability in the warehouse;
- order lead time;
- the number of outstanding back orders;
- damaged stock;
- returns and customer complaints.

Note that some of these may be joint measures involving functions outside of the warehouse. It is also quite common to combine some of these measures. For example, one common measure is 'on time in full' (OTIF - see also Chapter 3), whereby an order is only considered successful if all the order lines are satisfied and if the order is delivered on time to the customer.

Cost-effectiveness

This includes monitoring the costs of:

- staff, including overtime and other special payments;
- building and site;
- equipment and other resources;
- maintenance;
- pallets and pallet repair;
- packing materials and other consumables;
- services including any bought-in services.

It may be helpful to isolate the costs of specific operations such as order picking or packing, and monitor these as a proportion of total warehouse costs. It may also be useful to express some of these measures as ratios such as the cost per unit of throughput, the cost per pallet stored or the cost per item picked.

Resource utilization

This is concerned with how effectively the warehouse facilities are being used. It can include utilization of storage facilities - percentage fill - and also the utilization and availability of handling equipment, and how much availability is lost through maintenance and breakdown. However, it should be noted that the measure of high resource utilization may be in conflict with the provision of capacity to handle infrequent peak volumes. For example, if stacker cranes in an AS/RS are normally fully utilized then it would not be possible to handle a sudden increase in throughput.

Safety and the effective use of staff

This includes performance and productivity monitoring such as pick and pack rates and order fulfilment rates. It is also concerned with the monitoring of overtime and absence, the provision of necessary skills and safety training, safe working practices and environment, safety audits and hazard monitoring. In this context, risk assessment is a legal requirement in many countries – to examine the total operation and identify potential hazards, and to assess the likelihood of accidents and identify action to eliminate risk.

Stock *integrity*

This is concerned with the condition and security of inventory, including minimizing loss, damage and deterioration. Relevant factors can include the control of stock rotation on the basis of first in first out (FIFO), and the meeting of 'sell by' dates and shelf-life constraints.

An important control parameter is the measurement of stock turn, which indicates the rate at which goods move through the system in relation to the average inventory level. For any stock line, stock turn is:

$$\frac{\text{annual throughput}}{\text{average inventory level}}$$

For example, if a product sells 1,000 units per year and the average inventory level is 100 units, the stock turn will be 10, ie on average the stock is 'turned over' 10 times per year. This figure is also often represented as the number of weeks of inventory held in the warehouse (ie a stock turn of 10 equals 52/10 or 5.2 weeks of inventory in the warehouse).

Operational parameters

It is particularly important to monitor the operational parameters that define the context in which the warehouse is operating. These parameters may have a significant impact on the performance indicators mentioned above. For example, a change in the size of order may result in a much greater workload for a warehouse (at the same throughput) and thus may account for an apparent reduction in performance. For this reason, great care must be taken when benchmarking across different warehouses, as performance measures are only comparable within the same operational context (and this may vary significantly within the same industry and even within the same company). These operational parameters include:

- throughput;
- number of SKUs;
- unit load characteristics;

- product characteristics (eg size and ease of handling);
- lines per order;
- units per order line;
- added value requirements.

Meeting legal requirements and local regulations

This particularly applies to working environment and safety. There is a wide range of legislation that impacts on warehouse operations, including for example health and safety, manual handling, lift equipment and working hours. In addition, there are often regulations relating to the goods themselves, such as food and hazardous goods regulations. It should also be remembered that there are codes of practice giving guidance on a wide range of warehouse operational issues, for example racking guidelines issued by such bodies as the Storage Equipment Manufacturers Association (SEMA) in the UK, and the Federation Europeenne de la Manutention (FEM) in Europe.

An increasing aspect of safety regulations is the requirement for formal risk assessments to be carried out within organizations to identify potential hazards and motivate preventative measures.

INFORMATION TECHNOLOGY

The use of computer-based information technology is now the norm in most warehouses, and is essential for the management of large facilities. Even in conventional warehouses, for example with reach trucks and ground-level picking, significant advantages can be achieved in terms of productivity, speed and accuracy with the benefit of a good warehouse management system (WMS).

The WMS normally interfaces with the company's main transaction system (such as an ERP or legacy system) to access information such as purchase orders and to download customer orders. In turn, the WMS will feed back information such as goods received and dispatched. The WMS is used to control all the operations in the warehouse and issues instructions to subsidiary systems, for example equipment control systems. Thus, a WMS will issue an instruction to an AS/RS control system for a crane to move a specific pallet from a pick-up and deposit station at the end of the aisle to a particular location in the racking. The equipment control system will then direct the crane and provide feedback and diagnostics if the crane cannot fulfil this operation (eg owing to mechanical failure). A typical systems architecture for a warehouse is shown in Figure 20.1.

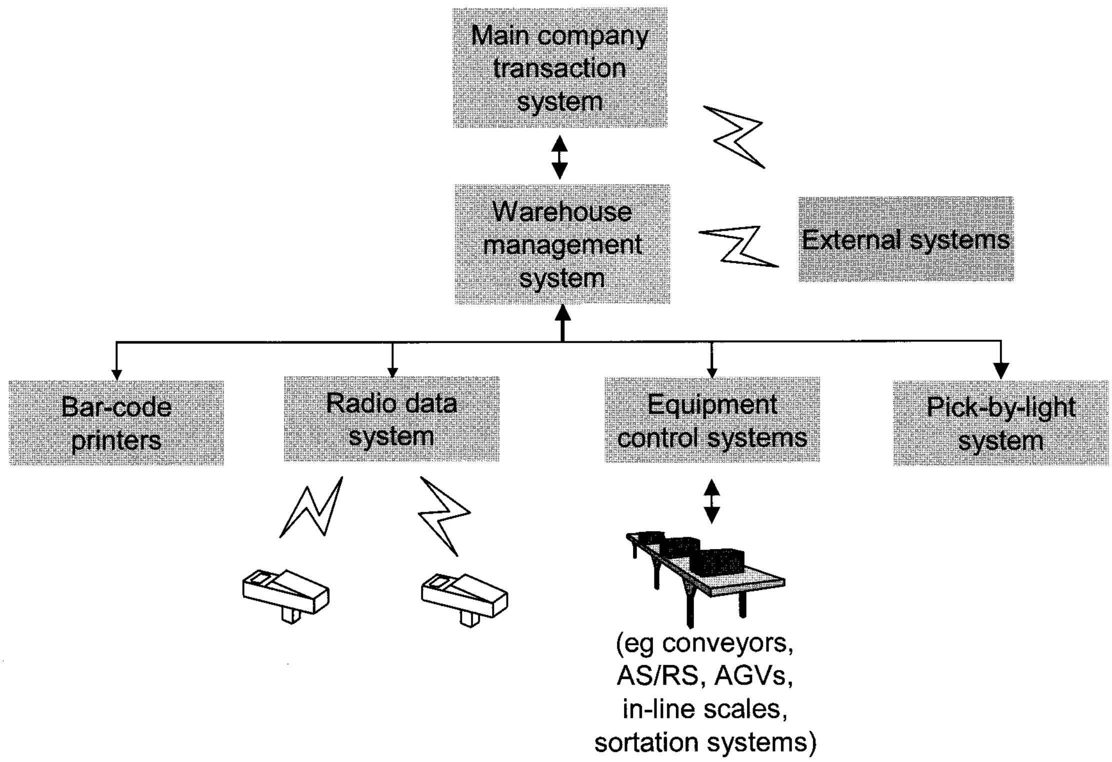


Figure 20.1 Typical systems architecture

The major WMS packages are very complex and have a wide range of functionality that may be turned on or off for particular applications. For example, in electronics, batch traceability of components in kitting operations may be significant, whereas in food manufacturing the control of sell-by dates may be important. By having common software across industries, it is easier to apply upgrades to the software. However, it is also common for companies to develop bespoke software to meet their particular requirements.

WMS functionality covers all the activities of the warehouse, as shown in the examples below:

- *receiving:* yard planning, checking against electronic advance shipping notices (ASNs), checking for dimensions and weights, quality sampling;
- *put-away:* algorithms to determine the best storage location, support for all feasible storage types (eg block stacking, double deep);

- *replenishment:* fixed trigger point or order-based replenishment to pick locations;
- *picking:* pick route optimization, slotting (ie optimum location of each SKU in pick face), wave management;
- *added value services:* kitting, labelling, final assembly (requiring bills of materials);
- *packing:* identification of correct carton size (by database of dimensions for all SKUs);
- *cross-docking:* planning, labelling and sortation;
- *sortation:* by various categories, such as by order, vehicle or geographical area;
- *dispatch:* marshalling lane control, documentation, transmission of ASNs;
- *management:* workload planning, performance measurement, productivity schemes, modelling (eg for new product ranges or new racks), billing, pallet management, customs reporting;
- *stock counting:* full count and perpetual inventory.

An increasingly important benefit of such systems is the ability to track individual goods and batches as they progress through a system, to provide quick and accurate information on progress and also to enable quality back-checks in the event of quality failures.

DATA CAPTURE AND TRANSMISSION

An integral part of exploiting the benefits of computer management packages is the data capture and communication systems to which they are linked. Data capture and transfer can be accomplished by a number of techniques.

Bar codes

The most widely used technique in warehousing is bar-coding, which represents numbers and letters in printed bar form and is machine-readable by appropriate scanning equipment. It is a fast and accurate technology, and fairly robust. There are various different bar-code types or 'symbologies'. In warehousing, bar-coding is used to identify goods and verify stock locations. It allows goods to be sorted and routed through a handling system, and enables them to be tracked as they move through the system. It simplifies stock checking and many other data input and capture requirements. Bar-code labels are cheap, although they can be damaged by scuffing, and the technology is established, reliable and fast. Normal bar codes can only provide a few digits of data, such as a product code or a pallet identification code.

There are two-dimensional bar codes available and, as the name suggests, these are scanned in two directions simultaneously. These can hold hundreds of numbers or characters, but their use is not widespread, as special scanners are required at each stage in the supply chain and common standards are not fully established. They are, however, used in 'closed-loop' situations.

Optical character recognition (OCR)

OCR technology uses labels that are both machine- and human-readable. It is appropriate in applications such as document handling and interrogation, and text scanning.

Radio frequency identification (RFID)

RFID is being applied increasingly in supply chains (see Chapter 5 for additional comment) for the tracking of unit loads (such as roll-cage pallets and tote bins), for carton identification (eg in trials by food retailers and by parcel carriers) and for security and other purposes at item level (eg for high-value goods). As the name suggests, RFID is basically the identification of items by means of radio waves. There are normally four components of such a system:

- a tag, which is affixed to the goods or container - this normally comprises a microchip and an antenna and may, or may not, contain a battery (depending on whether it is an 'active' or a 'passive' tag);
- an antenna, which receives the data from the tag (and may also emit to it);
- a reader, which reads the data received by the antenna;
- a host station, which contains the application software and relays the data to the server or middleware.

Active tags tend to be used for high-value units (eg for tracking car chassis in assembly plants or ISO containers). However, the greatest current interest in commercial supply chains is in passive tags. These tags rely on incoming signals to provide power and are thus limited in range to between about 1 and 4 metres. This is because they need very strong signals to provide the power and because the power they can emit is very weak. The reader and tag therefore have to be in close proximity. The real interest is in their low and falling costs, which mean that it is becoming increasingly cost-effective to place these tags on pallets or cases or even to integrate them into individual products. However, there are still issues to be fully overcome in such areas as standards, technical feasibility, operational robustness, financial business cases and, in some instances, civil liberties.

Other technologies

Other data capture and transmission systems include voice recognition and pick-by-light (and put-to-light) systems. Both of these were described in Chapter 17 under order picking.

Error rates

An interesting set of experimental data derived some years ago by the US Department of Defense gave the following results for error rates when capturing data:

Technique:	*Error rate (characters):*
Written entry	25,000 in 3 million
Keyboard entry	10,000 in 3 million
OCR	100 in 3 million
Bar code (Code 39)	1 in 3 million
Transponders (radio frequency tags)	1 in 30 million

These data, although experimental, illustrate the levels of accuracy achievable using information technology.

RADIO DATA COMMUNICATION

A technique of communication commonly found in warehouse information applications is the use of radio data communication. This is usually linked into the warehouse management computer system and provides radio communication between the computer and any required workstation, which can be static or mobile. For example, fork-lift trucks may be fitted with remote radio data terminals and sometimes also with a label printer mounted with the terminal. The operator is online to the computer, takes instructions from the computer, confirms work carried out and interrogates the computer for further information if required. Radio data terminals may also be hand-held or wrist-mounted, and are often fitted with bar-code scanners (see Figure 20.2). In the case of wrist-mounted terminals, the scanners may be located on a ring on a finger, thus keeping both hands free for picking.

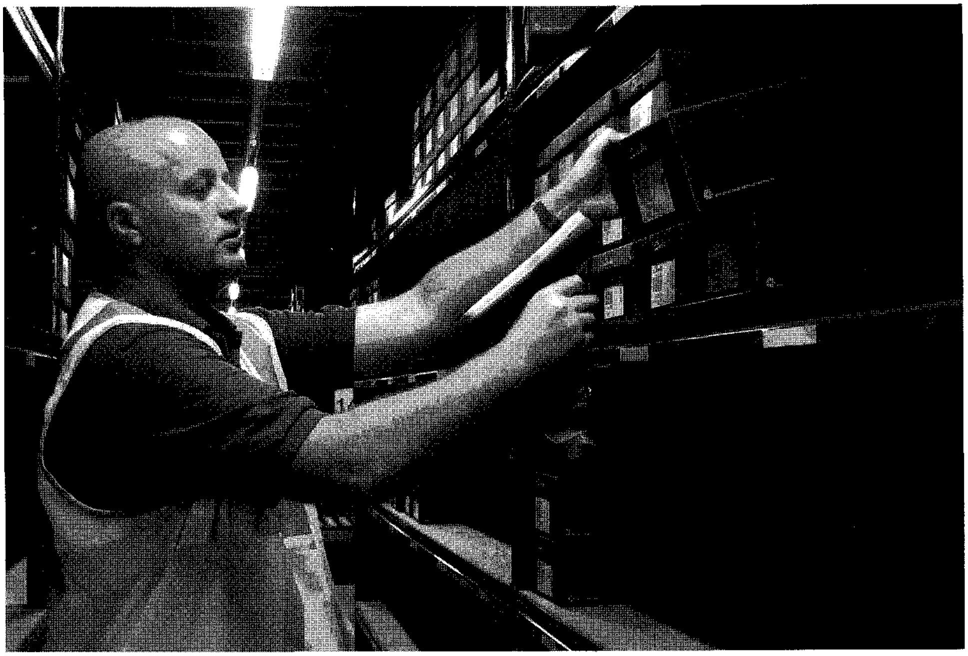


Figure 20.2 Radio data terminal with bar-code scanner (courtesy of Knapp)

This sort of technology facilitates major improvements in communication between the operator and the warehouse management computer, resulting in much greater speed of response within warehouse systems and more efficient and productive utilization of people and equipment. Specific benefits of such systems include:

- paperless operation;
- real-time information and prioritization (eg so that pick faces can be replenished just as they are becoming empty);
- high levels of accuracy (eg through bar-code scanning and WMS interrogation);
- dual cycling (eg a truck may be tasked with two or more activities during one visit to an aisle, such as put-away, replenishment and full pallet picking).

SUMMARY

Warehousing and associated storage and handling operations are not stand-alone activities, but integral and key elements in a supply chain. They use expensive resources - people, equipment, buildings, materials - and they play a vital role in the achievement of high levels of customer service.

This chapter has discussed the management of warehouse and distribution centre operations, and the role of monitoring to identify potential performance issues. The fundamental importance of information and communication in these processes has been emphasized, and the information technology utilized in these operations has been reviewed.

The pressures on management have been to reduce costs and inventory whilst maintaining or improving customer service, in a context of increased legislation regulating such aspects as quality, safety and environmental constraints. Developments that have enabled management to meet these requirements include information technology and, where appropriate, the use of high levels of automation.

Nevertheless, achieving warehouse objectives and meeting management responsibilities still depend ultimately on the quality of management and staff running the operation. There has been significant development of management skills and awareness in recent years, as well as an upgrading of operational staff to exploit the potential benefits of technology and information systems.

Part 5

Freight transport

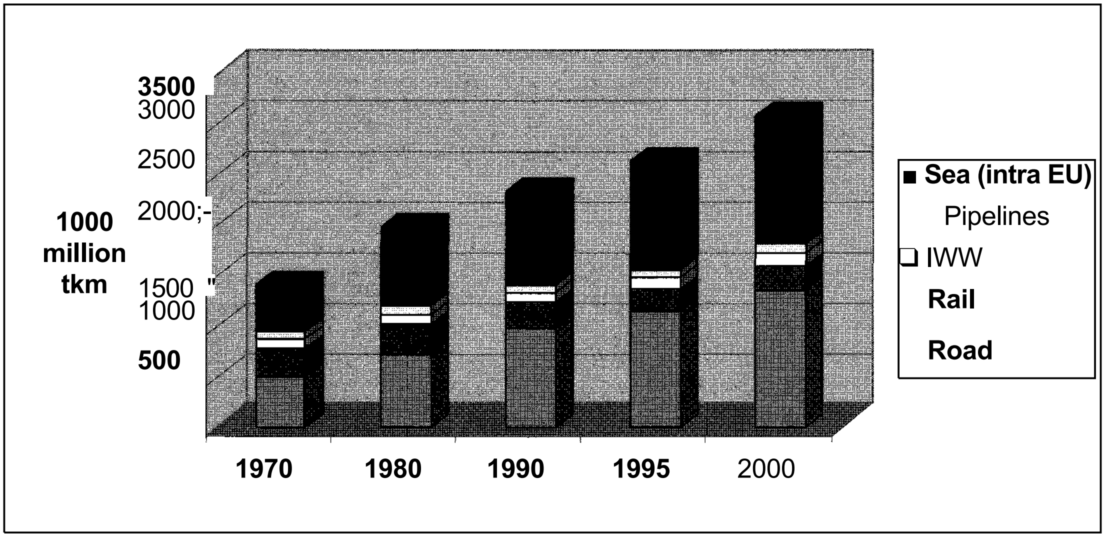
21

International logistics: modal choice

INTRODUCTION

The changing nature of logistics and the supply chain, particularly the move by many companies towards global operations, has had an obvious impact on the relative importance of the different modes of transport. In a global context, more products are moved far greater distances because companies have developed concepts such as focus factories, with a single global manufacturing point for certain products, and because of the concentration of production facilities in low-cost manufacturing locations. Long-distance modes of transport have thus become much more important to the development of efficient logistics operations that have a global perspective. Thus, the need to understand the relative merits of, say, sea freight as against air freight is crucial although, for many localized final delivery operations, it is still road freight transport that offers the only real option. All of these developments serve to emphasize the need to appreciate the many different facets of transport modal choice for international logistics.

In Europe, road freight transport continues to be the dominant mode of transport, together with coastal transport for bulk movements. A look at recent European statistics confirms this. The upward trend in the use of road transport has continued for many years, and it seems unlikely that the importance of road freight transport



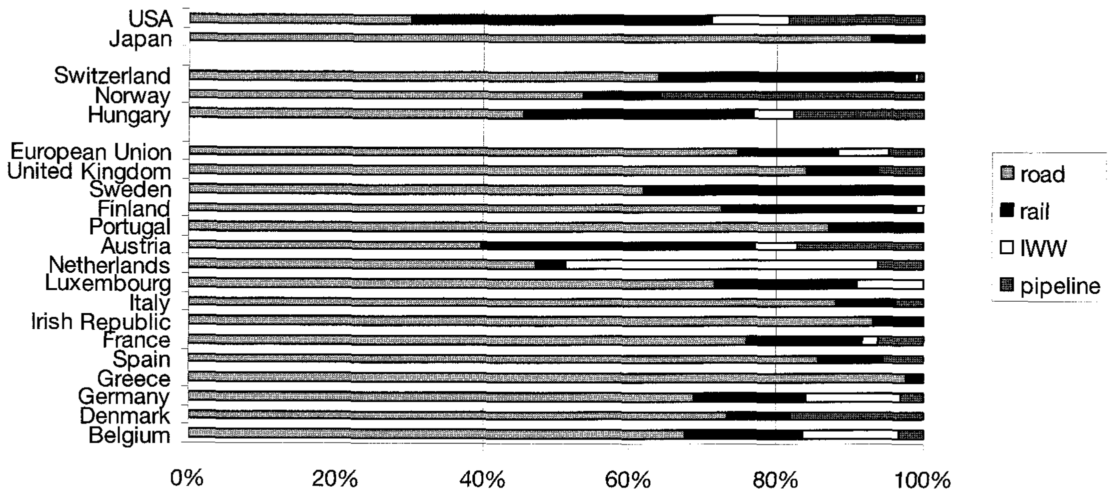
Source: Eurostat

Figure 21.1 Freight transport in the EU-15 by mode

will diminish in the near future. Rail freight has declined for many years, but is now holding its decline. Inland waterways are still important. The use of pipelines has continued for certain specialized movements. Figure 21.1, based on statistics for the 15 longest-standing members of the EU, indicates the relative importance of the different modes for freight transportation within Europe. Deep-sea and air freight transport are not represented in these particular statistics because they are mainly concerned with intercontinental freight movements.

The importance of road freight transport is also emphasized when the modal split is compared for freight transport movements within individual countries, as Figure 21.2 illustrates. However, it is also clear from this figure that for some countries rail freight transport does still play a major role. This applies particularly to the USA, Switzerland, Hungary and Austria. Rail freight transport tends to be more prevalent in countries with a large geographical spread or where there are significant environmental issues and restrictions.

All of the major modes of transport can be considered for the movement of goods internationally. The selection of the most appropriate transport mode is thus a fundamental decision for international distribution and logistics, the main criterion



Source: Eurostat and others

Figure 21.2 Freight transport modal share by country (percentage of tonne kilometres)

being the need to balance costs with customer service. There are very significant trade-offs to be made when examining the alternatives available between the different logistics factors and the different transport modes.

In this chapter, a broad method of modal selection is outlined. This takes into account operational factors, transport mode characteristics, a series of consignment or route factors and cost and service requirements. In addition, some particular aspects of international trade are also considered.

METHOD OF SELECTION

In this section the process for selecting a suitable mode of transport is introduced. The broad approach is split into four key stages, covering operational factors, transport mode characteristics, consignment factors, and cost and service requirements. These key elements are described in the remainder of this chapter, whilst the overall process is summarized in Figure 21.3. Many of these considerations are relatively obvious ones, but the problem lies with the large number of different

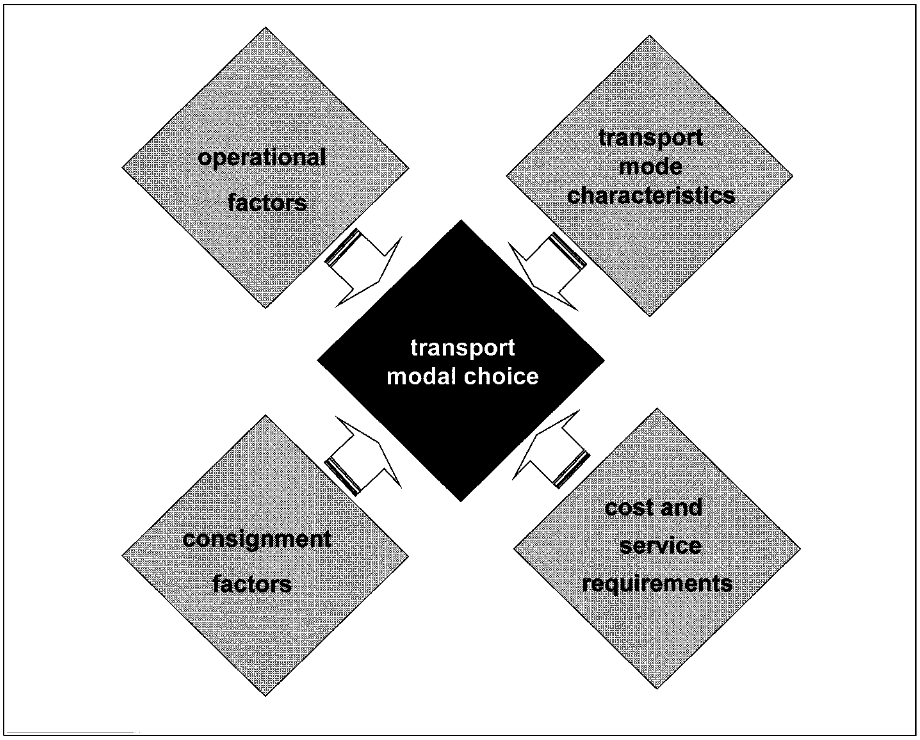


Figure 21.3 Modal choice: selection process

aspects that need to be taken into account. This is why a methodical selection process is required.

There are a large number of associated operational factors that need to be considered as a part of the modal selection process. These have been categorized as those that are external to the direct distribution operation, customer characteristics that need to be taken into account, physical product characteristics and other logistics components. The different transport mode characteristics also need to be understood and assessed. Clearly, some transport modes are more suitable to certain types of operational requirements than are others. A series of consignment factors also need to be addressed to ensure that the particular choice of mode is appropriate. For example, an urgent order or consignment should be moved via a fast transport mode. Finally, there is the ever-present and important logistics trade-off between cost and service that needs to be included in the selection process.

OPERATIONAL FACTORS

External factors

Encompassing the many operational factors that may need to be considered are those that are external to direct distribution-related factors. These are particularly relevant when contemplating the international context of modal choice because from country to country these factors can vary significantly. They include:

- *The basic infrastructure in the country*. In particular, the transport infrastructure is likely to be important. For example, opportunities to use rail will be significantly affected by the rail network that exists within a country. Many countries have limited track availability, whilst others may have mainline track but an insufficient number of railheads or railheads in inappropriate locations for industrial or commercial use.
- *Trade barriers*. These might include, for example, customs duty, import tariffs or quota payments. These can have a big impact on the overall cost of a product, and this may affect the decision concerning the most appropriate mode of transport for cost reasons.
- *Export controls and licences*. With these, there may be implications for the quantity of product that can be shipped in given periods of time.
- *Law and taxation*. Clearly, legal requirements in both a general and a specific context are likely to differ from one country to another. There is, for example, some very different road transport and environmental legislation that can affect the use of vehicles in terms of size restrictions, load restrictions and time restrictions.
- *Financial institutions and services, and economic conditions*. Elements such as exchange rate stability and inflation, for example, can influence modal choice. Where financial changes occur at a dramatic rate in a country then speed of delivery may be important.
- *Communications systems*. These can have an impact, for example, on the supporting processes and paperwork of freight movements. Delays can be more likely with some modes of transport. For example, sea freight can have particularly lengthy and onerous procedures.
- *Culture*. Differing cultural aspects may influence how trade and commerce are undertaken. For example, the choice of transport mode may rest on ownership rather than cost-effectiveness.
- *Climate*. Extremes of weather, temperature and humidity can have a major impact on some products. Thus, modes of transport must be selected carefully

to ensure that prevailing climatic conditions do not badly affect freight whilst it is in transit. Suitable protection must be guaranteed.

This list can be a long one, and the relevant inclusions will vary according to the country under consideration.

Customer characteristics

The particular customer characteristics may also have a significant effect on the choice of transport mode. Most of the characteristics will need to be considered for both national and international modal choice, that is, they are not specific to overseas distribution. The main characteristics to take into account are:

- *Service level requirements*. Some service level requirements can have a significant impact on choice of transport mode. Delivery time constraints can mean that certain relatively unreliable modes cannot be considered. This may occur when there is a need for delivery to be by a certain time or date, or when a specific time delivery window is stipulated. It is very common in retail delivery operations.
- *Delivery point constraints*. This factor is a very important one. It refers particularly to the physical aspects of delivery, including the location of the delivery point, any access constraints concerning the size of vehicle that can make the delivery and any equipment requirements for unloading. Once again, these are common problems in retail delivery.
- *Credit rating*. The credit rating of a customer may help to impose a limit on route selection and modal choice. New customers and existing customers with a poor credit rating mean that a company will want to be sure that payment is confirmed before delivery is made. Thus, commercial arrangements may override any logistical preference for a particular transport method.
- *Terms of sale preference*. There are a number of different terms of sale that can be used, ranging from ex works (at the supplier factory) to delivered duty paid (at the customer's delivery point). The terms of sale preferred by a customer therefore have a very large implication for the choice of transport mode — and of course who makes that choice, the supplier or the customer. The different terms of sale (Incoterms) are outlined later in this chapter.
- *Order size preference*. The physical size of an order clearly has an impact on modal choice, as some modes are more suitable for small orders and others for large ones. There may be significant cost implications here.

- *Customer importance.* Most suppliers have 'A' rated customers who are deemed to be their most important and who really must be given a delivery service that does not fail. For these customers, service reliability is essential and so certain routes and transport modes will be preferred.
- *Product knowledge.* Some products or orders may necessitate some knowledge transfer to the customer at the time of delivery. This may relate to the need to assemble the product in some way, or how to use the product. It is not likely to be an element that affects many orders, but would be important to route and modal choice where it does.

Physical nature of the product

The physical nature of the product is as important in determining modal choice as it is with all the other logistics functions. The main factors that need to be considered include:

- *Volume to weight ratio* – which concerns the relative amount of cubic capacity taken up by a given weight of product. For example, 1 tonne of paper tissues takes up far more space than 1 tonne of bricks. This is relevant when considering the different charging structures of the different transport modes – whether charged by weight or by cubic volume. For example, 1 tonne is normally charged the same as 1 cubic metre for sea freight, but the same as 6 cubic metres for air freight. Heavy goods are thus relatively more expensive by air freight.
- *Value to weight ratio* – which takes into account the value of the product to be transported. The relative transport cost of a high-value, low-weight product is likely to be so insignificant to the overall value of the product that the choice of mode from a cost perspective is irrelevant (eg jewellery or computer chips).
- *Substitutability* (product alternatives, etc) – whereby, if a product can be substituted by an alternative from another source, it may be worth while using a fast but expensive mode of transport to ensure the order is accepted by the customer. Where no substitute is possible, a slower and less expensive mode can be used.
- *Special characteristics* (hazard, fragility, perishability, time constraints, security) . A hazardous product may be restricted in how it is allowed to be transported (eg some chemicals), and a time-constrained product may have to be moved on a fast and expensive mode of transport to ensure it does not miss its time deadline (eg newspapers and promotional products).

These characteristics are considered in more detail in Chapter 6.

Other logistics components

The final series of important characteristics that need to be considered when determining modal choice concerns the other logistics components. These are the elements concerned with the classic logistics trade-offs described in Chapter 2. In any company's distribution structure there will be a number of factors that are interrelated. These may be fixed and unchangeable, and seen as sacrosanct by certain sections of the company. They may be subject to change — providing overall benefits can be identified from any change. These factors need to be known. There is no point in designing a system or choosing a mode that fails to allow for these other factors. It is important to be aware of the constraints that any fixed factors impose on any newly devised system, as the cost implications may well indicate that a trade-off would produce a better overall solution. The main characteristics may include:

- *Supply points.* The location of raw material or component suppliers will clearly impact on route and modal choice. This applies particularly where supply is sourced from abroad. Modal choice issues often arise where a raw material or component is vital to a manufacturing process or where inventory levels are relatively low at the point of production.
- *Production plants.* The location of manufacturing and production plants will impact on route and modal choice. This applies particularly where supply is sourced from abroad, as shipment delays may be unacceptable.
- *Warehouses and storage facilities.* Finished goods warehouses are often located adjacent to production points and factories, but they may be some distance away and thus involve regular movement of finished product from factory to warehouse.
- *Depots.* Inventory and stock-holding policy will usually determine where depots are located. The location of depots with respect to their supply points (usually production or warehouse facilities) in terms of distance and geography will have an impact on the choice of transport mode.
- *Marketing plans and policies.* These may affect transport choice because some plans and policies call for a very fast response time to customer orders, so, depending on depot location, a fast method of transport is essential. A good example is where new products are marketed or where there is a promotion of a particular product. Fast transport may often be required to support any marketing-related surges in demand.

- *Existing delivery system*. There maybe elements of the existing delivery operation that need to be retained. This often applies where there are sunk costs in a transport fleet, which means that it is a cost imperative to keep all or some of the vehicles.

TRANSPORT MODE CHARACTERISTICS

The modal choice selection process described so far has been concerned with the various operational factors that might need to be taken into account. The next main set of considerations involves the various attributes of the different modes themselves. It is not intended to describe here the detailed operations of the different modes, but what will be considered is their major attributes specifically in relation to the factors described in the previous section.

Conventional sea freight

Of the main alternative types of sea freight, both the conventional load and the unit load are relevant. The unit load (container) is considered later. For conventional sea freight, the main points to note are:

- *Cost economies*. For some products, the most economic means of carriage remains that of conventional sea freight. This particularly applies to bulk goods and to large packaged consignments that are going long distances. Where speed of service is completely unimportant, then the cheapness of sea freight makes it very competitive.
- *Availability*. Services are widely available, and most types of cargo can be accommodated.
- *Speed*. Sea freight tends to be very slow for several reasons. These include the fact that the turnaround time in port is still quite slow, as is the actual voyage time.
- *Need for double-handling*. Conventional sea freight is disadvantaged by the slow handling methods still used. This is especially true when compared with the more competitive 'through transport' systems with which sea freight must compete. The problem is particularly apparent on some of the short sea routes.
- *Delay problems*. There are three major delay factors that can lead to bad and irregular services, as well as helping to slow up the transport time itself. These are over and above the journey time. They are pre-shipment delays, delays at

the discharge port and unexpected delays due to bad weather, missed tides, etc.
- *Damage*. The need to double-handle cargo on conventional ships tends to make this mode more prone to damage for both products and packaging.

International road freight

As already indicated, road freight transport is the most important mode for national movements within most individual countries in Europe. In the context of international distribution, road freight transport is also important, even where there are fairly significant geographic constraints such as to and from the UK. Here, for example, road freight is viable via the use of roll-on roll-off (RORO) ferry services and the Channel Tunnel route. These allow for the through transport of goods from factory or warehouse direct to customers' premises abroad.

Compared with the other forms of international freight transport, the major advantages and disadvantages of road freight transport services are as follows:

- They can provide a very quick service (ferry and tunnel schedules can be carefully timed into route plans if they are a necessary part of the journey).
- For complete unit loads with single origin and destination points, they can be very competitive from the cost viewpoint.
- There is a greatly reduced need to double-handle and trans-ship goods and packages, and for direct, full-load deliveries this is completely eliminated. This saves time and minimizes the likelihood of damage.
- Packaging cost can be kept to a minimum because loads are less susceptible to the extreme transit 'shocks' that other modes can cause.
- The system can provide regular, scheduled services due to the flexibility of road vehicle scheduling.
- Road freight transport can lose its speed advantage when used for less than lorry-sized loads. These entail groupage and so involve double-handling (at both ends of the journey), additional packaging and time delay.

Rail freight

There have been many recent developments in rail freight systems, especially the development of intermodal containerized systems using ISO containers as the basic unit load and the introduction of the swap-body concept of transferable road—rail units. These are described in Chapter 22. More conventional rail freight systems have the major benefit of being a relatively cheap form of transport. This is particularly true for bulky and heavy consignments that require movement over medium to long distances and where speed is not vital. The principal disadvantages of conventional rail freight are as follows:

- Rail wagons are prone to some very severe shocks as they are shunted around goods yards. Shunting shocks can cause damage to products. To overcome this, costly packaging needs to be used.
- There is a need to double-handle many loads because the first and last leg of a 'through' journey often needs to be by road transport.
- There are a limited number of railheads available at factories and depots, making direct origin-to-destination journeys very rare. In recent years, many companies with railway sidings on their premises have closed them down due to their high cost of upkeep and operation.
- In general, rail transport is a very slow means of carriage - particularly when the whole journey is taken into account. Many freight trains have to fit their schedules around passenger trains, which take priority. This can cause significant time delays to the rail freight.
- Rail freight transport can be very unreliable. Batches of wagons may arrive at irregular intervals. This can cause further delays for international traffic if a complete shipment is on a single customs document.
- For international movements, there are significant compatibility issues (especially across Europe). These include variations in track gauge sizes, bridge heights and (lack of) electrification.

Air freight

The use of air freight as an alternative transport mode has grown rapidly in recent years. Major developments in the areas of integrated unit loads, improved handling systems and additional cargo space, together with the proliferation of scheduled cargo flights, have increased the competitiveness and service capability of air freight.

The major attributes of air freight are as follows:

- Air freight compares very well with other transport modes over longer international movements. This is because it has very rapid airport-to-airport transit times over these longer distances.
- Although air freight is very quick from airport to airport, there can be a tendency for this speed factor to become less of an advantage because time can be lost due to airport congestion and handling, paperwork and customs delays.

- One particular advantage is known as 'lead-time economy'. This is where the ability to move goods very quickly over long distances means that it is unnecessary to hold stocks of these items in the countries in question (spare parts, etc). The short lead time required between the ordering and receiving of goods, and the resultant saving in inventory holding costs give this benefit its name of ' lead-time economy'.
- The air freighting of products allows for a great deal of market flexibility, because any number of countries and markets can be reached very quickly and easily. This is particularly advantageous for a company that wishes either to test a product in a given area or to launch a new product. The flexibility of air freight means that a company need not necessarily set up extensive stockholding networks in these areas.
- The movement of goods by air freight can result in a marked reduction in packaging requirements. The air freight mode is not one that experiences severe physical conditions, and so its consignments are not prone to damage and breakages.
- Air freight transport is very advantageous for certain ranges of goods, compared to many of the alternative modes. This includes those commodities with high value to weight ratios (a lot of money is tied up, therefore an expensive freight on-cost is not significant), perishables (where speed is vital), fashion goods (which tend both to be expensive and to have a short 'shelf life'), emergency supplies (speed again is vital) and finally spare parts (the lack of which may be holding up the operation of a multimillion-pound project).
- For the vast majority of products, air freight is a very expensive form of transport. This is by far its greatest disadvantage. In some instances, and for some products, cost is of very little consequence, and it is for these types of goods that air freight tends to be used.
- Air freight has suffered to a certain extent due to security concerns. This is one reason for the increasing trend towards all-freighter aircraft, rather than freight being carried in the belly hold of passenger aircraft (which has generally been the predominant means of air freight).

Container systems

Container systems can be viewed as a specialized mode of freight transport, although the container is now a fundamental feature of all the major national and international transport modes - road, rail, sea and air. Containerization makes possible the development of what is known as the 'intermodal' system of freight transport, enabling the uncomplicated movement of goods in bulk from one transport mode to another. (See Chapter 22 for more details.)

The main attributes of containers and container systems are as follows:

- They enable a number of small packages to be consolidated into large single unit loads.
- There is a reduction in the handling of goods, as they are distributed from their point of origin to their point of destination.
- There is a reduction in individual packaging requirements, depending on the load within the container.
- There is a reduction in damage to products caused by other cargo.
- Insurance charges are lower due to the reduced damage potential.
- Handling costs at the docks and at other modal interfaces are reduced.
- There is a quicker turnaround for all the types of transport used. Port utilization also improves.
- The all-round delivery time is speedier, and so raises service levels.
- Documentation is simpler.
- The concept of 'through transit' becomes feasible, and allows for a truly integrated transport system to be developed.
- In the early days of containerization, the systems that were developed tended not to be well integrated across the different transport modes. This has considerably improved in recent years.
- There is a need for special facilities and handling equipment, and these are very costly. Thus, there are a limited number of transfer points available.
- The initial cost of the containers themselves is very high.
- The return of empty containers can often be an expensive problem. Trade is seldom evenly balanced, so return loads may not be available.
- Containers may leak, thereby causing damage due to rain or sea water.
- Loads may be affected by their position of stow, eg above or below deck.

CONSIGNMENT FACTORS

There are important consignment or route factors that may have an impact on the final decision concerning the best mode of transport for each individual shipment. These are specific elements related to the order or load that may influence the choice of transport mode. Often only a few of these factors will apply, but sometimes several need to be taken into account at one time. The main factors include those that are noted below:

- *Routeing and through transit responsibility:*
  - Is a direct route stipulated by the customer?
  - Are there countries through which the shipment may not travel?
  - Who is responsible for the through transit?
  - Who is paying for the freight costs?
- *Distance:*
  - What is the distance to be moved?
  - Does distance restrict the options that are available?
- *Type of cargo:*
  - If it is bulk or general cargo, will a certain specific route be preferable?
  - If it is bulk or general cargo, are certain routes cheaper?
  - Does the cargo have specific features that make certain routes more attractive (perishable, high value)?
  - If hazardous, are all routes available?
- *Quantity:*
  - full load;
  - part load;
  - small size, etc.
- *Unit load:*
  - Will unitization help?
  - Is it a small or large unit load?
  - Is containerization feasible?
  - Is groupage an alternative?
- *Priority:*
  - How soon must the goods reach their destination?
  - Does 'Urgent!' really mean 'Urgent!'?
  - Who pays the freight costs for an urgent order?
- *Commodity value:*
  - How important is the transport cost element?
  - If it is import/export, how is the commodity rated?
  - Will a fast, expensive mode enable reduced inventory holding and associated cost savings?
- *Regular shipments:*
  - How often will these shipments be made?
  - Should a contract be negotiated or is 'spot hire' adequate?

COST AND SERVICE REQUIREMENTS

The ultimate decision for modal choice is the familiar logistics trade-off between cost and service. This must be considered in relation to the relevant operational factors, transport mode characteristics and consignment factors that have been outlined previously. In theory, the volume of freight (or size of load) to be moved and the distance to be travelled dictate the choice of mode based on relative costs. This is summarized in Figure 21.4.

Size of order/load	short	medium	long	very long
100T	road	road/rail	rail/sea	sea
20T	road	road	road/rail	rail/sea
pallet	road	road	road/rail	air/sea
parcel	post/road	post/road/air	post/road/air	post/air

Delivery distance

Source: Alan Rushton, Cranfield University (unpublished)

Figure 21.4 Modal choice matrix

On one extreme there is the small parcel that has to go a short distance. This is likely to be routed via road transport or perhaps post if a very small parcel. At the other extreme there is the 100-tonne-plus load going thousands of kilometres. This is most likely to go via sea freight.

In practice, other elements such as the speed of delivery required or the reliability of service may override these purely economic factors:

- *Speed of delivery*. Orders may be required quickly for a number of reasons that override the cost factor — such as urgent orders for spare parts. Air freight is often used instead of sea freight because the additional transport costs can be offset against inventory savings/stock availability.

- *Service reliability*. Some customer service policies are based on orders reaching customers to meet tight delivery windows, so control and reliability are important. Rail is often cheaper than road for long-haul, but some aspects of the industry have been beset by service issues, so many customers have switched from rail to road after suffering service interruptions.

ASPECTS OF INTERNATIONAL TRADE

In this section, some key elements of international trade that are important to logistics and to the choice of international transport mode are considered. These major elements cover:

- trade agreements and economic unions;
- financial issues;
- terms of trade;
- documentation;
- the use of freight forwarders.

Trade agreements and economic unions

This is a particularly exciting period for the development of logistics in a global context. The establishment of a number of international trade agreements and economic unions, such as the European Union, the North American Free Trade Association (NAFTA) and the Association of South East Asian Nations (ASEAN) amongst others, has had a major impact on the globalization of trade. Many products are produced and distributed across regions and continents, and there has been a significant impact on transport opportunities. As these changes have taken place, they have been a major influence on the structure of distribution and logistics systems throughout Europe and the rest of the world as trade barriers have broken down and new transport networks have been initiated.

In a European context, for example, major barriers to trade have been or are being overcome. They include:

- physical barriers — removal of customs control, introduction of the single administrative document and removal of immigration and passport control;
- technical barriers — removal of all barriers to trade between member states, free movement of goods, capital, services and workers, harmonization of technical standards, common protection for intellectual and industrial property, and opening up of public procurement;

- fiscal barriers - approximation of indirect taxation (VAT and excise duties), and consequent removal of fiscal frontier checks;
- access to Central and Eastern European countries;
- introduction of the euro currency, which allows greater transparency of pricing.

Those provisions and changes that are particularly relevant to logistics can be summarized as:

- Goods and services can be bought anywhere in the community.
- Customs barriers have been virtually abolished.
- Documentation has been simplified and standardized.
- Operating (transport) permit restrictions have been removed.
- Testing standards are acceptable in all community states.
- There is free movement of capital.

There remain certain policy areas where there are still some important differences between member states that have an impact on transport and logistics. These include:

- environmental issues (some countries ban road freight movements at certain periods during the week);
- duty on fuel (this varies between the different EU countries, making it more attractive to locate fleets in some countries);
- rail subsidy (providing some advantage to move products by rail in some countries);
- labour laws (important in a number of ways, making it more attractive and cheaper to employ labour in some countries).

Some significant opportunities have arisen for transport and distribution companies resulting from the development of economic unions. These have encouraged companies to increase the scope of their services across the wider geographic areas. They include the following:

- There is more competition between third-party companies because of the increased market.
- Transport and third-party distribution companies can give a more comprehensive European-wide service.

- There is easier and faster movement of goods across borders.
- Distribution and transport can be bought in any country - there is more cross-trading and cabotage (transport companies moving goods in other member states).
- Increased opportunities for joint ventures with other European and international operators enable European-wide and global integrated logistics and transport organizations.
- New depot locations and consequent transport flows can be determined to suit both sources and markets.

Financial issues

Identifying the most cost-effective opportunities in international transport and logistics requires a very sophisticated understanding of some of the key financial issues involved. There are many different elements that need to be taken into account when trying to identify the most cost-effective solution from a myriad of alternatives. The main factors include:

- *Types of payment*. These can include, in order of risk, an open account (where terms of payment are pre-arranged with the buyer), a draft (where title of the goods is retained until payment is received), a letter of credit (where the bank will authorize payment for an order once the precise conditions of the letter of credit have been met) and cash in advance (money paid up front - which few customers are happy to accept).
- *Taxes and duties*. These can have a big impact on the overall cost of a product. They may include import tariffs, value added tax or quota payments.
- *Transport costs*. These will include costs related to any of the different modes. Unless direct delivery is being undertaken using a single mode of transport, an allowance should be made for inland carriage from point of origin, plus international carriage, plus final delivery from the destination port.
- *Associated transport charges*. These can include port fees, bunker adjustment fees or fuel charges.
- *Other charges*. These can include insurance, break-bulk, storage and handling.

Terms of trade

It is important to be aware of the basic methods of undertaking business when concerned with international transport. There are a number of different ways in which goods can be purchased on an international basis, and it is essential that both the buyer and the seller are aware of which terms have been agreed. Different terms mean very different responsibilities for both the organization and the payment of the transport element of the order. These are known as Incoterms, and the main alternatives are outlined in the box below.

The main Incoterms

- EXW - ex works (named place) (any mode of transport). The seller must place the goods at the disposal of the buyer at the seller's premises or another named place not cleared for export and not loaded on any collecting vehicle.
- *FCA* - free carrier (named place) (any mode of transport). The seller must deliver the goods, cleared for export, to the carrier nominated by the buyer at the named place.
- FAS - free alongside ship (named port of shipment) (maritime and inland waterway transport only). The seller must place the goods, cleared for export, alongside the vessel at the named port of shipment.
- *FOB* - free on board (named port of shipment) (maritime and inland waterway transport only). The seller delivers the goods, cleared for export, when they pass the ship's rail at the named port of shipment.
- *CFR* - cost and freight (named port of destination) (maritime and inland waterway transport only). The seller delivers the goods when they pass the ship's rail in the port of shipment and must pay the costs and freight necessary to bring the goods to the named port of destination. The buyer bears all additional costs and risks after the goods have been delivered (over the ship's rail at the port of shipment).
- CIF-cost, insurance and freight (named port of destination) (maritime and inland waterway transport only). The obligations are the same as under CFR with the addition that the seller must procure insurance against the buyer's risk of loss of, or damage to, the goods during carriage.
- CPT-carriage paid to (named place of destination) (any mode of transport). The seller delivers the goods to the nominated carrier and must also pay the cost of carriage necessary to bring the goods to the named destination. The buyer bears all additional costs and risks after the goods have been delivered to the nominated carrier.
- *CIP* - carriage and insurance paid to (named place of destination) (any mode of transport). The obligations are the same as under CPT with the

addition that the seller must procure insurance against the buyer's risk of loss of, or damage to, the goods during carriage.

- *DAF* - delivered at frontier (named place) (any mode of transport). The seller must place the goods at the disposal of the buyer on the arriving means of transport not unloaded, cleared for export but not cleared for import, at the named point and place at the frontier.
- DES - delivered ex ship (named port of destination) (maritime and inland waterway transport only). The seller delivers when the goods are placed at the disposal of the buyer on board the ship, not cleared for import, at the named port of destination.
- *DEQ* - delivered ex quay (named port of destination) (maritime and inland waterway transport only). The seller delivers when the goods are placed at the disposal of the buyer, not cleared for import, on the quay at the named port of destination.
- *DDU* - delivered duty unpaid (named place of destination) (any mode of transport). The seller must deliver the goods to the buyer, not cleared for import, and not unloaded at the named place of destination.
- *DDP* - delivered duty paid (named place of destination) (any mode of transport). The seller must deliver the goods to the buyer, cleared for import, and not unloaded at the named place of destination.

(*Source:* SITPRO, www.sitpro.org.uk)

Documentation

Types of documentation are also very important. The requirements for these may vary according to the origin and destination of the shipment, and the mode of transport used. The most common documents are:

- the shipper's export declaration;
- bill of lading, or sea or air waybill;
- import and export licences;
- certificate of origin and consular documentation;
- CMR note (for carriage of goods by road);
- CIM note (for carriage of goods by rail);
- packing note;
- insurance certificate;

- shipping delivery note (eg standard shipping note);
- export invoice;
- customs requirements for import and export, eg single administrative document (SAD).

It is absolutely essential that all documentation is completed accurately and in good time; otherwise substantial delays can occur. In some instances, delays related to incorrect or inadequate documentation can lead to significant additional cost and, of course, loss of business.

Freight forwarders

Because of the particular complications concerning import and export documentation, as well as for other reasons, many companies use the services of freight forwarders. Typical services that are offered include:

- preparation and checking of shipping documents;
- booking space with carriers;
- arranging the order collection from the point of origin to the shipping port;
- arranging the customs clearance and final delivery at the destination country;
- provision of advice in export regulations, documentation requirements, etc;
- detailed knowledge of carriers, ports, etc;
- knowledge of the different modes of international transport;
- knowledge of the different costs associated with different modes and destinations.

Many freight forwarders act as principals to the transport contract, for example by providing road and container groupage services or air freight consolidation. In these situations, the freight forwarder takes responsibility for the transport, rather than just acting as an agent.

SUMMARY

In this chapter, the very broad area of international logistics, with a particular emphasis *on* the choice of transport mode, has been described. Some statistics were introduced to help illustrate the different modal split in a number of countries. Emphasis has been given to the selection process involved in modal choice, covering the following aspects:

- operational factors relating to:
    - the external (non-distribution) environment,
    - customer characteristics,
    - the physical nature of the product,
    - other logistics components;
- transport mode characteristics covering:
    - conventional sea freight,
    - international road freight,
    - rail freight,
    - air freight,
    - intermodal systems;
- the main consignment or route factors;
- cost and service requirements.

Finally, certain key aspects of international trade were considered. These were:

- trade agreements and economic unions;
- financial issues;
- methods of undertaking business;
- documentation;
- the use of freight forwarders.

From the viewpoint of the different modes of transport, it seems likely that the higher productivity and adaptability of road freight transport together with the increasing demands on service levels will put additional pressure on rail, and strengthen the already strong position of road transport. If concepts such as just-in-time continue to flourish, with the requirement for regular, frequent deliveries, flexibility and reduced stock levels, then it will be less easy for rail and water transport to compete. Railway companies need to develop intermodal systems to offer flexibility and cost advantages comparable to road freight transport and container services. For long-distance movement, rail should be able to compete with road. Air freight should continue to flourish in the niche area of fast delivery from global stock-holding centres. Computerized systems should enable improvements in reliability and transit times for all modes.

22

Intermodal transport

INTRODUCTION

What is meant by intermodal transport? The following is a useful definition from the European Conference of Transport Ministers: 'the movement of goods in one and the same loading unit or vehicle, which uses successively several modes of transport without handling of the goods themselves in changing modes'.

Undoubtedly the introduction of unitized loads in the form of International Standards Organization (ISO) containers and pallets revolutionized the movement of freight from the 1960s onwards. Pallets first appeared on the global transport stage courtesy of the United States military forces in the 1940s. The assembly of goods on to pallets allowed swift transfer of loads from warehouse to truck or any other mode of transport such as trains, ships or aircraft. The reduction in personnel required and transit times was remarkable. In 1958, Fred Olsen's reported loading 975 tons of unitized cargo in 10 hours with an 18- to 22-man longshore gang (stevedores) instead of the usual 200 tons (Van Den Burg, 1975).

Rudimentary freight containers were certainly in use as early as 1911 when they were known as lift vans in the USA, but it was the 1960s that saw the birth of the ISO container for freight movement. Pioneering companies in container transport were Sea-Land Service Inc on the US Atlantic coast, Matsons on the US Pacific coast and Associated Steamships Ltd in Australia. A number of ISO recommendations helped the standardization of containers and therefore allowed for interchangeability between different modes of transport around the world:

- R-668 in January 1968 defined the terminology, dimensions and ratings.
- R-790 in July 1968 defined the identification markings.
- R-1161 in January 1970 made recommendations about corner fittings.
- R-1897 in October 1970 set out the minimum internal dimensions of general-purpose freight containers.

These standards allow the same container to be safely carried by truck, train, deep-sea cellular container ship and aircraft. This removes the requirement for multiple handling of the products, improves security, reduces loss and damage and above all speeds up the whole process of freight transportation. Containers of freight move around the globe with an ease that could only have been dreamt of at the start of the 20th century. It is said that as much as 90 per cent of all international shipments are carried inside containers. This ability to move freight swiftly and safely aids the logistics process, as the elimination of wasted time is a key objective of logistics management. Containers also have another benefit in that they can be traced through the transport system and their progress monitored.

INTERMODAL EQUIPMENT

The following section is designed to provide an overview of the various types of equipment specifically used in intermodal transport. The list is not exhaustive but the most common equipment will be identified and described briefly.

Intermodal containers

ISO containers

ISO containers are so called because the International Standards Organization has standardized the design of containers to allow for the widest possible use of this equipment around the world. Containers are usually rectilinear boxes constructed of steel. Open-topped versions, which are covered by a fabric curtain, are available for loads that may not fit into a standard container. Another common variation is the tanktainer, which is a steel frame that conforms to the ISO dimensions but has a tank container fixed inside the frame. This allows bulk loads of liquids or powders to be carried by intermodal carriers. Refrigerated and flat-rack options are also available.

The most common sizes of container available are 20 feet, 40 feet and 45 feet in length. The height and width dimensions are the same for all lengths at 8 feet wide by 8 feet 6 inches high, although high-cube containers at 9 feet 6 inches high are becoming increasingly common. As with most rules, exceptions do exist, but these are the most commonly used dimensions.

Two acronyms used widely in intermodal circles are TEU and FEU. The initials stand for 'twenty feet equivalent unit' and 'forty feet equivalent unit'. They are often used as definitions of cellular container ship capacities. A ship may be described as being able to carry 6,000 TEU. The twenty feet equivalent unit refers to the 20-feet container. Therefore two 40-feet containers would equal four TEU or two FEU.

The swap-body

This is a type of container used primarily on bimodal intermodal operations, which use the road and rail modes of transport. The swap-body is a self-supporting body that has supporting legs that may be folded away when not required. Swap-bodies conform to different international standards. There are three standard lengths of 7. 15 metres, 7.45 metres and 7.82 metres. These lengths are used because the swap-body will be carried by road transport for part of its journey and must conform to the strict requirements pertaining to vehicle dimensions inside the European Union.

The swap-body is transferred from road vehicle to rail wagon by means of an overhead straddle crane, which has four arms that locate into slots permanently fixed to the bottom of the swap-body.

A further version of the swap-body is the caisse mobile. This is 12 metres or 13. 6 metres long, which conforms to European Union dimensions for articulated semi-trailer lengths. Caisse mobiles do not usually have self-supporting legs but very often are able to be top-lifted in the same way as ISO containers. Unlike ISO containers, most swap-bodies cannot be stacked.

Road-Railer trailers

Road-Railer is the brand name for a method of effectively converting a road-going articulated semi-trailer into a rail-going rail wagon. This is achieved by placing a railway bogie under the rear of a specially designed road semi-trailer. This same bogie attaches itself to the kingpin of the following road trailer. This process is repeated until the train is complete. The road wheels of the semi-trailer are mechanically retracted to prevent them from interfering with the movement of the train. This system does not require specially adapted rail wagons and allows for a more rapid transfer of vehicles from road to rail. It does require that the road vehicles are specially designed for the purpose.

Unaccompanied trailers

Unaccompanied road semi-trailers may be used to send goods by roll-on roll-off sea ferry (RORO). This method does not require any adaptation of the road trailer and avoids the added cost of sending the tractive unit and driver with the trailer. This is important, as tariffs on shipping services usually relate to the length of the vehicle. Therefore unaccompanied trailers will be shorter and cheaper. The unaccompanied trailers are moved on and off the ferry by means of a motive unit (often called a tug) fitted with a hydraulic mechanism for attaching to the front of the trailer and lifting the semi-trailer without the need to raise the landing legs. This speeds up the operation at both ports.

Another effective use of unaccompanied trailers is called piggyback. This uses the same principle as the road-sea version but applies the principle in a road-rail context. In this situation, unaccompanied semi-trailers are carried on specially constructed rail wagons. Because articulated road semi-trailers tend to be higher at the front than at the rear, a specially constructed well in the rail wagon allows the landing legs to sit at a lower level than the rear wheels. This has the effect of making the trailer sit on the rail wagon with the roof at an overall even height to the ground. The French have dubbed this method 'le kangarou' because of the well being likened to a kangaroo's pouch.

The problems caused by the landing legs and the road wheels are effectively overcome by a recent development known as the spine rail wagon (see Figure 22.1) . In this system road trailers are loaded on the rail wagon with the road wheels and landing legs either side of a central spine on the rail wagon. This allows the semi-trailer to sit squarely on the rail wagon and reduces the overall height. The spine wagon is also able to carry ISO containers. In Figure 22.1, the twist locks for securing ISO containers are visible, which demonstrates the versatility of the system.

These methods of unaccompanied transport have been in use for some time and are not always thought about when intermodal transport is discussed. However, they do fit the strict definition of intermodal transport above and use effectively the road, rail and sea modes.

Intermodal handling equipment

Transtainers

These are large devices mounted on rails, which are able to transfer containers from the sea-going vessel to trucks or rail wagons. A large boom spans the distance

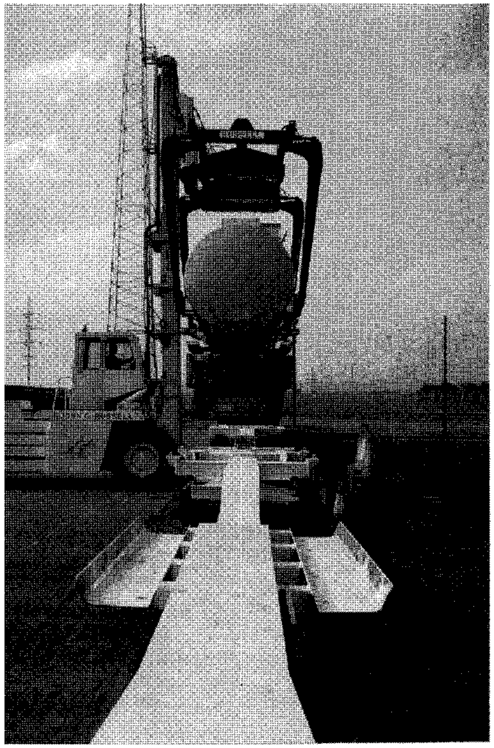


Figure 22.1 Spine wagons being loaded by a reach stacker equipped with a grappler (courtesy of John G Russell (Transport) Ltd)

between the ship's cargo holds and the quayside. The transtainer is capable of moving along the quayside parallel to the ship's side to aid positioning.

Gantry (or portal) crane

Sometimes referred to as a straddle carrier, this is a crane designed to lift containers and swap-bodies (see Figure 22.2). It has four legs, one at each corner, with wheels at the bottom of each leg. It has the ability to straddle rail wagons and road vehicles. It is able to transfer containers and swap-bodies quickly from road vehicles to rail wagons and vice versa. It is equipped with a spreader beam that has a twist-locking device at each corner, which locates in the corner casting of the container. The spreader beam is able to move in several directions to aid accurate location either of the spreader beam prior to picking up the container or when positioning the container on a road vehicle or rail wagon.

Figure 22.2 Gantry crane moving ISO containers

Grappler lift

This is a similar handling vehicle to the gantry crane except that it is fitted with four arms and is designed specifically to handle swap-bodies. The arms locate in the special slots built into the bottom of every swap-body. The grappler lift straddles the vehicle, positions the four arms and then lifts the swap-body.

Reach stacker

This is a heavy-duty material handling truck that is fitted with a lifting arm and a spreader beam. It is capable of lifting containers and swap-bodies (only if the swap-body is equipped with twist locks on top). It can be used to load and unload road and rail wagons (see Figure 22.3). It can also be used to stack containers one on top of the other and to reach over a row of stacked containers. Empty containers can be stacked up to eight high using specially equipped lift trucks.

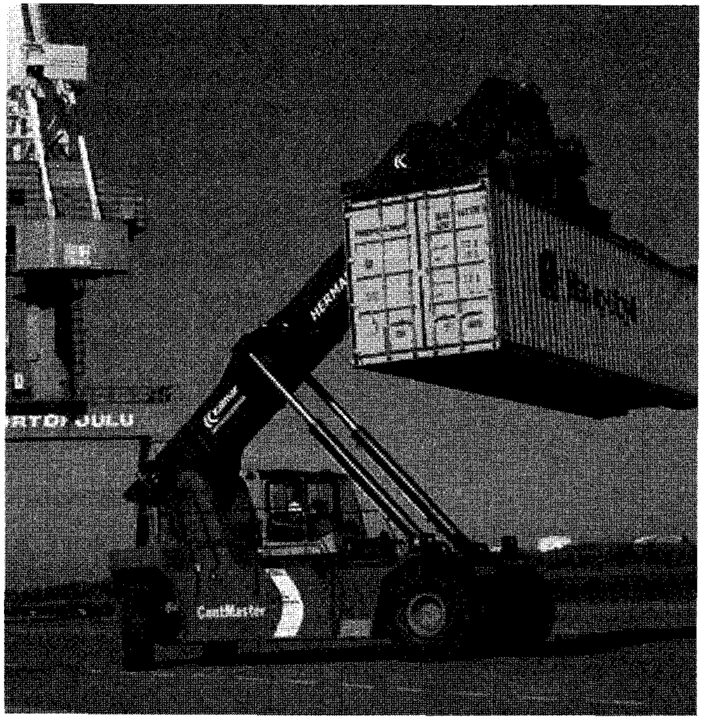


Figure 22.3 Reach stacker handling an ISO container

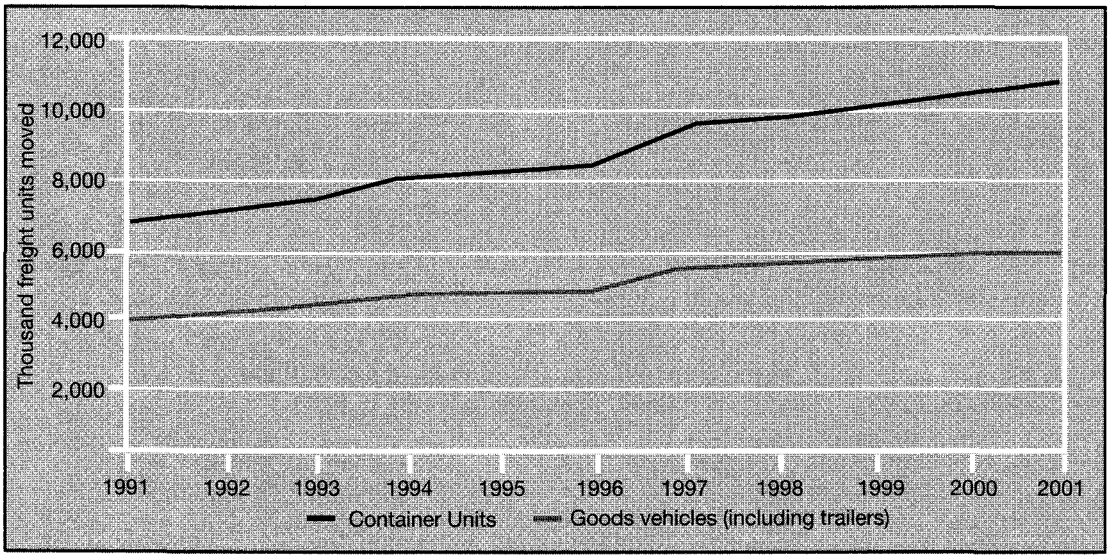
INTERMODAL VEHICLES

Sea

The cellular container ship

This is a custom-built sea-going vessel for the carriage of containers. The containers are loaded one on top of the other and guided into position by the means of vertical guides at each corner of the container. This aids the process of loading, as the guides position the container accurately enough to preclude the need for any further manoeuvring once the container is released by the overhead crane. It also eliminates the potential problems caused by the vessel listing or the crane not being accurately positioned.

Once in position, the containers are secured together by means of a twist-locking device. The stacks of containers are also secured by means of deck lashings for added stability during the sea journey.



The numbers of freight units handled at UK ports has increased steadily: from 6.7 million in 1991 to 10.8 million in 2001. Fifty six per cent of these units were goods vehicles or unaccompanied trailers, the remainder were containers. Over the 10 years to 2001 the growth in the number of containers handled (69 per cent) has been greater than that for vehicles and trailers (55 per cent). Some container traffic, especially at Felixstowe, is transhipment cargo, and not therefore UK imports or exports.

Source: Department for Transport (2003)

Figure 22.4 Unitized international freight passing through UK ports

Containers may be stacked four or more high above deck level. This ability is limited by the structure and stability of the vessel. Owing to the cubic nature of the container load, which is at odds with ship design, some vessels carry other cargo in the spaces in the holds created by the squaring-off effect.

The service provided by these vessels is sometimes referred to as LOLO (lift on lift off). International freight carried in containers passing through UK ports continues to grow (see Figure 22.4).

The roll-on roll-off ferry (RORO)

This type of sea vessel is designed to carry road vehicles. The vehicles are either driven on to the vessel by the driver or, as in the case of unaccompanied trailers, by port-based vehicles. This allows unaccompanied vehicles or trailers to be delivered to the port of departure and then collected from the port of arrival. International freight using the RORO system has grown significantly in recent years (see Figure 22.4).

Other versions of the roll-on roll-off ferry are specifically designed to carry rail wagons. The decks of these vessels are equipped with railway lines to allow ease of loading rail wagons.

River barges

On large inland waterways such as the Rhine /Danube in Europe and the Mississippi river in the United States, there is considerable use made of the water as an artery of transportation. Roll-on roll-off facilities and container transport as well as break-bulk cargo facilities are available and cannot be forgotten when considering long journeys using different modes of transport. This type of transport is useful for non-urgent freight, as it is by definition slower than other modes.

Rail

It should be noted that a movement of freight that uses both road and rail to complete the journey is sometimes referred to as combined transport.

Rolling motorway

This is the rail version of the roll-on roll-off sea ferry. Vehicles are driven on to specially designed rail wagons by their drivers. In some cases the drivers stay with their vehicles and in others they are accommodated in a passenger car for the duration of the journey. This type of system is used in Switzerland to carry trucks between Germany and Italy. Another use of this system is in the Channel Tunnel between the UK and France where it is known as Le Shuttle.

Piggyback and Road-Railer

These methods of carrying road trailers by rail were discussed above.

Double stacking

In some parts of the world, such as the United States and Australia, containers may be carried by rail double stacked, ie one container loaded on top of another. This method greatly improves utilization of equipment especially over the very long distances found in these countries. This method is not practical in the European Union due to the restrictive loading gauges.

Multifret wagon

This is a specially designed low-platform rail wagon for use by intermodal trains using the Channel Tunnel.

Ferrywagon

This is a conventional rail wagon that is capable of being loaded on to a train ferry.

European rail containers

These containers are slightly wider than ISO containers, which are 2.4 metres wide. These containers are 2.5 metres wide and are used in the European rail system.

Road

Skeletal trailer

This is an articulated semi-trailer that is designed to carry ISO containers. It is fitted with twist locks at various points on the trailer to allow the carriage of different sizes of container. It is called a skeletal trailer, as it does not have any loading platform as such. It is a framework designed to support containers alone. In effect the containers become the body of the vehicle when loaded on to the trailer.

Some skeletal trailers are equipped with hydraulic rams to facilitate the tipping of the container. Some granular and powder products may be carried in ISO containers. The product is loaded through the top of the container via a special hatch, and the product is retained by means of a plastic liner inside the container. At the point of delivery the container is tipped up by the hydraulic ram and the product is allowed to flow out of another hatch set in the rear of the container. In some cases this process is assisted through the use of pneumatic conveyance.

Extendable trailers

These trailers are sometimes called 'slider' trailers because of their ability to be extended or shortened depending on the size of the container to be carried. In all other respects they resemble skeletal trailers.

INTERMODAL INFRASTRUCTURE

The European Union and UK government are committed to the promotion of intermodal transport. They see the removal of certain types of cargo from the EU's roads as an environmentally sound policy. The reduction of road congestion, improvements to urban environments and reduction of harmful gaseous emissions from road vehicles are the objectives. Consequently, considerable investment is being made in intermodal infrastructure.

The Channel Tunnel

The fixed link between the UK and France has opened up new possibilities for the movement of freight by rail. Various distances are cited by railway economists for the point at which movements by rail become profitable. One thing is clear, that rail freight has a greater chance of being profitable if longer distances and full train loads are involved. The Channel Tunnel has opened up the possibilities for much longer journeys into continental Europe.

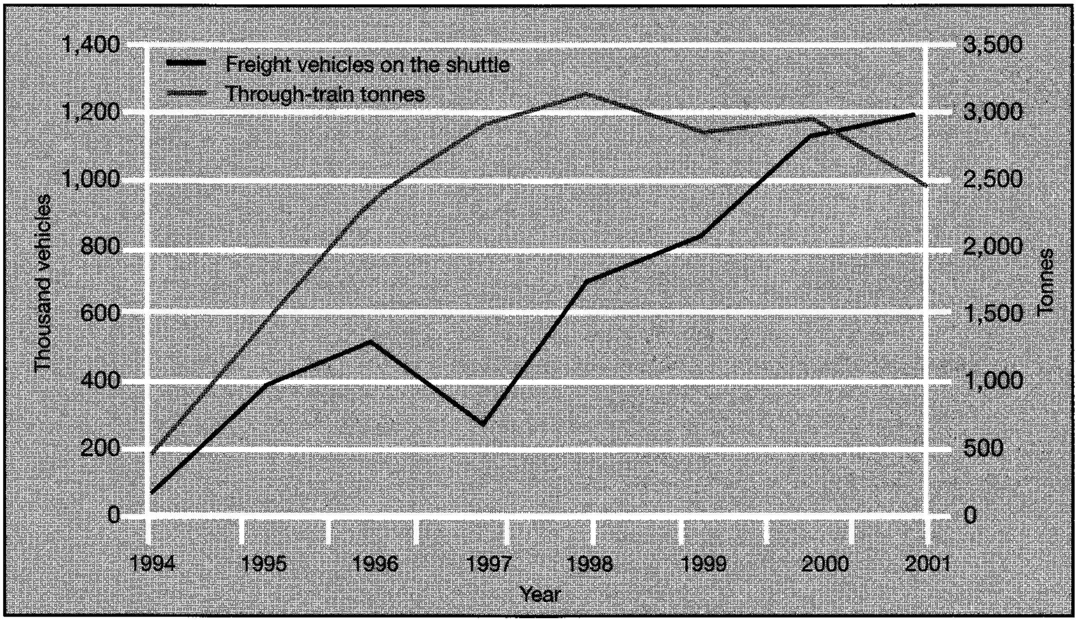
Significant amounts of intermodal traffic pass through the fixed link every day, and the quantities of traffic are growing. Figure 22.5 illustrates the volume of freight carried through the Channel Tunnel and demonstrates the pattern of growth clearly.

International intermodal terminals and freight villages

These are road–rail interchange points that have been strategically placed on the UK mainland and are directly connected to the European rail network via the Channel Tunnel. These termini and freight villages usually have warehouse and distribution companies based alongside the rail facilities. Break-bulk and freight consolidation services are usually also available. Some of these facilities are classified as inland ports and so customs services are available.

The main international intermodal terminals in the UK are:

- Mossend, Glasgow;
- Trafford Park, Manchester;
- Seaforth Docks, Gartree (Liverpool);
- Hams Hall, West Midlands;
- Daventry International Rail Freight Terminal, Daventry;
- Doncaster International Railport, Doncaster;
- Wakefield;
- Willesden, London.



The number of goods vehicles carried on the shuttle has increased fairly steadily since the Channel Tunnel opened for freight services in June 1994. Figures for 1996 and 1997 were affected by the fire on the shuttle in November 1996. Full freight services resumed in June 1997. The tonnage carried on through trains peaked in 1998 at 3.1 million but has since fallen to 2.4 million in 2001. Some of this fall will be because of the reduction in services following security concerns.

Source: Department for Transport (2003)

Figure 22.5 Freight traffic to and from mainland Europe through the Channel Tunnel

FREIGHT FACILITIES GRANTS

These are grants paid by the UK Department for Transport to help industry cover the capital cost of developing freight handling facilities that are used exclusively for rail freight. These may be completely new facilities or a reopening of old facilities. The applicants must demonstrate that without the facility the freight would be moved by road. The grant may cover handling equipment, sidings, rail wagons and locomotives.

TRACK ACCESS GRANTS

These grants are designed to help towards the costs payable to Network Rail for access to the UK's railway network. As Network Rail owns the railway network, anyone wishing to operate trains on the network pays a track access fee. These grants are designed to encourage industry to consider using the railways where practicable in preference to using the road network. To qualify for a grant, the applying company must clearly demonstrate that without the grant the only economically viable alternative would be to use road freight. The grants are also payable if it is in the public interest that the freight in question travels by rail. Track access grants are available for traffic that does not qualify for company neutral revenue support grants.

COMPANY NEUTRAL REVENUE SUPPORT GRANTS

The European Commission has approved the introduction of these grants in the UK for a trial period of three years until 31 March 2007, when their performance will be reviewed. The grants are designed to support intermodal container traffic moving by rail with the objective of promoting growth. The movement of ISO containers, swap-bodies and piggyback trailers is covered by the grants but traffic through the Channel Tunnel is not. The grants are available to support deep-sea, short-sea and domestic intermodal rail traffic.

From 2007-08, the UK government is planning to merge the budget for rail freight grants with the budget for grants supporting inland water freight and road freight under one overall sustainable distribution fund.

Detailed information on these grants is available on the UK Department for Transport's website, www.dft.gov.uk.

SUMMARY

This chapter has covered the area of transport known as intermodal transport. After a brief description of the history and development of unitization in the form of pallets and ISO containers, a description was given of the equipment used in intermodal transport. ISO containers, swap-bodies, Road-Railers and unaccompanied trailers were all briefly covered.

The equipment used to handle intermodal containers was explained and described. Included in this section were transtainers, gantry cranes, grappler lifts and reach stackers.

Each mode of transport has specially adapted vehicles designed to carry intermodal containers. The modes were looked at in turn, namely sea, inland waterway, rail and road. The workings of cellular container ships and roll-on roll-off systems were detailed. For rail, rolling motorways and other specialized methods were discussed. The use of skeletal trailers was included in the section covering road transport.

The intermodal infrastructure is obviously important for the development of intermodalism, and therefore a section was included that discussed the Channel Tunnel and international intermodal terminals.

Finally, there were sections on the UK government grants available for supporting the transfer of freight carried by road to the railways.

23

Road freight transport: vehicle selection

INTRODUCTION

As with most of the decisions that have to be taken in physical distribution, there are a number of aspects that need to be considered when trying to make the most appropriate choice of vehicle for a vehicle fleet. Vehicle selection decisions should not be made in isolation. It is essential that all the various aspects should be considered together before any final conclusions are drawn. There are three primary areas that need to be carefully assessed — efficiency, economy and legality.

Efficiency, in this context, means the most effective way to do the job, based on a number of important factors. The truck should be fit for purpose. These factors might include:

- the nature of the operation, ie annual mileage, the terrain, climate, etc;
- the characteristics of the load, ie physical features, weight, etc;
- the specification of the vehicle, ie engine, gearbox, axle configuration, body, etc.

The area of *economy is* concerned with the purchase price and operating costs of different choices of vehicle. There are a number of points that should be taken into account. These should be analysed and compared with the costs and performance of the various alternative vehicles. The main points concerning economy are:

- the fixed cost of a vehicle, ie depreciation, licences, insurance, etc;
- the variable cost of a vehicle, ie fuel, tyres, maintenance, etc;
- the residual value of a vehicle (some types of uncommon vehicle do not have good resale values);
- the whole life costs of the vehicle, ie a calculation of the above cost over a given life of the vehicle;
- utilization factors, ie fuel efficiency, other costs per mile/kilometre, etc;
- vehicle acquisition, ie outright purchase, contract hire, lease, etc.

The third and final area for consideration in vehicle selection is that of *legality*. This emphasizes the need to ensure that vehicles are selected and operated within the existing transport legislation. Transport law is complicated and ever-changing, so constant awareness is imperative. The major factors concern:

- operator's licences;
- construction and use regulations;
- weights and dimensions of vehicles;
- health and safety features, ie seatbelts, handrails, walkways, etc;
- mandatory environmental features, ie airbrake silencers, emission controls, etc.

In this and the following two chapters, these various aspects are considered in some detail. This chapter is concerned with those aspects of vehicle selection that relate to the physical effectiveness of the vehicle for the particular job in hand.

MAIN VEHICLE TYPES

There is a variety of vehicle types. It is important to be clear as to the precise definition of each type, because these definitions are typically used throughout the transport legislation laid down by different governments. The main types described in this section reflect UK government definitions and are therefore provided as examples.

The *motor vehicle* is a mechanically propelled vehicle intended for use on roads. Mechanical propulsion covers all those methods that exclude the use of human or animal power. If a vehicle is driven by petrol or diesel, by gas turbine, by electric battery or by steam generation, it is classified as a motor vehicle.

A goods vehicle is a motor vehicle or trailer that is constructed to carry freight. The term covers all such vehicles, but there are also distinct definitions that relate to the different weights of goods vehicles.

A trailer is a goods vehicle that is drawn by a motor vehicle. There are two main types of trailer: 1) a draw-bar trailer that has at least four wheels and actually supports its load of its own accord; and 2) a semi-trailer, which is a trailer that forms part of an articulated vehicle. This trailer does not support the load on its wheels, but only when it is standing with the use of legs or jacks at one end.

As previously indicated, an *articulated vehicle is* a combination of motive unit (tractor) and semi-trailer (see Figure 23.1). Thus, the trailer carries the load and the motive unit pulls the trailer.

Figure 23.1 Articulated vehicle made up of a tractor and semi-trailer (courtesy of Daf Trucks)

A rigid vehicle is a goods vehicle where the motor unit and the carrying unit are constructed as a single vehicle (see Figure 23.2).

A small goods vehicle is a goods vehicle where the permissible maximum weight does not exceed 3.5 tonnes. This weight includes the load and also any additional

Figure 23.2 24-tonne rigid vehicle (courtesy of Daf Trucks)

trailer that may be pulled. *A medium goods vehicle is* one where the permissible maximum weight, including any trailer, exceeds 3.5 tonnes but does not exceed 7.5 tonnes. *A heavy goods vehicle is* a goods vehicle where the permissible maximum weight, again including any trailer, exceeds 7.5 tonnes. The term 'heavy goods vehicle' (HGV) is still in common parlance. However, since 1 April 1991 the term has been replaced by 'large goods vehicle' (LGV) for legal purposes when referring to driver licensing categories.

There are two main reasons why these definitions have been outlined so carefully. The first is to provide a clear definition of the main types of vehicle available. The second was mentioned earlier. It is to differentiate between vehicle types for the purpose of interpreting some of the legal requirements for transport. There are two major vehicle classifications used for UK transport legislation. First, a company must hold a special licence (an operator's licence) if it wants to use any vehicle that exceeds 3.5 tonnes gross weight. Thus, small goods vehicles are exempt from this requirement. Second, a driver who wants to drive a large goods vehicle must hold a special licence (an LGV licence). This licence is required for the drivers of all vehicles exceeding 7.5 tonnes gross vehicle weight (GVW). It should be noted that from 1 January 1997 new car drivers no longer have the entitlement to drive vehicles that exceed 3.5 tonnes but do not exceed 7.5 tonnes. Drivers of such vehicles require a C1 licence in the UK.

TYPES OF OPERATION

Goods vehicles are required to undertake a wide variety of jobs. For each of these different jobs, it is important that the most appropriate type of vehicle is chosen. Some jobs or operations may require a vehicle with a powerful engine; others may necessitate a good clutch and gearbox because of high usage. Consideration must therefore be given to the work that the vehicle will be doing for the majority of its working life, and also to the conditions within which it must operate. The most important classifications are described below.

Vehicles that are required to travel long distances tend to be involved in trunking (line-haul) operations. A trunking (line-haul) operation is one where the vehicles are delivering full loads from one supply point (eg a factory) to one delivery point (eg a warehouse or distribution depot). Such long-distance journeys tend to include a large amount of motorway travel; thus the vehicle is often involved in carrying heavy loads at maximum permissible speeds. Further to this the vehicle may be used throughout a 24-hour, seven-day duty cycle. Clearly, for this duty cycle a very high specification is required if service failures are to be avoided. Professional operators usually deploy their newest vehicles on this duty cycle early in the vehicles' life before 'retiring' them to less critical work. These vehicles are often large articulated or draw-bar combinations, given that the loads are often full loads moving from point to point and maximum loads bring the best vehicle economy.

In places like North America, Australia and the United Arab Emirates it is not unusual to see articulated vehicles with more than one trailer. Where there are two semi-trailers and one motive unit this is called *a double bottomed articulated vehicle* or road train. Especially in Australia, road trains may consist of more than two trailers. In the UK, serious consideration is being given to their use on motorways.

Increasingly for loads with a low weight but a high volume, draw-bar combinations are favoured, as they provide a higher cubic capacity for loading within the legal limits (see Figure 23.3). Articulated semi-trailers with two decks may also be used for loads that fall somewhere between the two extremes in terms of weight and volume (see Figure 23.4).

Vehicles involved in middle-distance runs (ie 100–200 miles/150-300 kilometres per day) are probably delivery vehicles making one or two drops per day from a

Figure 23.3 A high cubic capacity draw-bar combination (courtesy of Daf Trucks)

depot to large customers. Typical journeys might involve a mixture of motorway and major and minor roads. The specification of vehicles on this duty cycle must also be reasonably high to avoid in-service breakdowns.

There are a number of duty cycles that require trucks to travel relatively short distances in a day. The main example is local delivery work or what is often known as van deliveries. A vehicle involved in this duty cycle will probably be making a large number of deliveries in the day and so may be covering only 40-100 miles/60-150 kilometres. Indeed, in some city centre areas the mileage may on occasion be even less. This type of operation tends to be concentrated in urban or city centres, although some of the delivery areas do involve rural settings.

Amongst the additional problems that this type of operation encounters are the many constraints on vehicle size. Because of the problems of narrow streets, congestion, bans on large trucks, and limitations on access at some delivery points, it is possible to use only smaller vehicles. The size constraints, the relatively short distances and the 'stop and start' nature of urban driving are the main factors that influence vehicle choice for this duty cycle.

Figure 23.4 An articulated vehicle featuring a double-deck trailer (courtesy of Daf Trucks)

As a consequence, the main vehicle type used is a rigid one with good gearbox and clutch mechanisms. Increasingly, more operators are using urban artic combinations for this duty cycle because they offer a higher payload potential with the bonus of being more manoeuvrable than certain rigid vehicles. They also reduce the likelihood of overloading the front axles in a diminishing load situation, ie where goods are progressively unloaded from the rear without the load being redistributed, which has the potential for overloading the front axle of a rigid vehicle.

Combination running concerns operations that constitute a mixture of features. A typical example is that of the urban delivery vehicle working out of a regional depot. Such an operation might involve a vehicle making a medium-distance run to a given town or urban area and then making six or seven deliveries in that area.

There is a need to balance the requirements of distance running and local delivery, so a vehicle must have strong engine power, together with a chassis that does not violate any delivery size constraints. A small articulated vehicle, or 'urban artic', may be the most appropriate in this instance.

Multiple deliveries are made by vehicles where the distribution operations are concerned with the handling and delivery of many different types and sizes of commodities and packaging. They are sometimes known as *composite delivery operations*. Typical examples are haulage contractors or third-party operators that run their businesses by handling and moving other companies' produce. Thus, they may get a wide variety of loads and may have to run short and long distances as well as making single or multi-deliveries. In this case, it is difficult to suggest any one type of vehicle that is the most appropriate. It is necessary to take account of all the different jobs undertaken and then select multi-purpose vehicles that can best cover them all, or provide for a mixed fleet of vehicles.

Quarry, mining and construction work is included as one of the main types of operation because there is a very high movement of sand, gravel, mineral ores, rubbish, etc to and from construction sites or other facilities. Vehicles that undertake this duty cycle are usually only travelling short distances, but the conditions in which they work are amongst the worst of all the different types of operation. Many operators choose an eight-wheeled rigid vehicle for this type of work (see Figure 23.5).

Figure 23.5 An eight-wheeled rigid tipper vehicle (courtesy of Daf Trucks)

International operations also present some particular problems that need to be taken into account. It is likely that all types of terrain may be encountered - flat, hilly and mountainous. Distances will clearly be very long. In addition, it is important to minimize the likelihood of breakdowns occurring in remote areas where it may be very expensive to complete repairs.

Vehicles undertaking international operations need to be very powerful and very reliable. Such vehicles tend to represent the expensive end of the goods vehicle market. With the relaxation of trade and political barriers in Europe, North America and other continents it is likely that this category of operation will become significantly more important.

As we have seen when vehicles are being selected, many factors need to be taken into consideration before any choices are made. Prior to selecting a specific type of vehicle, it is worth making a checklist of the requirements the operation demands. The following list is not exhaustive but does serve to illustrate the potential complexity involved:

- *Product characteristics:*
  - size;
  - weight;
  - unitization;
  - susceptibility to damage;
  - hazardous;
  - frozen;
  - liquid;
  - powder;
  - hygiene requirements (food);
  - live animals.
- *Method of loading or delivery:*
  - by fork-lift truck;
  - by manual handling;
  - by overhead gantry (height limitations);
  - by straddle carrier (containers);
  - from the side, rear, front, top or bottom (oil tankers).
- *Restrictions at the point of delivery or loading:*
  - narrow roads;
  - low bridges;
  - weight restrictions;
  - night-time restrictions because of noise;
  - lack of material handling equipment;
  - low or limited building access.

- *Terrain to be covered:*
  - motorways;
  - urban roads;
  - low-quality rural roads, lanes or graded roads;
  - mountainous;
  - flat geography;
  - extremes of temperature: extreme heat or cold.
- *Fuel type:*
  - diesel;
  - petrol;
  - LPG;
  - natural gas (CNG or LNG).
- *Vehicle configuration:*
  - articulated tractor and trailer;
  - two-, three- or four-axle rigid vehicle;
  - draw-bar combination;
  - small goods vehicle.
- *Body types:*
  - curtain-sided;
  - platform;
  - skeletal suitable for carrying containers, demountable bodies or swap-bodies;
  - van bodies;
  - tankers;
  - tipping body;
  - Road-Railers suitable for transfer to rail wagons;
  - bulk carriers.
- *Legal requirements:*
  - gross vehicle weight limits;
  - vehicle dimensions;
  - mandatory equipment;
  - vehicle licences;
  - insurances.
- *Vehicle economy:*
  - fuel consumption;
  - tyre wear;
  - whole life costs;
  - residual values; ease of maintenance.

- *Drivers' cab types:*
  - sleeper;
  - day cab;
  - crew carrier.
- *Ancillary equipment required:*
  - self-loading cranes;
  - blower units;
  - refrigeration units;
  - fork-lifts carried with the vehicle;
  - tail-lifts;
  - fire extinguishers.
- *Vehicle security:* locks;
  - alarms;
  - sealing devices;
  - tracking devices using satellites, GSM or GPS.

This list may appear to be lengthy, but it is by no means exhaustive. These days, vehicle manufacturers are able to use computing power to aid the decision-making process. They can feed the details of vehicle dimensions, weights and terrain into computerized models, which then produce anticipated performance figures for the proposed vehicle. These might include the ability of the vehicle to turn in a given area, potential fuel economy for different-sized engines and driveline combinations and potential axle loading under different load situations.

LOAD TYPES AND CHARACTERISTICS

The particular load to be carried is another vital factor when choosing a vehicle. Once again, it is essential to consider the alternatives with the prime objective of selecting the best chassis and the best body suitable for the load. The principal load features are described below.

Light loads are those loads that consist of lightweight commodities that are extremely bulky. There are a large number of examples from the different industries. Some of these are:

- breakfast cereals;
- tissues;
- polystyrene products.

The important point is that light loads such as these are high space users of vehicles in relation to the weight of the goods being carried. This is known as having a 'high cube factor'. The consequence is that, although a vehicle may have high cubic capacity utilization, it will have very low weight utilization (ie it is not carrying as much weight as it could).

Where a light load is carried, the consequent low weight means that the motive unit of the vehicle does not have to be a particularly powerful one. It is important not to over-specify vehicle requirements, as the use of high-quality, powerful equipment is very expensive.

Two additional points concerning the selection of vehicles for light loads are, firstly, that it is often possible to operate by using a large rigid vehicle coupled with a draw-bar trailer (see Figure 23.3) and, secondly, that a double-decked semi-trailer could be used (see Figure 23.4). This increases the volume capability.

Very *heavy loads* pose problems for vehicle choice because of the gross vehicle weight restrictions on roads and also because of axle weight restrictions. In the UK, vehicles specifically designed to carry loads heavier than the maximum permissible gross weight are covered by the Special Types General Order (STGO) and fall into three categories, with a maximum of 150 tonnes permissible. Some loads are even likely to require special vehicle construction, although special low-loader vehicles are available (see Figure 23.6).

Not all heavy loads are necessarily abnormal loads. For example, machinery that has a total weight within the legal limit can be carried on a standard trailer providing the weight is adequately spread over the axles.

The problem of *mixed loads* – where quite heavy products are mixed on the same vehicle as quite light ones – would not appear to indicate the likelihood of any constraining factors. The indication is that the mixture of light and heavy products would result in a balanced load where the total weight and the total cubic capacity are both about right for the vehicle, and this is indeed often true.

The problem that can occur, however, arises when a vehicle has to make a number of deliveries on a journey. What can happen is that the removal of parts of the load can change the spread of weight over the vehicle and thus over the individual axle weights. These changes can mean that the vehicle suddenly has an illegally high weight on one of its axles – this is often referred to as 'the diminishing load scenario'.

This effect can occur on any delivery vehicle. When there is a mixed load of light and heavy goods, it can be much worse because of the variable spread of the load within the vehicle. Where this effect is likely to be a problem, it is important to select the most appropriate vehicle chassis and body from the outset, so that the problem can be overcome. A simple solution may be to equip the vehicle with a manual pump-up truck to assist the driver in quickly redistributing the load.

Figure 23.6 STGO heavy haulage vehicle (courtesy of Daf Trucks)

All *valuable loads* represent some sort of security risk. Vehicle selection must, therefore, take this into account. There may be a need for a special chassis or body construction. It should be appreciated that valuable loads are not just the more obvious ones such as money or jewellery. Many consumer products, when made up into a large vehicle consignment, represent a very high value. Examples include wine and spirits, electrical goods, clothing, etc. Thus, it is very often important to select vehicles that can be easily but securely locked during the course of daily delivery work. There are many anti-theft devices available on the market, including satellite tracking, intruder alarms and immobilizers. Drivers need to be trained to deal with various situations where criminal activities may be a problem (see Chapter 31).

Liquids and powders in bulk have to be carried by road tankers that are specially constructed (see Figure 23.7). They are subject to the construction and use regulations. They may also be subject to other specific regulations such as Pressure Systems Regulations or ADR. These regulations are related to the type of commodity that is to be carried. It is also important in vehicle selection to ensure that the correct input and output mechanisms are provided. For example, some products may be handled by gravity alone, whilst others require a variety of loading and discharging

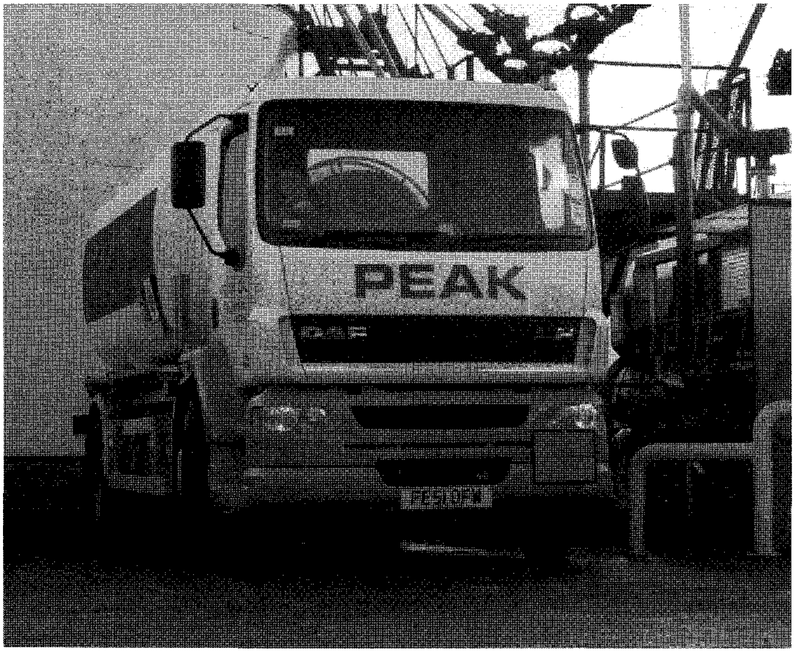


Figure 23.7 A four-wheeled rigid tanker (courtesy of Daf Trucks)

mechanisms for pumping products on to and off the vehicle. These mechanisms can create a lot of noise, so consideration needs to be given to noise attenuation and ear defence for the drivers.

The bulk movement of *hazardous goods* by road is often carried out by road tanker, so the particular considerations for liquids and powders mentioned above apply automatically. In addition, the fact that hazardous substances are of a high risk means that care must be taken to select the correct material or lining for the tanker so as to avoid any potential chemical reaction. Another point to note is that special fitments may be necessary to prevent electrical flashes from the vehicle's engine from igniting flammable goods. Some vehicles also need to be equipped with earthing points to neutralize the adverse effects of static electricity.

MAIN TYPES OF VEHICLE BODY

Decisions regarding the selection of the most suitable body type for a vehicle should be based on both the operating and the load requirements. Various body types have particular advantages and disadvantages according to the work to be

Figure 23.8 An articulated combination featuring a box trailer, which in this case is refrigerated (courtesy of Daf Trucks)

undertaken and the products to be carried. Nearly all of the different vehicle bodies considered below may be fitted to either a rigid or an articulated vehicle.

A box is an enclosed body that normally has a sliding door at the rear, often known as a box van (see Figure 23.8). As an alternative, some box vans may be fitted with side doors instead of, or as well as, doors at the rear. One common feature is the hydraulic tail-lift. This enables the load to be moved from the bed height to the ground automatically by lowering the tail-lift.

Box vans are by far the most common body type for urban delivery vehicles, especially for those delivering consumer products, food and packaged items. Their advantage lies in the protection to be gained from all types of weather, and also from the reduced risk of pilferage, because they are enclosed and so can be made secure. Increasingly, curtain-sided bodies are being used because of the ability to gain side access to the load if required. Large box vans are also now in very common use for trunking (line-haul) operations. The reasons are similar to those given for urban delivery vehicles. This additional popular usage has come about because of the great increase in the use of the wooden pallet as a unit load, and the fact that box vans with reinforced floors can be readily loaded by fork trucks.

Figure 23.9 Platform or flat bed rigid vehicle with drop sides and rear - in this case fitted with its own crane to assist loading and unloading (courtesy of Daf Trucks)

The platform or flat bed is the traditional body type (see Figure 23.9). It consists merely of a wooden base above the skeletal chassis, with a possible range of heights. It is sometimes fitted with drop sides and rear to help secure the load. It is, of course, uncovered. It is still in common use for many raw materials and products that are unaffected by inclement weather. The majority of loads need to be roped and sheeted, a skilled but time-consuming occupation. It is for this reason that curtain-sided bodies are used more extensively in Europe than flat beds.

The road tanker is another very common vehicle. The tank body can be used to carry a variety of liquids and powders. The different requirements for loading and discharging tankers, and the problems of hazardous goods in terms of selecting the correct material or lining, were indicated previously in this chapter.

The tilt body is quite a recent innovation. The tilt is a curtain-sided vehicle that broadly consists of a fabric cover over a framework secured to the platform of a lorry. This fabric cover can be drawn together to cover the load completely and then fixed by lacing or strapping down the length of each side of the vehicle.

A cord may be fed through all of the securing buckles and sealed by customs officials.

In appearance, a tilt body is very much like a box van, although the sides of the tilt van are made of a combination of drop sides and flexible curtain fabric. The introduction of the tilt body was to eliminate the need for loads to be roped and sheeted and facilitate faster customs clearance under TIR regulations. If the tilt superstructure has to be stripped down to allow loading from above by crane, or even from the side, this can be very time-consuming as compared to the curtain-sided vehicle.

Curtain-sided bodies have become very popular in recent years. They are different from tilt bodies in that they have a rigid roof, and one movable curtain each side of the body (see Figure 23.10). This is a very flexible and effective vehicle body that eliminates roping and sheeting and the problems associated with stripping out tilt bodies.

'Tipper' is the description that applies to vehicles that have the capacity to tip loads directly. These can be open-topped bulk carriers or tankers. They are normally

Figure 23.10 Curtain-sided trailer giving ease of access to the load (courtesy of Daf Trucks)

worked hydraulically and are used to discharge a variety of bulk materials. Typical loads include grain, gravel, sand, cement and plastic pellets. They may be covered, depending on the particular characteristics of the product carried. The inherent dangers of tipping vehicles falling over are being overcome through the use of non-tipping tankers that use bottom discharge systems. These vehicles have the added advantage of being able to carry a higher payload.

As previously indicated, the low loader is used for the carriage of specifically large or heavy loads.

There are several other vehicle bodies used to carry certain types of product. These are basically self-explanatory, but in their construction they do reflect the special needs and requirements of the products concerned (see Figures 23.11 and 23.12). Typical examples are those bodies used for livestock, furniture, hanging garments, transportation of cars and refrigerated products.

The final vehicle body to be considered is also a fairly recent alternative. This is the demountable box van or body, which is used in a similar way to a standard container. The demountable body can be carried directly on the platform or flat bed of the vehicle or can be mounted on the skeletal chassis. In direct contrast to the

Figure 23.11 17-tonne rigid vehicle with maximum cube body for high-volume/low-density goods — in this case furniture (courtesy of Daf Trucks)

Figure 23.12 A car transporter (courtesy of Daf Trucks)

container, however, the body is removed by the use of jacks, which are positioned at each corner of the demountable body and then raised, allowing the vehicle to drive away.

There are a number of ways of removing the body. These may include screw-type jacks, power- or hand-operated hydraulic jacks, electrically operated portable jacks or power-operated lifting equipment fitted to the chassis of the vehicle. Demountable systems provide an increased flexibility to distribution operations by improving vehicle utilization and fleet economy.

The swap-body is a body used by intermodal operators. It combines the features of a tilt body but it is detachable like an ISO container. These swap-bodies conform to standard sizes and may be used by both rail wagons and road vehicles. See Chapter 22 on intermodal transport.

THE WIDER IMPLICATIONS OF VEHICLE SELECTION

There are several additional points that should be considered when choosing a vehicle. Some of these are clearly associated with those factors and features that have already been discussed; some reflect quite clearly the wider implications of vehicle selection, and others show how it is possible to use knowledge and experience to help in decision making. These associated factors can be summarized as follows.

Is there a proven model or make of vehicle that is known from experience will be good at the job in question? This knowledge may be obtained from looking at other depots and their fleets from within the same company, or it may be available from studying similar types of operation that are undertaken by other companies, or by reference to the trade press.

Also, it may be possible to assess the reliability of certain models and types of engine, etc by analysing the history of similar vehicles. Thus, various measures of performance can be produced and studied to give useful data on fuel economy, breakdowns, cost of maintenance, etc. Where information is not available from own-company records, it is still possible to use a variety of published data, which are available from the commercial press and other sources. Some companies now use fleet management computer packages to provide this type of historical information.

In selecting a vehicle, it is important to be aware of the need to undertake maintenance and repairs. If a depot has its own maintenance facilities or garage available then this is not a great problem. The likely problems can and do arise for companies that do not have their own facilities and discover that the nearest dealer or garage with appropriately trained mechanics for their make of truck is situated at a great distance from the depot itself. With the new levels of vehicle technology, it is becoming increasingly difficult for own maintenance facilities to justify the investment in the necessary equipment needed to maintain these modern vehicles. Manufacturers' geographical spread and level of support have major implications for vehicle selection.

One area that is difficult to cater for, but must nevertheless be borne in mind, is that of likely future transport legislation that might affect the choice of vehicle. There are a number of factors that may be of importance, such as the construction and use regulations, drivers' hours, maximum vehicle weights, environmental issues, new levels of vehicle technology, etc.

Another point concerns drivers. It should be remembered that it is drivers who have to work with the vehicles every day of their working lives. They will understand many of the particular operational problems involved with the work that they have to do, and they will undoubtedly have an opinion on the 'best' type of vehicle from their point of view. It makes good sense to listen to this viewpoint. At least, it is important to consider the safety and comfort of drivers at work.

The final factor for which allowance must be made is, in many ways, one of the most important. It has been emphasized that there is a need to balance a variety of operational and economic aspects to ensure that the truck is efficiently run. Another vital factor to take into account is that, as well as loading at the depot or warehouse and travelling legally on the roads, the vehicle also has to access the delivery points. Thus, the accessibility at the delivery interface is a very important consideration. It is essential to be able to provide a vehicle that is fit for purpose.

VEHICLE ACQUISITION

It has been shown that the process of vehicle selection is one that requires a good deal of thought and analysis to ensure that the most suitable vehicles are acquired. Having determined the vehicle requirements, the next task is to ascertain the most appropriate means of acquiring the vehicle. There are several options available – outright purchase, rental, lease or contract hire. Vehicles may also be acquired by outsourcing the whole operation to a third-party contractor. Indeed it is often when large numbers of vehicles need to be acquired and large amounts of capital have to be approved that outsourcing is considered.

The traditional means of vehicle acquisition is that of outright purchase. This gives the operator unqualified use and possession, together with the choice of when and how to dispose of the vehicle. Discounts for cash may well be available, and in the UK there are currently tax allowances for capital purchases. A major problem is likely to be the lack of capital available for purchases of this nature. Other ways of obtaining finance include bank overdrafts, bank loans, hire purchase and lease purchase. These have a clear cost associated with them and, although in the UK allowances may be set against tax, reductions in capital allowances have made other methods of acquisition more attractive. Investing capital in rapidly depreciating assets such as vehicles rather than in other investments with higher rates of return is a major concern for business managers. This has helped fuel the trend towards outsourcing transport operations to third-party providers.

The leasing of vehicles is a popular alternative. Here, operators do not actually own the vehicles. With fixed-term leasing, operators make regular payments over an agreed period and have full use of the vehicles. The payment covers the cost of borrowing the capital (to purchase the vehicle) and may cover maintenance if required. Finance leasing means that operators cover the full cost of the vehicle over the leasing period and so may be given the option of extending the period of use at a significantly lower lease cost. The main advantages of leasing are that the standing (fixed) cost of vehicles is known and that the company does not use its own capital to purchase the vehicle; the disadvantage is that operators must keep the vehicles for a prescribed period in which time, for example, operational requirements may alter. In addition, accounting practice (SSAP 21) means that vehicles acquired on finance leases have to be shown in the balance sheet, so the rate of return on capital employed is reduced.

Owing to the changes in accounting practice previously mentioned, the contract hire of vehicles has become a much more attractive option. Contract hire arrangements can vary from the supply of the vehicle alone, through maintenance, insurance, drivers, etc to the provision of a complete distribution service. Thus, there has been a rapid growth in third-party distribution companies offering a variety of services. The financial advantages of contract hire include the release of capital and the easier, more predictable costing of operations.

Vehicles can also be acquired via rental agreements. The vehicle does not become the user's property, but can be operated as required. Agreements may include maintenance and driver. Costs are generally higher than for the other alternatives, but rental periods are often very short-term, allowing the user greater flexibility, particularly providing the means to accommodate temporary peaks of demand. Costs are predictable and can be treated as variable for specific jobs.

SUMMARY

It can be seen from the various sections in this chapter that there are a multitude of factors that need to be considered when selecting road freight vehicles. The alternative options have been briefly discussed under the main headings, as follows:

- main vehicle types;
- types of operation;
- a vehicle selection checklist;
- load types and characteristics;
- main types of vehicle body;
- wider implications of vehicle selection;
- acquiring vehicles through leases, contract hire, rental, outright purchase or outsourcing options.

A more detailed discussion on those aspects concerning vehicle costing and road transport legislation can be found in Chapters 24 and 25.

It is sensible not to treat the answers to the vehicle selection question as being hard-and-fast rules. They should be used as guidelines to be followed but not as strict rules. It must be remembered that companies, applications, operations and environments are all different in their own special ways, and all guidelines must be adapted to suit them accordingly. This is especially true in a global context.

24

Road freight transport: vehicle costing

INTRODUCTION

This chapter begins with a discussion of the reason why road vehicle costs need to be assessed separately from the costs found in most companies' financial accounts. The fundamental elements of road freight transport costing are reviewed, showing how these costs should be considered and what can be gained from this type of information.

The need to know the details of vehicle and fleet performance is emphasized, as is the importance of gaining this information in good time. The two main uses of these types of costing systems are identified as the monitoring and control of operations and the formulation of budgets.

The major costs are categorized as standing costs, running costs and overhead costs, and examples show how these costs are calculated. The concept of whole life costing is explained. Some simple comparisons of different vehicle costs demonstrate the relative importance of the different types of transport cost, and show how this cost relationship can vary according to the size of vehicle.

REASONS FOR ROAD FREIGHT TRANSPORT VEHICLE COSTING

At the end of every company's financial year, the company has to produce a financial statement that shows how well or how badly it has performed during that year. This is known as a profit and loss statement. This statement is useful in a broad context because it can show whether or not the company has performed satisfactorily. It may also be possible from this information to ascertain a good picture of the overall performance of the company's transport operation for that year, but it does not provide a detailed account of exactly where any profit or loss is made within the operation itself. In short, it fails to give sufficient details of each vehicle and its operation to enable good control of the transport fleet.

There is another problem. The final profit and loss statement is produced after the financial year has ended. Because of this, it is too late for management to make any effective changes to the transport operation if the results show that its performance is not acceptable. The statement, therefore, fails to provide its information in sufficient time for any useful changes to be made.

In summary, there are two main reasons why a special form of cost reporting is beneficial to a manager running a transport operation. These are: 1) the need to know the details of the vehicle and fleet performance in order to control the operations; and 2) the need to know in sufficient time to make any necessary changes. Outlined below is an example of how such a reporting system can be used for the monitoring and control of transport operations:

> A weekly system of reports for every vehicle in a fleet will show, amongst other things, the distance that the vehicle has travelled and how much money has been paid out for fuel for this vehicle. For several weeks, the fuel costs for this vehicle may be very similar week on week. In one week the fuel cost increases considerably. Is this important? What can be done about it?
>
> There are a number of reasons why this might have happened:
>
> - The cost of fuel might have increased.
> - The vehicle might have travelled more miles/kilometres in this week and so used more fuel.
> - The vehicle might not be performing properly, so its fuel consumption per mile/kilometre has increased.
> - Figures have been incorrectly recorded.

It is important to know the real reason. In our example, we can perhaps see the following:

- The cost of fuel has not changed.
- The vehicle distance has not altered — the vehicle has not run significantly more miles/kilometres than usual.
- A check shows that figures have been recorded correctly.
- Measuring the amount of fuel used against the mileage travelled (which gives the vehicle miles per gallon) shows that the vehicle is travelling fewer miles per gallon than in previous weeks.

It can be concluded that the reason for the increase in the money paid out for fuel is neither a rise in the cost of fuel nor an increase in miles travelled by the vehicle. It is because there is a fault with the vehicle or the driver's behaviour — it is not operating cost-effectively. With this knowledge, the necessary steps can be put in motion to remedy the problem.

This example shows how useful an efficient costing system can be. In particular, it illustrates three important aspects of a good costing system:

1. to know, very quickly, that something is wrong;
2. to be able to identify where the problem lies;
3. to be able to take some form of remedial action and solve the problem.

THE MAIN TYPES OF COSTING SYSTEM

It has already been indicated that a good costing system can provide the means to make effective use of and keep adequate control over transport resources. Another important use for costing systems concerns the need to ensure that customers are being charged a sufficient price to cover the cost of the transport provided. This is clearly important for third-party contract operations. This type of costing system allows for costs to be budgeted in order to be able to determine an adequate rate at which to charge for the use of vehicles. For own-account fleets, this will enable a company to determine an appropriate cost to add to the price of the product or order to ensure that all own transport costs are covered.

Two types or aspects of a costing system have been identified: 1) the recording of actual costs and performance in order to monitor and control the transport operation; and 2) the measuring of costs to identify the amount to allow to cover costs and to budget for a job. Both of these types of costing system require the same detailed collection of cost information. This information concerns the resources that are used in a transport operation. The types of transport resources that need to be considered can be classified as the '5 Ms'. They are:

- *manpower:* the drivers of the vehicles;
- *machinery:* the vehicles themselves;
- *materials:* associated resources, such as tyres, fuel, etc;
- *money:* the respective costs of the resources;
- *minutes:* the time when these resources are used for different purposes.

In order to be able to understand how costing systems can be used, it is helpful to be aware of common costing terminology in transport. The main categorizations are:

- *Cost unit — a* unit of quantity in which costs may be derived or expressed. Examples include:
  - cost per distance travelled (miles/kilometres run);
  - cost per tonne mile;
  - cost per carton delivered.
- *Cost centre —* a piece of equipment, location or person against which costs are charged. Examples include:
  - a vehicle;
  - a fleet of vehicles;
  - a driver;
  - a depot.
- *Direct cost — a* cost that is directly attributable to a cost centre. For example, if a vehicle is a cost centre, then direct costs would include:
  - fuel;
  - the vehicle road licence;
  - vehicle insurance.
- *Indirect costs —* the general costs that result from running a business. They are also referred to as overhead costs, administrative costs or establishment costs. These costs have to be absorbed or covered in the rates charged to the customer. Thus, they need to be spread equally amongst the vehicles in the fleet. Examples include:
  - office staff wages;
  - telephone charges;
  - advertising.

- *Fixed costs* — refer to the cost centre itself (ie the vehicle). These costs will not vary over a fairly long period of time (say, a year) and they are not affected by the activity of the vehicle, ie the distance the vehicle runs over this period. They are very often, in transport, referred to as standing costs. Examples include:
  - depreciation of the purchase cost of the vehicle;
  - vehicle excise duty;
  - vehicle insurance.
- *Variable cost* — the opposite of a fixed cost in that it varies with respect to the distance the vehicle travels. Thus, it varies according to the amount of work the vehicle undertakes. It is sometimes known as the running cost. Examples include:
  - fuel;
  - oil.

It should be noted that some cost factors can be defined as direct costs and then classified once again as either fixed or variable costs. In the examples above, fuel is both a direct cost (it is directly attributable to the vehicle as its cost centre) and a variable cost (the amount used varies according to the distance that the vehicle travels).

Transport costs are broken down into three main types, and each of these will be considered in detail in the remainder of this chapter. These types are:

- standing or fixed costs;
- running or variable costs;
- overhead costs.

VEHICLE STANDING COSTS

In this section, consideration is given to the different resources that are included as vehicle standing costs or fixed costs. Each of these resources must be paid for, regardless of the extent to which the vehicle is used. Thus, these resources are a cost that must be borne whether the vehicle is run for 5 or for 500 miles in any working week. Fixed costs, therefore, remain the same, independent of the level of activity.

The vehicle is an expensive piece of equipment that in most companies is expected to last from about five to eight years. The working life of a vehicle is dependent on the type of job that it has to do. A local delivery vehicle may carry relatively light loads and travel only 40,000 miles in a year. A long-distance primary (line-haul) vehicle may be pulling heavy loads and may be running for 80,000 miles a year or more.

Whatever the working life of the vehicle, it is necessary to take account of the original purchase cost over the period of its expected life. One reason for this is so that appropriate costs can be recovered for the service that the vehicle performs. Failure to do this might affect the ability to run a profitable operation.

The method of taking account of the original purchase cost of a vehicle is known as *depreciation*. This is a means of writing down annually a proportion of the original purchase cost of a vehicle over its expected lifetime. There are a number of different methods used for calculating depreciation, and their use depends on the particular policy of each individual company. The two main types are: 1) the straight-line method; and 2) the reducing balance method.

The *straight-line method of* depreciation is the simplest method of assessing the annual apportionment of the original purchase cost of a vehicle. It requires three figures:

1. the initial purchase cost of the vehicle (usually, but not always, less tyres, which are treated as a running cost);
2. the anticipated resale or residual value of the vehicle (ie the amount for which the vehicle might be sold at the end of its expected useful life);
3. the expected life of the vehicle in years.

The annual depreciation of the vehicle is then calculated by subtracting the resale value of the vehicle from its initial purchase price, and then dividing the result by the expected life of the vehicle.

Example:

	£
Purchase price of vehicle	50,000
Less cost of tyres	6,000
	44,000
Less anticipated resale value	5,500
	£38,
Expected vehicle life = 5 years	
Annual depreciation (£38,500 divided by 5 years)	£7,700

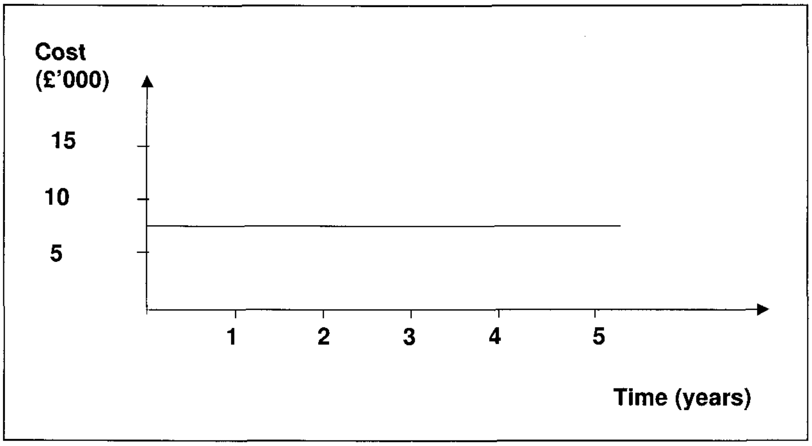


Figure 24.1 Depreciation — straight-line method

This is illustrated graphically in Figure 24.1.

The *reducing balance method is* slightly more complicated, but probably more realistic. The method assumes that depreciation is greater in the early years of a vehicle's life and becomes less severe in later years. This approach reflects the fact that assets lose a greater proportion of their value in their early years and also mirrors the fact that repairs associated with a vehicle's early life tend to be few and inexpensive, but tend to increase as the vehicle gets older.

The principle for the reducing balance method is to write down the vehicle to its expected resale value at the end of its life. This is calculated by reducing the value of the asset by an equal percentage each year. The same data requirements are needed as for the straight-line method.

Example:
£50,000 to be written down at 36 per cent per annum.

	£
Initial value:	50,
Year 1 @ 36%	18,
	000
Written-down value	32,
Year 2 @ 36%	11,
	520

Written-down value	20,480
Year 3 @ 36%	7,373
Written-down value	13,107
Year 4 @ 36%	4,718
Written-down value	8,389
Year 5 @ 36%	3,020
Resale value	£5,369

The relationship of the reducing balance method of depreciation with maintenance costs over time is shown in Figure 24.2.

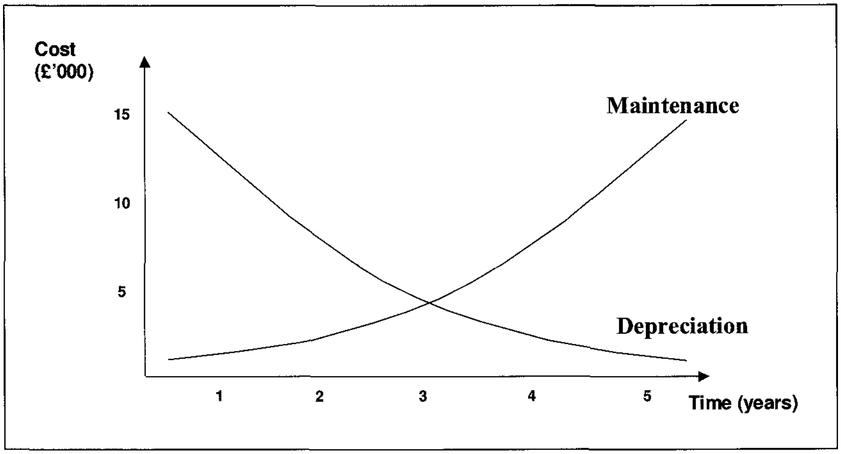


Figure 24.2 The reducing balance method of depreciation

There are four types of *tax and licences* that need to be costed against a vehicle. These are:

1. *Vehicle excise duty,* which is based on the 'revenue weight' of the vehicle or tractive unit (eg in the UK, the confirmed maximum weight, which for plated vehicles is the permissible gross or train weight shown on the DfT plate).
2. *The operator's licence* — an indirect cost for the whole fleet, plus a cost per vehicle. This is a legal requirement for a transport operator running a business in the UK.

3. *The driver's licence* required for individual drivers.
4. *Congestion charges*, as in London and other cities, as well as any toll charges for tunnels, bridges and roads.

The excise licence is by far the most costly of the four.

The cost of *vehicle insurance is* also a fixed or standing cost. The actual amounts can vary for a number of reasons, such as:

- the area or region of operation;
- the number of vehicles in the fleet (ie a discount might be available for a large fleet);
- the type of loads carried;
- the value of the products carried;
- the accident history;
- the driver's age;
- the excess paid by the customer (eg the first £500 on each incident).

The sources for these costs are from company records or directly from an insurance broker.

Most companies treat *drivers' basic wages* as a fixed cost because they are payable regardless of whether or not a driver is actually 'on the road'. In addition to basic wages, allowances must be made for National Insurance contributions, holiday pay, overnight subsistence and pensions. Although basic wages are treated as a fixed cost, any additions, such as incentive bonuses and overtime, are classified as a running (or variable) cost, because they vary in relation to the amount of work that is done. Wages and other related costs can be found from payroll records.

An allowance for *interest on capital is* frequently omitted from cost calculations, being included, in the main, when assessing the overall performance of the company. It is an allowance that indicates one of two possibilities: 1) the cost of borrowing money (that is, the interest repayable on a loan used to purchase a vehicle); or 2) the opportunity cost of forgoing interest on a company's own capital (that is, the interest that is lost because the money is used by the company to purchase a vehicle and therefore cannot be invested elsewhere).

Because each individual vehicle is treated as a cost centre, the 'interest' can be included as a standing cost. This cost should be related to the current official interest rate or the rate at which the company can borrow money.

Vehicle standing costs are summarized in Figure 24.3.

Fixed costs do not change with the level of activity. They accrue on a time basis rather than with activity level. 'The costs incurred in having a vehicle standing ready and available for work in the depot yard.'

Fixed costs include:

- **licences: driver's licence; vehicle excise duty; operator's licence**
- **vehicle insurance**
- **driver's costs: wages; National Insurance contributions; pensions; holiday pay; etc**
- **vehicle depreciation**
- **notional interest**

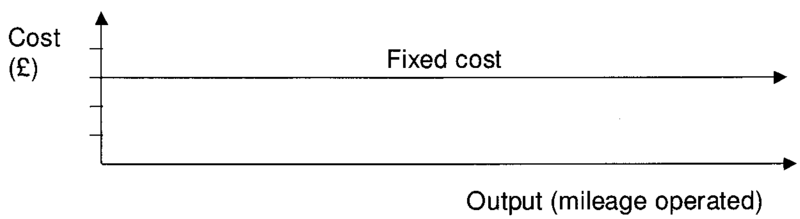


Figure 24.3 Vehicle standing (fixed) costs

VEHICLE RUNNING COSTS

This section concentrates on the second major category of transport costs — vehicle running or variable costs. A variable cost is said to vary in relation to the activity of the particular object with which it is concerned. The cost centre in this instance is the vehicle. The activity of the vehicle is the amount that it is used, which is the same as the distance that it travels. Thus, we can see that the running cost is directly related to, and can be measured by, the distance covered by the vehicle.

Vehicle standing costs were defined as the fixed costs that had to be accounted for before a vehicle could be used 'on the road'. Vehicle running costs are the virtual opposite, being the costs that are incurred as a result of the vehicle being used. The major classifications of vehicle running costs are discussed below.

The cost of *fuel* is normally the largest of all the variable or running costs. There are two reasons why fuel is a particularly significant cost: 1) because of the high fuel consumption of commercial vehicles (ie low miles/kilometres per litre); and 2) because of the constant rise in energy costs due to periodic shortages and heavy taxation. Because the cost of fuel is such a significant portion of running costs, it is important that its usage is regularly monitored. Excess use of fuel can be the result of a number of factors, such as:

- fuel leaks;
- a worn engine;
- poor vehicle maintenance, ie binding brakes;
- under-inflated tyres;
- poor aerodynamics;
- bad driving;
- theft.

Running costs are related to an activity (ie the distance, in miles or kilometres, that a vehicle travels), so they are generally measured in pence per mile or pence per kilometre.

Example:
Price of diesel = 95 pence per litre
Vehicle's average number of miles per litre = 2 miles per litre
Cost of fuel, in pence per mile: 95/2 = 47.5 pence per mile

The use of engine *oil and lubricants is* a very small variable cost. It is important to be able to measure usage, however, because high consumption may be a pointer to some mechanical problem. The costs of oil should also be measured in pence per mile (eg 0.5 pence per mile).

Tyres are classified as a running cost because tyre usage is directly linked to the distance the vehicle travels. Tyre usage is recorded as a variable cost in pence per mile as follows:

Example: Six-wheeled vehicle

Cost of tyres	£300 each
Estimated tyre life	40,000 miles each
Total cost of tyres (6 x £300)	£1,800

Tyre cost per mile

£1,800 x 100

40,000 miles = 4.5 pence per mile

Repairs and maintenance costs (including spare parts) tend to be the second-highest of the variable costs and are again related to distance because vehicles are (or should be) regularly maintained after a given number of miles (eg every 6,000 miles). There are three principal factors that make up these costs. They are:

1. labour (fitters, mechanics, supervisors, etc);
2. spare parts; and
3. workshop or garage.

Records should be kept for each vehicle in respect of the work that is done. This is a legal requirement. Other information sources include mechanics' time sheets, suppliers' invoices, parts requisitions, etc. Costs are again in pence per mile/kilometre. Many companies now outsource their repair and maintenance operations to third-party transport companies that specialize in vehicle maintenance.

As indicated in the section concerning standing costs, some of the costs associated with drivers are treated as variable or running costs. These are drivers' *overtime*, *bonus* and *subsistence* costs.

Vehicle running costs are summarized in Figure 24.4.

OVERHEAD COSTS

The two cost elements considered in the previous sections, vehicle standing costs and vehicle running costs, could both be classified as direct costs that relate directly to an individual vehicle. Vehicle overhead costs are indirect costs because they do not relate directly to an individual vehicle but are costs that are borne by the whole fleet of vehicles. There are fleet overheads and business overheads.

Fleet overhead costs consist of the costs of all the 'back-up' or 'reserve' equipment and labour required to run an efficient fleet of vehicles. As such, they cannot be costed directly to a particular vehicle. The main resources are spare tractors and trailers, hired equipment and agency drivers. These are over and above what are called the 'on-the-road' requirements. The spare equipment is necessary to cover for the other vehicles as they are repaired or maintained, or if there is a breakdown. The agency drivers are necessary to cover for holidays and sickness during the

Variable costs vary with the level of activity or output. When there is no output there are no variable costs.

Variable costs include:

- **fuel**
- **oil and lubricants**
- **tyre wear**
- **drivers' overtime, subsistence and other expenses**
- **repairs and maintenance**

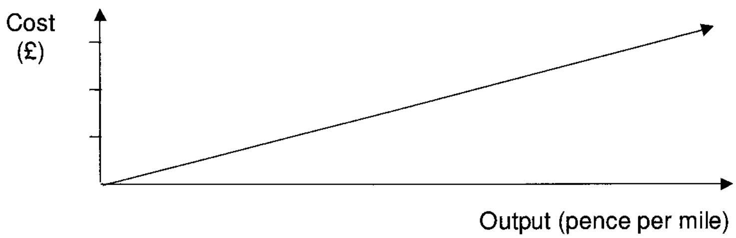


Figure 24.4 Vehicle running (variable) costs

year. These 'spares' are apportioned by taking the total cost over a period (eg a year) and then dividing by the number of vehicles in the fleet.

Business overheads can be subdivided into transport department and company administrative overheads. Transport department overheads consist of the charges and costs that are clearly concerned with the transport department but cannot be directly related to any one vehicle (eg salaries and wages for managers and vehicle schedulers, cars and expenses, telephone, fax, rent and rates, and training). Company administrative overheads are those costs that are central to the running of a business and that have to be apportioned between all the different company departments. They include, for example, directors' fees, legal fees, bad debts and bank charges.

COSTING THE TOTAL TRANSPORT OPERATION

This section draws all the previous information together, so that it is possible to determine how to cost the total transport operation. The first step that must be taken is to estimate the likely vehicle utilization. This is essential so that vehicle costs can be divided according to the activity of the vehicle. The estimate should be based on the history of vehicle usage and on any likely increase or decrease in this usage that might be foreseen.

There are two areas of utilization that need to be determined. These are for days worked in the year and distance driven per year. Days worked can provide the basis for covering vehicle standing cost, and distance travelled can be used for assessing vehicle running cost. History will indicate what the figures might be.

Example:
Number of working days per year, eg
52 weeks x 5 days = 260 days/year
Estimated annual mileage = 80,000 miles

It is possible to determine the costs for the three main cost elements, as the following calculations illustrate:

Standing cost
Annual standing cost = £9,000

Therefore, $\frac{\text{£9,000}}{\text{260 days}}$ = £34.62 per day

or $\frac{\text{£9,000}}{\text{80,000 miles}}$ = 11.25 pence per mile

So the standing cost can be expressed on a daily basis or on an average mileage basis.

Running cost

Pence per mile	
Fuel	20.0
Oil and lubricants	0.5
Tyres	4.0
Repairs and maintenance	6.0
Total	30.5

Running costs should be calculated on a mileage basis.

Overhead cost

Apportioned vehicle overhead = £1,200

Therefore, £1,200

= £4.62 per day

or $\frac{\text{£}1{,}200}{80{,}000 \text{ miles}} = 1.5 \text{ pence per mile}$

As with the standing cost, the vehicle overhead cost can be expressed on a daily basis or an average mileage basis. With this breakdown of costs, it is possible to derive in detail the costs of different elements of the delivery operation that is being undertaken. If this is achieved, accurate and realistic charges can then be made to customers to ensure that transport costs are adequately covered.

If vehicles are allocated as a whole to a particular operation, it is easy to identify the appropriate standing, running and overhead costs and to make the necessary charges or allowances.

Where vehicles are multi-user, and deliveries are made for a number of different customers, a further breakdown is required to reflect the extent of usage by the different customers. This is likely to be related to the number of cartons that are moved (or pallets, kilograms or cubic metres, depending on the measurement in use) and to the number of drops that are undertaken.

WHOLE LIFE COSTING

This approach to assessing the cost of owning and operating an asset has become accepted as a particularly good way of identifying the true cost of a vehicle. It is especially useful when trying to compare quotations from different companies. In this section, whole life costing is considered in the context of commercial vehicle acquisition and operation.

The idea is to include in the analysis all the cost elements that are involved in a vehicle's life or at least that part of its life when it is owned by a particular organization. The major cost elements are:

the initial purchase price of the vehicle
plus
the total operating costs incurred by that vehicle during its life, ie maintenance, tyres and fuel
less
the achieved/guaranteed residual value of the vehicle

One obvious problem is that some of these figures will not be available until after the vehicle has been sold. This is true where companies purchase their vehicles outright and then manage them throughout their life until disposal. If these same companies change their vehicles every three years, whole life costing provides them with a valuable way of comparing not only how different makes of truck perform but also how different configurations of engine and drive-train perform. This can be invaluable when the time comes to make decisions about replacement vehicles. Armed with information such as fuel consumption and cost over a given distance, cost of repair and maintenance and the value placed on this type of vehicle by the second-hand market, a transport manager can make discerning judgements about which trucks best suit the operation.

Before the adoption of whole life costing, decisions about truck purchase tended to concentrate solely on the initial purchase price of the vehicle. By looking at the costs incurred throughout the life of the vehicle it may emerge that it is better to pay a higher purchase price for the vehicle at the outset, as the achieved economies in operating costs more than compensate for the initial extra outlay.

In recent years, manufacturers have started offering whole life packages to commercial vehicle operators. This involves a purchase price, a cost for maintenance over a given mileage and a guaranteed residual value in the form of a buy-back price. Therefore it becomes possible for a potential purchaser to make a whole life comparison between manufacturers' offerings before the choice is made. Of course, this will not include the performance on fuel consumption.

Information about achieved fuel performance may be obtained from the trade press, which often conducts vehicle road tests and publishes the results. Another good way of gaining a view about fuel economy is to ask the manufacturer for a demonstration vehicle that can be tested on the company's operations for a couple of weeks. This will provide useful practical information to aid decision making.

When making comparisons between different manufacturers' quotations, a further sophistication may be introduced. This is to create a discounted cash flow (DCF) for each of the quotes. This is especially useful when pence-per-mile figures are quoted over different total distances, purchase prices are different and residual values are also different. Unless systematically laid out in a DCF, it becomes very confusing to try to gain a true picture of which offering is the best. The discount factor is applied to each successive year's figures in order to represent the decline in the real value of money over time. By calculating a net present value (NPV) for each quotation, comparison becomes much easier. It is not absolutely essential that a discount factor is used because when the costs are laid out in this way a straightforward addition will allow the quotes to be ranked in order of best value. The advantage of the NPV is that it provides a more accurate picture of the whole life cost of each quotation in today's money.

Table 24.1 demonstrates what a practical example will look like. The vehicles being purchased are 6x2 articulated tractive units, which will be operated on a 24-hour basis at maximum gross vehicle weight. The life of the vehicles will be four years at 120,000 miles per annum. The manufacturer offered maintenance either on the basis of a fixed price, which is described as inflation-proof, or on an annual review basis. In order to make allowance for this it has been assumed that an annual review would involve approximately a 3 per cent increase each year. It is worth noting that the guaranteed residual value is very generous because this manufacturer was attempting to increase its market share at the time. The resultant NPV appears to be better for the inflation-proof option but there is very little in it and the 3 per cent annual review figures are speculative. One very important aspect of this deal is that the guaranteed buy-back price is not only generous but it also insulates the operator from the vagaries of the second-hand truck market by transferring the risk to the manufacturer.

When five or six of these DCF calculations are placed side by side for comparison, it is a powerful way of judging which deal is the best.

Whole life costing is widely used these days, not only in the field of commercial vehicles but also in the field of company car fleet management, because it is such a reliable indicator of the true cost of ownership.

VEHICLE COST COMPARISONS

It is important to be aware of the relative importance of the different elements of vehicle costs. This can be illustrated by the consideration of a typical road freight vehicle, in this instance a 38-tonne GVW articulated tractor and trailer. Figure 24.5 demonstrates that the driver costs, at about 29 per cent, and the fuel costs, at about 25 per cent, are by far the most significant costs for such a vehicle averaging about 70,000 miles per year.

It is also important to be aware that these comparative relationships may well change according to the type and size of vehicle. In a second example, a comparison

Table 24.1 A practical example of whole life costing

Vehicle life is four years at 120,000 miles per annum

	Purchase Price of Vehicle	Inflation-proof Maintenance	Annual Review 3%	10% Discount Factor	Inflation-proof *Option* Result	Annual Review *Option* Result
	£	£	£	£	£	£
Year 0	68,362.00	0.00	0.00	0	68,362	68,362
Year 1		3,515.04	3,515.04	0.909	3,195	3,195
Year 2		3,515.04	3,620.49	0.826	2,903	2,991
Year 3		3,515.04	3,729.11	0.751	2,640	2,801
Year 4		3,515.04	3,840.98	0.683	2,401	2,623
					79,501	79,972
Less residual value	18,780.00			0.683	12,827	12,827
				NPV	£66,674	£67,145

<u>**Standing costs**</u>	**£pa**	**%**
Vehicle Excise Duty	3,100	4.1
Insurance	1,696	2.2
Depreciation – tractor	7,217	9.5
– trailer	1,683	2.2
subtotal	*13,696*	*18.0*
Driver	22,257	29.3

<u>**Running costs**</u>	**£pa**	**%**
Fuel	19,265	25.3
Tyres	2,168	2.9
Maintenance – tractor	4,739	6.2
– trailer	2,839	3.7
subtotal	*29,011*	*38.1*

Overheads – transport	5,550	
– business	5,550	
	11,100	14.6

	£pa	pence per mile
Total	76,064	108.7

Figure 24.5 A comparison of vehicle costs, emphasizing the difference in importance of some of the main road freight vehicle costs

Table 24.2 Typical operating cost breakdown, showing the relative cost difference for two different vehicle types

	Percentage Breakdown	
	7.5-tonne	**38-tonne**
Depreciation	15%	12%
Driver	40%	29%
Running (fuel, oil and tyres, and repairs and maintenance)	20%	38%
Licence/insurance and overheads	25%	20%

is made between a large articulated vehicle and a smaller 7.5-tonne vehicle. Here, the relative importance of the driver of the vehicle, in cost terms, is much higher for the smaller vehicle, whilst the running costs are much lower. This is shown in Table 24.2.

ZERO-BASED BUDGETS

In most companies, part of the annual cycle is the time in the year when the next year's operating budgets are prepared. Very often this is nothing more than an exercise by which last year's budgets are increased incrementally, usually by the rate of inflation. For most operations, this approach will produce a workable budget, but where questions about cost-effectiveness have been asked, then another approach may be required. One such approach is known as zero budgeting.

This form of analysis requires a return to first principles. It is almost as though the operation had never existed and is being planned for the first time, hence the name ' zero' or back to the starting point. Each element of the operating budget must be analysed line by line. For example, the cost of fuel will be calculated by examining the fuel consumption of the different types of vehicle in the fleet according to the manufacturers' technical figures, which will be divided into the annual mileages for this type of vehicle and finally multiplied by the cost of fuel, for example:

38-tonne GVW 4x2 tractor should achieve say 8.5 miles per gallon
There are six similar vehicles in this fleet
Their combined annual mileage is 480,000 miles
The current cost of fuel is say £2.50 per gallon
480,000 miles/8.5 miles per gallon = 56,471 gallons x £2.50 = £141,176 pa

This process will have to be repeated for all the different types of vehicle in the fleet to achieve the final budgetary figure. Unless the operation is already in excellent shape, the chances are that the figure arrived at will be less than the current cost of fuel used. This is because part of the process entails using the best possible achievable figures such as the manufacturers' fuel consumption figures or the best bunkered price for fuel.

The object of the exercise is, firstly, to have managers take a fresh look at their operations. Secondly, because the best possible figures are used to formulate the budget, it highlights areas for improvement. Perhaps the drivers are not achieving the best fuel consumption achievable and require training? Maybe more can be done to achieve a better price for the fuel used?

The exercise will cause managers to ask many uncomfortable questions about their area of responsibility. Some will find this so uncomfortable that they will simply attempt to replicate the current system by using their current fuel consumption figures and fuel purchase prices. This should be avoided, as the best results accrue from an honest line-by-line re-evaluation of the operating budget. If diligently undertaken, the resultant budget will be accompanied by a number of action points that will serve to improve overall operational cost-effectiveness.

SUMMARY

This chapter has considered the fundamental aspects of road freight transport costing — how these costs can be broken down and what use can be made of this type of information. The major costs have been categorized as standing costs, running costs and overhead costs, and examples have shown how these costs are made up.

Emphasis has been placed on the need to know the details of vehicle and fleet performance and the importance of gaining this information in good time. The two main uses of these types of costing systems have been identified as the monitoring and control of operations and the formulation of budgets.

The concepts of whole life costing and zero-based budgeting were explained.

Some simple comparisons of different vehicle costs have demonstrated the relative importance of the different types of transport cost and shown how this cost relationship can vary according to the size of the vehicle.

A more detailed discussion on the monitoring and control of logistics operations is given in Chapter 27. This identifies key indices for both costs (eg cost per mile) and performance (eg miles per drop or drops per journey) for road freight transport. It shows how they can be determined and used to help management ensure that the transport operation is run cost-effectively and that any changes in both cost and performance can be readily identified.

The advent of a number of specific fleet management and costing computer programs and packages has enabled costing to be undertaken much more easily and with much greater accuracy. These packages are outlined in Chapter 26, where road freight transport information systems for planning and control are described.

25

Road freight transport: legislation

INTRODUCTION

In many parts of the world national governments have recognized the need to regulate road transport activities. Driver licensing, weights and dimensions, drivers' hours of work, and the construction and use of vehicles are often covered by local laws. Depending on the quality of enforcement, legislation of this kind helps improve both the safety and the quality of road transport operations. However, these national or regional differences can cause problems. Variations in legislation may present real barriers to both international and domestic road freight movements. For example, both the United States of America and China suffer from internal differences in regulations from one area to another. A domestic interstate movement of cargo in the USA will have to be limited in overall vehicle weight to the lowest state weight restriction en route. In China the situation is much more complex, and serious barriers to domestic trucking activities are a fact of life. On the other hand the European Union (EU) has made significant progress in harmonizing regulations across its region. In turn the United Kingdom (UK) has harmonized its regulations in line with the EU. It is reasonable to argue that EU road transport legislation is amongst the most stringent and highly developed in the world. Therefore for this reason the UK regulations serve as a good example of how road transport legislation may be formulated.

The legislation covering road freight in the UK is both vast in scope and complicated in nature. This chapter could not possibly deal with this subject in any great depth and it must in no way be viewed as a legal work of reference. The approach will be to highlight certain key areas that are common to all types of operation. It is highly recommended that matters of specific detail are clarified through reference to publications such as Croner's *Road Transport Operation* or the FTA's annual publication *Road Transport Law*. It is also recommended that with regard to matters related to legal actions the opinion of professional legal advisers should be sought.

The method by which the UK government chose to regulate road transport was fundamentally changed by the Transport Act in 1968. This act established the principle of managing the quality of road transport operations rather than controlling market access, as was the case prior to this piece of legislation. The Act laid down certain key fundamentals that continue to form the basis of regulation to this day.

The UK's admission to the European Union in January 1973 introduced a further dimension to the legislation governing this area. Many EU directives and regulations are designed to harmonize the rules across the whole EU, and much UK road transport legislation is derived from or directly based on EU legislation. Some specialist areas of operation, such as the carriage of livestock and hazardous chemicals, are covered by EU rules.

OPERATOR LICENSING

Road transport operators - both 'own-account' and 'hire or reward' - who carry goods for commercial purposes on the public highway in the UK are required to hold an operator's licence. This licence may be one of the following:

- *Standard national*. This applies to the carriage of goods for hire or reward in the UK. Own-account operators may also apply for this type of licence, which will allow them to carry both their own goods and goods for hire or reward should they so choose.
- *Standard international*. This is the same as a standard national licence with the key difference being that it also authorizes the holder to operate internationally.
- *Restricted*. This licence is available only to own-account operators and covers these operations both in the UK and abroad. This licence has less stringent requirements than the two above. Own-account operators must only carry goods connected with their own trade or business.

The weight threshold for vehicles covered by operator licensing regulations is 3.5 tonnes maximum gross weight. However, there are certain categories of vehicles that are exempted from these regulations. Examples include agricultural tractors, police vehicles and tower wagons. Once a vehicle is specified on a licence, it will be issued with a windscreen disc. The disc will be either blue for standard, green for standard international or orange for a restricted licence. The disc will display both vehicle and operator details. It is possible to obtain an interim licence, in which case the disc issued will be yellow.

The criteria for obtaining an operator's licence cover the following areas:

- the operator's fitness to hold a licence;
- operating centres and their suitability;
- the organization and quality of vehicle maintenance arrangements and record keeping;
- adherence to drivers' hours and tachograph regulations;
- compliance with vehicle loading and speed restrictions;
- the financial resources of the undertaking;
- professional competence;
- good repute.

There are different criteria for financial standing depending on the type of licence being sought. The good repute and professional competence rules apply only to standard licences (national and international).

Operator licences are issued by traffic commissioners, and mainland Britain is divided into traffic areas. Currently different rules apply in Northern Ireland, but this is under review and may change in the future. An operator may hold only one licence in each traffic area.

There are various bodies that have a statutory right to object to any application for a licence; they include the police, some trade unions, trade associations and local authorities.

Once issued, a licence will run in perpetuity but will be formally reviewed every five years or when there is a major variation to the licence. There are rules governing variations to the licence such as a change in the number of vehicles, the operating centre or the professionally competent person.

Failure to adhere to the rules may result in the licence being revoked, suspended or curtailed. Traffic commissioners may decide to call operators before them to answer for their actions at a public inquiry. In extreme cases vehicles may be impounded by the authorities.

The practice of 'flagging out' vehicles by registering them in other EU member states in order to avoid UK vehicle excise and other duties was outlawed from the end of April 2001.

DRIVER LICENSING

An EU-style driver licence, now in the form of a photocard, will be issued to any person over the age of 17 who has passed the relevant driving test. This test comprises both a written and a practical test. This confers entitlement to drive motor vehicles up to a maximum authorized mass of no more than 3.5 tonnes and with no more than eight seats in addition to the driver's seat. This is a category B licence and essentially covers cars, light vans and small passenger-carrying vehicles.

Most existing ordinary licence holders will also have entitlement to drive medium-sized (not exceeding 7.5 tonnes maximum authorized mass – MAM) goods vehicles and, within certain limits, such vehicles towing trailers. These subcategories are known as Cl and C1+E.

Large goods vehicle (LGV) licences are divided into several further categories. It is important to note that any driver wishing to drive vehicles in these categories must first hold a category B licence and be at least 21 years old. Drivers have to pass the C category test before progressing to the C+E test. It is also possible to progress from B to Cl by passing a Cl test. Passing a Cl test allows the driver to drive vehicles of up to 7.5 tonnes MAM.

Large goods vehicle categories are as follows: category C – a rigid goods vehicle with a maximum authorized mass of more than 3.5 tonnes; and category C+E – an articulated goods vehicle or draw-bar vehicle combination. Essentially this category covers LGVs that tow trailers with a category C drawing vehicle.

Please note that the driver licensing rules are complex, with some differences in entitlement limited to the date when a licence was issued. Drivers' licences should always be visually inspected by management in order to verify their true entitlement, and regularly checked thereafter.

LGV licence entitlements will be valid after passing the appropriate test until the driver's 45th birthday or for five years, whichever is the longer. Thereafter renewal must be made every five years and be accompanied by a medical report. From the age of 65 the renewal process must be annual. The traffic commissioners retain some disciplinary powers relating to LGV entitlement.

DRIVERS' HOURS REGULATIONS

The European Union drivers' hours rules apply directly to drivers of most goods vehicles over 3.5 tonnes maximum gross weight undertaking journeys within the EU both domestically and internationally.

The rules apply to laden as well as unladen vehicles. The weight of any trailer drawn must be taken into account. There is a long list of exemptions to the drivers' hours rules, but these are often complex and professional advice should be sought prior to taking advantage of an exemption. Driving is deemed to be any period spent at the controls of a vehicle in motion or stationary with the engine running. Rest is deemed to be a period when drivers are free to do anything they choose other than work.

The basic rules are as follows:

- A tachograph must be used to record drivers' activities (see 'Tachographs' below).
- A week is defined as the period of time between 0000 hours on Monday and 2400 hours on Sunday.
- A day is any 24-hour period, beginning when the driver starts work after a rest period.
- A fortnight is any two successive fixed weeks.
- The daily driving limit is 9 hours. This may be extended to 10 hours twice a week.
- The weekly driving limit is not explicitly stated, but is 56 hours in practice. The rules set a limit of 90 hours in a fortnight.
- Breaks from driving must total 45 minutes at or before the end of 4.5 hours' accumulated or continuous driving unless a daily or weekly rest period is begun. This period can be split into breaks of at least 15 minutes. It is important to note that this rule has seen different interpretations over the last few years. If in doubt, professional advice should be sought.
- A daily rest period of 11 hours must be taken in every period of 24 hours commencing at the end of the last daily or weekly rest period. Three times a week this may be reduced to a minimum of 9 hours; however, any such reductions must be made up with equivalent compensating rest by the end of the following week. Separate reductions may be compensated for by one continuous period of rest of the appropriate length. These compensating periods of rest must be in addition to standard rest periods.
- Daily rest periods may be taken in a stationary vehicle equipped with a bunk.
- After a maximum of six daily driving periods, a weekly rest of 45 hours must be taken. This may be reduced to a minimum of 36 hours if taken at home or at the vehicle's base. If the vehicle is away from base, the weekly rest period may be further reduced to 24 hours. Any reductions must be fully compensated by the end of the third week following the week in which the reduction occurred. As with daily rest compensating periods, these must be additional to standard rest periods.

In some cases drivers exempt from the EU hours rules are covered by a limited set of rules known as the domestic hours rules.

THE ROAD TRANSPORT DIRECTIVE

In *addition* to the EU drivers' hours rules, mobile transport workers have their working hours regulated by the Road Transport Directive (RTD). This directive came into force in April 2005 amidst some controversy. It has had the practical effect of making the task of managing drivers' hours extremely complex. It is a development from the Horizontal Amending Directive, which came into force in August 2003. This directive extended the original Working Time Directive (1993) to cover all employed road transport staff, which includes office staff and drivers who were not covered by EU drivers' hours.

The key provisions of the RTD are:

- The working week is limited to an average of 48 hours (with a maximum of 60 hours in any week) over a reference period of four months. This may be extended to six months by agreement.
- Breaks must be a minimum of 30 minutes if working for 6 to 9 hours. When work exceeds 9 hours, a 45-minute break is required.
- Night work is defined as a 4-hour period between midnight and 0400. Night working is limited to 10 hours in any 24-hour period. There is an existing derogation that extends this to 12 hours. Night workers must be given free health assessments.
- Holidays will be a minimum of 20 days paid at an average rate of earnings for the previous 12 weeks including overtime.
- Self-employed workers are exempt from the regulations until 2009.

According to the UK Freight Transport Association, this new piece of legislation will reduce the productivity of the UK road transport industry by 9 per cent at a cost of £1 billion per annum. The companies that have to abide by this legislation have the daunting task of ensuring that their drivers comply with *both* the drivers' hours of work regulations and the RTD at the same time.

TACHOGRAPHS

Goods vehicles over 3.5 tonnes gross vehicle weight must be fitted with a tachograph. Exemptions do exist but the majority of goods vehicles will be required to have one fitted. These exemptions are identical to those regarding the EU hours rules. The tachograph must be used to record the driver's hours of driving, rest and other work.

Tachographs must also record distance travelled and vehicle speed. They must be properly maintained, calibrated and sealed at an approved tachograph centre. A two-yearly check is required, and they must be recalibrated every six years.

Employers are bound to provide drivers with sufficient charts (see Figure 25.1), and ensure that the charts are returned within 21 days of use and retained for one year. For their part drivers must fill out the charts correctly, use a different chart for each day worked and not tamper with the equipment. Employers must have an effective checking system to ensure that hours and tachograph rules are applied.

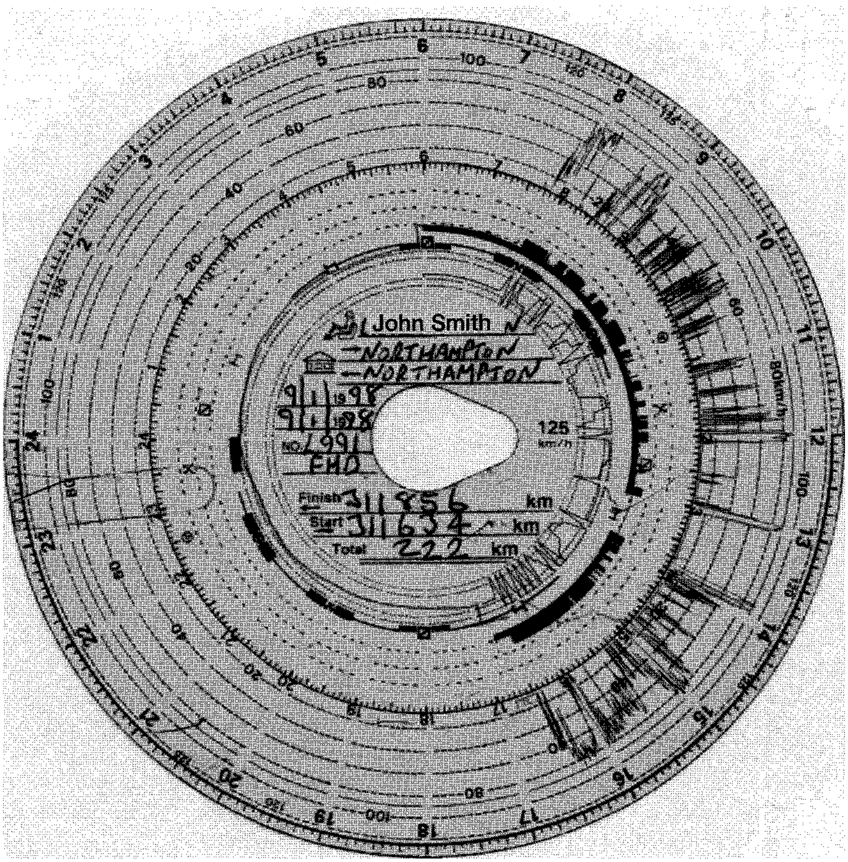


Figure 25.1 A tachograph chart

Tachographs provide a useful source of management information and can be used to achieve some of the following results:

- more economical driving habits, which will lead to improved fuel consumption and reduced maintenance costs;
- improved planning and routeing of vehicles, as real data on journey times and average speeds may be calculated;
- reduced vehicle accidents where drivers are aware that their driving performance and speed are being monitored;
- improved productivity from drivers;
- the prescribed method of ensuring compliance with the drivers' hours regulations.

As tachographs are the means by which both drivers and operators are prevented from working excessive hours, they have become the target for many forms of abuse. Some of the most common forms of abuse are listed below:

- winding the tachograph forward at the end of a duty period;
- removing the fuse;
- fitting a hidden switch to turn the tachograph on or off as required;
- putting a polo mint (lifesaver) in the middle of the disc to blur the reading;
- bending the stylus to give a false reading;
- placing chewing gum in a strategic place on the disc.

It has to be said that many of the more obvious forms of tachograph abuse have been superseded by more sophisticated forms of fraud, which concentrate on tampering with the equipment's electronics. It goes without saying that all of these practices are illegal.

A new generation of digital tachographs based on a vehicle monitoring unit and a driver smart card is being introduced. This new generation of tachograph is required to be fitted to all new goods vehicles over 3.5 tonnes gross weight from a date to be confirmed unless they are exempt. Further to this, existing vehicles over 12 tonnes gross weight will need to have a new digital tachograph fitted in the event that their existing analogue tachograph fails. (At the time of writing some doubt existed regarding the actual date that digital tachographs could be fitted to new vehicles. However, it is safe to say that these will be the vehicle categories involved when the final date is resolved.)

VEHICLE DIMENSIONS

The length, width, turning circles and ground clearance are regulated for different classes of vehicles. There is no legal height limit for vehicles in the UK although the EU requires a 4.0-metre limit.

The standard maximum *width* for goods vehicles and trailers is 2.55 metres. This may be increased to 2.6 metres for vehicles constructed to carry goods at low temperatures, but the walls of the vehicle must be at least 45 millimetres thick.

Turning circles for different classes of vehicle refer to the ability of the vehicle to turn within the confines of two concentric circles. For example, an articulated vehicle manufactured after 31 May 1998 must be able to turn within the confines of two circles with radii of 12.5 metres and 5.3 metres.

Maximum vehicle lengths are as follows:

Rigid vehicles	12 metres
Articulated vehicles	16.5 metres
Draw-bar vehicles	18.75 metres

Trailers and other vehicle combinations are also subject to length restrictions. These are the main dimensions:

Articulated semi-trailers:
- from the kingpin to the rear of the trailer 12.00 metres*
- from the kingpin to any point on the front of the trailer 2.04 metres*

Composite trailers 14.04 metres

* These limits apply to trailers where the overall length of the vehicle and trailer is 16.5 metres.

For all goods vehicle trailers manufactured after 1 April 1984, *a ground clearance* of 160 millimetres is required if the trailer has an axle spacing of more than 6 metres but less than 11.5 metres. A clearance of 190 millimetres is required if the trailer axle spacing is 11.5 metres or more.

Vehicle weights

The gross vehicle weights of LGVs are clearly defined in the construction and use regulations. Maximum axle loadings and spacings are also of prime importance when specifying goods vehicles. The following list outlines the main maximum gross vehicle weights for vehicles operating in the UK. Please note that the maximum gross weights quoted below are the maximum possible, but they may be dependent on the fitment of road-friendly suspension (RFS), twin tyres, axle spacing and the type of work the vehicle is undertaking:

- two-axled rigid - 18 tonnes;
- three-axled rigid - 26 tonnes (with RFS);
- four-axled rigid - 32 tonnes (with RFS);
- four-axled articulated combination (two-axled tractor plus two-axled trailer) - 36 tonnes (or 38 tonnes if the tractor unit does not exceed 18 tonnes and the semi-trailer does not exceed 20 tonnes, although the distance between the axles of the semi-trailer must be greater than 1.8 metres);
- five-axled articulated combinations (two-axled tractor plus three-axled trailer, and three-axled tractor plus two-axled trailer) - 40 tonnes (44 tonnes under certain circumstances);
- six-axled articulated combinations (three-axled tractor plus three-axled trailer) - 40 tonnes (or 41 tonnes if the drive axle does not exceed 10,500 kilograms, is fitted with RFS and twin tyres, and the trailer has RFS; or 44 tonnes if on intermodal work - see Chapter 22);
- four-axled draw-bar combination - 36 tonnes;
- five- and six-axled draw-bar combinations - 40 tonnes (41 or 44 tonnes for six-axled draw-bars in certain circumstances).

Since 1 February 2001 the UK government has authorized the use of 44 tonnes gross vehicle weight for general road haulage operations. These vehicles are limited to a 10.5-tonne drive axle weight limit.

Construction and use regulations

These regulations are used to control the technical specifications of goods vehicles. They also control the maximum limits of use that the vehicles may be required to undertake. This area of the rules covers matters such as the extent to which a load may project over the sides of a vehicle and how this should be dealt with, eg with additional lights or markers.

The main areas covered by the regulations include:

- projecting and abnormal loads;
- marker board sizes and dimensions;
- braking systems;

- exhaust emissions;
- under-run equipment such as side and rear protection;
- horns;
- lighting;
- mirrors;
- noise emissions;
- speed limiters;
- spray suppression;
- suspension systems;
- steering;
- tyres.

This list is not exhaustive, but it does illustrate the scope and depth of the regulation in this very technical area of road transport legislation.

THE IMMIGRATION AND ASYLUM ACT 1999

In many parts of the world, economic migrants seeking a better life use trucks as a means of smuggling themselves across international borders. Sometimes this occurs with the driver's knowledge and sometimes it occurs without. The borders between the USA and Mexico, Morocco and Spain, Italy and the Balkans, and China and Hong Kong are all facing this problem. The UK government has sought to solve its problem by enacting the Immigration and Asylum Act. This Act sets penalties of £2,000 for each illegal immigrant found inside a truck. Operators could have their vehicles confiscated. Drivers can also face heavy fines and even imprisonment if convicted under the Immigration Act 1971. This clearly places a heavy responsibility on drivers and operators alike. The only defence is to prove ' due diligence', which in effect means that every precaution was taken to prevent illegal immigrants gaining access to the vehicle.

SUMMARY

This chapter has set out the main areas covered by road transport legislation. It is a subject that is very detailed and complex. In order to avoid any future legal problems, professional advice should always be sought where questions exist in the mind of the operator prior to engaging in any activity.

The main subjects covered were:

- the rules regarding operator licences and licensing;
- driver licensing;
- drivers' hours of work regulations;
- the Road Transport Directive;
- tachographs;
- vehicle dimensions;
- vehicle weights;
- the construction and use regulations;
- the Immigration and Asylum Act 1999.

FURTHER READING

Lowe, D (2005) *The Transport Manager's and Operator's Handbook*, Kogan Page, London

This book is updated and published annually. It is a very detailed source of useful information regarding UK road transport legislation.

26

Road freight transport: planning and resourcing

INTRODUCTION

There are a number of reasons why road freight transport operations need to be carefully planned and resourced. These are discussed in the first section of this chapter. In addition, some of the main approaches for the management of vehicle fleets are reviewed.

The major content of this chapter is concerned with the basic methods of identifying fleet resource requirements. This can be achieved both manually and by computer analysis, and both of these approaches are considered. The main objectives of these types of analysis are discussed. In addition, the need to differentiate between strategic and tactical considerations is outlined.

The key data requirements are set out in some detail, and then a particular approach to manual routeing and scheduling is used as an example. Finally, an identical analysis is undertaken using a computer package, and these results are reviewed.

NEED FOR PLANNING

There are some very general, as well as some very specific, reasons for carefully planning and managing road freight transport operations. As has been discussed in previous chapters, one of the real keys to creating an effective logistics operation is to get the right balance between customer service and costs.

This applies to an equal extent when considering the transport component of logistics. Some of the major elements include:

- *Assets.* Road freight transport fleets consist of some very high-value assets, ranging from the tractors, trailers and rigid vehicles themselves to the drivers. It is important that these assets are made to 'sweat' through the development of efficient schedules that keep the vehicles and drivers on the road and active, and through the introduction of double- and treble-shifting of vehicles, which maximizes their use. Computer routeing and scheduling packages play a major role in achieving this high utilization, so a discussion of their characteristics will be a key part of this chapter. In addition, fleet management packages offer real opportunities to monitor very closely the costs and utilization of these assets. Both time and space (or load) utilization are important considerations.
- *Service.* Delivery transport acts as the main physical interface with the customer, so it is important that all customer service requirements are met. For transport, this applies particularly to set delivery windows and timed deliveries. Once again, computer routeing and scheduling packages are key to achieving these goals.
- *Costs. As* well as the major assets discussed above, there are also costs associated with the operation of the vehicle, specifically the running costs such as fuel and tyres. Good scheduling can also help to keep these costs to a minimum.
- *Maintenance.* It is important to ensure that vehicles are maintained on a regular basis to reduce the occurrence of breakdowns, which can lead to both a loss of service and a higher operational cost.
- *Driver management.* This can be significantly improved by the use of appropriate tachograph analysis. As well as providing a better and more accurate picture of fleet efficiency, tachograph output can be used to monitor the detailed effectiveness of individual drivers.
- *Replacement.* A key decision for any transport manager is to be able to identify when vehicles need to be replaced and also which type of vehicle is the most effective for the particular type of operation that is being undertaken. A good fleet management system will be able to provide this information.

- *Security and tracking.* Some modern technology allows for the real-time tracking of vehicles. This enables up-to-the-minute information to be provided to schedulers and to customers, so can help to improve operational effectiveness, security and service.

FLEET MANAGEMENT

Several different fleet management information systems have been developed that are aimed at assisting the transport manager to monitor, control and administer the transport operation. These are very broadly specialized database packages that are aimed specifically at fleet operations. The main functions covered are as follows:

- *Maintenance scheduling.* This includes the monitoring of the service life of vehicles in a fleet and the scheduling of routine and non-routine maintenance and repairs. Package features include:
  - service history;
  - maintenance schedule reports;
  - workshop costs analysis.
- *Vehicle parts control.* This is the stock control function of spare parts requirements. Features may include:
  - stock enquiry;
  - maintenance of supplier information;
  - stock location;
  - stock reports;
  - the generation of purchase orders.
- *Fleet administration.* Fleet administration packages are used to ensure that vehicles are legal and roadworthy. Package features may include: vehicle licence renewal;
  - reports required by government regulations;
  - insurance lapse reports, etc.
- *Fleet costing.* These packages provide detailed information relating to vehicle and fleet costs. They assist the manager by providing analyses and information concerning individual vehicle and overall fleet profitability. Features include:
  - vehicle cost analysis;
  - driver cost analysis;
  - overall fleet costs.
- *Tachograph analysis.* Information from tachograph recordings can provide the input data for an analysis of driver/vehicle performance. A number of systems

are available that can read tachograph charts and produce itemized information on rest time, driving time and break time, as well as details of legal infringements. Typical package features are:

- infringement reports;
- driver and vehicle utilization reports;
- fleet reports.

Tachograph analysis packages or modules are usually stand-alone, but can be integrated with other transport management modules.

MAIN TYPES OF ROAD FREIGHT TRANSPORT

Road freight transport operations can be broken down into two main types. These are *primary* transport and *secondary* transport. It is important to be aware of the major difference between these two, because *they should be considered quite separately for both planning and operational purposes.* The key difference can best be viewed within the context of the supply chain as a whole. This is illustrated in a domestic transport network in Figure 26.1. This supply chain consists of two manufacturing points that feed finished products into a national distribution centre (NDC) as and when product is available. The NDC then feeds three regional distribution centres (RDCs) with regular full vehicle loads. Retail stores are then delivered selected orders on a daily basis from the RDCs.

The *primary* transport element is the movement of full loads on large vehicles with a single delivery point. This may be from plant to NDC, or from NDC to RDC. These are sometimes called trunking or line-haul operations.

The *secondary* transport element is the movement of loads on smaller delivery vehicles from the RDC to retail stores. Deliveries are typically made to several drop points during one vehicle journey. Orders are pre-selected for each delivery point on to some type of unit load (a wooden pallet or a roll-cage pallet). These are often known as multi-drop or local deliveries.

Primary transport

The focus on primary transport is often one of cost reduction. It is seldom regarded as an activity that 'adds value' to an operation because there is no direct link to the final customer or, as in Figure 26.1, with the retail store. Primary transport is all about moving the product at minimum cost, which generally involves using as large a vehicle as possible and making sure that the vehicle is filled to capacity. These movements usually consist of delivery to a single drop point. Other key aspects include:

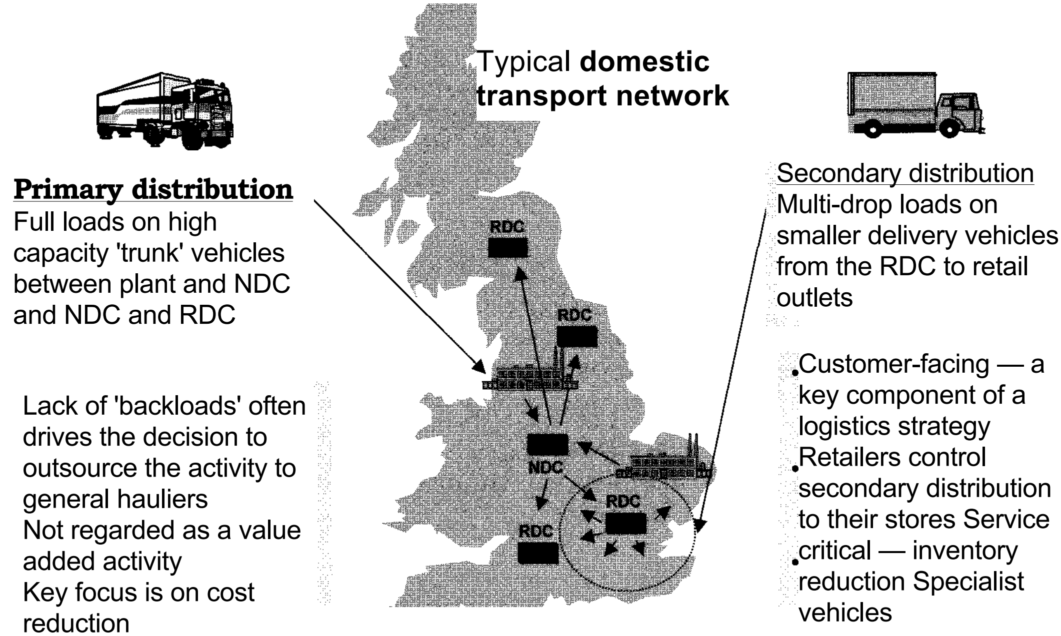


Figure 26.1 Typical road freight transport operations consist of 'primary' and ' secondary' transport or distribution

- Vehicles are operated for as long as possible, sometimes on a 24-hour, three-shift basis, to maximize vehicle time utilization.
- Return loads for the vehicle are important so as to fulfil the criteria for maximum utilization. The lack of return loads or 'backloads' often drives the decision to outsource the activity to general hauliers.
- Additional vehicle specification, for example special on-vehicle handling equipment, is less important than for delivery operations.

Secondary transport

Secondary transport and delivery usually involves direct contact with the customer or end user (or, as with retail operations, the key end user interface). These are, therefore, what are known as 'customer-facing' logistics operations, and they can be an important part of the customer service element of logistics strategy. Because of this, cost reduction is not the main operational criterion as it is with primary transport (although it is important). Customer service is the major criterion.

Important related factors include:

- Many customers have very restricted delivery windows (the time in which a delivery may be made). This makes the accurate scheduling of secondary vehicles very important.
- Service is usually critical. In particular, inventory reduction in retail stores and the increase of store selling space and elimination of stockrooms makes timely delivery essential. This is to ensure that the store does not run out of stock.
- Specialist vehicles have been developed for secondary delivery, eg grocery multi-temperature compartmentalized trailers. These are used to maximize the opportunity to make frequent and full deliveries of essential stock to the stores.

It is important to understand the difference between the two to ensure that the proper balance between cost and service is achieved. The methods used for the planning and management of these types of operation and the selection of appropriate vehicles can be very different.

TRANSPORT RESOURCE REQUIREMENTS

The basic method of assessing the road freight transport resources required for a given operation necessitates some very detailed and time-consuming analysis. This is the case whether the method adopted is a manual one or whether one of the many computer routeing and scheduling packages is used. Basically, it is necessary to identify specific delivery route requirements (routeing) and then calculate from these how many vehicles and drivers are required to undertake the operation (scheduling). Computerized systems for fleet planning and operations are used to help determine basic transport resource requirements but are also used to maximize the utilization and effectiveness of *a given* set of resources (eg an existing fleet of vehicles).

In summary, there are two key areas: 1) determining initial fleet resource requirements; and 2) identifying effective vehicle schedules using an existing fleet. These may have different implications according to the type of road transport operation that is being considered. The major use of these packages is for secondary delivery or local delivery. Here, vehicle routeing and scheduling are concerned with the efficient organization of road transport delivery to the final customer or retail outlet. Many large manufacturing, retailing and distribution companies have logistics structures with many depots spread across large geographic areas. Each depot will be responsible for supplying customers within a given region, that is, within the depot boundary.

This supply of products from a depot is often undertaken by a fleet of delivery vehicles that vary in size and capacity. Equally important, the particular demand for products from the depot may vary day by day and week by week. The two main problems are, therefore, to try to minimize the number of vehicles that are needed to achieve this, and to deliver this variable amount of goods and products as efficiently as possible. 'Efficiency' in this instance can be to maximize the amount of product moved on the vehicles and minimize vehicle mileage. It is principally about providing a balance between supplying an adequate service to customers on the one hand and doing so at an acceptable cost on the other.

Other types of transport operation may also benefit from a similar approach to resource utilization, but the means of achieving this may require additional or different requirements. Two examples are primary or trunking (line-haul) operations, which generally involve just one point of delivery for each vehicle, and stockless depot or demountable operations, which require a single stock-holding base plus additional stockless distribution points.

From the viewpoint of a depot manager or transport operator, objectives for local delivery can be stated quite simply as follows: *to plan journeys for vehicles operating from a single depot, delivering known loads to specific customers and returning to the depot after completing the journey*. Although this sounds relatively straightforward, there are a number of additional constraints that must be considered. Some examples are:

- the weight or volume capacity of the vehicles;
- the total time available in a day;
- loading and unloading times;
- different vehicle speeds;
- traffic congestion;
- access restrictions.

A fairly general definition of the aim of vehicle routeing and scheduling has already been outlined. For an existing fleet, this can be summarized as the 'best' use of vehicles when providing a particular delivery service (known as the 'optimization' of vehicle usage). There are, however, a number of different ways in which this can be achieved, and any or all of these maybe acceptable objectives for vehicle routeing and scheduling, depending on the particular transport operation concerned. Some examples of these different objectives are:

- to maximize the time that vehicles are used (ie make sure they are working for as long as possible);

- to maximize the capacity utilization of vehicles (ie ensure that all vehicles are as fully loaded as possible);
- to minimize mileage (ie complete the work by travelling as few miles as possible);
- to minimize the number of vehicles used (ie keep the capital or fixed costs to a minimum);
- to ensure that customer specific delivery requirements are met, ie timed deliveries or vehicle type restrictions.

VEHICLE ROUTEING AND SCHEDULING ISSUES

Vehicle routeing and scheduling problems are relatively complicated. There are several reasons for this: firstly, there are many different types of problem that can arise, each of which needs to be understood and approached in a different way; secondly, there are many detailed aspects that need to be taken into account (some of these were listed in the previous section, and the detailed data requirements are reviewed later in this chapter); and, finally, there are a number of different methods or algorithms that can be used to produce solutions.

The first point, concerning the *different types of problem, is* now described. These are linked very closely with some of the points made in the previous section of this chapter. These different problem types can be categorized in four main ways:

1. strategic;
2. tactical or operational;
3. interactive;
4. planning.

Strategic problems are concerned with the longer-term aspects of vehicle routeing and scheduling, in particular where there is a regular delivery of similar products and quantities to fixed or regular customers. Typical examples are most retail delivery operations (such as grocery multiples), bread delivery and beer delivery to ' tied' houses.

The main characteristic is that of a fairly regular demand being delivered to virtually the same locations. Thus, it is possible to derive vehicle schedules that can be fixed for a certain period of time (eg three to six months). Some changes will be necessary as shops open or close, or as new products come on to the market, but in general the schedules can be maintained for a reasonable length of time. These schedules are drawn up on the basis of past or historical data. Strategic scheduling is now often undertaken by using modern computer techniques.

Tactical or operational problems are concerned with routes that have to be scheduled on a weekly or a daily basis. This type of scheduling is typically undertaken by parcels delivery companies, by companies supplying spare parts and by contract haulage companies that work for a number of different clients. The major factor of importance is that either the demand (quantity) of goods cannot be estimated (eg it is 'random' demand) or the location of delivery points can vary, or that both of these occur.

Thus, for tactical or operational scheduling it is impossible (or very difficult) to plan delivery schedules based on historical information. It is necessary to look at each series of orders on a daily (or weekly) basis, and plan vehicle routes and schedules according to this ever-changing demand. This type of scheduling is often still undertaken manually by a load planner in a depot, but now computer applications are available that allow for 'live' scheduling. This is described below.

Many delivery operations are now planned on an *interactive* basis that allows the scheduler to use the computer to derive the most effective routes. Actual demand data are used rather than historical demand, and these 'real-time' data provide the basis on which routes are scheduled. Thus, much more accurate routes can be formulated. A rather obvious question might therefore be asked. Why aren't all sets of routes derived in this way? The answer is that the cost of setting up and using a routeing and scheduling package on a daily basis can be very expensive - both as to the cost of buying the package and as to the time and cost of providing the demand data every day. Also, of course, when such packages are used for planning purposes, historical data are perfectly adequate.

Schedules produced interactively can result in very varied routes day by day. This is because the computer is able to reappraise demand requirements and come up with a completely original result each time it is used. One of the major benefits of an interactive approach is that the scheduler is in a position to make changes to routes as they are required. For example, should an urgent order be received after the initial routes have been planned using the computer, the scheduler can manually input the order into the package and assign it to an existing route. The computer will then check the route to see if the new order can be accepted. It may be rejected for a variety of reasons - insufficient capacity left on the vehicle, insufficient time available, etc. Thus, the scheduler can use the package to ensure that the order is only placed on a vehicle that is in a position to complete the delivery both legally and within the allotted service constraints.

Some software packages now also allow for multi-depot routeing so that deliveries are made from the depot that has the available resources. Thus, resources at all depots can be utilized more effectively, enabling the maximization of asset utilization.

The final type of routeing and scheduling problem concerns the *planning* and measurement of the effect of change. This use of routeing and scheduling has really come into its own as a result of the development of computer-based techniques. Computer models may be used to test or simulate the effect of changing demand, new vehicle availability, legislative changes, etc. This is often known as 'what-if' planning. Some examples include:

- Third-party contractors typically use routeing and scheduling packages to help them respond to invitations to tender for business. The package will allow them to identify fleet and driver requirements and thus cost out the operation accordingly.
- A large manufacturer of soft drinks uses a routeing and scheduling package to help it to identify the implications of adopting different minimum order/drop sizes for its various products to its many different customer types. Any reduction in minimum order size will bring an increase in revenue for the products, but will be associated with an increase in delivery costs, because many smaller orders have to be delivered. The routeing and scheduling package is used to test and identify these potential cost increases.
- Own-account operators use routeing and scheduling packages to help them identify the implications of changes in transport legislation. An increase in maximum vehicle weights is a case in point, as this will impact on the size of loads that can be carried, the buying policy for the fleet, etc.

The actual method used for routeing and scheduling varies according to the nature and difficulty of the problem, and whether a manual or computer-based approach is used. Each different method is known as *a routeing and scheduling algorithm*. The most common algorithm is known as the savings method. This can be explained by a relatively simple example, as indicated in Figure 26.2. Depot 0 services two delivery points, A and B. The distances between these two delivery points OA, OB and AB are a, b and c respectively. If each delivery point is served by a single vehicle from the depot, then the total distance is 2a + 2b. If only one vehicle is used in a single trip then the total distance covered is a + b + c. The savings achieved by linking together the two delivery points A and B are thus:

$$(2a + 2b) - (a + b + c), \text{ or } a + b - c$$

The saving is the distance/time saved by combining the route

$$= (2a + 2b) - (a + b + c)$$

$$= a + b - c$$

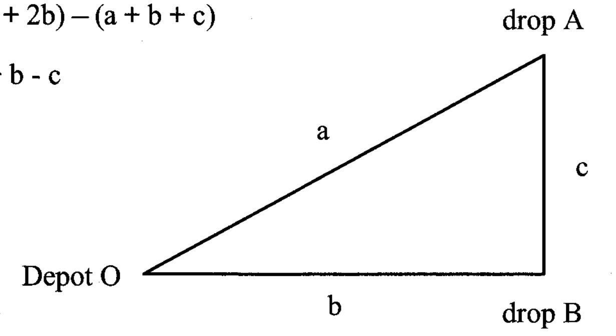


Figure 26.2 The savings method – a heuristic scheduling algorithm

ha any problem with a significantly large number of delivery locations, the advantage of using a computer is quite obvious. It would not be feasible to test all possible different routes manually.

The distance between every delivery location is recorded. A 'savings matrix' is then generated, recording the savings made by linking together each of these pairs of locations. Taking the link with the highest potential saving first, and then adding successive links, a route is put together, measured against the vehicle capacity and driver time constraints. Eventually all delivery points will be allocated to a vehicle route, and the schedule will be complete.

As indicated previously, other algorithms have been developed and are used in the many different computer packages available.

Note that it is generally thought that a useful rule of thumb for the justification of using a computerized system as opposed to a manual system is 8 to 10 multi-drop vehicles. This is because a fleet of this size should be large enough to enable the saving of a complete vehicle, thus offsetting the initial cost of the routeing and scheduling software.

DATA REQUIREMENTS

It has already been noted that there are many different factors that need to be taken into account when planning the delivery operation of a road transport fleet. These factors require a great deal of data and information to be collected and collated. The advent of improved computer routeing and scheduling techniques has enabled many more detailed aspects to be analysed, which more simple manual methods are unable to include.

As well as the basic demand data, routeing and scheduling require data that reflect the different characteristics of road transport delivery. The major areas for data are thus:

- demand data;
- distance factors;
- customer and service constraints;
- vehicle restrictions;
- driver constraints;
- route factors;
- product/unit load constraints.

The most important data requirement is for the *demand data*. Where possible this should be for daily, weekly or annual demand by customer at the point of delivery. This can often be the most difficult data item to collect, will certainly be the most time-consuming and will also require the most manipulation and clarification prior to use within the manual method or computer package. It may be necessary to undertake additional analyses (and collect additional data) to take account of peak demand periods, because they are likely to require different schedules.

There are several ways in which demand data can be represented, which is fortunate because often the most appropriate choice of data is not available, so second or even third choice has to be sufficient. The key requirement is for the demand data that are collected to be representative of the *main measure* of vehicle capacity constraint. This might be weight-, volume- or unit-related. Examples include:

- weight (per product type delivered or as a total delivered tonnage figure - in kilograms or tonnes);
- cube or volume (in, say, cubic metres or cubic feet);
- carton/case/parcel (numbers to be delivered - common in retail distribution);
- unit load (eg numbers of pallets or roll cages - again common in retail distribution);
- value in revenue or sales (rarely appropriate because of the problem of interpreting value as a physical measure);
- product item (generally too detailed);
- product group.

Demand data must also be classified by location, and this can be represented in a variety of ways. Clearly the level of detail and accuracy is very important in order to ensure good results from the scheduling process. Certain computer packages are more amenable to some classifications than others. The best (and often only) option is the classification that is in general use within the company. This will usually be drawn from electronic files of customer orders that record the customer delivery address and postcode (or zip code). The main alternatives are:

- postcodes or zip codes - the most common classification;
- Ordnance Survey codes, or any other type of map referencing system;
- 10-kilometre grid squares - a useful simplification if there are many delivery points;
- gazetteer (main town or city) - rather imprecise, but easily recognizable;
- latitude and longitude - again, may not be sufficiently precise;
- population-based - can be a good approximation of geographic demand if there are no other data available.

A demand data file might look like this:

Name	*Town*	*Postcode*	*Demand*	*Type*
Cannons	Redditch	B97 4YR	32	delivery
Broomfield	Nantwich	CW5 5LW	8	delivery
Nash's	L Eaton	NG10 1JA	14	delivery

For routeing and scheduling analysis, there are various methods for estimating or measuring *distance travelled*. Distances include those from the depot to the many delivery locations and those between the different delivery locations. In the real world, these are of course the mileages travelled by the vehicles as they go about the distribution operation. The three main alternative methods of measurement are:

1. *True distance method* - where all the actual distances are physically measured on a road map. This is very time-consuming and could not be undertaken for large applications.
2. *Co-ordinate method* - where the depot and customer delivery points are located (on a map) by grid reference, and the straight-line distances are measured (sometimes called the 'crow fly' or 'aircraft' methods) and factored up to an approximate road distance. Typically, the factor that is used is 1.2 (this is sometimes called the 'wiggle factor'). This method uses 'barriers' to represent

practical constraints such as rivers, railways, etc. A few computer applications adopt this technique.

3. *Digitized road network* — most computer scheduling systems now use a special digitized road network of the country concerned, which usually consists of the major roads and junctions of the national road network. These provide a very accurate representation of travel distances. They also make allowances for different road types (eg motorway, trunk, etc) and for land use (eg city centre, town centre, etc), which allows for variable speeds to be used when calculating the time taken to travel. The road networks of most major countries are now represented by digitized maps.

There are a number of *customer and service constraints* that may need to be taken into account during the scheduling process. These relate to the ease of delivery or the ability to make a delivery to certain destination points. They maybe concerned with physical aspects or be time-related. Some of the more detailed ones can only be applied if computer routeing is used because of the difficulty of taking so many complicated variables into account at the same time. The most common customer and service constraints are:

- specified times for delivery (eg 8 am);
- specified delivery windows (eg between 10.15 and 11.00 am);
- early closing days;
- lunch breaks;
- access restrictions (eg only vehicles of a certain size can deliver);
- unloading restrictions (eg no fork-lift truck available to unload pallets);
- drop size limitation (eg only a certain number of packages/pallets can be received);
- parking problems (eg cannot park or unload in the main road);
- paperwork problems (eg all goods must be checked by the driver and signed for).

Certain *vehicle restrictions* will also need to be taken into account. Typical examples might include:

- the type of vehicles available;
- the number of vehicles available;
- the need to pre-load trailers;
- mixed fleets (ie rigid and articulated vehicles);

- vehicle capacities (in weight or volume);
- use of compartmentalized vehicles.

Driver constraints will also be relevant, the major ones for consideration being:

- drivers' hours legislation;
- shift patterns and hours of work;
- the number of drivers available;
- different types of licence and training;
- the need for a second person to assist with deliveries.

Route factors refer to the different constraints that apply to the make-up of individual vehicle routes. These include:

- the road infrastructure;
- maximum number of calls per route;
- multiple trips (ie more than one journey in a day by one vehicle);
- two-day trips (ie the vehicle and driver do not return to the depot every night);
- simultaneous delivery and collection.

There is a variety of factors that may need to be considered with reference to the *product or unit load* that is being distributed. Typical examples are:

- the weights and dimensions of the different products;
- the weights and dimensions of the different unit loads;
- variable unloading times (different products or unit loads may vary in the time it takes for their unloading);
- separation of products within a vehicle because of potential contamination or fire hazard;
- the need to collect empty containers;
- a requirement for special handling equipment.

MANUAL METHODS OF VEHICLE ROUTEING AND SCHEDULING

In this section different examples of vehicle routeing and scheduling procedures are described. Because of the detailed nature of such an exercise, only a broad picture of what actually takes place will be painted. Bearing in mind the objectives and major characteristics that were described in the previous section, however, it should be possible to get a good general understanding of what is required.

The examples include a manual system for day-to-day scheduling and a manual system for long-term planning.

A daily (manual) scheduling system

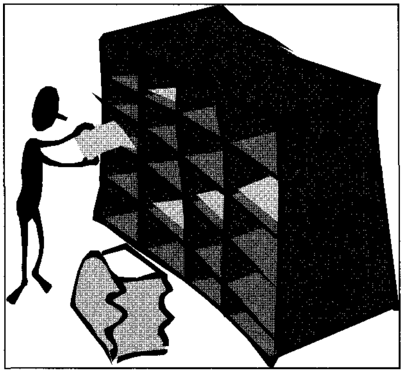
This example describes the daily routeing and scheduling system and procedure undertaken by a load planner for a depot situated in London. The company is a contract haulier with a few large and several small clients for which it undertakes delivery. This particular depot covers London, East Anglia and the south-east of England. Although some locations are visited quite often, there are no regular deliveries made and new locations occur quite frequently.

Procedures at the depot are relatively straightforward. The majority of orders are received from the head office by fax or electronic transfer, although some may come directly to the depot. The orders give information relating to the delivery address, deliver-by date, product, quantity, packaging, gross weight and any special delivery instructions. The deadline for receipt of orders is midday. This leaves the afternoon for the load scheduling and preparation of order picking notes for the following day's work. It also provides for some time allowance for the adjustment of the existing planned loads to take account of urgent orders that are required for delivery the next day.

On the day following the receipt of order, the goods will be picked and marshalled by the warehouse staff and then loaded on to a vehicle by the driver on returning in the late afternoon. Delivery takes place the next day.

A copy of every order is date-stamped, and then order types are categorized according to delivery status. These different categories are as follows:

- *Forward orders* (ie delivery required at a later date) – these are placed in a forward-order tray one week ahead, two weeks ahead, etc.
- *Normal delivery* – these are to be delivered according to the company's standard service level (say within five days). These orders are used as the prime basis for making up loads.
- *Urgent orders* – these occasional orders are for delivery within 24 hours. They are also used for making up full vehicle loads, but outside contractors are brought in if this is not feasible.



	Beds	Cambs	Norfolk	
Oxford	E Bucks	W Herts	E Herts	Suffolk
W Bucks	NW	N	NE	N Essex
Berks	W	C	E	S Essex
	SW	S	SE	
N Hants	W Surrey	E Surrey	W Kent	E Kent
	S Hants	W Sussex	E Sussex	

Figure 26.3 Pigeon-hole racking

Orders are accumulated in a system of pigeon-hole racking, which is arranged on the basis of geographic areas in a formalized layout. The aim is to have a number of main delivery areas spread around the depot. The depot should be near the centre of the system. For the East London depot, the pigeon-hole racking is arranged as shown in Figure 26.3.

After the orders are placed in the pigeon-holes, the load scheduling and routeing exercise takes place. As already indicated, the loads are assembled with urgent orders as a priority when forming the basis of a load. The planner schedules so that the furthest drops in each area are chosen first. The full load is then made up from other drops within that pigeon-hole that are relatively close, and from drops that can easily be made en route from or to the depot. These additional drops can be readily selected using the pigeon-hole system because of its geographical format. Using a system such as this, it is easy, on a daily basis, for a load planner to develop 'petal-shaped' routes that have the depot as their central point. This can give very efficient vehicle routeing.

Manual scheduling for strategic purposes

Manual vehicle scheduling can also be undertaken for strategic or long-term planning. The procedures that are used are somewhat similar to the scheduling system that has just been described, but they are in much greater detail. The results are used to plan fleet schedules that may be used as the basis of a delivery operation for a given period of perhaps up to about six months.

The main information and data requirements are the same as those characteristics of road transport delivery that were outlined in the previous section on data. Within these different categories there are many detailed items of information that need to be collected and then used when the scheduling procedure takes place. The main data sources for this information may be as follows:

- historical records of a company (eg sales orders);
- special surveys that are undertaken specifically for the scheduling exercise (eg vehicle loading and unloading times);
- 'standards' of performance that are accepted within an industry or by union agreement;
- legal specifications and regulations (eg driving hours, lunch breaks, etc);
- tachograph records (for vehicle speeds);
- customer surveys (delivery windows and access restrictions).

The different data requirements for any one schedule can vary for several reasons, eg type of product, type of company, type of vehicles, etc.

AN EXAMPLE OF MANUAL ROUTEING AND SCHEDULING

In this section, the steps to undertake a detailed strategic manual routeing and scheduling exercise are described. Routes are created from the required orders (routeing) and then vehicles are scheduled to these routes (scheduling). This is a very iterative process because some of the initially created routes may have to be modified in the light of vehicle availability or vice versa. The two activities are inextricably linked together. The key elements are shown in Figure 26.4.

The basic *delivery data* describe the operational parameters from a depot near Northampton in the UK. The depot is used by an FMCG distribution company, and deliveries are made from the depot to customers in an area largely to the north of Northampton. The depot closes at the weekend. All deliveries in this very basic example are to be scheduled for a single day. The parameters and constraints are:

- Two vehicle types are available. These are 16-tonne rigid vehicles each with a carrying capacity of 700 cases, and 32-tonne articulated vehicles each with a carrying capacity of 2,100 cases. Volume capacities are not used.
- Order sizes are represented as the number of cases.
- The acceptable times at which deliveries can be made vary amongst customers. There are six groups of delivery time window codes:

Establish delivery data & parameters

Determine geographic area (map/grid)

Determine demand

Determine customer drop constraints

Allocate demand to geographic area

Decide on geographic `rules'

Plan trips

Plan routes

Calculate vehicle requirements & mileage travelled

Calculate the delivery cost

Calculate vehicle utilization

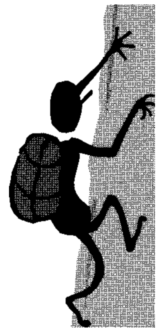


Figure 26.4 Steps taken to undertake a manual routeing and scheduling exercise

Code		
1	All day	9.00 am - 6.00 pm
2	Lunchtime closing	9.00 am - 1.00 pm and 2.00 pm - 6.00 pm
3	Early closing	9.00 am - 1.00 pm
4	Early am only	9.00 am - 11.00 am
5	Lunchtime only	12 noon - 2.00 pm
6	Late pm only	4.00 pm - 6.00 pm

- Drivers work a 10-hour day. Drivers must take a 45-minute break after driving for 4 hours and 30 minutes. Maximum driving time is 9 hours a day. There is an average 48-hour working week.
- The average road speeds are:

	Urban	*Rural*
Motorway	44.0 mph	56.0 mph
Dual carriageway	27.5 mph	35.0 mph

A roads	22.5 mph	31.0 mph
B roads	17.5 mph	25.0 mph

- The time taken to unload goods at customers' premises varies as a result of access problems and unloading equipment available. There are three main groups. Each group has a fixed time (which is incurred regardless of the quantity delivered) and a variable time related to the size of the delivery. The groups are as follows:

	Fixed (minutes per drop)	*Variable (minutes per case)*
1	1	0.025 (1.5 seconds)
2	2	0.050 (3 seconds)
3	0 2 5	0.075 (4.5 seconds)

- The drivers are able to leave the depot at any time after 6.00 am. The latest return time of a vehicle to the depot is 7.30 pm.
- Vehicles are pre-loaded for delivery.
- Second trips in a day are allowed. If a vehicle does multiple trips in a day, the time required to reload vehicles at the depot is 10 minutes fixed time and a variable time of 0.015 minutes (0.9 seconds) per case. The minimum time that must be available for a further trip is 2 hours.

Demand data are given for each of the locations to which a delivery is to be made. Any delivery constraints need to be identified. Demand and constraints are indicated in Table 26.1.

A suitably detailed map should be used and the drop points indicated accordingly. An example of a computer-generated map is given in Figure 26.5.

A process of *measuring distances* needs to be established. This might be according to the actual roads that are used during the delivery run, although this can take a lot of time if there are some complicated routes developed. A simplified approach is to measure any distance as a straight line and then multiply this up by a 'wiggle factor' that is representative of the way that roads twist and turn. A factor of 1.2 is appropriate. Sometimes motorways are measured directly and other roads estimated using the straight-line approach.

Once the basic data are identified and recorded, then the actual *planning procedure* can take place. The overall objective for such an exercise is likely to be to 'find the best routes that will minimize the numbers of vehicles and minimize delivery distance travelled - within the set demand and delivery constraints'. Routes are

Table 26.1 Demand data for the FMCG distribution company

Number	Name	Location	Number of Cases for Delivery	Fixed Unloading Time (mins)	Total Variable Unloading Time (mins)	Vehicle Type Restriction	Delivery Time Window Code	Grid Reference
E046	GOMM	DERBY	40	25	3	both vehicles	1	4350,3360
F450	BROWN	BURTON-U-TRENT	240	25	18	both vehicles	1	4240,3230
F251	LOW	BURTON-U-TRENT	180	10	5	16-tonne only	1	4240,3230
E248	BULL	SWADLINCOTE	180	20	9	both vehicles	1	4300,3200
A508	ANDERSON	COALVILLE	50	20	3	16-tonne only	1	4425,3140
F353	ASKEW	RUGBY	320	10	8	both vehicles	1	4524,2766
A502	ALEXANDER	RUGBY	300	20	15	16-tonne only	6	4485,2730
B416	TOMLINSON	WARWICK	278	10	7	16-tonne only	1	4280,2640
G460	BRICKWOOD	KENILWORTH	30	10	1	both vehicles	1	4290,2710
C420	CHARLESWORTH	COVENTRY	130	10	3	both vehicles	1	4330,2790
C322	WATTS	COVENTRY	170	10	4	both vehicles	3	4330,2790
B717	TATE	PETERBOROUGH	150	10	4	both vehicles	1	5190,2980
A204	RAWLINSON	PETERBOROUGH	285	20	14	both vehicles	5	5190,2980
F058	LANCY	STAMFORD	75	10	2	16-tonne only	1	5025,3080
D334	MARSDEN	UPPINGHAM	160	10	4	both vehicles	1	4865,3000
C328	MARSHALL	WIGSTON	140	25	11	both vehicles	4	4610,2990
B711	EVANS	LEICESTER	220	25	17	both vehicles	3	4590,3050
D939	MANDERS	WEST BRIDGFORD	810	10	20	both vehicles	3	4580,3370
E341	BOSWORTH	NOTTINGHAM	60	10	2	both vehicles	5	4570,3415
A409	DAVIES	NOTTINGHAM	360	20	18	both vehicles	1	4570,3415
D838	COOK	BEESTON	105	25	8	both vehicles	1	4530,3360
D636	BURNS	LONG EATON	110	25	8	both vehicles	1	4480,3320
C624	WILLIAMS	BEDWORTH	310	25	23	both vehicles	1	4360,2870
A307	SAUNDERS	NUNEATON	125	25	9	both vehicles	1	4360,2920
C325	HOPKINS	TAMWORTH	1200	20	60	both vehicles	3	4210,3040
A401	WATSON	HINCKLEY	100	20	5	both vehicles	2	4430,2940
C626	WILSON	HINCKLEY	200	10	5	both vehicles	1	4430,2940
D430	HOWARTH	BEDFORD	1950	10	49	both vehicles	1	4935,2539
B319	TAYLOR	RUSHDEN	230	25	17	both vehicles	1	4960,2670
A703	ALLRED	HUNTINGDON	280	25	21	both vehicles	1	5240,2720
F359	BULL	OUNDLE	450	10	11	both vehicles	1	5030,2885
F055	GRAHAM	KETTERING	70	10	2	both vehicles	1	4870,2790
A906	JORDAN	KETTERING	215	25	16	both vehicles	2	4870,2790
F654	ROBERTS	ROTHWELL	140	10	4	both vehicles	1	4810,2810
B818	BEATTIE	WELLINGBOROUGH	200	25	15	both vehicles	1	4900,2680
	DEPOT	COLLINGTREE						4760,2550

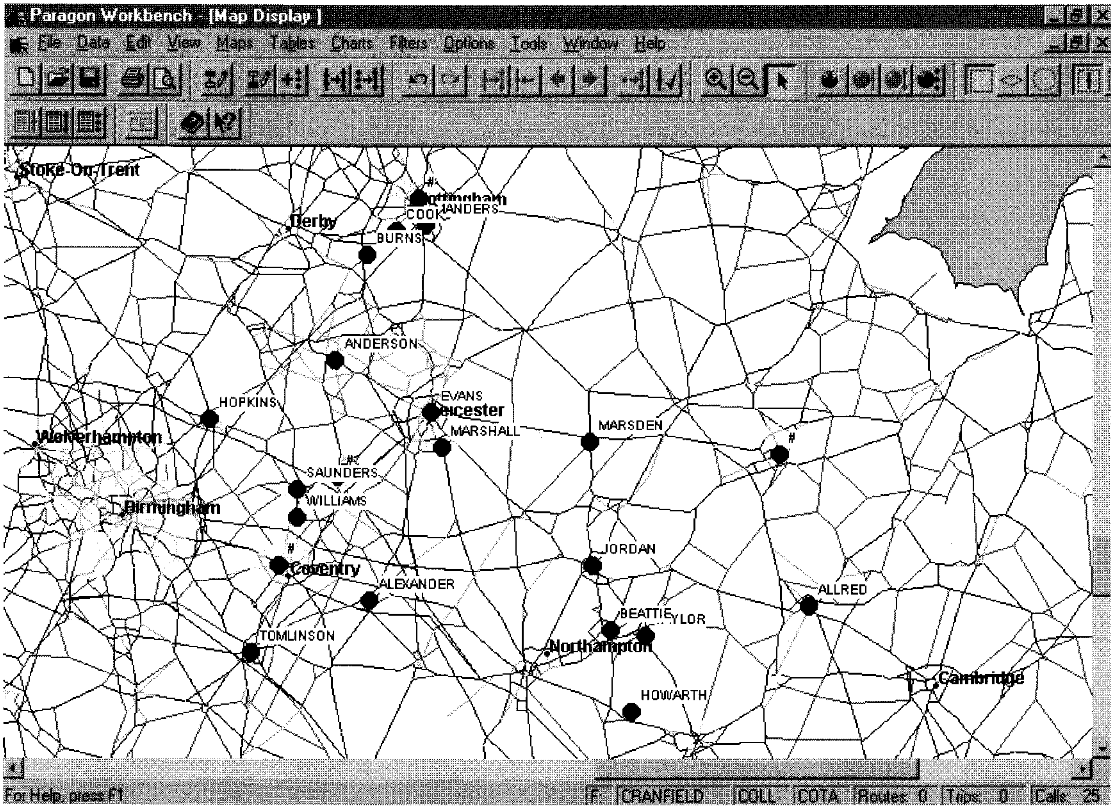


Figure 26.5 Digitized map of drop points and depot (courtesy of Paragon Soft-ware Systems, www.paragon-software.co.uk)

planned based on what are known as the principles of 'maximum drop density' (drops that are close together are scheduled on the same vehicle) and the full use of vehicles (use as much vehicle load capacity and vehicle time as is possible). The basic steps are thus:

- Identify drop points on the map.
- Identify demand and constraints by drop point.
- Decide on distance measurement rules.
- Identify drops that can provide a single drop trip and schedule these.
- Form clustered trips as follows:
  - Start with the drop that has the most constraints or that is the furthest from the depot.

- Form trips by combining adjacent drops until there is a full vehicle load.
- Identify a suitable vehicle (by its capacity).
- Record the total time taken (travel time plus delivery time).

- Final trips are short ones near to the depot.
- Combine trips into routes where possible (ie two trips per vehicle day).
- Determine fleet requirements (number and type of vehicles) and distance travelled.

The procedure is straightforward, but very time-consuming if there are a large number of vehicles to be scheduled.

The final stage is to *cost the operation* by calculating the fixed cost, based on the number of vehicles used, and the variable cost, based on the mileage travelled by the fleet. In addition, the respective utilization factors can be calculated. For the small problem outlined here, the results are as follows:

Costs and utilization factors for the vehicle fleet:

Vehicle costs (calculated on a daily basis):

2 rigid vehicles @ £75 per day		£150
634 kilometres @ 20 pence per kilometre		£127
3 articulated vehicles @ £146 per day		£438
662 kilometres @ 31 pence per kilometre		£205
Total cost per day		£920
Annual cost		£220,800
Cost per case delivered	(£920/9,863 cases)	9.3pence/case
Cost per kilometre	(£920/1,296km)	71.0pence/km

Vehicle utilization:

Time utilization:	actual hours / available hours	44 hours 13 minutes / 55 hours	80%
Load utilization:	actual cases / maximum cases	9,863 cases / 11,200 cases	88%

Examples of the routes are given in the next section — although these have actually been derived by using a computer routeing and scheduling package!

COMPUTER ROUTEING AND SCHEDULING

As discussed earlier in this chapter, there are four main uses to which computer vehicle routeing and scheduling packages may be put - strategic, tactical, day-to-day operational and planning. Some computer packages are designed to address one particular aspect, but most are likely to cover more than one. Most packages that have digitized road databases to support their scheduling capability will be capable of undertaking all of these approaches.

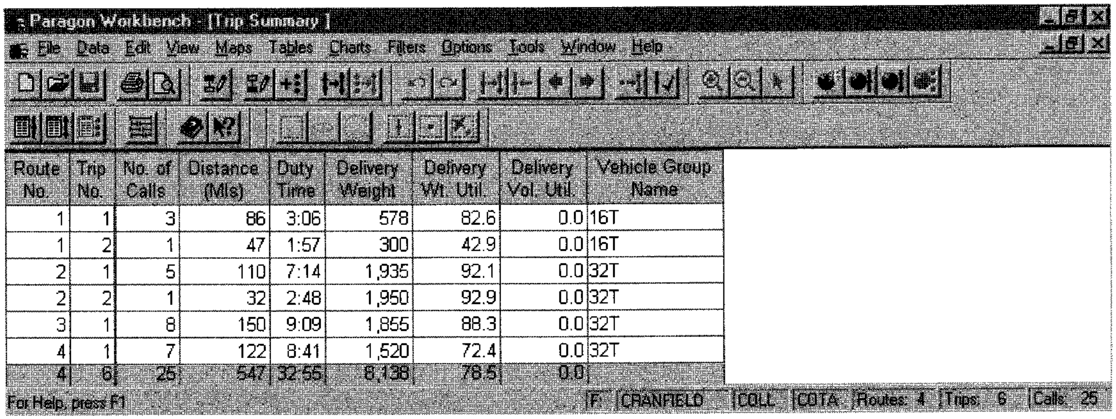
The general aim of computer routeing and scheduling is similar to that indicated for manual routeing and scheduling. Note that the majority of packages do not, in fact, provide an optimum solution to a problem. They provide the best answer within a given set of constraints and demands. The computer provides the transport planner with the ability to go into even greater detail than is possible with a manual system because it can undertake many more calculations; and many more alternatives can be investigated than when using a manual system.

There are a number of different routeing and scheduling computer packages available. New ones are brought on to the market periodically, and existing ones are continuously developed and updated. The scheduling procedures used in computer packages vary according to the nature of the answers that are required, but the basic system is again similar to that used for manual scheduling, albeit a lot more sophisticated.

Computer systems incorporate advanced scheduling methods (algorithms) that can generally be relied upon to provide very efficient solutions. Used interactively, a computer package can enable the scheduler to make fundamental changes to existing routes to allow late or urgent orders to be planned into the schedule whilst the computer checks for any implications (missed delivery windows, legal infringements, etc).

The manual exercise described earlier was also carried out using a computer software package, and the output and results are shown here. This includes extremely detailed vehicle routes that indicate the precise order of delivery drops, the locations, the drop sizes, summary results (see Figure 26.6), visual maps of the trips (see Figure 26.7), bar charts to show route summaries (see Figure 26.8), etc. The visual output makes it much easier to interpret and understand the results, and the detailed delivery schedules can be used by the drivers.

Some of the main routeing and scheduling packages are shown in Table 26.2. Additional information on these and other packages can be found in several annual guides to logistics software. Some of the advantages claimed for computerized vehicle routeing and scheduling systems are as follows:



Route No.	Trip No.	No. of Calls	Distance (Mls)	Duty Time	Delivery Weight	Delivery Wt. Util	Delivery Vol. Util	Vehicle Group Name
1	1	3	86	3:06	578	82.6	0.0	16T
1	2	1	47	1:57	300	42.9	0.0	16T
2	1	5	110	7:14	1,935	92.1	0.0	32T
2	2	1	32	2:48	1,950	92.9	0.0	32T
3	1	8	150	9:09	1,855	88.3	0.0	32T
4	1	7	122	8:41	1,520	72.4	0.0	32T
4	6	25	547	32:55	8,138	78.5	0.0	

Figure 26.6 Summary results of Paragon run (courtesy of Paragon Software Systems, www.paragon-software.co.uk)

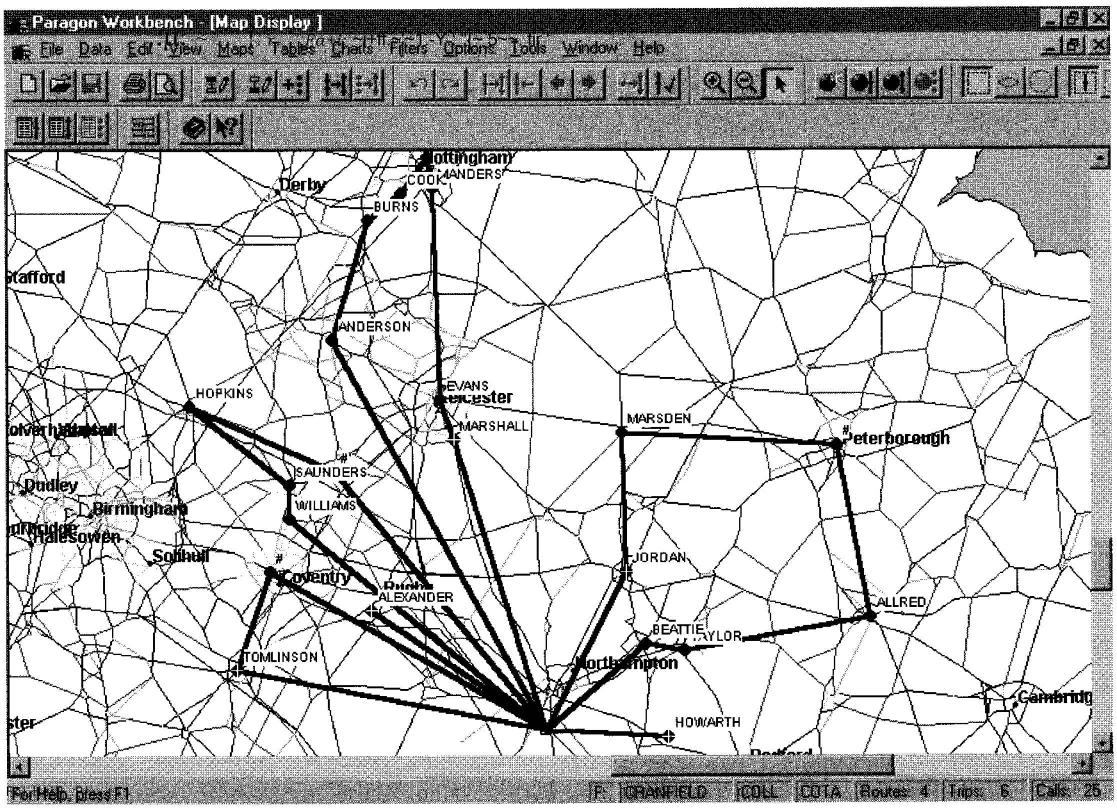


Figure 26.7 Map showing final routes

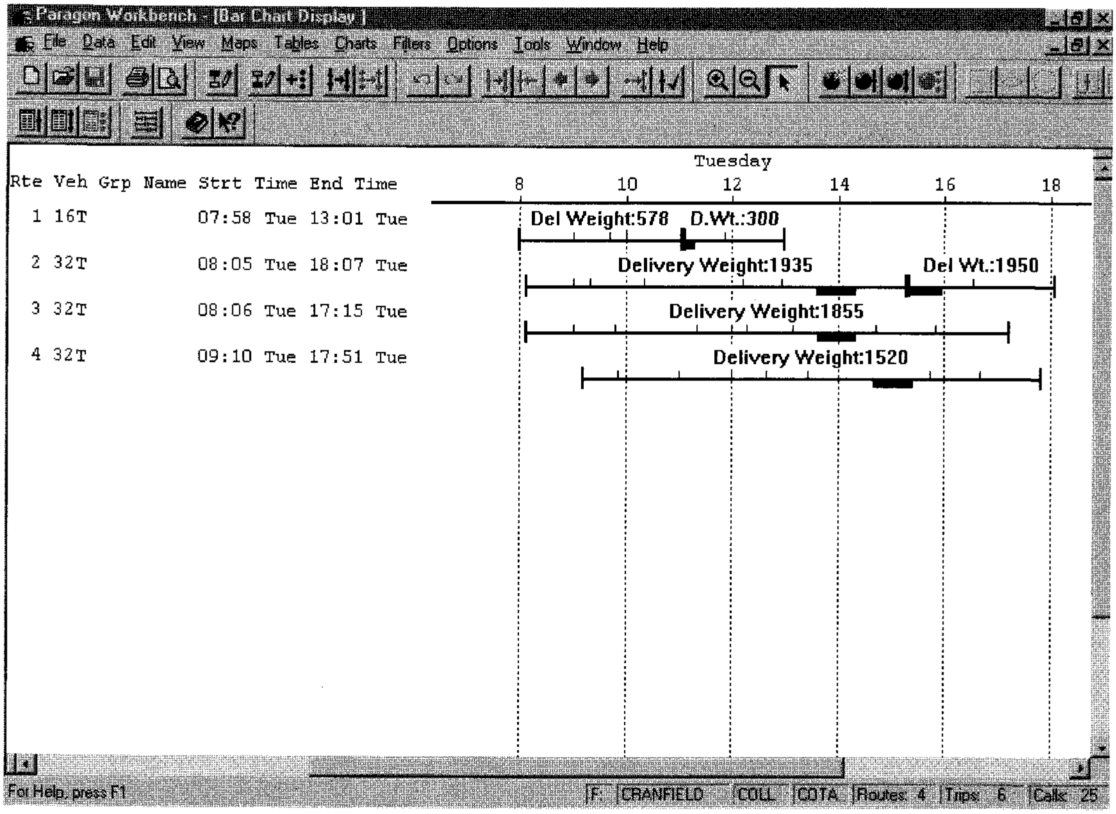


Figure 26.8 Bar charts showing the recommended routes (courtesy of Paragon Software Systems, www.paragon-software.co.uk)

- decreased standing costs as the vehicle establishment can be minimized;
- decreased running costs as efficient routeing reduces mileage;
- less need to hire in vehicles;
- increased customer service through consistent and reliable schedules;
- less chance of breaking transport regulations through the ability to program in legislative constraints;
- savings in management time as schedules can be calculated quickly;
- an increased level of control because more accurate management reporting is possible.

Table 26.2 Major vehicle routeing and scheduling packages

Name	Company	First Developed	Country	Website
Logixcentral	DPS International	1982	UK	www.logixcentral.com
Optrak 4	Optrak Distribution Ltd	1992	UK	www.optrak.co.uk
Route Planning	Advanced Planning Systems	1999	UK	www.apsystems.com
Paragon Routing and Scheduling System	Paragon Software Systems	1979	UK	www.paragonrouting.com
Routemate	Nemsys	n/a	Italy	www.nemsys.it
Logisplan	Advantur Technologies	1990	Spain	www.advantur.com
Trandos	P-E International	1983	USA	www.p-einternational.com
Roadshow	Descartes	1987	USA	www.descartes.com
Truckstops	Kingswood	1983	USA	www.mapmechanics.com

Source: Transportweb.com and associated websites (2005)

OTHER INFORMATION SYSTEM APPLICATIONS

There are other types of road freight transport planning undertaken using different computer hardware and software. One example is for *single vehicle routeing* - these computer packages use the very detailed computerized road databases that are found in most routeing and scheduling software. However, they do not undertake the scheduling element. By indicating origin and destination points and any intervening points to be visited on the route, the program will construct routes based on the real road network. Routes can be determined on the basis of shortest, quickest, cheapest, etc. Very detailed parameters can be user-input, such as road speeds, costs, etc. Output is provided by a detailed description of the route, giving instructions on when to change from one road to another, together with the times and distances between these road links. As with routeing and scheduling packages, these packages provide colour screen maps of the chosen routes, enabling visual comparisons to be made.

In recent years, there have been substantial developments in a variety of in-vehicle intelligent transport systems, of which the major subsection is *telematics*. Telematics systems help to support sustainable mobility and distribution by providing tools and mechanisms to enable improved network management, safer vehicles and more effective driver utilization. Many of these have both planning and operational benefits for road freight transport. The main usage includes:

- Driver and vehicle performance data, enabling reduced fuel consumption through the monitoring of fuel consumption rates and driver performance. Also, maintenance costs may be reduced through improvements in driving techniques.
- Vehicle tracking systems whereby a vehicle's geographic position can be moni tored using global positioning systems (GPS). These can provide a variety of different benefits, from improved vehicle, load and driver security to better customer service, with the provision of accurate delivery times to lower costs through reduced waiting and standing time as exact vehicle arrival times are available.
- Trailer tracking allows for vehicles and their loads to be monitored in real time using satellite GPS technology. This can be particularly beneficial for the security of vehicles, drivers and loads - many of which can be high-value. Trailers can be tracked automatically, and 'red flag' warnings can be issued if there is any divergence from set routes. In addition, these systems can be used for consignment tracking to provide service information concerning delivery times, and load temperature tracking for refrigerated vehicles so that crucial temperature changes can be monitored and recorded - essential for some food chain and pharmaceutical products.
- In-cab/mobile terminals enable paperless invoicing and proof of delivery. These are used by parcels and home delivery operators, based on electronic signature recognition, and also by fuel companies for the immediate invoicing of deliveries where delivery quantities may be variable.
- On-board navigation systems are common in many private cars, but are also used in many commercial vehicles. They can provide driver guidance to post-codes and addresses - very beneficial for multi-drop delivery operations where the final customer location may be new or unfamiliar. They can result in significant savings in time, fuel consumption and re-delivery and can, of course, greatly improve customer service.
- Linked with on-board navigation systems are traffic information systems. These provide real-time warnings of traffic congestion and road accidents, allowing drivers to avoid these problem areas and considerably reduce delays and the associated additional costs. In tandem with routeing and scheduling software, this information can be used to enable the immediate rescheduling of deliveries and re-routeing of vehicles.

Understandably, these systems can be expensive, but for many large fleets and operations the cost saving and improved service make a compelling case for their adoption.

SUMMARY

In this chapter the emphasis has been on the means of undertaking planning and resourcing for road freight transport. The reasons for this were outlined at the outset.

The importance of the careful planning of road freight transport operations was explained, with a description of the range of different transport components of logistics - assets, service, costs, etc. Planning and resourcing of these can be addressed through the use of various fleet management software packages and also through the use of vehicle routeing and scheduling packages.

Also important was the recognition that road freight transport operations can be broken down into two main types - primary and secondary transport - and that these should be considered quite separately for both planning and operational purposes.

The prerequisite for successful fleet resourcing is to identify, understand and analyse the basic detailed work requirements for the fleet, hence the use of routeing and scheduling techniques. It was shown that routeing and scheduling problems can be categorized in four different ways:

1. strategic;
2. tactical or operational;
3. interactive;
4. planning.

As well as the basic demand data, routeing and scheduling require data that reflect the different characteristics of road transport delivery. The major data requirements were identified as:

- demand data;
- distance factors;
- customer and service constraints;
- vehicle restrictions;
- driver constraints;

- route factors;
- product or unit load constraints.

A daily (manual) scheduling system was described, and then a manual approach to scheduling for strategic purposes was outlined. A particular approach to manual routeing and scheduling was used as an example. Finally, an identical analysis was undertaken using a computer package, and these results were reviewed. The basic steps were as follows:

- Establish delivery data and parameters.
- Determine geographic area.
- Determine demand.
- Determine customer constraints.
- Allocate demand to the geographic area.
- Determine the geographic transport 'rules'.
- Plan trips.
- Plan routes.
- Calculate vehicle requirements and mileage travelled.
- Calculate the delivery cost.
- Calculate vehicle utilization.

The use of a computer routeing and scheduling package was considered, and some typical output was reviewed. Finally, the main developments and uses of telematics in road freight transport were outlined.

Part 6

Operational management

27

Cost and performance monitoring

INTRODUCTION

Recent advances in information technology have focused attention on the importance of good information systems to support logistics and distribution activities. This requirement for information has always existed, but the computer has enabled the development of more sophisticated means of data storage, processing and presentation.

Information can be seen as the 'lifeblood' of a logistics and distribution system. Without the smooth flow and transfer of information, it is impossible for a distribution system to function adequately and effectively. To this end, it is important that a company develops an appropriate corporate strategy for its information requirements. This plan will need to take account of a number of different objectives, from strategic planning through to operational control.

A typical framework illustrating the planning and control cycle is shown in Figure 27.1 (introduced in Chapter 2). This framework emphasizes the cyclical nature of the planning and control process, starting with the question 'Where are we now?', where the aim is to provide a picture of the current status of an operation. This might be through an information feedback procedure and/or through the use of a distribution audit.

The second stage is to identify the objectives of the distribution process. These should be related to such elements as customer service requirements, marketing

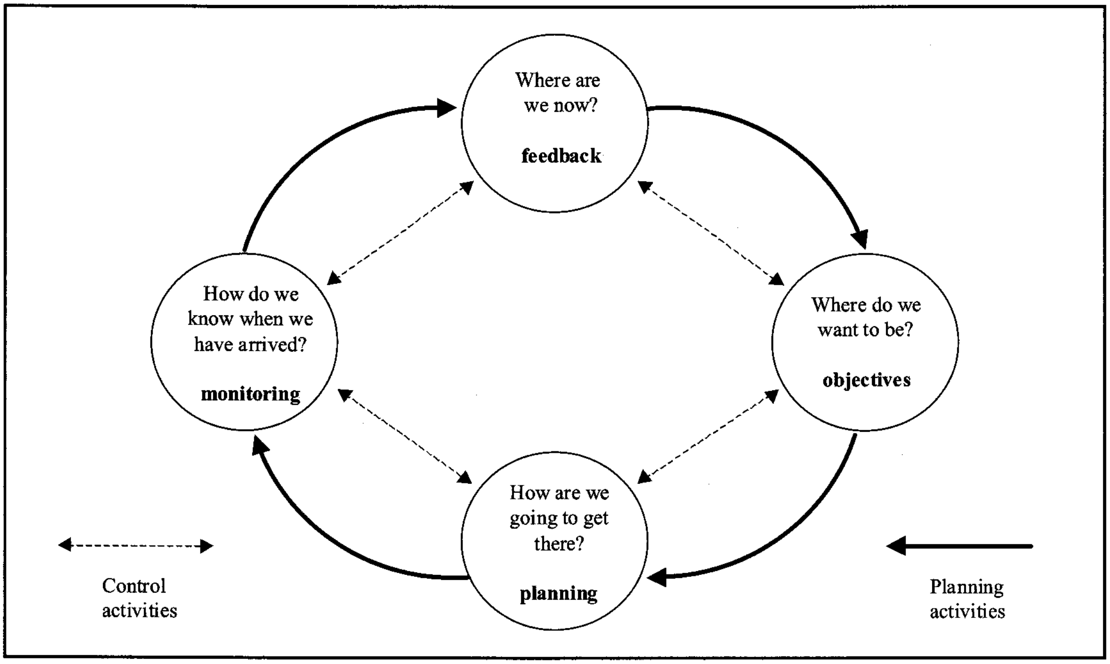


Figure 27.1 The planning and control cycle

decisions, etc. The third stage in the cycle is the process that includes the development of appropriate strategic and operational plans to achieve these objectives. Finally, there is a need for monitoring and control procedures to measure the effectiveness of the distribution operation compared to the plan. The cycle has then turned full circle and the process is ready to begin again. This emphasizes the dynamic nature of distribution, and the need for continual review and revision of plans, policies and their operations. This must be undertaken within a positive planning framework to ensure that continuity and progress are upheld.

This chapter begins with the consideration of the need to monitor logistics operations. The importance of identifying clear business objectives as the basis for setting up appropriate operational measures is emphasized. A formal approach for monitoring and control is outlined, and the major comparative standards are discussed. The basis for a simple operational planning and control system is outlined, and two specific approaches are described: the SCOR model (supply chain operations reference model) and the balanced scorecard.

Some key areas of good practice are considered. Although based on sound common sense, these factors are essential to the development of an effective monitoring system. In addition, several influencing factors are highlighted. These are used to help explain the differences that occur when systems are monitored for comparative purposes. Finally, a number of detailed and key cost and performance monitoring measures are described.

WHY MONITOR?

To establish an effective system for cost and performance monitoring and control there is a need to identify some overall guidelines or aims that the system is designed to fulfil. These are likely to reflect major business objectives as well as more detailed operational requirements. Thus, it is important to be aware of the role of logistics and distribution within the context of the company's own corporate objectives. It is also essential that the control system reflects the integrated nature of logistics within an organization.

Typical aims might be:

- To enable the achievement of current and future business objectives — where these are directly linked to associated logistics and distribution objectives.
- To facilitate the effective provision of logistics services, thus enabling checks to be made that the distribution operation is appropriate for the overall objectives ('doing the *right* thing').
- To enable the efficient operation of logistics resources, to ensure that the distribution operation is run as well as it can be ('doing the *thing* right').
- To support the planning and control of an operation, so that any information can be fed back to the process of planning and management.
- To provide measures that focus on the real outputs of the business — this enables action to be taken when the operations are not performing satisfactorily or when potential improvement to the operation can be identified. This will generally be linked to some form of productivity improvement or better use of resources.

In addition, some fairly specific objectives need to be identified that relate to the logistics operation itself. A major feature is likely to be to measure actual progress against a plan. Typically this will be to monitor the budget in a way that identifies if some change from plan has taken place but also to provide a usable indication of *why* actual performance or achievement does not reflect what was originally planned. Another feature may well be to highlight specific aspects or components of the system that need particular attention.

Care needs to be taken in identifying these broader objectives. They need to be meaningful. Examples that fail the test include:

- *'The aim for distribution is to minimize costs.'* Is this to be at the expense of customer service? There needs to be a clearly identified relationship between cost and service requirements.
- *'The level of service is "as soon as possible".'* What does this really mean? Are all orders treated as urgent?
- *'Everything is to be delivered on our own vehicles.'* Does this mean resourcing the fleet to cover peak demand all year round? This is almost certainly not a cost-effective approach for determining transport requirements.

An example of carefully prepared objectives comes from a manufacturer and distributor of soft drinks:

Overall objectives

To provide accurate, timely and useful information on distribution cost and operational performance to enable:

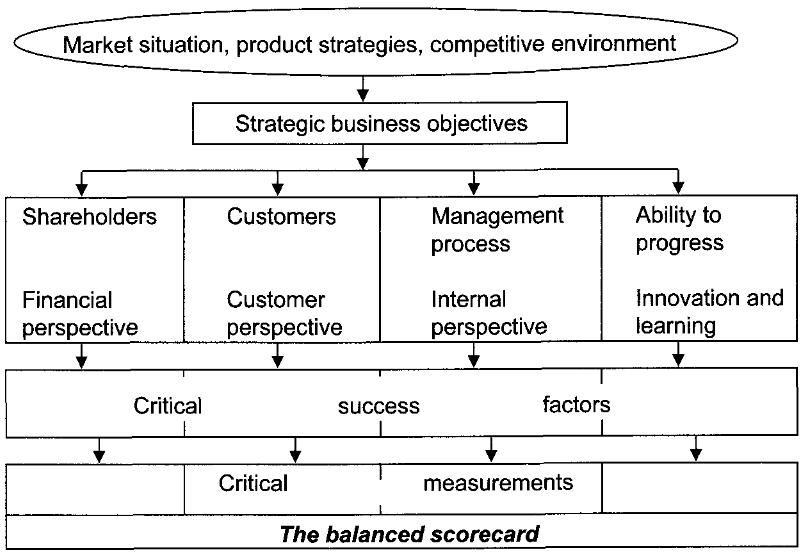
- the business to monitor progress towards set objectives at the total distribution level;
- the operational departments within distribution to measure their performance against their objectives and targets, and to make operational adjustments as necessary;
- the regular provision of information to other internal operations and functions to help assess wider trade-off opportunities;
- a solid database of information for use in strategic and operational planning.

Overall, the information must be quantitative and comparative wherever possible, relating to set objectives.

DIFFERENT APPROACHES TO COST AND PERFORMANCE MONITORING

The monitoring and control of logistics and distribution operations are often approached in a relatively unsophisticated and unplanned way. Control measures are adopted as problems arise, almost as a form of crisis management. It is important to adopt a more formal approach, although this should not necessitate a complicated format. There are several systematic approaches that have been developed with a varying degree of sophistication and detail. There are some very obvious similarities between these different approaches, as can be seen from the following descriptions.

The *balanced scorecard* was initially put forward by Kaplan and Norton in 1996. This is a broad business approach that translates the strategic mission of a business operation into tangible objectives and measures. Key performance indicators (KPIs) are developed to represent a balance between external measures for shareholders and customers, and internal measures of critical business processes, innovation and learning. This structure is shown in Figure 27.2.



Based on Kaplan and Norton (1996)

Figure 27.2 The balanced scorecard

The financial perspective concerns the relationship with shareholders and is aimed at improving profits and meeting financial targets. The customer perspective is designed to enhance customer relationships using better processes to keep existing customers and attract new ones. The internal element is to develop new ideas to improve and enhance operational competitiveness. Innovation and learning should

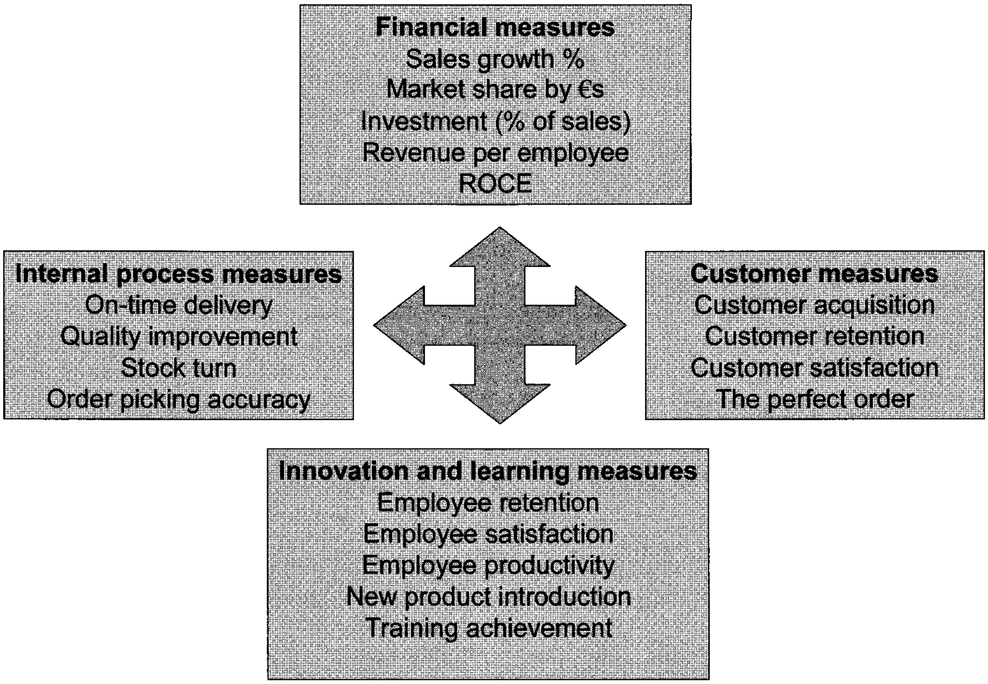


Figure 27.3 Balanced scorecard: typical measurements

help to generate new ideas and to respond to customer needs and developments. A series of critical success factors is identified that relate directly to the main business perspectives. These are then used as the basis for creating the critical cost and performance measurements that should be used regularly to monitor and control the business operation in all the key areas identified. Some typical measures are shown in Figure 27.3 under the appropriate scorecard categories.

The SCOR *model* (supply chain operations reference model) is an important approach that has been developed as an aid to cost and performance monitoring. It is a hierarchical model, consisting of four different levels: competitive advantage, strategy implementation and process definition, detailed process elements, and implementation. It is very much a process-oriented approach, where the initial aim is to benchmark, refine and improve key operational processes, and then to identify and introduce key measures that monitor set cost and performance targets. Eventually, the major company performance attributes are identified and the appropriate metrics are developed. A typical example of this performance metric development is shown in Figure 27.4.

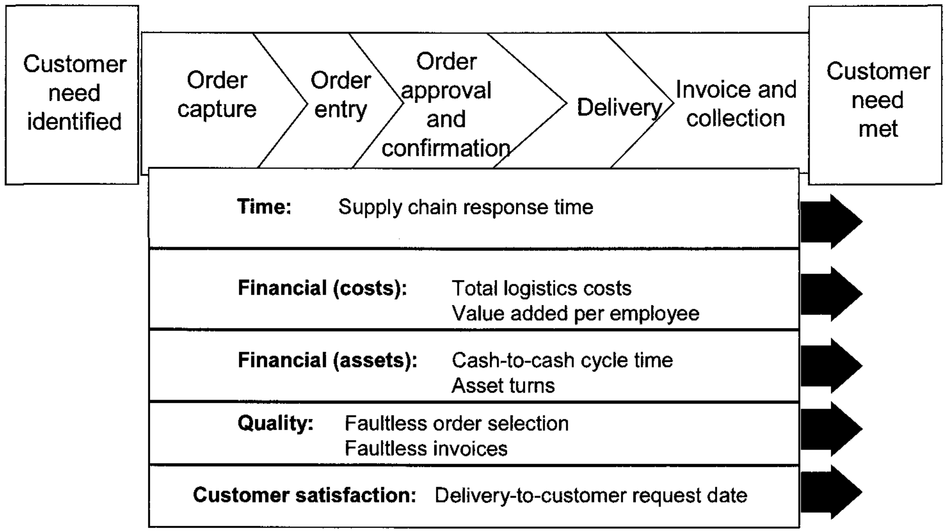
Performance attributes	Attribute definition	Metrics
Supply chain delivery reliability	The performance of the supply chain in delivering against the perfect delivery criteria	Delivery performance Picking accuracy Perfect order fulfilment
Supply chain responsiveness	The speed at which the supply chain provides products to the customer	Order fulfilment lead time Ease of order placement
Supply chain flexibility	The agility of the supply chain in responding to marketplace changes to gain or maintain competitive edge	Supply chain response time Production flexibility
Supply chain costs	The costs associated with operating the supply chain	Cost of goods sold Supply chain management costs Value added productivity
Supply chain asset management	The ability to manage assets to support customer satisfaction	Capacity utilization Equipment utilization

Figure 27.4 SCOR: typical performance metric development

SCOR metrics are generally arranged under a number of categorizations. There are many different individual measures that come under the different categories. The main categories are:

- *assets* (such as capacity utilization, equipment availability);
- *cost* (inventory holding, invoicing);
- *data* (forecast accuracy, visibility);
- *flexibility* (order, returns);
- *inventory* (availability, obsolescence);
- *orders* (fulfilment accuracy, invoice errors);
- *productivity* (direct versus indirect labour, vehicle subcontracting);
- *time* (order cycle time, on-time delivery).

An *integrated supply chain* approach can be used. This recognizes that a total systems approach can be adopted for the whole business or supply chain and that any performance metrics should be developed on this basis. This, again, is a process-



Source: from PRTM Study

Figure 27.5 Integrated supply chain metrics

oriented approach that attempts to enable cost and performance monitoring to be based on a horizontal view of a business rather than the traditional, vertical, silo-based functional structure that is traditionally used. See Chapter 9 for a related discussion. This approach to the development of supply chain metrics is outlined in Figure 27.5.

This type of framework can be used initially to help to identify required outcomes that need to be measured, and then subsequently for establishing any relevant diagnostic measures. Suitable and accurate diagnostic measures are essential to enable the reasons for any problems to be identified and then rectified. This is a vital element of good cost and performance monitoring that is often neglected. Some examples are indicated in Figure 27.6.

A simple and straightforward *operational approach is* sometimes the most appropriate to follow for small to medium-size companies. This is as follows:

1. Determine the scope of logistics activities.
2. Identify the organization and departmental objectives.
3. Determine operating principles and methods.
4. Set productivity and performance goals (using standards, etc).

Metric type	Outcomes	Diagnostics
Customer satisfaction/ quality	Perfect order fulfilment Customer satisfaction Product quality	Delivery-to-commit date Warranty costs, returns and allowances Customer enquiry response time
Time	Order fulfilment lead time	Source/make cycle time Supply chain response time Production plan achievement
Costs	Total supply chain costs	Value added productivity
Assets	Cash-to-cash cycle time Inventory days of supply Asset performance	Forecast accuracy Inventory obsolescence Capacity utilization

Source: from PRIM Study

Figure 27.6 Integrated supply chain metric framework

5. Measure and monitor performance (develop MIS).
6. Take corrective action if necessary.

The *scope* of distribution and logistics activities will, of course, vary from one company to another, as will the extent of integration. Because of this, it is impossible to identify a standard system that can be adopted generally. A company must first determine the scope of activities that need to be considered, taking into account the overall logistics requirements and objectives as well as the traditional components of the functional subsystems (primary transport (line-haul), distribution centre operations, local delivery, etc).

More detailed *departmental objectives* should be defined. These will include such areas as stock-holding policies by individual line or product group, customer service levels by product, by customer type or by geographical area, delivery transport costs, utilization and performance, etc.

Operating principles and methods need to be clarified with respect to the different logistics components, such as primary transport (line-haul) and delivery transport, warehousing resources and usage, together with implications for seasonality, etc. These factors will provide the basis for establishing realistic and relevant measures.

Productivity and performance goals should then be set in relation to the detailed operational tasks that are performed and with respect to the overall output requirements for the integrated logistics system as a whole. These should cover all the essential aspects of the physical distribution system. It is often easier to categorize these under the major subsystems of warehousing (order picking performance, labour utilization, cost per case, etc), transport (vehicle utilization, cost per mile/kilometre, fuel consumption, etc) and administration/stock-holding (customer orders received, stock-outs, percentage of orders fulfilled, etc).

Goals should be set based on some acceptable standards or comparative information. There are several different approaches used by organizations, and these are discussed below. They include:

- measuring cost and performance against historical data;
- measuring against a budget plan;
- developing physical or engineered standards;
- using industry standards;
- benchmarking against 'best practice'.

Finally, *key indices and ratios* need to be developed to allow for appropriate monitoring and control to be undertaken (eg actual work against planned work, cost per case, cases per hour, tonnes per journey, etc). These need to be representative of the distribution operation, and they should be capable of clearly identifying why a deviation has occurred as well as if a deviation has occurred.

WHAT TO MEASURE AGAINST?

As already indicated, there are a number of different approaches that can be adopted to determine appropriate goals. These range in sophistication from very simplistic internal year-on-year comparisons to quite detailed externally related engineered standards. Most well-developed systems are internally budget-oriented, but are also linked to external performance measures.

Historical data

Systems that merely compare overall activity costs on a period-by-period basis may not be providing any useful information that can be used to monitor operational performance. As an example, a measure may indicate that the cost of distribution for a company has reduced as a percentage of total revenue for this year compared to last year. Without any background to this measure it is impossible to be sure whether or not this is an improvement *in terms of distribution performance*.

Budget

Almost all companies will have a budget plan, and this should include a breakdown of the logistics costs in appropriate detail - an activity budget. A traditional means of monitoring an operation is, therefore, to evaluate the cost of the logistics operation in relation to the expectations of the budget plan.

The budget approach has been developed in a variety of ways to enable more sophisticated and more meaningful measures to be created. The *'activity' concept* means that the budget - and the respective measurement process - can identify and differentiate between functional activities (warehouse, transport, etc) and, more importantly, across core business-oriented activities. This might, for example, be by product group or by major customer, thus allowing for very detailed measurements reflecting the integrated nature of the logistics activities under scrutiny.

An additional development is the concept of *flexible budgeting*, which recognizes one of the key issues of monitoring - the need to be able to identify and take account of any changes in business volumes. This is particularly important in the logistics environment, where any reductions in volume throughput can lead to the underperformance of resources. The concept is based on the premise that budgets are put together with respect to a planned level of activity. The fixed, semi-variable and variable costs appropriate to that level of activity are identified and form the basis of the budget. If activity levels fluctuate, then the planned budget is flexed to correspond with the new conditions. Thus, semi-variable and variable costs are adjusted for the change. In this way the change in cost relationships that results from a change in the level of activity is taken into account automatically, and any other differences between planned and actual cost performance can be identified as either performance or price changes.

This approach is particularly applicable to logistics activities, as there is very often a high fixed cost element, and any reduction in levels of activity can increase unit costs quite significantly. With a fixed (ie non-flexible) budget system it can be difficult to identify the essential reasons for a large variance. To what extent is there a controllable inefficiency in the system, and to what extent is there under-utilization of resources due to falling activity? A typical example is the effect that a reduction in demand (throughput) can have on order picking performance and thus unit cost. A flexible budget will take account of the volume change and adjust the original budget accordingly.

Finally, an effective budget measurement system will incorporate the idea of *variance analysis*. In the context of logistics activities, variance analysis allows for the easier identification of problem areas as well as providing an indication of the extent of that variance, helping the decision process of whether or not management time should be assigned to solving that particular problem. As indicated earlier, an effective system will indicate if a variance has occurred, the extent of that variance and also why it has occurred with respect to performance/efficiency change or price/cost change (or a mixture of both). Variance analysis is best used within the context of a flexible budget, because the flexible budget automatically takes account of changes in activity.

Engineered standards

A number of companies use internally derived measures for certain logistics activities through the development of engineered standards. This involves the identification of detailed measures for set tasks and operations. The means of determining these measures is a lengthy and often costly process involving the use of time and work study techniques.

When suitable and acceptable standards have been agreed for specific tasks, then a performance monitoring system can be adjusted to allow for direct measurement of actual performance against expected or planned performance. The advantage of using engineered standards is that each task is measured against an acceptable base. A monitoring system that measures against past experience alone may be able to identify improved (or reduced) performance, but it is always possible that the initial measure was not a particularly efficient performance on which to base subsequent comparisons.

Apart from cost, a potential drawback with engineered standards is that the initial time or work study data collection is difficult to verify. There is no certainty that an operative who is under scrutiny will perform naturally or realistically (whether consciously or subconsciously).

Many logistics tasks do lend themselves to the application of engineered standards. Most warehousing activities fall into this category (goods receiving, pallet put-away, order picking, etc), as well as driver-related activities (vehicle loading, miles/kilometres travelled, fixed and variable unloading). An outline example is given below:

Developing standards for delivery transport: an example
Standard costs can be related to measured or standard times. These should cover the three main operations:

1. running/driving time (speeds related to road types);
2. selection and delivery time (fixed and variable);
3. distribution centre/loading time.

Standard time journeys can then be built up. These can be incorporated with standard costs to give a standard cost per minute. Thus, the planned performance and actual performance are linked, and variance analysis can be undertaken. This provides for a stronger system of control.

External standards and benchmarking

Another approach to cost and performance measurement is to make comparisons against industry norms. The intention here is that a company's performance can be compared to similar external operations and standards, making comparison more realistic and therefore more valuable. For some industries, such as grocery retailing, these measures are fairly readily accessible through industry journals and associations. Examples of typical measures include order picking performance (cases per hour), delivery cases per journey, etc.

A further development to this is the idea of 'benchmarking'. Here, the aim is to identify appropriate 'world-class' or 'best-in-class' standards across a whole range of different organizations and operations. This enables a company's performance to be compared with the very best in any industry. It is a broader concept than merely identifying variations in performance, the intention being to identify the reasons why a certain operation is the best and to establish ways and means of emulating the operation. A number of 'benchmarking' clubs have been formed to this end (see Chapter 28).

AN OPERATIONAL PLANNING AND CONTROL SYSTEM

The budget should be used as the basis for providing quantitative objectives for the relevant elements to be monitored within the logistics operation. Linked to this should be any appropriate internal (engineered) or external standards that are deemed to be important measures of the business.

The operating plan should be drawn up based on the above factors to indicate the operational parameters or cost centres. This will show how costs are to be split by period (week or month), by functional element (eg fuel or wages), by logistics component (storage, local delivery, etc) and by activity (major customer, product group, etc). The plan should also show which key business performance indicators

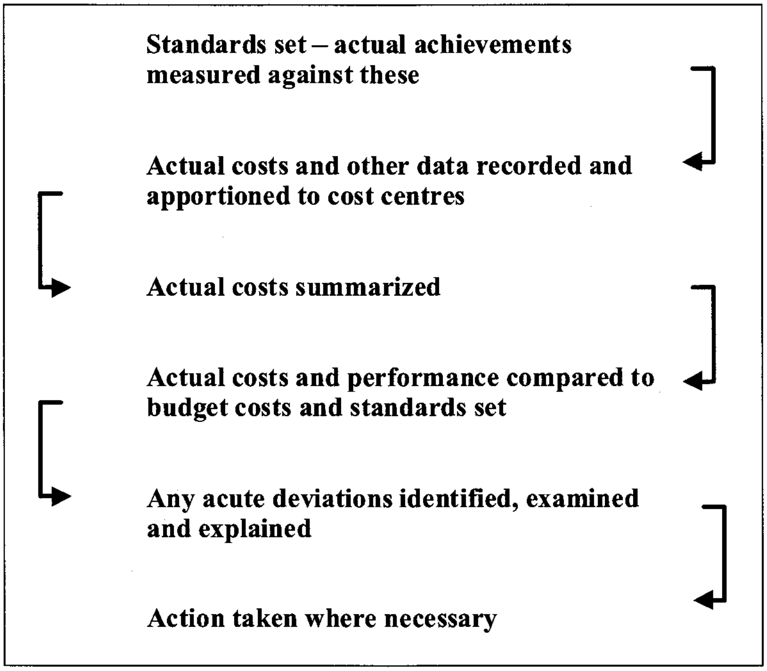


Figure 27.7 An operating control system

are to be used (eg tonne/miles or kilometres delivered, etc) and demonstrate how they are linked to set standards.

The operating control system involves the process of identifying whether the operating plan has been adhered to - what deviations have occurred and why - so that remedial action can be speedily taken. Figure 27.7 outlines this process.

In measuring these deviations, it is important to be aware of three major causes of deviation. These are:

1. changes in the levels of activity (ie less work is available for a fixed capacity - labour or equipment);
2. changes in efficiency or performance (ie the resource, labour or equipment has not performed as expected);
3. changes in price (ie the price of an item, say fuel, has increased so costs will increase).

Activity level changes can, of course, be taken into account by the use of flexible budgets.

Key indices and ratios need to be developed to allow for appropriate monitoring and control to be undertaken (eg actual work against planned work, cost per case, cases per hour, tonnes per journey, etc). These need to be representative of the distribution operation, and they should be capable of clearly identifying why a deviation has occurred as well as if a deviation has occurred.

GOOD PRACTICE

There are a number of key areas of 'good practice' that need to be considered when developing the detail of an effective cost and performance monitoring and control system. These are all fairly straightforward but bear discussion. They can be broadly categorized as:

- principles;
- content;
- output.

Most of the main *principles* associated with an effective system are based on sound common sense. They can be used to provide distinct guidelines for the development of an appropriate new control system as well as to help identify reasons why an existing system is not functioning satisfactorily. They include:

- *Accuracy*. The basic input data to the system must be correct. Inaccurate data will obviously produce incorrect measures, but will also undermine confidence in the system as a whole.
- *Validity/completeness*. The measures used must reflect a particular activity in an appropriate way, and must cover all the aspects concerned. For example, a broad carton-per-hour measure for order picking is clearly inappropriate if there is a substantial element of full pallet picking or broken case picking.
- *Hierarchy of needs*. Individuals within an organization require only certain pieces of information. To swamp them with unnecessary information is expensive and may diminish the usefulness of an information system. Typically, the higher the level of personnel within an organization, the more general or more aggregate is the information required. Figure 27.8 indicates this hierarchy, illustrating the relationship between what might be termed as command information and feedback/control information.
- *Targeting of the correct audience*. Linked very much to the previous point is the need to ensure that the correct audience is identified and that all the key information is then directed to this audience.

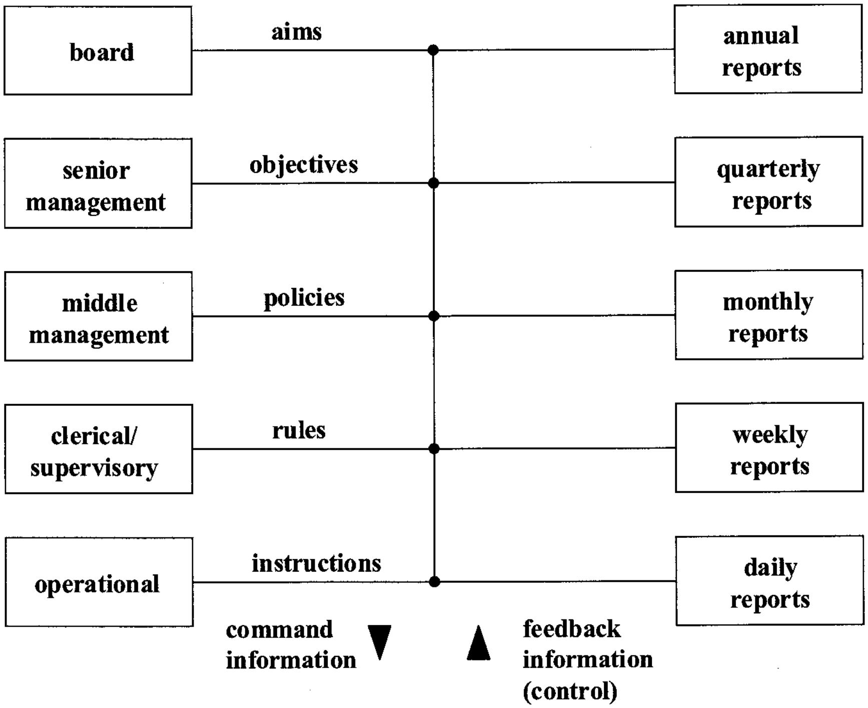


Figure 27.8 Hierarchy of needs showing the different information requirements at the different levels of an organization

- *User ownership.* The fault of many an information system is to impose information on individuals without first including them in the process of identifying and determining information requirements. This can be very demotivating. It is a very valid step to include potential users at the systems design stage, thus conferring user ownership of the information when the system is in place. The information should be useful, and those who use the information should understand the detail.
- *Reactivity to changes in business activity.* Not a simple requirement to put into practice, but an effective control system will need to be dynamic and so take account of any changes in business activity. To a certain extent this is achieved through flexible budgeting.
- *Timeliness.* Reports must be available at the agreed time, and the frequency of reports should be such that suitable control action can be taken.

- *Ease of maintenance*. A fairly obvious comment is that an effective system must not be overly complicated to maintain and progress. Simplicity is certainly a virtue.
- *Cost-effectiveness*. Again, a fairly obvious but very relevant point is that a monitoring system should not cost more to set up and run than can possibly be saved through using the system.

The elements of good practice that come under the category of *content* have almost all been covered in previous sections, and they are as follows:

- the need for clear cost categories, with careful identification of fixed and variable costs;
- the use of flexible budgeting;
- the use of variance analysis;
- the clarification of controllable and non-controllable elements;
- the use of reference points against which the monitored elements can be measured – these might include:
  budget;
  – forecast;
  – trends;
  – targets;
  comparative league tables.
  (The final two factors are useful for monitoring contractor operations and for setting up inter-site comparisons.)

The final aspect of good practice concerns the type of *output* that the system produces. This is the information on which any form of action is based. It has already been emphasized that this information must be relevant and useful. The major output characteristics are:

- Reports can vary. They may be:
  summary (providing key statistics only);
  exception (identifying the major deviations from plan);
  detailed (including all information).
- Reports should be made to a standard format – especially important where any inter-site comparisons are to be made.
- Data should be presented in whatever means is most appropriate to the eventual use of the data.

Different types of data output are as follows:

- *trend data* - based upon moving annual totals to identify long-term changes;
- *comparative data:*
  data analysis over *a short period* (eg this month against last month),
  data analysed against a *target* (eg this month compared with budget),
  data analysed against a *measured standard* (eg this month compared with standard),
  comparative data analysis *also* identifies *variances* that indicate the degree of performance success;
- *indices* - data in statistical form compared with a base position over time;
- *ratio* - a combination of two or more pieces of meaningful data to form a useful figure for comparison;
- *graphs* - comparative trends in pictorial form.

What do companies see as being the most valuable characteristics of a good monitoring system? The example outlined below provides an indication:

> An international manufacturer and supplier of computer equipment identified the need for a more adequate information system for monitoring and controlling performance in its three warehouses. The company set up a project team to investigate these requirements, and produced some interesting output.
>
> Five key areas for measurement were identified:
>
> *1. Volume* - what is moving through the warehouse?
> *2. Efficiency* - how well is the operation being run?
> *3. Cost-effectiveness* - *is* the cost reflecting the work being undertaken?
> *4. Quality* - how well are the service levels being met?
> *5. Stability* - what does the staff turnover picture look like?
>
> Outline requirements were:
>
> - overall business control;
> - activity measures within the business area;
> - trend indicators and productivity measures.

Factors for consideration were:

- *Action* — the system should lead to a change in the current position, and should be used.
- *Confusion* — the system should filter out the irrelevant information that confuses and diverts attention.
- *Comprehensibility* — everyone who receives information must understand it.
- *Defensiveness* — the defence reaction to figures, especially adverse ones, needs to be overcome.
- *Timeliness* — the information has to be available in sufficient time for action to be taken.
- *Validity* — actual changes in performance must be reflected by the system.
- *Dynamism* — the system must be sensitive to the changing internal and external conditions, as tomorrow's problems cannot be solved with yesterday's measurement system.

INFLUENCING FACTORS

Many monitoring systems are developed with a view to using them to enable comparisons to be made between different distribution centres. Some companies will do this across their own operations. It is also common practice for some of the major users of dedicated contract operations to compare how well one contractor is performing against the others.

If this is the major use of a monitoring system, then *it is essential that there is a broad understanding of any different operational factors that might influence the apparent effectiveness or efficiency of one operation compared to another.* Thus, a number of operational influencing variables can be identified, and may need to be measured, to enable suitable conclusions to be drawn and explanations given for any comparative assessments.

Any number of these may be relevant, but typical examples are:

- *throughput variability* (by day) — this is likely to affect labour and equipment utilization;
- *product profile* — some products are more difficult to select or handle than others;
- *order profile* — orders with many line items take longer to pick than single line orders;

- *store profile* – sites serving mainly small stores may expect to have less efficient picking operations than those serving large stores;
- *store returns* – this will influence workloads;
- *special projects* (promotions, alternative unitization) – these will create additional work;
- *equipment specification* – specialized equipment may be essential but also underutilized;
- *regional distribution centre* (RDC) design (building shape, mezzanines);
- *employee bonus schemes* – these may influence picking rates;
- *methods* – different operational methods (such as secondary sortation) will influence productivity;
- *local labour market* – staff quality, need for training, etc;
- *regional cost variations* – labour, rent, rates, etc;
- *staff agreements* – some, such as guaranteed hours, can affect productivity and utilization figures;
- *unit definitions* – 'case' sizes and types may be very different at different sites.

DETAILED AND KEY MEASURES

For most logistics operations it is possible to identify certain key measures that provide an appropriate summary measurement of the operation as a whole and of the major elements of the operation. These are very often called key performance indicators (KPIs). Detailed measurements are likely to differ from one company to another, depending on the nature of the business.

Measures are generally aimed at providing an indication of the performance of individual elements within an operation as well as their cost-effectiveness. In addition, the overall performance or output is often measured, particularly with respect to the service provided, the total system cost and the return on capital investment.

KPIs can be categorized in a number of different ways, but an effective measurement system will cover all of the major operational areas within a business. A typical categorization might be:

- *financial KPIs:* return on investment (ROI), return on capital employed (ROCE), stock turn;
- *customer KPIs:* new customers, lost customers, on time in full (OTIF);
- *sales KPIs:* total volume, total value, sales per customer;
- *process KPIs:* productivity, efficiency;

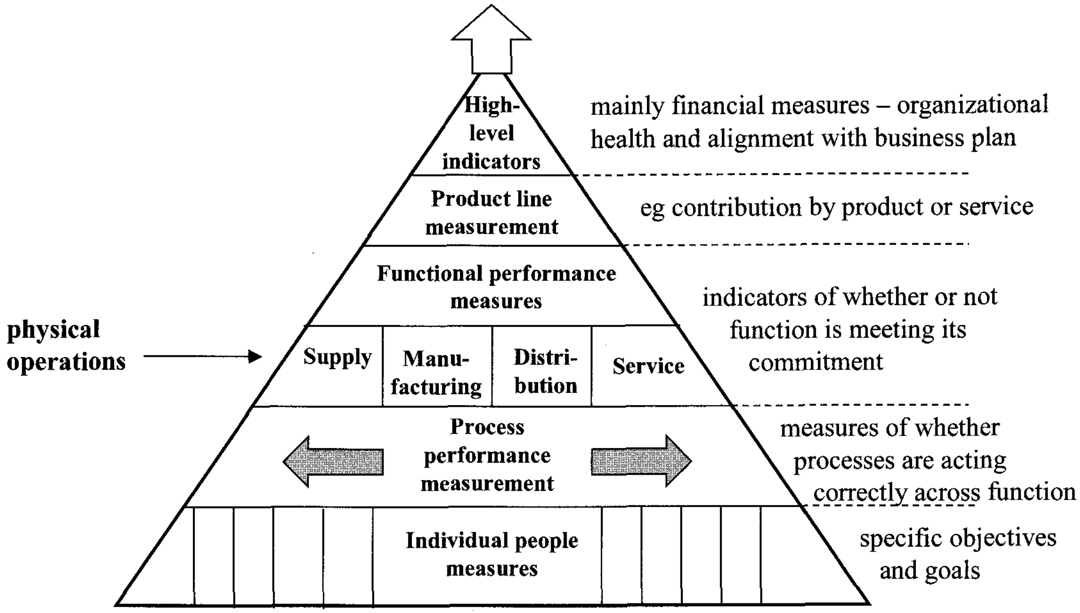


Figure 27.9 Hierarchical structure of a measurement system used by a household goods manufacturer

- *people KPIs:* labour turnover, training, average length of service;
- *supplier KPIs:* OTIF, cost per piece.

It is also worth re-emphasizing the importance of hierarchy in a performance measurement system. Figure 27.9 shows how a manufacturer of household products uses a hierarchical model to drill down to the much more detailed measures that are used to assess the more detailed operational aspects of its business.

Typical detailed and key operational measures are summarized in three different case examples. These cover customer service requirements, a multi-site delivery transport operation and a warehouse operation. Both the transport and the warehouse examples indicate adherence to the principle of the hierarchical nature of information requirements. Also, see Chapter 3 for customer service measurements.

Example 1

For a supplier of consumables, major customer service measurements are:

- percentage of orders satisfied in full;

- percentage of items supplied at first demand;
- percentage of overdue orders;
- number of stock-outs;
- orders delivered within set lead times;
- percentage of deliveries outside fixed delivery windows/times.

Example 2

For a grocery multiple retailer, measures are designed to assess the performance of the delivery transport system. They are aimed at measuring the cost-effectiveness of the operation and also the quality of service. Note the hierarchical approach and also that there are no cost-related measures at the lowest level. The levels and associated measures are:

- director/head office (strategic planning and control):
  - ROCE,
  - cost per case (divisional),
    cost per vehicle (divisional),
  - cost per value of goods delivered,
    cost as a percentage of company sales;
- site managers (management control):
  - cost per mile or kilometre,
    cost per vehicle,
  - cost per roll pallet,
  - average earnings per driver,
  - maximum earnings per driver,
  - maintenance costs per vehicle;
- transport manager (operational control):
    cost per mile or kilometre,
    cost per case,
  - cost per vehicle,
  - cost per roll pallet,
  - cost per journey,
    roll pallets per journey,
  - journeys per vehicle,
  - damage repairs per vehicle,
    miles (kilometres) per gallon (litre) per vehicle,
  - damages in transit and cases delivered,
    percentage cases out of temperature,
    percentage journeys out of schedule;

- supervisors:
  - overtime hours as percentage of hours worked,
  - contract vehicles as percentage of vehicles,
  - percentage of vehicles off the road,
  - percentage of drivers absent,
  - percentage vehicle fill,
  - percentage of vehicles over weight,
  - percentage of breakdowns,
  - average hours worked per driver.

Example 3
These are the information requirements for a fast-moving consumer goods (FMCG) manufacturer and supplier at three levels, related to the company's warehouse operations in terms of performance measurements and operating ratios:

- CEO:
  - profit,
  - return on investment,
  - growth,
  - stock turnover,
  - distribution cost,
  - sales value;
- distribution director:
  - service achievement,
  - cost-effectiveness,
  - capital employed,
  - stock turnover by site,
  - storage cost per unit,
  - warehouse handling cost per unit,
  - overall labour efficiency;
- warehouse manager:
  - inventory level, stock availability, operating cost, operating productivity,
  - actual hours,
  - standard hours (stock receiving and location, order picking, packing, dispatch),

- warehouse cost per unit (order),
- stock turnover.

A good cost and performance monitoring system will cover all of the major elements of a business operation, but, aside from the importance of the accuracy of the data, it will only be effective if it is presented in a usable and clear format. A number of companies have developed very visual output to try to achieve this. Figure 27.10 shows a measurement dashboard that represents the output data very visually. The main KPI is that of order fulfilment. This order fulfilment measure is calculated from a number of supporting measures that are also visually represented. Thus, any underachievement in the overall order fulfilment measure can easily be compared to the supporting measures to identify where the problems have occurred so that remedial action can be taken.

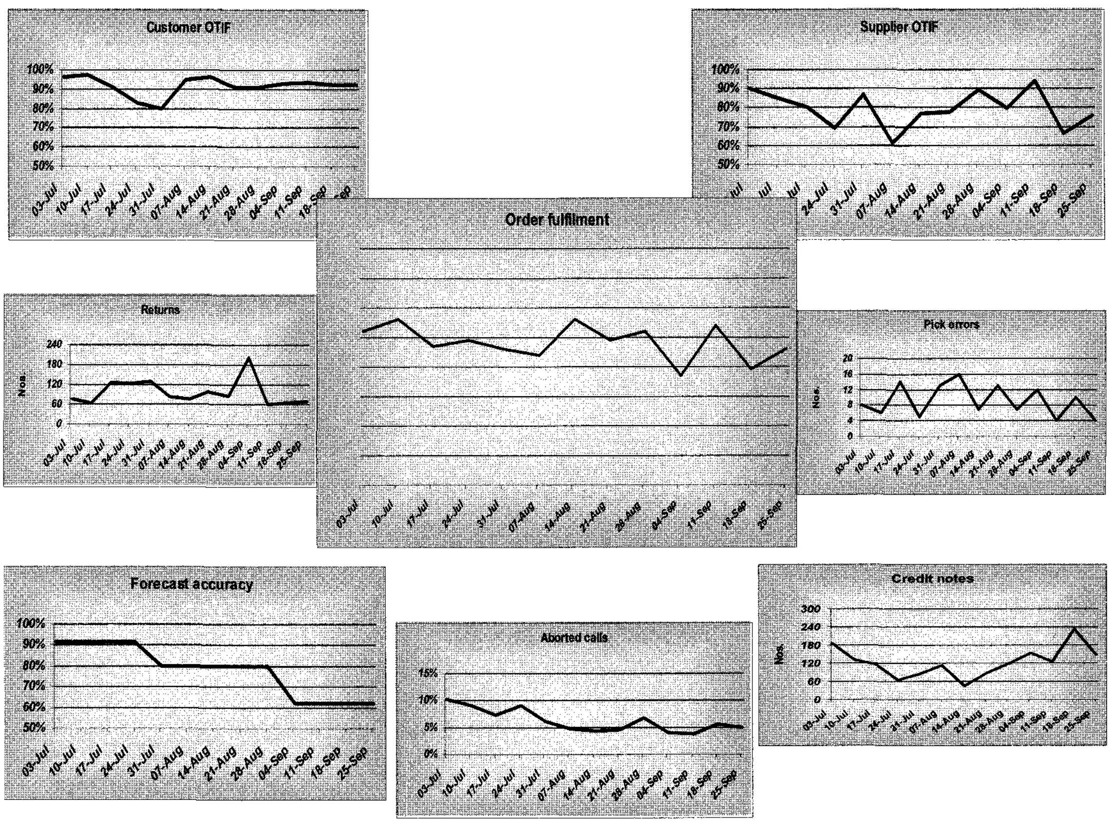


Figure 27.10 A measurement dashboard

The means by which the detailed measures are used to produce the overall order fulfilment KPI are shown in Figures 27.11 and 27.12. The actual measurement for each element is scored according to how successfully it achieved its goal for the given period. These scores are then aggregated to produce the overall KPI.

		03-Jul	10-Jul	17-Jul	24-Jul
ACTUAL MEASUREMENT	**Supplier OTIF**	90.37%	85.04%	79.95%	68.96%
	Supplier presentation	85.44%	85.55%	81.93%	86.30%
	Aborted calls	10.21%	9.12%	7.28%	9.15%
	Forecast accuracy	91.19%	91.19%	91.19%	91.19%
	Pick error	8	6	14	5
	Customer OTIF	96.20%	97.66%	90.93%	82.80%
	Credit notes	183	130	117	66
	Returns	77	64	125	122
SCORE	**Supplier OTIF**	8	7	5	2
	Supplier presentation	7	7	6	7
	Aborted calls	4	4	6	4
	Forecast accuracy	8	8	8	8
	Pick error	6	7	3	8
	Customer OTIF	9	10	8	6
	Credit notes	3	5	6	8
	Returns	7	8	5	6
	ORDER FULFILMENT	**52**	**56**	**47**	**49**

Figure 27.11 Example of actual measurements for the dashboard

SUMMARY

An approach to cost and performance monitoring for logistics and distribution operations has been described in this chapter, linked wherever possible to actual company practice. The need for monitoring and control procedures to measure the effectiveness of actual distribution performance against a prescribed distribution plan has been identified within the context of the framework of a planning and control cycle. The need to establish clear, business-related objectives has been emphasized.

RATING

Supplier OTIF %		Supplier presentation %		Aborted calls	
0	<60	0	<60	0	>15
1	60–64	1	60–64	1	13.5–15
2	65–68	2	65–68	2	12–13.5
3	69–72	3	69–72	3	10.5–12
4	73–76	4	73–76	4	9–10.5
5	77–80	5	77–80	5	7.5–9
6	81–84	6	81–84	6	6–7.5
7	85–88	7	85–88	7	4.5–6
8	89–92	8	89–92	8	3–4.5
9	93–96	9	93–96	9	1.5–3
10	97–100	10	97–100	10	0–1.5

Figure 27.12 Process calculations for the dashboard

A number of different approaches for developing a monitoring and control system were outlined. These included:

- the balanced scorecard;
- the SCOR model (supply chain operations reference model);
- integrated supply chain;
- an operational approach.

Several different means of identifying suitable goals were introduced. These were:

- measuring cost and performance against historical data;
- measuring against a budget plan;
- developing physical or engineered standards;

- using industry standards;
- benchmarking against 'best practice'.

The major factors related to these alternatives were discussed, together with the relative advantages and disadvantages of the different approaches. Finally, an operational planning and control system was described, with the emphasis on the need to identify and measure what deviations had occurred and why they had occurred. This should specifically consider changes in:

- levels of activity;
- efficiency or performance;
- price or cost.

A number of key areas of good practice were considered. These were deemed essential in developing the detail of an effective monitoring and control system. These were considered under the heading of principles, content and output. In addition, a number of influencing factors were highlighted as being important to help explain the differences that occur when systems are monitored for comparative purposes.

Finally, a series of key and detailed cost and performance measures were considered. These were drawn from a number of specific case examples.

28

Benchmarking

INTRODUCTION

> Benchmarking is the process of continuously measuring and comparing one's business performance against comparable processes in leading organizations to obtain information that will help the organization identify and implement improvements.
>
> (Benson, 1998)

> The continuous process of measuring our products, services and business practices against the toughest competitors and those companies recognized as industry leaders.
>
> (Xerox definition of benchmarking)

The process known as benchmarking is quite straightforward to explain but is extraordinarily difficult to conduct successfully in practice. The reason for including this chapter is that benchmarking or comparison lies at the heart of performance measurement.

As with many approaches to improving performance, benchmarking has its enthusiasts and its detractors. There is no doubt that, conducted sensibly, a bench -marking project can be of benefit to an organization, not least because it forces the participants to look closely at their own organization's processes and question them.

It is worth sounding a note of caution at this stage. Benchmarking partners need to be chosen carefully because no two organizations are *exactly* alike. This may sound obvious, but it is remarkable just how different organizations can be even when they are engaged in the same business, never mind a completely different industry. This tends to lead to the participants having to examine generic areas of operations, which can dilute the power of the exercise.

Another point to note is that benchmarking partners may, for their own reasons, not be strictly open and honest with others involved in the exercise. For example, competitors would fit into this category. All information derived from the process should be carefully weighed and considered in the light of corroborative evidence. Acting on incorrect information could send an organization off on a path that is not fruitful.

It is worth pointing out that some detractors suggest that benchmarking only serves to make the organization aspire to be average rather than to lead the field. This may be true in certain areas of the business, but it is also the case that organizations can learn from one another, and benchmarking is one way of facilitating this learning process.

Benchmarking by definition forces an organization to change its focus from the internal to the external environment by attempting to compare its performance with that of the best-in-class companies.

WHY SHOULD AN ORGANIZATION ENGAGE IN BENCHMARKING?

The simple answer is to remain competitive. The process of institutionalizing benchmarking leads to the organization having a better understanding of its competitive environment and its customers' needs. Table 28.1 neatly sums up the main reasons for benchmarking.

HOW TO CONDUCT A BENCHMARKING EXERCISE

This section will describe a framework for conducting a benchmarking project. Given the diversity of organizations and processes, it will not be possible to go into great detail. The Japanese are credited with starting the benchmarking approach to continuous improvement. At a very simple level, employees are seconded to other companies in order that they may learn new ways of working. This practice is called Shukko.

 Table

28.1 Reasons for benchmarking

Objectives	Without Benchmarking	With Benchmarking
Becoming competitive	Internally focused	Understanding of competition
	Evolutionary change	Ideas from proven practices
Industry best practices	Few solutions	Many options
	Frantic catch-up activity	Superior performance
Defining customer requirements	Based on history or gut feeling	Market reality
	Perception	Objective evaluation
Establishing effective goals and objectives	Lacking external focus	Credible, unarguable
	Reactive	Proactive
Developing true measures of productivity	Pursuing pet projects	Solving real problems
	Strengths and weaknesses not understood	Understanding outputs
	Route of least resistance	Based on industry best practices

Source: Camp (1989)

The following examples illustrate benchmarking approaches developed by two companies, Xerox and Alcoa.

The Xerox approach to benchmarking is as follows:

Planning

1. Identify what is to be benchmarked.
2. Identify comparative companies.
3. Determine the data collection method and collect data.

Analysis

4. Determine current performance 'gap'.
5. Project future performance levels.

Integration

6. Communicate benchmark findings and gain acceptance.
7. Establish functional goals.

Action
8. Develop action plans.
9. Implement specific actions and monitor progress.
10. Recalculate benchmarks.

Maturity
11. Leadership position attained.
12. Practices fully integrated into processes.

The Alcoa approach to benchmarking is as follows:

1. Decide what to benchmark — what is important to the customer, mission statement, business needs, etc.
2. Plan the benchmarking project (choose a team leader and team members, submit the project proposal).
3. Understand own performance (self-study in order to examine factors that influence performance positively or negatively).
4. Study others (identify candidates for benchmarking, short-list, prepare questions of interest, conduct the study).
5. Learn from the data (identify performance gaps and which practices should be adopted).
6. Use the findings (for the benefit of the organization and its employees).

(*Source:* Zairi, 1994: 11—12)

The following is a step-by-step guide to conducting a benchmarking exercise. Naturally, each organization will have its own special needs and circumstances that will dictate how it will conduct its own projects; therefore this is only an example of how the exercise may be undertaken.

Step 1 - Senior management commitment

As with any major project, senior management commitment to the exercise must be secured at the outset. This is necessary not only to ensure that resources are made available for the project but also because any potential improvements identified by the benchmarking team will need senior management support to progress them satisfactorily. Ideally a senior management champion should be identified who can take ownership of the project. This will ensure that any useful outcomes are presented at the highest level in the organization. If senior management commitment is not secured then progress to a satisfactory conclusion is unlikely. Middle managers may feel threatened by change and quietly bury the results.

Step 2 - Set objectives

Objectives need to be set for the project. It is a mistake to attempt to do too much immediately. These types of project can generate huge amounts of data. The trick is to be able to identify the useful information buried in all the data. It is much easier to identify a specific process or activity and concentrate on this one area before moving to the next one. Therefore a list should be prepared of specific processes and performance criteria that the company wishes to benchmark first.

Step 3 - Choose benchmarking partners

The next stage involves deciding whom to benchmark against. There are several options.

Internal colleagues

This is the easiest form of benchmarking to conduct, as the information should be readily available and accurate. Different divisions in the same organization may be compared easily. The problem with this approach is that if performance is generally poor in the company then any benchmarking project will not improve competitive performance.

Industry benchmarking

Benchmarking against competitors can be fraught with problems. Firstly, it seems unlikely that a competitor would wish to engage in an exercise that might lead to a loss of competitive advantage, but some organizations are very open with their information so it is not impossible. Secondly, information provided by a direct competitor without corroborative evidence should be treated with scepticism. Finally, trade associations do produce industry statistics, but these are likely to be non-specific and based on averages. This information will be of little use if the benchmarking organization is already exceeding these standards. The statistics may provide some comfort through the knowledge that the company is not below average, but it will not be helpful if offshore competitors are exceeding these standards significantly. The desire of many companies is to be the best in class or world-class for their industry.

Non-competitive benchmarking

This type of benchmarking involves benchmarking against other companies in different industries. This has the advantage of excluding market competition from the process of comparison. By the same token, it does make it more difficult to identify specific areas of comparison between non-competitive benchmarking partners. For example, a retailer is unlikely to have areas of operations that are similar to a manufacturing company. However, what they will have in common is processes such as purchasing or supplier appraisal. It is through examining in detail the processes used by the different partners that areas of improvement will be identified.

Many companies see the advantages of continuing benchmarking activities on a regular basis and so they have set up benchmarking clubs as a forum to continue the activity.

Other benchmarking activities

Obtaining competitors' products or services and dismantling them (reverse engineering) is one way of comparing the organization with its direct competitors. Published accounts, trade conferences, articles in the trade press and employees recruited from competitors are all sources of useful information about competitors. It must not be forgotten that the organization's customers are a good source of competitive information. Through asking the customer questions about the organization's performance it is possible to glean information about competitors' performance in key areas also. This should help to forge stronger links with major customers.

Step 4 - Choose a mixed-discipline team

Having decided on objectives and benchmarking partners, it is necessary to identify what disciplines are required in the team. Clearly, one member of the team should be intimately acquainted with the process to be benchmarked. Other useful disciplines might include an accountant for financial information or an information systems expert, if that is appropriate. Apart from relevant related disciplines, it may be worth including one member of the team who is simply there because he or she knows the business and where it is going but is not aligned to the process under review. This approach can often prompt the naive question: 'So why do we do it this way?' It is a well-used idiom, which says that sometimes individuals are so intimately involved in a process that they find it hard to question fundamental principles. Managers being unable to 'see the wood for the trees' is as common as it ever was.

Next it is essential that any available information is identified and located. Information is unlikely to be forthcoming from the benchmarking partner in a format that matches the company format. Time will have to be spent configuring and sifting the information from both sides to allow meaningful comparisons to take place. Mapping out the steps in a process by producing a process flow diagram is also very useful by way of preparation. Information may flow between the partners even at this stage by means of questionnaires, company literature or informal meetings.

In some cases, confidentiality agreements are exchanged between the participating companies. If required, these need to be in place at an early stage and are useful if a long-term relationship is envisaged.

Step 5 - Getting acquainted with your partner

It is highly likely that a number of visits and meetings will be required as requests for information from both sides are processed after each round of meetings.

Early meetings are likely to include tours of facilities. This helps set the scene for the visiting team. Establishing agreed terms of reference at this stage will also be useful.

If the planning and preparation have been carried out thoroughly then the process will move swiftly to exchanging information. The process will be iterative as partners return to their companies to digest the information they have received. As the analysis progresses, many questions will emerge on both sides that will require answers. These must be logged for future meetings. Eventually, useful information will begin to be extracted.

Step 6 - Analysis

Obviously not all the information gleaned from an exercise will be useful, but it would be unusual if absolutely nothing of benefit emerged.

If conducted with appropriate energy then the very minimum to be gained will be a better understanding of how the company functions in a given area. Some may throw their hands up in horror and say that a company should already know what is going on inside itself without going through such an elaborate process. The truth is that many companies do not really know what is going on inside their organization. Where there are written operating procedures, senior management (understandably) tend to assume that this is how things get done. At the point where the operating procedures are supposed to apply, things may be very different. In the course of collecting information and possibly mapping the process in preparation for a benchmarking exercise, these anomalies should be exposed. When and if this situation arises then an open-minded approach will be useful. It may well be that the way the job is really done, as compared to the way the procedure says it should be done, might be the most effective way of working.

When better ways of working or tighter targets are identified through benchmarking as achievable then systematic plans should be made to implement the necessary changes. Assuming that senior management support for the process is in place then resources and responsibilities need to be allocated. Once this has been decided, the staff involved in the planned change need to be involved fully. They should already be involved to some extent, as they will probably have participated in the preparation stage of the project.

As with any change in the management situation, there will be a measure of concern amongst the staff involved, because change usually augurs (for them) a step into the unknown. If these fears are recognized and dealt with sympathetically by management then communication and involvement will generate commitment to the process of change.

The success of any improvements instigated as the result of benchmarking should show up in the relevant performance measures for that functional area. It could be in the business ratios such as return on capital employed or in something as straightforward as reduced picking errors in the warehouse.

Step 7 - Continuing the process

There are several ways of continuing the process:

- Allocate staff on a permanent basis to engage in continuous benchmarking activities. Obviously the organization needs to be large enough to justify this kind of action.
- Identify long-term benchmarking partners. Join a benchmarking club, for example the Best Practice Club. There is also a benchmarking exchange website on the internet. Try to identify the best-in-class organizations for the area of operations that is being benchmarked.
- Use benchmarking as part of a continuous improvement culture. Measure and communicate performance improvements widely within the organization.
- Use industry-specific trade association figures. For example, the UK Freight Transport Association produces *The Manager's Guide to Distribution Costs* every year.
- Create a computerized database of benchmarking information. This will require constant updating in the light of the latest information.

FORMAL BENCHMARKING SYSTEMS

The following are some of the formal benchmarking systems that have been developed over the years:

- *Quality function deployment (QFD).* This benchmarking approach has been developed by Japanese managers. It takes the customer's requirements as the starting point and aims to improve performance by converting customers' perceptions of suppliers' performance into an improvement agenda.
- *ISO 9004.* As part of the ISO 9000 series of quality management frameworks, ISO 9004 provides a framework of constant comparison for any type of business.
- *The Malcolm Baldridge National Quality Award benchmarking framework.* This is an award for quality awareness started in 1987 in the United States. The framework is based on four basic elements:
  the role of senior managers in promoting quality excellence;
  the processes used to achieve the objectives of the organization; -
  quality achievements;
  customer satisfaction.

BENCHMARKING DISTRIBUTION OPERATIONS

This section outlines the major features of a benchmarking or auditing exercise for a group of companies involved in grocery distribution. The aim is to describe an approach to distribution benchmarking. In addition, some of the potential problems and pitfalls are identified, and some key issues are highlighted. The major emphasis is on distribution centre operations, but a similar approach can also be used for benchmarking transport operations.

The key elements described are:

- the main principles behind studies such as these;
- a typical format and approach;
- data collection and analysis;
- interpreting the results.

For this type of benchmarking, there is a recognized benchmarking hierarchy that can be summarized at four different levels:

1. *Single task* benchmarking – covering single distribution activities such as goods inwards, order assembly, etc.
2. *Function-wide* benchmarking – where all the tasks in a distribution function are reviewed with an aim to improving overall performance. For example, this might include all the processes from goods receipt to vehicle loading in a given distribution centre.
3. *Management process* benchmarking – covering broader cross-functional issues such as quality, information systems, payment systems, etc.
4. *Total operation* (logistics) benchmarking – where the complete logistics chain is reassessed, from procurement and supply through to end-user delivery.

The approach described here is for the quite specific function-wide benchmarking that applies to a distribution centre. The example used is based on an inter-firm comparison in the grocery industry. The major factor is that it *is* a single industry study. This helps to ensure that any comparisons between the different operations are drawn on a reasonably similar base.

The study broadly consists of a series of snapshot evaluations of the actual cost and performance derived for the different distribution centres. This is under-taken through detailed data collection and analysis of the key functions within the sites. Data are broken down according to various activities (goods receipt, reserve storage, etc) and various product groups (chilled, ambient, wines and spirits, etc). Other categorizations may be relevant in different circumstances – for manufacturers, customer classification may be important (national account, wholesale, independent, etc). Comparisons are made across different distribution centres and/or companies according to a series of 'league tables' drawn up for all the key statistics. The cost and performance of an individual site can then be assessed according to the position in the league table.

Such an audit procedure is likely to be a two-stage process: 1) an initial function-wide study to identify the key cost and performance drivers; and 2) subsequent smaller and more directed studies to monitor the key drivers and identify any activity shifts and new drivers that might evolve. These might suggest a revision of certain operations or activities.

Format and approach

There are two main areas for data collection and analysis. The first includes all the major functional distribution centre activities, costs and performance factors. These are likely to be fairly standard (cases picked per hour, etc). The second includes those other elements that may be essential to help *explain* the cost and performance indices derived. Why is site X performing so badly in its order picking operation? Why does site Y have such a high-cost goods reception facility? These are often classified as a part of the logistics 'environment' in which the distribution function operates. Typical examples of the essential elements within the logistics environment are:

- source of goods coming into the depot;
- product characteristics;
- sales characteristics;
- customer profile;
- inventory profile;
- returns, etc.

One additionally important element is the information system that supports the physical distribution operation. A clear understanding and measurement of this may help explain some of the audit results. Thus, information *flows*, hard-copy versus paperless operations, software and associated systems, electronic point of sale (EPOS) and other external systems may all need to be included within the audit structure.

Finally, distribution centre performance will be very dependent on the impact of service levels. The importance of these may vary from company to company, but they may include:

- levels required (and achieved!);
- lead time;
- stock availability;
- minimum delivery/order size policy;
- order and delivery frequency;
- quality checks;
- full loads delivered on time.

The general approach to the distribution audit is outlined in Figure 28.1. It follows a logical sequence of data collection, collation, analysis and interpretation. The steps are:

1. *Identify major elements.* These are the major activity centres that best represent the *flow* of product through a distribution centre (see Figure 28.2).
2. *Identify important categorizations.* These should consist of any major categories that are fundamental to the operations under review. Careful selection will

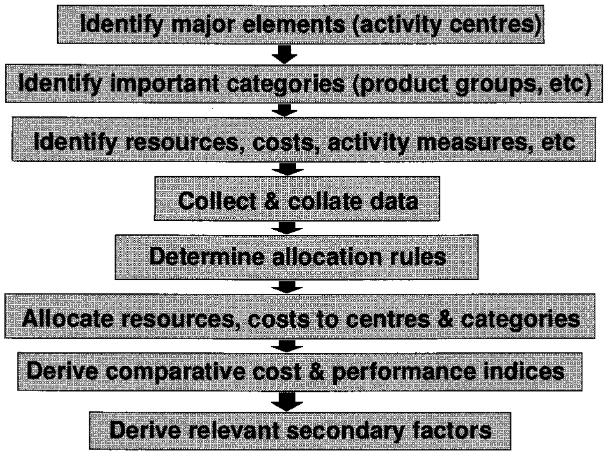


Figure 28.1 General approach

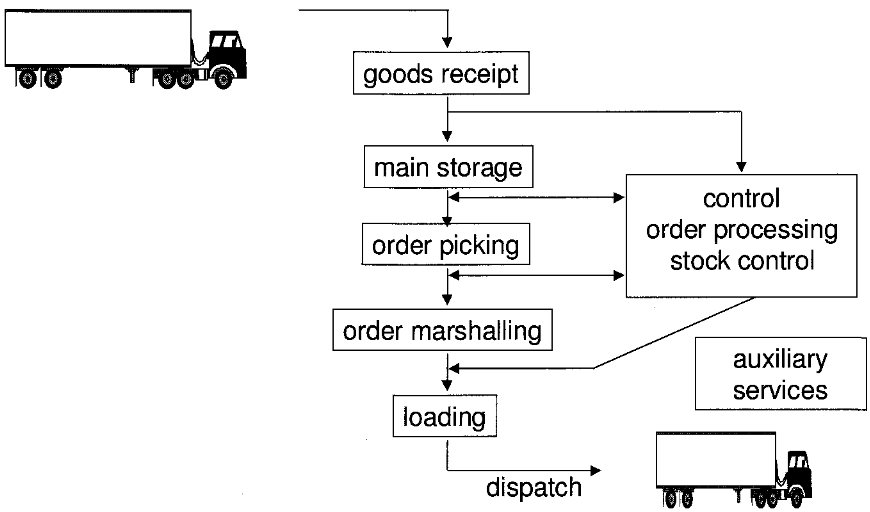


Figure 28.2 Typical activity centres

enable some useful comparisons to be made of key elements within the business. For grocery distribution, this typically means different product categorizations — chilled, ambient, fresh, etc.

3. Identify resources, costs and activity measures. All resources and their associated costs need to be included. A classic breakdown covers buildings, building services, equipment and labour. In addition, some key activity measures need

to be made. These are likely to include throughput in an appropriate unit of measurement. Examples may include: receipts in outers; storage in pallets; picking in line items; the number of orders; the number of picking lists; the number of lines per picking list; etc.

4. *Collect and collate data.* This is ideally undertaken using a spreadsheet format. Such a format is outlined in Table 28.2. This shows the main activities across the top of the spreadsheet and the main cost elements along the side of the spreadsheet.
5. *Determine allocation rules.* This is an important aspect of the process. A typical example might be how to allocate main storage costs across a number of different product groups where products are randomly located. Most rules will follow a logical, common-sense approach – in this example, allocate main storage on the basis of the number of pallets stored per different product group.
6. *Allocate resources and their costs to centres and categories.* Use the allocation rules. Ensure that all the inputs (resources, costs, throughputs, etc) are double-checked for accuracy. An example of how this might look is also given in the allocation matrix in Table 28.2.
7. *Derive comparative cost and performance indices.* Many of these will be common to most distribution centre operations (cases picked per hour, etc); others may be particular to one type of operation (units returned and reprocessed in a mail order depot, etc).
8. *Derive relevant secondary factors.* These are the elements of the logistics 'environment' that might help to explain the main results.

The key points to the approach can be summarized as:

- A formalized approach such as this should be used to ensure that all the appropriate costs are included in the analysis.
- There is a need for relevant support information. This concerns the 'logistics environment', and the information is essential to help explain the results.
- It is important to select the appropriate functional elements. These are the activity centres, and they should represent relevant elements of the distribution operation.
- Valid activity measures should be used to ensure that the costs are allocated correctly.
- The matrix structure provides a very suitable format for data analysis.

Company-level ('top-down') costs should be collected as well as detailed operational ('bottom-up') costs. This allows for consistency checks to be made using costs derived from different sources.

Table 28.2 Allocation matrix with costs (all product groups)

Averaged 'Weekly' Cost £	Unloading	Mainstore	Order Picking	Marshalling	Loading	Control	Auxiliary Services	Totals
Direct Labour	516	722	1,821	486	24	168	–	3,737
Supervision	247	180	180	180	43	138	–	968
Buildings	60	1,102	431	74	17	8	25	1,717
Building Services	70	1,406	555	102	22	10	32	2,197
Equipment	475	1,558	346	76	10	–	46	2,511
Total	1,368	4,968	3,333	918	116	324	103	11,130
General Administration								
– Direct								1,906
– Supplementary								1,533

Data collection and analysis

The collection of accurate and useful data is by far the most problematic aspect of a distribution audit. It is also, of course, essential to a successful auditing or benchmarking exercise.

Some of the major problems and potential pitfalls are:

- *Data availability*. It will always be necessary to compromise. The data required will never be available in their entirety. This is especially so where several companies are involved.
- *Sampling*. It is likely that some sampling will be required. Care must be taken to ensure that sample sizes are sufficient and that samples are adequately representative.
- *Data consistency*. Again, especially where cross-company analysis is to be undertaken, care must be taken that allocation rules and procedures are common. Most companies have different accounting practices, so there is ample opportunity for error due to inconsistent classification. It is likely that a uniform or generalized allocation procedure will need to be designed and used.
- *Appropriate categories and groups*. Any categorization needs to be relevant for all participating companies. An example might be where different companies have different product groups.
- *Time periods*. Clearly, these need to be common for all distribution centres. Any sales cycles, seasonality, etc need to be taken into account. Data availability is likely to be a prime driver. Beware of the problem of 12 calendar months as compared to the 13 four-week periods used by some organizations.
- *Units of measure*. These may differ from one company to another, and will be especially important when drawing comparisons across industry sectors.

Interpreting results

The grocery distribution audits produced a series of results that could be interpreted in a general context, as well as some that were specific to a particular distribution centre as it was compared to the others in the study. In general terms, there were two key drivers identified as being crucial to the understanding of each site's efficiency in the context of grocery distribution. These are consistent with earlier studies.

Firstly, the results indicated that building costs could vary considerably from one location to another. The extent of this variation, and the impact of these costs, meant that some distribution centres that appeared to be operationally expensive were not in fact so, because the major cost element was a very high building cost.

Thus, it was clear that building costs needed to be treated carefully when assessing operating efficiencies. It was possible, however, to identify economies of scale to the benefit of the larger distribution centres. Also, a clear lesson to be learned was the need to maximize space utilization within each centre. In particular, this applied to the full use of height in a building.

Secondly, the highest-cost operational area in all the sites was that of order picking. Clearly, good picking performance was one of the keys to a cost-effective operation. There were obvious benefits to accrue through reviewing layout and reducing travelling time, and through reviewing the information processing time spent by order pickers.

It is possible to produce a myriad of detailed results from a study of this nature. These can be represented in chart or histogram format. For ease of comparison, ' league tables' that rank the performance of different sites may be produced. Some useful results from this study showed:

- the overall warehouse unit cost analysis broken down by main costs;
- the relative weekly throughputs for the different sites involved – these can help to explain some of the differences in cost and performance results;
- the breakdown of direct labour costs for the different sites;
- the range of picking performance for the different sites in cases picked per person-hour. Different handling and information systems as well as lines per order and picks per line will influence these results.

A number of general issues are relevant to the interpretation of results from such a study. These can be summarized as:

- It is useful to draw up a number of 'league tables' to compare individual site performances.
- Even in a single industry study, major differences can be apparent. It is necessary to take special care in a cross-sector study when comparing operations that are very dissimilar.
- It is a good idea to group common operations and concentrate comparisons on these.
- It is possible to identify key drivers from this type of study.
- It can be useful to compare the cost and performance implications for different product groups, etc.
- High-cost and low-performance areas can be readily identified, allowing significant improvements to be made.

- It is very important to identify and select suitable measures that help to explain any major differences in the results (the logistics environment). Typical variables that might influence operations are:
  - volume forecast accuracy;
  - throughput variability (by day);
  - product profile;
  - retail store profile;
  - retail store returns;
  - special projects (promotions, alternative unitization);
  - equipment specification;
  - distribution centre design (building shape, mezzanines);
  - employee bonus schemes;
  - warehouse methods used (secondary sorts, etc);
  - local labour market (quality, need for training, etc);
  - regional cost variations;
  - staff agreements (guaranteed hours, etc);
  - unit definitions.

It is useful to differentiate between controllable and non-controllable elements and costs. An expensive building may lead to a relatively high-cost operation overall. The actual operation itself (that is without consideration of the cost of the building) may be very cost-effective. There is little a manager can do to affect the cost of a building.

Regional differences may impact on results, especially considering relative labour costs. Scale effects may be relevant - that is, economies that result from large-scale operations.

Other logistics *audit types*

The example described above demonstrates in some detail an audit for a distribution centre. Similar approaches can be used for transport and other logistics operations. In addition, quality audits can be undertaken. Example elements for a transport audit are as follows:

- groups:
  - by vehicle type,
  - by vehicle make,
  - by depot/site,
  - by job type;

- costs:
  - cost per vehicle type,
  - cost per kilometre,
  - cost per kilogramme/case/etc;
- utilization:
  - weight,
  - volume,
  - time;
- service:
  - next-day delivery;
- others:
  - maintenance costs,
  - cost of hired vehicles and drivers.

An example of a quality audit for a wines and spirits manufacturer using a contractor is summarized in Figure 28.3.

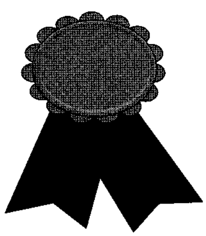


Figure 28.3 Quality audit for a wines and spirits manufacturer using a contractor

SUMMARY

This chapter has covered benchmarking. Two working definitions of benchmarking were reproduced. The rationale for benchmarking was discussed. This comparative process forces organizations to look outside at competitors' performance or the performance of companies in other industries. The idea is to aid the process of continuous improvement and increase competitiveness.

A framework for conducting a benchmarking exercise was described in some detail, and formal benchmarking systems were briefly covered.

Finally, a section on benchmarking distribution activities was included. The detailed description covered:

- the main principles behind these studies;
- a typical format and approach;
- data collection and analysis;
- how to interpret the results;
- other types of logistics audit.

29

Information and communication technology in the supply chain

INTRODUCTION

There can be no doubt that the availability of cheap computing power has led to dramatic developments in the science of logistics management. The ability to handle breathtaking amounts of data quickly and accurately has in the last 35 years literally transformed the way business is conducted. It has been described, with good cause, as the second Industrial Revolution. The ability to pass information between supply chain partners via electronic data interchange is being exploited by more and more companies daily. The advent of mass access to the internet has sparked off a boom in home-/office-based shopping, to say nothing of the use of e-mail as a means of communicating with friends and business colleagues around the globe.

Information and communication systems along with the associated hardware used in supply chain management fulfil different roles. They may aid the decision-making process, help to monitor and control operations, create simulated systems, store and process data, and aid communication between individuals, companies and machines.

A great deal has already been written about this vast area; therefore it is not the purpose here to go into any great detail. What is intended is to highlight the most common features with respect to distribution and logistics, and to explain briefly what they are and how they work.

BASIC COMMUNICATION

Electronic data interchange (EDI)

EDI has been defined as: *computer-to-computer exchange of structured data for automatic processing.* EDI is used by supply chain partners to exchange essential information necessary for the effective running of their businesses. These structural links are usually set up between organizations that have a long-term trading relationship. For example, some multiple retailers will supply electronic point-of-sale (EPOS) data directly to suppliers, which in turn triggers replenishment of the item sold. As a consequence of this type of strong link, suppliers will be able to build a historical sales pattern that will aid their own demand forecasting activities. In this context, EDI has many benefits. It is providing timely information about its customers' sales, it is highly accurate and it is very efficient because it does not require staff to collate the information manually. EDI is used to send invoices, bills of lading, confirmation of dispatch, shipping details and any information that the linked organizations choose to exchange.

UN/EDIFACT is the standard that ensures that information may be sent and retrieved in an appropriate format by trading partners. The initials stand for: United Nations/Electronic Data Interchange for Administration, Commerce and Transport.

The main advantages of using EDI are:

- information needs to be entered on to the computer system only once;
- speed of transactions;
- reduced cost and error rates.

There have been developments in this field that use extensible mark-up language (XML) that helps users to connect different companies' systems via the internet without the need for expensive hardware.

Bar codes

A bar code is the representation of a number or code in a form suitable for reading by machines. Bar codes are widely used throughout the supply chain to identify and track goods at all stages in the process. Bar codes are a series of different-width lines that may be presented in a horizontal order, called ladder orientation, or a vertical order, called picket fence orientation.

For example, goods received in a warehouse may be identified by the warehouse management system and added to stock held in the warehouse. When put away, the bar code is used to associate the storage location with the bar-coded stock, and on dispatch the stock record is amended. The use of bar codes can speed up operations significantly. Problems can occur if bar codes are defaced or the labels fall off in transit.

Radio frequency identification (REID)

RFID is a rapidly developing technology that allows objects to be tagged with a device that contains a memory chip. The chip has a read-and-write facility that is currently executed using a variety of radio frequencies. This means that a pallet of goods can have an RFID tag attached that contains a large amount of information regarding the pallet. This might include product details, the number of cartons, stock keeping unit number, the origin and the destination of the goods, the location in a warehouse and so on. One of the advantages over bar codes is that the information contained in the tag can be updated or changed altogether. The tags are less vulnerable to damage, as unlike the barcode label they are not easily defaced. Another advantage is that the tags may be read from a distance and in some cases do not require 'line of sight' visibility at all. It is also possible to read RFID tags through packing materials but not through metal. A mixed pallet of different products may be read simultaneously by one scanner, thus reducing the time significantly for this process. RFID tags may be used to track many different types of assets, people and animals included. As the cost of this technology reduces, so the take-up of its use is likely to become more widespread. The use of RFID in warehousing is described further in Chapter 20.

Order processing

Customer order processing is often not the direct responsibility of a logistics department. However, the consequences of order processing in terms of the allocation of stock and the construction of picking lists are very important.

The main developments have occurred in two specific areas. The first of these is the information now provided to order takers. This includes the visibility of stock availability, which allows the order taker to identify immediately whether or not stock can be supplied 'off the shelf' to the customer. Also, the order taker is often required to provide the customer with an agreed delivery date at the time the order is taken. This means that delivery schedules must be clear and reliable. These developments help to allow a much better service to be offered to customers, but also, of course, pose a new discipline on logistics operations.

Secondly, there has been an increase in the ability to place orders automatically and directly through EDI or through internet sites. This has been extended in some instances to allow customers to have automatic access to their order status, so as well as placing orders remotely via EDI or the internet they can track their progress through the supply chain.

SUPPLY CHAIN PLANNING

Enterprise-wide information systems

An important development for many major companies has been the introduction of enterprise-wide information systems, often known as ERP or enterprise resource planning systems. These are transaction-based information systems that are integrated across the whole business. Basically, they allow for data capture for the whole business into a single computer package, which then gives a single source for all the key business information activities, such as customer orders, inventory and financials.

Proprietary names such as SAP, SSA Global (Baan) and Oracle (J D Edwards and Peoplesoft) feature strongly whenever these systems are discussed, and many companies are using them to their advantage. It must be remembered that installation of such systems will entail widespread change within the organization and must not be entered into lightly. It will have implications in terms of organizational structure as well as of the way in which individuals work. It is not a question of simply computerizing an existing paper-based system (with all its current flaws) but rather a matter of installing a completely new system. This must take place whilst the rest of the organization tries to keep the business running. It must be thoroughly planned and executed, which will require significant extra resources to achieve a successful outcome.

Many companies have benefited from using these systems, whilst some have experienced severe problems with their application. Generally, they are very expensive to purchase, require a lot of tailoring for each user company, and take a lot of expensive consultancy time to implement and a high degree of training for use at the operative level. It is a logical extension of the principles of supply chain management to have one overarching computerized system that allows for the organization and support of the planning of the whole enterprise. Base ERP systems do not do this, although specialist planning modules are available. Frequently, ERP systems are linked to appropriate supply chain management and network strategy software so that the relevant planning can be undertaken.

In the future these linked systems are likely to be commonplace. For today, apart from implementation problems, it is necessary to be aware that IT is developing at such a speed that provision must be made for systems to be easily updated. Ideally, they should be 'open' systems that are linked to suppliers and customers alike to ease the flow of information up and down the supply chain. Significant provision must be made for disaster recovery in the event of system failure, because effectively all of a company's eggs are placed in the one basket.

Supply chain management/advanced planning and scheduling (APS) systems

Supply chain management systems are, very broadly, decision support and operational planning tools. They enable a company to plan and manage its logistics operations through the use of an integrated system-wide package. Such tools will use information such as real-time demand and/ or forecasting, linked to production capacities and run rates, inventory holding levels and locations, supplier lead times, associated costs, etc, to help determine operational production and inventory requirements.

To be effective, these systems rely on the accuracy and real-time nature of the data that are fed into the system. Planners can then undertake 'what-if' analyses on the basis of the latest (or potential) customer orders, manufacturing capability, inventory disposition, etc. They rely on the appropriate algorithms embedded in the system to arrive at useful solutions. Typical packages include Manugistics, i2 and Numetrics. Such supply chain management software is now being associated much more directly with some of the major ERP system providers, as in the case of SAP/APO.

Network strategy

Network strategy systems consist of a variety of different strategic rather than operational decision-making tools. Typical of this type of package is the distribution centre (DC) location package, which attempts to optimize the number and location of DCs within a company's distribution network.

These systems allow for the analysis of data using various algorithms to arrive at an optimum solution for a given situation. For example, the problem may be to establish the optimum location to make a product within a network of production sites that themselves are spread across a wide geographical area. The system will enable the analysis of the costs of sourcing raw materials, the costs and availability of production capacity, and transport costs, to arrive at the optimum location.

Amongst the main packages are SSA CAPS Logistics and Cast DPM. A more detailed discussion of the use of network strategy modelling is given in Chapter 8.

WAREHOUSING

Warehouse management systems

Warehouse management systems (WMS) have been described in Chapter 20. They are used to control all the traditional activities of a warehouse and often include radio frequency (RF) communications with operators and fork-lift trucks. They may interface with equipment control systems, which control automated equipment such as automated storage and retrieval systems (AS/RS) and automated guided vehicles (AGVs).

A number of computer models have now been developed to assist in the planning of warehouse design and configuration (eg CLASS package). These are generally very sophisticated 3D simulation models that provide a graphic, moving illustration on the computer screen of the layout of the warehouse. They enable different design configurations to be simulated, depending on varying demand requirements, etc.

INVENTORY

Forecasting and inventory management systems

The area of forecasting future customer demand and associated inventory carrying requirements has been revolutionized by the use of customized computer packages. These packages contain many different algorithms that allow the forecaster to use various techniques, such as regression analysis, exponential smoothing and moving averages. These systems may be fed with information directly from sales order processing and inventory management systems to allow them to assess very quickly how customer demand is developing by individual stock-keeping unit.

Inventory management systems provide the ability to run the day-to-day detailed management and control of stock within a company. They are absolutely essential for the location of stock and in their ability, if used effectively, to control the levels of stock within a system. This type of expertise allows organizations to reduce their inventory carrying requirements, which improves stock turn and return on capital invested. Customer service is also maintained through the use of these systems by reducing the incidence of stock-outs.

TRANSPORT

Vehicle fleet management

These types of system assist transport managers in the task of monitoring the effectiveness of their vehicle fleet. Information regarding vehicle activities will be collected, such as:

- mileage/kilometres travelled;
- vehicle details – age, gross vehicle weight, type of body, axle configuration, engine capacity, etc;
- tonnes carried;
- idle time;
- maintenance details;
- fuel used;
- driver details;
- tachograph details and analysis;
- details of deliveries made.

This information may be manipulated to produce key performance indicators for the vehicle fleet. These are likely to include:

- miles/kilometres per gallon/litre;
- vehicle utilization in terms of time in use and vehicle fill;
- tonnes per mile;
- average drop size;
- average drop miles;
- costs per mile/kilometre;
- tyre costs;
- maintenance costs;
- fuel costs;
- costs per tonne;
- whole life costs of the vehicles.

Very often, computerized fuel monitoring equipment controls and records fuel dispensed to each vehicle. This information may be transferred automatically into the fleet management system. In a similar way, tachograph records can be analysed and the information downloaded into the main system.

Many modern heavy vehicles are equipped with engines that are controlled by computerized engine management. This information can provide a great deal of detailed information about the vehicles' activity. Also, reprogramming can enable some of these engine management systems to change the horsepower rating of the engine itself.

The European Union has required the introduction of an electronic tachograph that will be fitted with a smart card rather than the existing system of recording drivers' activities on a wax-covered disk. One of the advantages of this development is that it will allow the smart card information to be easily downloaded into the fleet management system.

Computerized routeing and scheduling

This is covered in detail in Chapter 26.

International trade management systems

With the growth in global trade, there are now specialist software packages available to control the international movement of goods. These include features to assist with the complex documentation requirements, trade finance, dispute management and export/import compliance, as well as monitoring the progress of orders around the world.

Supply chain event management systems

Either linked to, or as part of the above, supply chain event management systems monitor the progress of orders and highlight any 'events' that the logistics managers should be aware of. These events normally relate to the late dispatch or arrival of orders at pre-specified milestone points (eg the container being shipped from a port). These events are notified to the relevant parties so that corrective action can be taken, and the event is continually monitored until the delay is rectified or the goods eventually arrive. For example, the software produces reports for management of locations or shipping lines where delays often occur.

OTHER APPLICATIONS

Electronic point of sale (EPOS)

Now a common sight in most large retail stores in the developed world, this facility has revolutionized the process of paying for goods purchased. Equipment includes scanning equipment, electronic scales and credit card readers. Goods marked with a bar code are scanned by a reader, which in turn recognizes the goods. It notes the item, tallies the price and records the transaction. In some cases this system also triggers replenishment of the sold item.

One of the major advantages of an EPOS system is that it provides an instant record of transactions at the point of sale. Thus, replenishment of products can be co-ordinated in real time to ensure that stock-outs in the retail store are minimized.

Another advantage of this system is that it has speeded up the process of dealing with customers when large numbers of items are purchased. It reduces errors by being pre-programmed with the selling price and avoids staff having to add up purchase prices mentally.

Many retailers offer loyalty card systems, which reward customers with small discounts for continuing to shop with a given retailer. The advantage to the retailer is that loyalty cards with customers' personal details are linked to their actual purchases; this allows the retailer to obtain vital marketing information about these customers.

Manufacturing planning and control systems

These have been dealt with in Chapter 10. It is worth pointing out that systems such as materials requirement planning (MRP) and manufacturing resource planning (MRPII) would not be possible without access to cheap computing power.

Many production plants use computers extensively to control and monitor operations.

General applications packages

It is easy to forget that it was not many years ago that desktop computers were not as common as they are today. This development has provided the business world with applications at their fingertips that have allowed them to be far more self-sufficient and flexible. For example, spreadsheets have allowed managers to manipulate information in a way that suits their individual needs. Word processing packages allow staff to produce letters and documents very quickly and to a high standard. Internal and external electronic mail has facilitated rapid communications between organizations and individuals across the globe. Most if not all of these applications are virtually standard specifications for desktop computers.

These standard tools, along with faxes and electronic calculators, contribute to creating fast, effective and flexible logistics operations.

TRADING USING THE INTERNET - E-COMMERCE

As more and more individuals and organizations become connected to the internet, the possibilities for creating business opportunities seem almost endless. By the same token, this phenomenon has created even greater challenges for the supply chains that support this type of commerce. Some of the implications of trading via the internet are outlined below.

A particular example to illustrate the extent of the implications for logistics is the opportunities for shopping from home. Home shopping is creating a need for deliveries of small quantities of goods to domestic premises. These goods may have different product characteristics, such as frozen and ambient goods. The consignee may very well be a busy individual who is only at home after 7 o'clock in the evening or in the early morning. Customers are likely to return unwanted goods with a much higher frequency than is normally expected when goods are delivered. All of these problems are not new, as the catalogue and domestic furniture delivery services know. What is different is the scale and scope of home shopping that is being facilitated by use of the internet. Specialist vehicles and drivers with good interpersonal skills will also be required.

The recipe of small delivery quantities, limited time windows, specialist small vehicles, poor vehicle utilization and returns adds up to an expensive mix. Distribution systems are currently being developed to cope with this new phenomenon.

Connections to, and use of, the internet are growing on an unprecedented scale. It is with good reason that it is often referred to as the second Industrial Revolution. Daily, more and more organizations and individuals are connecting their computer systems to the internet. Not only does this open up access to vast amounts of information but it also presents the opportunity of trading on a global scale. One side-effect has been to generate a whole new subset of logistics terms. Most, if not all, would fit into a single generic category called 'e-commerce'. The 'e' stands for ' electronic' and is an obvious reference to the use of digitized information being transferred between computer systems. Where the prefix 'e' is used, it is a fair bet that internet trading is involved.

It is useful to be aware of the difference between what is known as businessto-consumer (B2C) and business-to-business (B2B) e-commerce. B2C internet commerce is concerned with the direct interaction and commercial relationship between a business and the end consumer. This can be either the traditional retailer dealing privately with a member of the public, or a manufacturer or supplier dealing with a member of the public who is an end user. B2B internet commerce is concerned with the interaction and commercial relationship between businesses. These may be any type of business trading raw materials, components, spare parts, finished goods or routine office items.

Initial attention has been concentrated on the opportunities for developments in B2C e-commerce, but there are significant opportunities and implications for B2B e-commerce.

'E-tailing' refers to the multiple retailers using the internet as another channel to market. In this particular case, the retailer creates a website, which allows it to display its wares to all those potential customers who possess a computer linked to the internet. Customers make their selection and pay using their credit card, and the groceries are delivered. What is significant, in this example, is that, whereas before customers effected the final delivery by transporting the goods to their homes, now final delivery will require a goods vehicle. This has environmental implications with regard to the possible increase or decrease in traffic congestion. It also calls into question the future size of retail outlets, the range stocked in them and logically their very existence in the longer term. When every household has a terminal, will all groceries be delivered directly from a distribution centre? Given our current perspective this is unlikely, as many people enjoy the social process attached to visiting a shop, but it must have some effect.

Trading on the internet offers businesses and consumers alike a much more sophisticated approach than simply buying and selling. Companies are able to publish details of their goods and services on their website, which saves them from having to produce masses of printed material. This obviously reduces costs for the organizations concerned, but consumers can also benefit through the use of customization. If consumers provide information about their particular preferences, then whenever they log on to a given site only those preferences are displayed as a matter of course.

As the internet is a global facility it opens up new geographical markets to businesses. It must be remembered that the internet may open up these markets, but if goods or services have to be physically delivered then this can present considerable challenges. For example, the whole world does not benefit from the standard of transport infrastructure that may be found in the United States, Europe and other parts of the developed world. On the other hand, if the goods themselves can be digitized then they may be delivered via the internet. Examples include music, films, television, photographic services, computer software, telephone calls and video conferencing. These goods do not require any further infrastructure to complete the transaction.

'E-fulfilment' is a term that has been developed to emphasize the need to ensure that the physical delivery of products ordered via the internet is carried out effectively. Although internet access provides a direct and instantaneous link from the customer to the selling organization, the actual physical fulfilment of the order must still be undertaken by traditional physical means. Very often this may even necessitate the introduction of a new means of physical distribution, because traditional channels are set up to distribute to shops rather than direct to the home. This is likely to necessitate a major change in the distribution strategy of many companies.

'E-procurement' refers to the development of electronic means of undertaking purchasing on a company-to-company basis, so this is an area of opportunity for B2B e-commerce. There are likely to be particular opportunities for the simplification of the purchase of low-value, routine items and the development of online catalogues.

There are a number of other logistics-related developments evolving from internet applications. From a supply chain management perspective, the internet provides many opportunities. Companies such as Tesco, the UK multiple retailer, are allowing their suppliers access to their computer systems to keep them updated on sales demand, current inventory carrying and promotional activity.

Express courier companies allow their customers to access their track-and-trace systems so that they can check on the progress of consignments easily. This type of initiative allows supply chains to be much more responsive and agile than ever before.

SUMMARY

This chapter has outlined the main areas where information technology has an impact on logistics. Brief descriptions were provided, as follows:

- Some of the basic elements of communications were considered first, including electronic data interchange (EDI), bar codes, RFID and order processing.
- Key developments in supply chain planning were considered to be those involving enterprise-wide information systems, APS/supply chain management and network strategy.

- Looking more closely at the basic logistics components, the IT-related aspects of warehousing, inventory and transport were reviewed.
- Finally, some other important aspects were considered, including electronic point-of-sale (EPOS) systems, general applications packages and the use of the internet and e-commerce.

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Outsourcing: the selection process

INTRODUCTION

One of the most fundamental developments in distribution and logistics has been the growth in the use of third-party service providers, or the outsourcing of logistics operations. Some of the main features of this development were introduced and discussed in Chapter 4. An important consideration concerns the need for the careful selection and management of service providers. This chapter describes an approach for the selection of service providers and explains the detailed steps that are required.

APPROACH

An approach to the contractor selection process is outlined below, and described in detail in the rest of this chapter. It is a step-by-step guide to the different stages that must be followed to ensure that all of the important elements are considered. It is typical of the approach that is used by any major company contemplating the use of a third-party service provider to undertake all or part of its logistics operation. It is important to adopt a clearly defined process that is well planned, has clear objectives and is adequately resourced, so that the many key stages can be successfully carried out.

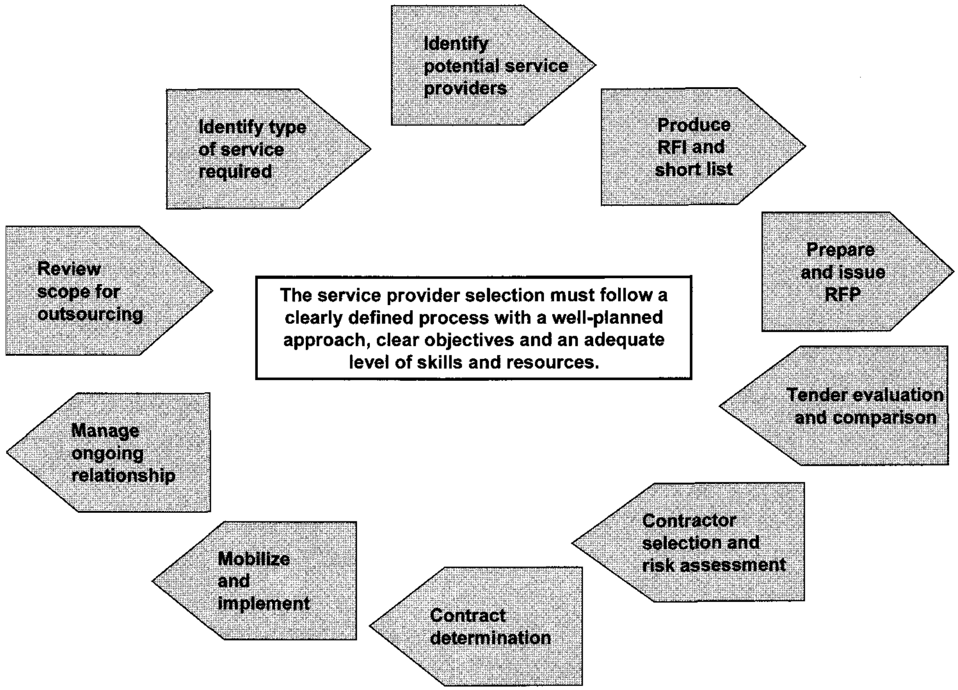

Figure 30.1 Key steps of the selection process

As well as the main identification and selection of a contractor, also included are the important topics of contract development and contractor management.

The approach to the selection process is outlined in Figure 30.1, and each of the key steps is described in the text.

Review the scope *for outsourcing*

There are a number of key questions that need to be considered as a first stage in the selection process. Although outsourcing a logistics operation is very common practice, it is not necessarily the best solution for all companies. Thus, a company needs to understand why it is making the decision to outsource. At the least, this provides some clear objectives that can be used as a selection measure when various alternative proposals are put forward by prospective contractors. These objectives should become clearly identifiable requirements that are used as decision criteria in the selection process. Also, a company needs to be sure that outsourcing is the right step for it to be taking. If the main reason is to cut costs, then a company must be certain that it understands the true cost of its existing operation so that it can make meaningful comparisons with any proposals that are put forward. If the main reason is to improve customer service in a particular way, then the company must be sure that the chosen contractor can provide the competitive advantage that makes this service improvement feasible.

A further scoping decision concerns the extent of the operation that is to be outsourced. The basic question is - what should be outsourced and what should be kept in-house? For most companies there is a broad continuum of possibilities, ranging from, say, the outsourcing of just the delivery transport operation to the outsourcing of the whole supply chain. Figure 30.2 gives a summary of this outsourcing continuum. It is essential for the eventual success of the user-provider relationship that the boundaries between the outsourced and the in-house operation are clearly defined, to avoid any potential conflict over operational responsibilities when the contract is under way.

At a very early stage in the selection process it is sensible for a company to undertake a broad strategic review of the likely distribution structure that it will be looking for. Many companies might complete this as a matter of course when

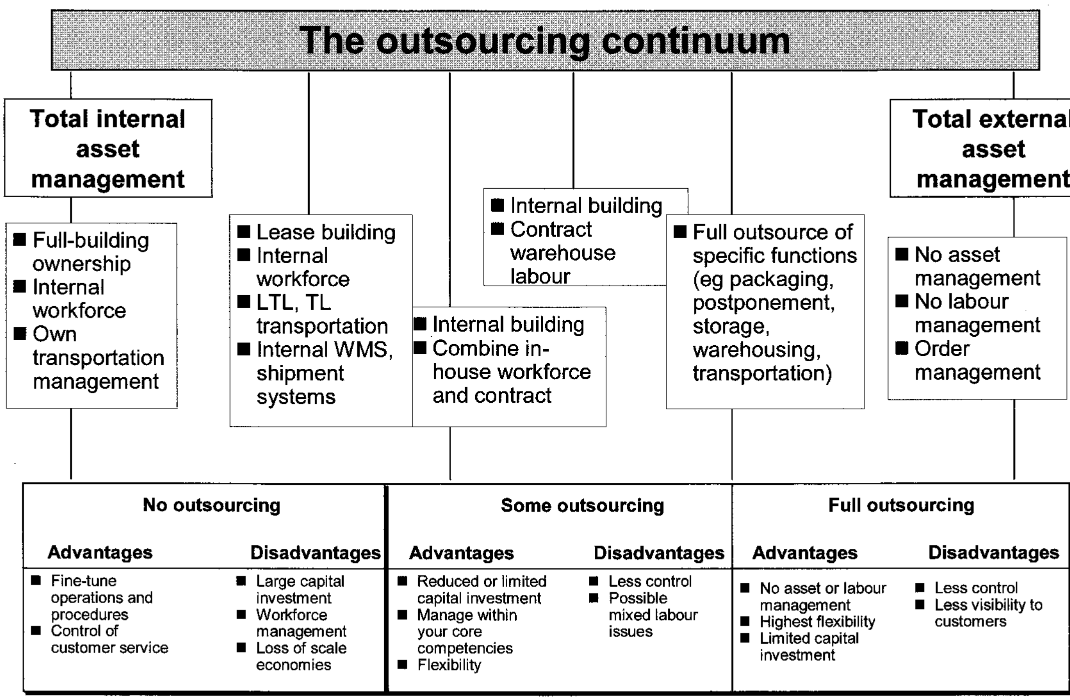

Figure 30.2 The outsourcing continuum

taking their initial decision over whether they should continue as own account or go the third-party route. It might be argued that this is an unnecessary step because the service providers will be expected to devise their own recommended structure. Although this will be the case, it is still a good idea for the user company to go through this review for the following reasons:

- *To provide a clearer idea of what the main requirements are.* It is far easier to assess the different quotations made by the third-party companies if the user already has a good understanding of what the operation should look like.
- *To help in the eventual preparation of the invitation to tender.* In requesting the third party to quote, it will be necessary to provide a great deal of data and information on which it can make its analysis. It is useful to use these data to undertake a strategic review to identify likely solutions.
- *To clarify key activities.* Certain activities will be outsourced, whilst others will be kept in-house. A strategic review will help to identify those elements of the business that should be considered by the third party. It will also help to clarify exactly where the line is to be drawn between outsourcing and own account. Clarification of these areas of interface is crucial at an early stage.
- *To enable a 'long list' of potential contractors to be drawn up.* The information from a strategic review will help to identify which contract companies are the most appropriate for consideration in the selection process. This will help to ensure that time is not wasted holding preliminary discussions with companies that are unlikely to be able to offer appropriate services.

Identify the type of service required

Having made the decision that all or part of the business is to be outsourced, the next step is to determine which of the many services offered by third-party providers are likely to be required. The main types of service were described in detail in the second part of Chapter 4. A major question is whether the user company should choose a dedicated operation or join a multi-user operation where resources will be shared with other user companies. For some companies this may not be a clear-cut decision, and they may decide to ask the short-listed service providers to quote on the basis of both of these different types of operation. The most important factor is that the providers are clear on what basis they should be quoting for the work, so that they don't base all of their effort and analysis on determining a solution that is inappropriate to the user.

Identify potential service providers

As already indicated, a 'long list' of potential contractors should be drawn up. The aim behind this is to identify a large list of service providers that are capable of undertaking the business, and then to draw up a short list of those that are the most interested and the most likely to provide a cost-effective and service-proficient solution. There is no point in contacting companies that specialize in small parcels delivery if it is a full trailer load service that is required. It is neither feasible nor sensible to have a large number of potential contractors provide a full tender, because the entire process is a very time-consuming one for both the contractor and the user company. Information on contractors can be obtained very readily from the trade press, where there are many articles to be found that review the service providers and comment on the latest contracts. In addition, there are websites available that summarize the major contractors, together with their resources and specializations (www.3PLogistics.com). A typical long list might have 20 to 30 contract companies.

Undertake the request for information process and then short-list

Each potential contractor that appears on the long list should be contacted with a brief description of the likely requirements. This is to ascertain whether the contractor would be interested in tendering for the business and to identify whether or not it would be appropriate to include the company on the short list of contractors. This description is often known as the request for information (RFI). The RFI should be a concise document consisting of key information, as follows:

1. introduction and confidentiality clause;
2. description of the company - operation and product overview;
3. description of opportunity:
   - overview of strategy and likely requirements,
   - contractual relationship;
4. the selection process:
   - procurement process,
   - key selection criteria;
5. content of response;
6. format of response.

Responses to the RFI and other factors should be evaluated against key selection criteria to enable a short list of between 5 and 10 contractors to be drawn up.

Selection of the key potential providers might be on the basis of:

- written response to RFI;
- assessment of supporting documents;
- current client list;
- contact with current clients;
- assessment of broad capability;
- financial probity of the company.

Preparation of invitation to tender or request for proposal or request for quotation

The major part of the contractor selection process revolves around the provision of detailed data and information to the short-listed companies, which they then use to develop a plan and cost the proposed operation. These responses are then compared by the user company to enable them to identify a limited number of companies with which to complete the final negotiations. This process is based on a very important document, known as the invitation to tender (ITT), the request for proposal (RFP) or the request for quotation (RFQ). There are two main objectives for the ITT: 1) to provide a specification of business requirements to selected vendors in a standard format to facilitate objective comparison of proposals; and 2) to maintain equitable flow of information across all tendering companies and establish total confidentiality rules.

More specific uses from the point of view of the contractor are to:

- design a distribution system to perform the task and meet the service requirements;
- determine the resources required (personnel, property, vehicles, plant and equipment);
- estimate the costs and hence decide on the structure and level of the rates to be charged;
- be clear which distribution components are to be provided by the contractor and which by the user company;
- be clear which information systems need to be provided and specify them in detail.

A great deal of detailed data and information must be included in the ITT. A typical ITT structure might be as follows, but the precise content will vary according to the company, operation and contract requirements:

1. introduction including confidentiality clause;
2. background to operating company;
3. business description;
4. data provided with the invitation to tender;
5. physical distribution specifications;
6. information systems;
7. distribution service levels and performance monitoring;
8. assets currently employed in distribution operations;
9. risk assessment and transfer;
10. industrial relations;
11. business relationship – contract type and contract management relationship;
12. charging structure;
13. terms and conditions;
14. environmental issues;
15. the selection process including key selection criteria;
16. response format;
17. criteria for award of contract;
18. timescale and method of submitting clarification questions regarding the ITT;
19. deadline for submission of a response to the ITT;
20. the proposed start date for the contract after award.

The data to be provided with the ITT should be at a sufficient level of detail to allow the contractor to undertake adequate analysis to calculate the resources required to run the operation and to identify all the associated costs. As might be imagined, this is a lot of data! Again this will vary depending on the services required, but typical distribution data are likely to include those elements outlined in Figure 30.3.

There are several different types of pricing or charging structure that might be adopted. The choice of these is the prerogative of the client, but in some instances low volumes of business that have to fit into a multi-user operation may offer less scope for some of these to be used. They can be broadly categorized as follows:

- *Unit price or fixed price agreements.* An agreed unit price is paid for the services provided. This might be cost per case, cost per mile, cost per drop, etc, or a combination of these costs, depending on the services being offered. This is the traditional method of third-party payment and is common for low-volume business.

Storage and order picking

Receipt

- Number of suppliers
- Extent of palletization
- Notice given for time of delivery
- Extent of inspection or check
- Dealing with returns

Stock profile

- Number of lines
- Stock volumes
- Activity levels
- Normal storage levels
- Peak levels and duration of peak

Throughput

Seasonal/daily variations in volumes

Order picking

- Order transmission procedure
- Order volumes including seasonal and daily variations
- Service time cycles from receipt to delivery
- Lines per order and total quantity per order including peak variations

Delivery

Dispatch

- Outlets including location defined by postcode, etc
- Delivery quantity by location
- Peak variations

Delivery

- Constraints on delivery times
- Problems at specific locations
- Delivery methods

Service

Service level requirements

Others

- Returns
- Repacking, stock checking
- Telesales, ordering
- Promotions, etc

Figure 30.3 Typical distribution data requirements

- *Hybrid unit price agreements.* These are based on a unit price but also include guarantees for specified volume throughput, resource usage, etc. This ensures that the contractor is not penalized by seasonal effects or unexpected demand fluctuations when the contractor may have resources that are underutilized. This approach allows for reducing unit price by degrees as throughput increases.
- *Cost-plus arrangements.* These provide for the payment of an agreed fee for the facilities used and the services provided. A pre-set profit margin for the contractor is added to this. One major criticism of cost-plus is that it offers no incentive for the contractor to improve the operation. Indeed, any trimming of costs would lead to a reduction in payments to the contractor.
- *Open book contracts.* As it suggests, an open book contract is where the client company pays for the entire operation plus a management fee to the contractor. This type of arrangement can only be used for completely dedicated operations. Performance is monitored against a budget that is agreed between the contractor

and the client. The danger with this type of arrangement is that it may compound any inefficiencies that are built into the original agreement. It is now common to include cost reduction or performance-related incentive clauses to provide a shared benefit where the contractor identifies improvements.

- *Evergreen contracts*. These contracts are for no defined length of time. A fixed price structure and specific performance requirements are agreed for a 12-month period. Performance is then monitored against the agreed KPIs. Notice to terminate the contract of, say, six months can be given by either side. The idea of these contracts is to eliminate the very stressful and time-consuming renegotiation that often occurs at the end of each contract period with traditional contract arrangements.

Response pro formas should be included in the ITT to ensure that contractors respond in such a way that comparisons can easily be made. These can then be evaluated against set goals, business metrics, costs and any other particular selection criteria. It is extremely difficult to make meaningful comparisons between tenders if all the responses are constructed to a different format. As well as a clearly defined format for the numerical response, many companies ask the service provider to identify specific elements on which they expect detailed information to be provided. These might include:

- the resources and facilities to be used;
- contract management and supervision;
- information systems - data processing and communications;
- security, insurance, stocktaking procedure, etc;
- structure and level of charges and procedure for price increases;
- penalties (if any) for premature termination of contract;
- invoicing and payment;
- draft outline contract, conditions of carriage or conditions of storage;

project management/transfer/implementation.

Tender evaluation and comparison

Tender evaluation is usually undertaken with a view to identifying key data and information from the tenders submitted and then drawing comparisons between the different submissions, hence the importance of using a response format that is straightforward for the contractor to use. Comparisons are going to be quantitative (mainly assessing the relative costs of the different solutions) and qualitative (a consideration of all the non-quantifiable aspects that may be relevant). For a typical warehouse and delivery transport proposal, the main cost elements are the same as the standard ones, and they have been discussed in previous chapters. They would include the costs of storage, delivery transport, information systems, administration, overheads and management fee - depending on the extent of the logistics operation to be outsourced. Costs may be expressed as totals for the operation as a whole or as unit cost per pallet stored, case delivered, etc. Some key considerations are:

- Compare quotations on a standard basis.
- Be clear what has and what has not been included (eg 'other' work, collections, etc).
- It is likely that the quotation includes some qualifications (perhaps because of the interpretation of the specification). These need to be clarified or eliminated.
- Beware of imponderables such as 'likely future rent reviews'.
- Check that service levels are clearly going to be met.
- The lowest price may not be the best.

Non-quantifiable factors that might be considered could consist of a large number of different aspects. The ones to use are those that are seen to be important to the user company. For one company these might be environmental or people-related. For another they might be more concerned with ease of management and control. Such factors could include:

- the quality of the proposal;
- the extent to which the proposal meets the ITT requirements;
- views on the extent to which it is felt that the proposed physical system can perform the required tasks;
- views on the extent to which it is felt that the proposed resources are appropriate to the task and the system;
- whether levels of utilization, productivity and cost are realistic;
- how appropriate the cost is to the recommended design;
- the overall design of the information systems;
- strategies for future enhancement of the operation;
- environmental policy;
- the culture of the company - whether it fits with that of the user company;
- the quality of the contract management team;
- staff training.

A useful approach is to adopt a structured assessment of the contractors' tender submissions. Each major factor can be listed and given an appropriate weighting that reflects its importance to the company. The tenders are then scored against all the different factors. An overall total for each tender will then provide a comparative measure to help differentiate between the various tender submissions. These structured assessments can be categorized between, say, operational, financial and contractor-related factors. An example of how a part of one of these might look is shown in Table 30.1.

Table 30.1 Example of approach to structured assessment

Contractor-Related Factors	Weighting (%0)	Score (1 to 5)	Total (%)	Comments
1. Financial standing				
2. Experience/client base				
3. Management structure and resources				
4. Understanding of requirements				
5. Flexibility and innovation				
6. Initial presentation				
7. Implementation plan				
8. Long-term strategic support				
9. References (existing clients)				
10. Site visits				

Contractor or partner selection

The use of a structured approach for the assessment of the different tenders makes the final selection process a distinctly simpler task because the main points for comparison are much clearer. The most favoured contenders can then be investigated further through visits to reference sites and through preliminary negotiations. For large dedicated contracts it is likely that two or three preferred service providers will be identified. These can then be taken forward for much more rigorous negotiation to ensure that the detailed elements of the proposal are satisfactory and to identify further opportunities for enhancing the contract arrangements. The entire process can now enter the final stages. These are set out in Figure 30.4.

For this final negotiation it is important to be aware of the different phases that a dedicated contract relationship might take. These are often termed the

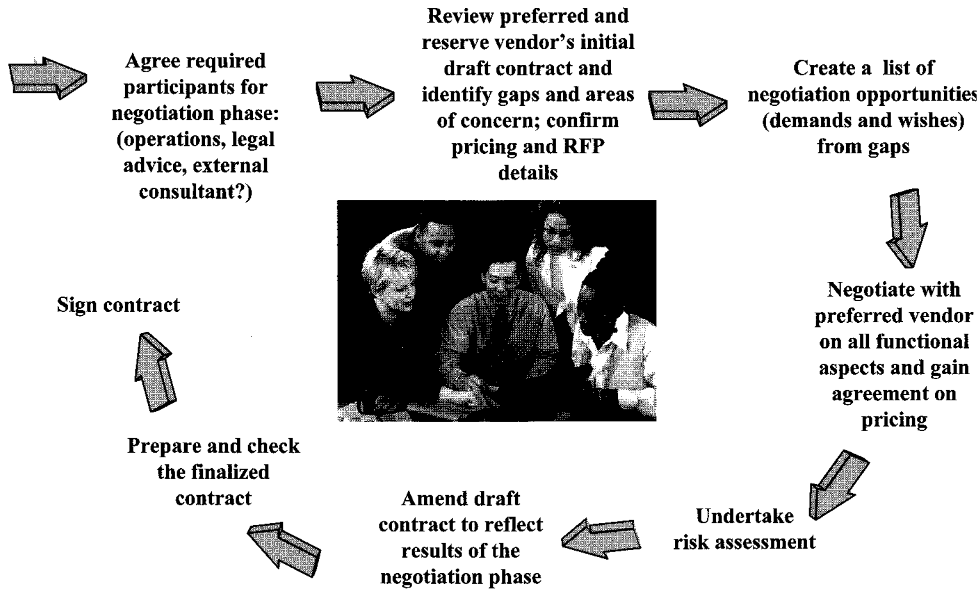

Figure 30.4 The final stages of contractor selection

'development cycle'. The development cycle reflects the evolutionary process of many dedicated contract arrangements. There are three different stages:

1. *Initial set-up*. The contractor takes over an existing operation with all its inherent problems and physical assets. The major aim is to keep the operation running efficiently during the changeover period.
2. *Medium term*. Here, the two parties enter into a more clearly defined agreement over three to five years.
3. *Longer term*. In the longer term, the contractor may wish to take on additional third-party work in association with the existing operation. This will occur as market opportunities arise and as scope for cost reduction by better asset utilization becomes apparent. It is essential that any benefits that arise are mutual to the contractor and the original user, and that the user is protected in terms of service and cost, as well as market competition. This stage of the cycle has become known as the development of shared-user opportunities. It is unlikely to arise with very large dedicated operations.

The complete development cycle may not occur for all dedicated contract arrangements, but it has occurred for some. It is important that the opportunities for potential future developments of this nature are borne in mind and are taken into account during the preparation of any initial contract.

Another important element in the change to a new contractor is the question of responsibility for existing staff. Legislation exists, particularly the Transfer of Undertakings (Protection of Employment) (TUPE) legislation, whereby care must be taken to respect the employment rights of current staff. The TUPE UK regulations grew out of the Acquired Rights Directive, which is European Union legislation. The real implications of this legislation are at times unclear because periodically it has been reinterpreted. The main requirement is that, if employees are transferred to a new contractor, the new contractor must honour the existing terms and conditions of employees - if it is a relevant transfer. The key question is - what is a relevant transfer? A relevant transfer is broadly one that is 'the same business in different hands'. Thus, whenever a new contractor takes on an operation, it must be clear where the responsibility lies for any redundancy payments that may have to be made.

Risk assessment may be undertaken with a view to identifying any elements that might be a major issue either at the time of the changeover to contract distribution (such as the loss or transfer of personnel, facilities, etc) or during the operation of the contract (such as delivery failure, etc). There are three main categories of risk in outsourcing that are often considered. These are service risks, relating to the provision of services; business risks, relating to the operating company's business requirements; and external risks, relating to external changes that might affect the contractor's business.

The final selection process needs to be undertaken by an experienced team that has all the relevant negotiating skills. Thus, it should include representatives with legal, procurement, human resource and logistics operational skills. Negotiations are likely to be a fairly long and drawn-out process because they entail the review and agreement of all the detailed aspects of the operation and the associated business arrangements, as well as the development of the contract. The results of all the negotiations need to be documented and agreed by all parties.

The contract

The contract contains a large amount of detailed information and requirements. It will include a comprehensive specification of the services that are to be provided, the associated tariffs and the obligations of the parties concerned. Some of the detailed points from the key areas are considered under the four headings of initial contract, cost-related/tariff structure, service-related, and administrative and other.

Initial contract points include:

- takeover of warehouse sites:
  - which are acceptable/unacceptable,
  - procedures for takeover;
- takeover of vehicles and capital equipment:
  - which vehicles and equipment are included,
  - how they are valued, etc;
- takeover of personnel:
  - which, if any, are transferred,
  - the financial basis,
  - terms of employment,
  - pension rights,

  etc;
- redundancy agreement - that agreement will be negotiated as necessary by the client, the basis of this agreement, etc.

Cost-related/tariff structure points include:

- capital/investment costs (vehicles, warehouse equipment, hardware, etc) and return on investment;
- operational costs (rent, building services, staff, transport running costs, administration, insurance, etc) and cover for operational costs;
- management costs and expenses (proportion of contractor head office cost - diminishing short to medium term, and including project work and time related to contract);
- cover risk/make profit - should be taken into account by return on investment and operational cost cover and length of formal contract.

Service-related points include:

- service requirements:

  definition of service to be provided,

  indication of main areas, including delivery zones and service levels (eg once a week), delivery/collection times, cut-off points for receipt of information at depots, special orders and how to deal with them, emergency orders and how to deal with them, etc;
- service-related aspects:
  - preferred vehicle specification,

- vehicle livery,
- driver uniforms;

- service/performance measurement:
  - measures, report format, etc,
  - damages, late delivery, refusals, etc.

Administrative and other points include:

- information systems:
  - formal means of communication,
  - operating requirements (order processing systems procedures, stock control, etc);
- administration/liaison:
  - head office (planning),
  - regional (liaison),
  - specific feedback (PODs, stock control, etc);
- 'prospective' agreement:
  - regular sight of client's business plans (with respect to the distribution operation),
  - one- to three-year horizons,
  - delivery point openings and closures, product mix, etc;
- 'retrospective'/inflation clause - to allow for regular (annual) readjustments where estimates are sufficiently different from actual to warrant financial adjustment (demand levels, product mix, etc);
- fuel surcharge mechanisms;
- penalty/termination clause:
  - in the event of premature termination by either party,
  - to cover, for example, the risk of 'unusable' assets specially taken on for the operation.

The specification will necessarily be very detailed. Typical components that need to be considered are shown above, although within a contract they would be to a greater level of detail. These will vary considerably from one contract to another, depending on the breadth of the operational coverage and the type of contractual arrangement. It is common practice to include the tender response from the contractor, as this contains a description of the operational elements. The measures by which operational performance is to be assessed may also be included.

A service level agreement will be an important part of the contract. It will identify all the key performance measures related to the provision of customer service and will indicate the levels of service that have been agreed.

A cost and tariff structure will be indicated. This may take a variety of forms and will, of course, depend on the precise payment method that has been agreed. Those elements that need to be covered are indicated above. Important considerations will be the costs of any additional activities that are to be included as exceptional payments (eg product returns), costs that are beyond the control of the contractor (eg fuel price increases and inflation) and any productivity targets or opportunities.

The length of a contract can vary from six months to five years. Three- to five-year contracts have become the norm for dedicated operations because of the amount of capital required for investment in depot and transport facilities and equipment.

Implementation plan

As with any large business project, it is essential to identify and agree a project plan to ensure that responsibilities are clear and that there is a feasible timetable for implementation. A typical implementation plan will need to identify the tasks for both the user and the contractor organization, including contingency planning. The aim is to effect a smooth transition from the old to the new contract. From the user perspective it is vital to ensure that there is clear visibility of the implementation process. A team that includes both user and contractor staff needs to be established, and this team needs to meet on a regular basis to monitor and discuss progress. Detailed project plan activity charts should be used.

Part of the implementation process is likely to include the preparation of new administrative, safety and service procedures, which will be incorporated in an operations manual.

Contractor management

The final part of the outsourcing process is to ensure that the contractor is adequately managed. This is a key consideration that is sadly neglected by some users. The signing of the contract should not be seen as the end of the outsourcing process. It is vital to continue to control and monitor the contractor to ensure that the overall business and operational objectives are achieved.

There are a number of different means of controlling and monitoring the contractor with respect to the usual twin goals of cost and service performance achievement or improvement. The main activities are likely to include:

- the contract;
- budgetary control;

- management information and metrics;
- review meetings;
- audits through open book;
- incentivization of the management fee.

Typically, a manager is nominated from within the user organization to be responsible for the management of the contract. The manager's objectives might be to ensure that cost and service targets are met and to develop opportunities and initiatives for continuous improvement. This will be achieved through the use of suitable metrics. The use of a nominated manager brings both focus and accountability to the outsourcing arrangement, as well as providing the contractor with a main point of communication. This manager is likely to meet with the contractor for regular reviews. As well as reviewing cost and service performance, these meetings should consider any operational difficulties that are at issue and look forward to future forecasts of changes in activity that might impact on the operation. As already indicated, the relationship that is developed should not just consider how well the contractor is complying with the contract arrangement, but should also look to identify opportunities for the continuous improvement of the operation through better service performance at lower costs. This is often associated with the use of incentives linked to the management fee.

There are many examples of good and bad contract arrangements, and it is clear that the safest way to ensure success is to follow a clearly defined process of contractor selection. This is the only way to make certain that all the important aspects have been covered. It is also important to include all the steps within such a process, right through to the requirement to monitor and manage the contractor. Many successful relationships reflect the need to treat outsourcing more as a partnership than as a strict contract-driven arrangement. The experience of one large user company shows this. Its first foray into outsourcing was on the basis of a cost-plus contract that provided for no input from its managers. This led to problems such as:

- lack of encouragement for the contractor to innovate or improve;
- lack of recognition of the need to manage the contractor;
- poor management structure – the managers were demotivated;
- loss of in-house distribution expertise.

In the renegotiation of a subsequently successful contract, the key areas for success were seen to be:

- an active role in implementation by the user company;
- communication with the contractor – a partnership approach was adopted;
- that the fee was a partly incentivized management fee, not cost-plus;
- that a detailed cost budget and monitoring system were included;
- that management responsibilities were clearly defined;
- that relevant management information systems were developed and used.

SUMMARY

This chapter has described an approach to the contractor selection process. As discussed throughout the chapter, it is very important that a carefully structured process is followed to ensure that all essential considerations are covered. The main task is to put together a detailed invitation to tender, which can be used by the contract companies to prepare a suitable proposal for their running of the operation to be outsourced. Tender proposals are then carefully evaluated and compared so that a short list of suitable contractors can be drawn up. After the final selection is negotiated, a detailed contract should form the basis for a provider–user relationship that is closely managed by the user, but allows opportunities for continuous improvement.

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Security and safety in distribution

INTRODUCTION

Unfortunately terrorist attacks and crimes against vehicles and property have become almost an everyday feature of life in today's world. The costs associated with the disruption caused by these events are difficult to quantify but are all too real to the victims. Management time, replacement of assets, service failures, increased insurance costs, legal costs and general upheaval are some of the consequences that may be expected.

Since the attacks on the World Trade Center in New York and the Pentagon in Washington, DC on 11 September 2001, the whole area of logistics security has attracted a lot of attention from national governments. One direct response to these terrorist outrages is a number of initiatives instigated by the United States government. Customs—Trade Partnership against Terrorism (C—TPAT), Free and Secure Trade (FAST), Container Security Initiative (CSI), and Advanced Manifest Regulations (AMR) — the '24-hour rule' — were introduced to reduce the likelihood of another attack. As we all know, terrorist attacks have by no means been limited to the United States, and this has led to questions being asked about supply chain vulnerability.

The aim of this chapter is to provide an outline of the measures that should be considered when planning logistics security. The most common areas and equipment will be briefly described, but any specialist requirements will not be covered. Vehicle, distribution centre and personnel security will be examined. A section on safety in distribution centres has also been included. International measures to combat terrorist attacks will be briefly described, and supply chain vulnerability will be discussed.

INTERNATIONAL SECURITY MEASURES

US cargo *security* measures

Given that the United States is the largest economy in the world and was the victim of the 11 September attacks, it seems appropriate to look in more detail at some of the measures the United States has put in place to avoid any further attacks.

Customs-Trade Partnership against Terrorism (C-TPAT)

This is a voluntary system established by the United States Bureau of Customs and Border Protection (CBP). It aims to create an environment of close co-operation between US importers, carriers and international exporters to the United States. Participants are required to conduct a comprehensive assessment of security in the supply chain (SC), submit an SC security profile questionnaire to CBP, develop and implement a programme to improve security, and communicate C-TPAT guidelines to other companies in the participant's SC. In return, C-TPAT participants benefit from expedited cargo release, a reduced number of inspections, an assigned account manager, access to the C-TPAT membership list, eligibility for account-based processes, an emphasis on self-policing, and access to 'FAST' lanes along the Canadian and Mexican borders.

Free and Secure Trade (FAST)

This initiative covers the borders between the United States and both Canada and Mexico. It aims to offer faster clearance of C-TPAT participants' cargoes at these borders. It is aimed at increasing SC security without unnecessarily hampering trade.

Container Security Initiative (CSI)

Under this system, customs officers from CBP are stationed at the major ports of departure around the world of containers bound for the United States. As almost half of all imports by value into the United States arrive in ISO containers by sea, this is seen as a major step in preventing suspect containers being dispatched to the United States. Approximately 7 million cargo containers arrive at US sea ports annually. CSI is based on four main elements:

1. the use of intelligence and automated information to target containers that pose a risk of terrorism;
2. the pre-screening of these target containers at the port of departure rather than when they arrive in the United States;
3. the use of detection technology to pre-screen these suspect containers quickly;
4. the use of tamper-proof containers.

Advanced Manifest Regulations (AMR)

These US regulations require both importers and exporters using any mode of transport to send electronically advance information regarding the cargo to be shipped. If the information submitted is incomplete, misleading or late, it can lead to the CBP issuing a 'no load' order to the carrier. It could also result in the cargo receiving additional inspection by customs officials or a withholding of permission to unload the cargo at a US port. The CBP require the advance information to be submitted using the automated manifest system. The timings are: 24 hours before loading for sea vessels, four hours before 'wheels up' from NAFTA and Central and South America above the equator for aircraft, two hours prior to arrival for rail, and one hour before arrival for trucks not covered by FAST. FAST truck carriers need to submit information only half an hour prior to arrival.

STRATEGIC SECURITY MEASURES

Supply chain vulnerability

> The vulnerability of networks has increased as a result of longer, leaner supply lines between focussed facilities within consolidating networks.
>
> (*Source:* Cranfield Centre for Logistics and Supply Chain Management, 2003)

The findings of a recent study carried out by the Cranfield Centre for Logistics and Supply Chain Management (CLSCM) in the UK illustrated that whilst many risks to supply chain integrity come from the external environment there is growing evidence that the very structure of supply chains themselves is a cause of vulnerability. The emphasis on leaner inventories and outsourcing to third-world countries has created a situation where supply lines are longer and inventories leaner. Therefore when the supply chain is broken due to inclement weather, political instability or, for example, the recent SARS epidemic, the consequences for individual businesses, industries or economies may be disastrous. The purpose of the study was to provide managers with some practical tools to ensure the resilience of their supply chains. Four levels of risk were identified as:

- *Level 1* — process/value stream;
- *Level 2* — assets and infrastructure dependencies;
- *Level 3* — organizations' and inter-organization networks;
- *Level 4* — the environment.

Recommendations from the study suggest that there are four issues that may generate improved supply chain continuity management. They are:

1. risk awareness among top managers;
2. risk awareness as an integrated part of supply chain management;
3. understanding by each employee of his or her role in risk awareness;
4. understanding that changes in business strategy change supply chain risk profiles.

(*Source:* Cranfield Centre for Logistics and Supply Chain Management, 2003)

Ensuring the integrity of supply chains is a strategic issue and should focus the minds of senior managers. The problems associated with extended vulnerable supply lines has always been an issue for military logisticians. Many military campaigns have failed because extended supply lines were broken and armies isolated.

TACTICAL SECURITY MEASURES

Vehicle *security*

Vehicles may be attacked because the thieves wish to steal the load, the vehicle itself or both. In recent years commercial vehicles have been targeted by thieves either to dismantle or to sell on intact. Sometimes vehicles are dismantled, loaded into containers and shipped abroad with extraordinary speed. In this type of situation, speed of response is essential. On other occasions, vehicles are simply driven away, sold in countries where checks on ownership are lax and never seen again. Therefore when specifying vehicles, one should consider security of the vehicle, the load carrying area and the driver.

The keys

Obviously, if a thief has access to the vehicle's keys then the thief's job is made very simple. Never leave keys in the ignition, and ensure that keys are securely locked away in the office when vehicles are at base. Keys should only be issued to known drivers or those with clear authority. A commonly used ploy is to pose as an agency (temporary) driver in the early hours of the morning, who requests the keys and drives away with a valuable vehicle and load.

Windows

Windows should be etched with the registration number of the vehicle. It is worth remembering that rubber surrounds to windows may simply be cut away, allowing access. Small panel vans with glass in the rear doors should be replaced with vans with complete steel door panels. Existing windows may be protected by grilles or bars if necessary.

Where vehicles have a walk-through arrangement between the driving area and the load area, a bulkhead should be installed that hinders easy access to the load.

Immobilization

The aim of this type of security is to prevent the vehicle being driven away or at least to buy time. It does not prevent the vehicle being unloaded where it stands. There are many types of immobilizer to choose from, but these are the more common varieties:

- steering locks;
- air brake immobilizers;
- starter motor immobilization;
- fuel valve immobilization;
- wheel clamps;
- kingpin locks.

Vehicle alarms

As with immobilizers, there are several different types of alarms for different circumstances. An alarm system will be either manual or automatic. The manual system relies on the driver to activate it before leaving the vehicle, and the automatic system sets itself. The manual system's weakness lies in the fact that if the driver fails to activate it then it is of no use. The use of automatic systems overcomes this problem.

Depending on the level of security required, alarm systems may require an independent power source, which is housed in a secure area of the vehicle. Commercial vehicles that have their batteries exposed would be vulnerable to the power supply being cut and the alarm deactivated. Even cars that have their batteries secure under the locked bonnet are not immune from someone cutting the power supply from beneath the car. A four-hour back-up requirement is specified by the British Standard BS6803.

This standard also specifies a minimum 115 dB (a) for audible warning alarms, but often the output is higher. As with the power supply, the audible alarm should be housed in a secure area of the vehicle to avoid the wires to the sounder being cut by a would-be thief.

The alarm wiring system may be of the single or twin circuit variety. Single circuit wiring may be suitable for cars, but twin circuit wiring is required if the driver's compartment needs locking whilst the loading area is open. Most security specialists recommend that the wiring is closed circuit, which means that the alarm is activated if the circuit is broken by someone cutting the wires. Monitor loops are another way of protecting the wiring from attack. Open circuit wiring does not provide this type of protection.

Alarm contacts should be fitted to all points of access into the vehicle. Some urban delivery vehicles have been robbed whilst they are stuck in slow-moving traffic. If this is a possibility then consideration should be given to fitting a rear-door ignition alarm. This alarm will sound if the rear doors are tampered with whilst the engine ignition system is still running, thus alerting the driver and hopefully warning off the criminals.

The internal spaces inside the vehicle may be protected in several ways listed below. However, it is important to note that commercial vehicle bodies that have glass-fibre roofs are vulnerable to being cut open and may need protection through the addition of steel mesh. Similarly, load protecting curtains are vulnerable to being cut by sharp knives. Neither the glass-fibre roofs nor the curtains will be protected by internal space detectors.

Internal space detectors include:

- *Ultrasonic detectors*. These work by emitting and receiving high-frequency sound waves. They are activated by air movement inside the space being monitored.
- *Inertia sensors*. These sensors work by monitoring vibration levels. Vibrations caused by someone attempting a break-in will trigger the alarm system.

- *Break-glass detectors*. These clever devices recognize only the sound of breaking glass and work if a window is broken (but not if the rubber surround is cut out).
- *Dual tec sensors*. These work by using two different types of sensors that only trigger if they both detect something is amiss. These types of sensor obviously reduce false alarms.
- *CO_2 detectors*. These devices are used to detect unwanted human passengers (stowaways).

The alarm system can be fitted with a pager that alerts the driver, when away from the vehicle, if the alarm system is activated. Alternatively, a radio panic alarm allows the remote activation of the alarm system if the driver feels that is needed. If required, the driver's personal security may be enhanced through the fitting of a panic button that sounds an audible alarm when pushed.

The driver's behaviour whilst going about daily duties can help avoid many opportunist-type crimes. The following is a list of dos and don'ts produced by the UK's Freight Transport Association (FTA):

- Lock your vehicle and its load space whenever it is left unattended – even when making a delivery.
- Do not leave windows open when away from the vehicle.
- Lock the doors while sleeping in the cab; back the vehicle up against a wall or other barrier to prevent access to the rear doors; remember the top of the vehicle will remain vulnerable.
- Remove the ignition keys and lock the door when you go to pay for fuel. Also remember to lock the fuel cap when you put it back on.
- If anti-theft devices are fitted to your vehicle – use them!
- Never leave the vehicle unattended in a secluded area or, at night, in an unlit area. Try to keep your vehicle in sight if you leave it unattended.
- Never leave vehicle keys hidden for collection by a relief driver.
- Don't leave trailers unattended in lay-bys. Where possible use pre-arranged secure parking areas for overnight stops. Particularly avoid using insecure casual parking places as a routine practice.
- Don't chat about your load or your intended route in public or over the radio. Avoid asking unknown people for advice on local off-road parking facilities. Remember that the first breach of security occurs when the existence of the target becomes known to the thief.
- Do not carry unauthorized passengers in your vehicle.

- After a driving break or other stop where the vehicle is left unattended, look out for signs of tampering with doors, straps or sheets - someone may be back to finish the job later.
- Be vigilant and cautious when returning to the vehicle alone. Check for other suspicious vehicles nearby or persons in the immediate vicinity, particularly if seen taking undue interest in the vehicle. Note descriptions, registration number, etc. Get assistance from other drivers if seriously concerned or telephone the police for advice.
- In the event of a breakdown, consider the possibility of tampering or sabotage. Always take into consideration the security of the load if it is necessary to leave the vehicle.
- Treat unsolicited offers of assistance from unknown persons with caution and treat signals from other drivers that something is amiss with your vehicle with extreme caution.
- If you make the same journey frequently consider whether the route/schedule can be varied, if this is possible or permitted.
- Where high-value loads are carried, travel in convoy with other known and trusted drivers if possible. Beware of bogus officials or staff - ask for identification. Carry a 'vulnerable load' card for production if stopped by the police - if in doubt keep going to the nearest police station!
- On arrival at your delivery destination, do not allow yourself to be persuaded to leave your vehicle in charge of anyone else or to deliver to any other location unless certain that such action is legitimate.
- Never leave valuables on view in your cab, whether these are loose equipment or your personal belongings.
- Look out for and report any security defects on your vehicle - faulty locks, bolts, straps, anti-theft devices, etc. Report unserviceable security equipment at once and insist on prompt rectification.
- Keep documentation about the load in a secure place. This can be used as authority to collect goods.

(*Source:* FTA, 1994: 57-58)

Satellite tracking/in-transit visibility

There are many systems available on the market today that allow operators to track their vehicles whilst away from base. Some use geostationary satellites and others use different technologies. For operators who need real-time visibility of their vehicles for service or security reasons, these systems are readily available at a reasonable price.

As mentioned in the list above, maintenance of anti-theft equipment is extremely important and should be included as a regular service item when vehicles are being maintained. Any vehicle-based equipment will be exposed to the elements to a far greater extent than static equipment and will require a higher level of maintenance as a consequence.

The distribution centre

The very nature of distribution centres (DCs) presents many headaches from the point of view of security. Access for large vehicles 24 hours a day requires large access gates that may be left open most of the time. Company employees, visiting drivers, customers, suppliers' representatives, contracted maintenance staff such as tyre fitters, and agency staff will all require access to the site at different times of the day. Most will be going about their business in a diligent fashion but this freedom of access also allows criminals similar freedom. Stories of commercial vehicles being driven away in broad daylight under the eyes of the DC staff are all too commonplace. The following are some suggested actions that will help reduce or eliminate this possibility.

Distribution centre location

Insurance companies are able to categorize different areas into those that are more or less likely to suffer from criminal activity. The same will be true for different areas within a region. DCs are located, by and large, in the best location to service their customers cost-effectively. In many cases the opportunity will not exist to relocate the DC. However, where it does the level of crime in the target location may be worth considering, along with all the other factors.

Fencing

Perimeter fencing should create an effective barrier to the would-be criminal. Security experts recommend that palisade fencing topped with barbed wire and at least 2.4 metres high should be used. The top of this fencing should be angled outwards and all the links in the fencing should be welded to minimize the possibility of the fence being dismantled from the outside.

It is most important that vehicles are not parked next to the fencing. The vehicles could aid the criminals in their endeavours either by shielding them from view or by acting as a platform for them to gain access to the depot. Do not stack pallets or other materials against the fencing, as these too could be used in a similar fashion. Once fencing has been installed, ensure that it is well maintained.

Gates

There is little point in having good fencing if the gates to the distribution centre are left wide open at all times. Electric sliding gates are expensive but very effective. If the price of electric gates is prohibitive then any gates that are fitted should have their hinges and bolts secured to prevent them being lifted off.

Pedestrians will require access, and this could involve them having to pass through a secure gatehouse where they are booked in and out by a competent security guard. Regular employees could be issued with swipe cards or identification cards complete with photographs to speed their access. The close control of visitors will discourage all but the boldest criminal, but it also helps from a health and safety point of view.

Some high-security establishments photograph all visitors every time they visit, and in some cases a video of all people and vehicles visiting the site is made and retained for a given period, say four weeks.

Road blockers that raise and lower may also be used to protect entrances, but these are very expensive as well as being very effective.

Closed circuit television (CCTV) and intruder alarms

The security of perimeter fencing can be enhanced through the use of intruder alarms that are activated when the beam is broken. In the same way, CCTV can help improve security, but again it is expensive. There are some shortcomings with CCTV. They are:

- The monitors need to be constantly viewed for them to be effective.
- Tapes need to be managed carefully to ensure that they do not get taped over or wear out.
- If the criminal is dressed in dark clothing at night with the face disguised, the tapes are of little value for identification after the event. If the monitors are being watched constantly then immediate action can be taken.
- If the equipment is not turned on then its value is compromised.
- The positioning of cameras needs to be well thought through. This is not only to ensure that the cameras have a good field of vision but also to ensure that they can be seen but not attacked and put out of action. The sight of CCTV cameras can have a deterrent value in itself.

Where intruder alarms and CCTV are used, advertise the facts prominently through the use of signs to aid the value of the deterrent.

Security guards

Employing your own guards will be expensive if seven-day, 24-hour cover is required. However, employed guards of the right calibre will know your business and your staff and can be an asset. Contract guards who visit the site on a mobile basis are an alternative, but the danger is that they fall into a routine visiting time that the criminals simply avoid. In this regard you get what you pay for, and the decision must be made in the light of the level of security required.

Lighting

Criminals in general do not like to operate where the area is well lit. Ensure that there is sufficient lighting to deter would-be thieves. In residential areas, lighting may also be a nuisance, so this must be borne in mind when positioning lights. Lights that are activated by heat or movement are an alternative to full-time lighting.

Personnel

Extreme care should be taken when recruiting new staff. Criminals have been known to insinuate themselves into the organization by applying for jobs either as direct employees or through employment agencies. The following useful advice regarding recruitment was prepared by the FTA:

1. Take references for all previous employers.
2. If possible speak person to person with the previous employer and discuss the applicant's work record and character.
3. When checking references by telephone, obtain the number you need from a telephone directory. Any number supplied by the applicant could be that of an accomplice.
4. Do not accept open references, such as 'To whom it may concern'.
5. Beware of unexplained gaps in the employment record – query them.
6. Avoid employing anyone with a known record of alcohol abuse, extreme habitual gambling or serious financial irresponsibility. A stable domestic background is to be preferred.
7. Insist on seeing the applicant's original birth certificate, not a photocopy.
8. Check driving licences thoroughly. Compare the date of birth against the birth certificate. An ordinary licence will expire the day before the holder's 70th birthday.

9. Examine the licence closely in a strong light for signs of alteration, discoloration or erasure. Ensure that the pink or green background is intact. Be suspicious of stained or damaged licences. Check for endorsements, photocopy the licence and retain this on file.
10. Be suspicious of duplicate licences, which usually have 'duplicate' printed on them. Most duplicate licences are issued for quite legitimate reasons but disqualified drivers have been known to apply for and receive a duplicate licence before their trial and use this to gain employment.
11. Obtain a photograph of the applicant and get the applicant to sign it in your presence.
12. Exercise special care when recruiting temporary drivers, unless they are personally known to you.
13. Agency drivers should be employed only from reputable agencies whose staff are vetted and ideally fidelity bonded. In any event, all agency drivers should be photographed before being allowed to drive any company vehicle. Driving licences should be examined, as described above. Do not rely on the agency to do this for you.

(*Source:* FTA, 1994: 23-24)

SAFETY IN THE DISTRIBUTION CENTRE AND WAREHOUSE

Despite the increased use of automation and mechanical handling equipment in distribution centres and warehouses, there are still many potential hazards involved. The increased speed of operations required these days has also created a new set of hazards.

Some of the hazards that are still very common include manual handling injuries, vehicle reversing incidents, the misuse of fork-lift trucks, unstable racking, and personnel slipping, tripping and falling, to name a few.

The causes of accidents in the workplace usually relate to the working environment, the task or the personnel involved. Many of the hazards that have the potential to cause accidents should be identified and hopefully eliminated through the formal use of risk assessments. Senior site management need to define health and safety policies and practices clearly. These should be reinforced through the clear allocation of responsibilities, the use of safe working practices, the provision of well-maintained equipment and personal protective equipment (PPE), and regular safety training. Senior managers should visibly support sound health and safety practices and set an example by their own actions. The standard of health and safety management achieved will be directly related to their level of support and action.

Health and safety issues

Some of the most common health and safety-related issues are listed below. This is intended as a general guide to some of the more common issues. It is by no means an exhaustive list, and professional detailed advice should be sought on these matters if there is any cause for concern.

The working environment

- Lighting levels should be sufficient.
- The integrity and strength of the warehouse floor are important for a number of reasons: pallet racking will apply point loadings; a level floor will avoid the possibility of people tripping or fork lifts and loads being destabilized; level floors are critical where tall stands of racking need to be at right angles to the floor.
- Vehicles and pedestrians should be separated both inside the distribution centre or warehouse and outside in the yard. Ideally this will be achieved through the use of physical barriers, but pedestrian walkways should be clearly marked on the floor as a minimum. Vehicle and pedestrian lanes should be kept clear of obstructions at all times.
- An untidy working area must be avoided. Pallets should be neatly stacked, waste packaging and rubbish should be placed in an appropriate area, spillages of any kind should be cleared up promptly, and fire exits should be free of all impediments.
- There should be sufficient natural ventilation in any area where humans are working. Local exhaust ventilation should be installed over battery-charging areas.
- Suitable and sufficient toilet, washing and rest facilities must be available for use by all staff.
- It maybe necessary to isolate certain types of stored products in separate areas. These might include hazardous chemicals, flammable materials or high-value items. This will allow management to better apply any special regulations regarding the safe handling of these materials.

Equipment

- All equipment used should be well maintained and fit for purpose. This will include all mechanical handling equipment, lifting straps or chains, conveyors, shrink-wrap machines, heavy vehicles used in the yard to shunt trailers, and so on. A scheduled maintenance scheme should be in place for all equipment.

- All pallet racking should be suitable for the products stored. The racking must be inspected by a competent person on a regular basis. Any necessary repairs should be carried out with a minimum of delay, as pallet racking collapses can be catastrophic. Unstable pallets or loads on pallets should not be put away before either the pallet itself is changed or the load is made safe.
- Block stacking of pallets one on top of another should only be to a height relative to the strength of the pallet(s) at the bottom of the stack. As a rule of thumb, four high doesn't usually present any problems so long as the point regarding the strength of the bottom pallet(s) is borne in mind.
- Safety-related equipment such as fire extinguishers, sprinkler systems, alarm systems, emergency lighting, first aid kits, eyewashes, emergency showers, signage and PPE should all be in place if required and serviced regularly.

Personnel

- All personnel should receive regular health and safety training. Specific personnel such as fork-lift drivers should have certificates of competence for the equipment they operate. Large goods vehicle drivers should also have the appropriate licence.
- There should be certain people who are trained as safety officers or first aiders, or trained to do specific jobs such as changing fork-lift batteries.
- Breaches of health and safety rules and regulations should be dealt with through visible disciplinary action, which in some cases may result in dismissal.
- Scheduled health checks should be made. Hearing and eyesight tests are obvious, but maintaining the general level of staff health is also important to avoid lost working days. General lifestyle advice and stress counselling could be made available. The vital indicators such as blood pressure, weight and temperature should be checked regularly by trained staff.
- Some companies have policies regarding the misuse of alcohol, tobacco and recreational drugs. They often include random checking of individuals.
- The selection of personnel is important, as having workers with the right behaviour traits can help create a safe working environment.

Legislation and regulation

Many aspects of health and safety in the distribution centre/warehouse environment have been the subject of national and international legislation. Due regard should be paid to this legislation both when planning and when managing distribution centres/warehouses. The scope and scale of this legislation is vast, and there is not room to go into detail here. Therefore professional advice should always be sought on these matters.

SUMMARY

This chapter has outlined areas of concern and actions taken in respect to international, strategic and tactical security measures. The recent moves by the US government as a result of the 11 September attacks were outlined. The strategic issue of supply chain vulnerability was briefly discussed. Some tactical measures to help ensure vehicle, personnel and distribution centre security were covered. These included:

- vehicle immobilization;
- vehicle alarms;
- a guide to dos and don'ts for drivers;
- distribution centre location;
- distribution centre fencing and gates;
- closed circuit television;
- personnel and security guards;
- satellite tracking.

Some key issues relating to health and safety in the distribution centre and warehouse were highlighted.

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Logistics and the environment

INTRODUCTION

It is not the purpose of this chapter to lay out in detail current and planned environmental legislation. However, it is inevitable that people managing logistics, either in an active operational role or in a strategic planning role, will at some stage have to consider the environmental effects of their actions.

What is meant by the environment? Broadly speaking it may be divided into the internal environment, ie inside the organization, and the external environment, which encompasses everything that is outside the organization.

The internal environment will be concerned with health and safety issues such as noise levels, and the handling of dangerous substances and occurrences, as well as risk assessments and safe systems of work. Naturally, some issues will be of concern to both the internal and the external environment, such as noise pollution and emissions of substances into the atmosphere or watercourses. This chapter concentrates on issues relating to the external environment.

The European Union (EU) has stated that 2 billion tonnes of waste are produced annually by its member states and that this figure is rising by 10 per cent every year. As a result, the EU and other national governments have produced a great deal of legislation relating to environmental issues over the last few years. Since 1972, the EU alone has enacted 200 pieces of legislation that have introduced minimum standards for waste management, and water and air pollution. Increasingly it is being recognized that environmental issues are everyone's responsibility and that ' the polluter must pay'. It is no longer sufficient to design, introduce and sell a product into a chosen market. Now manufacturers must consider the long-term effects of their products. Is it possible to recycle all or part of the product? What will happen to the packaging after delivery has been effected? Do the processes involved in manufacture cause unacceptable levels of pollution? Which mode of transport will be used to deliver the goods?

Those involved in logistics will increasingly have to deal with used products being brought back through the system for recycling or disposal. Waste packaging will most likely also follow the same route or at least arrangements will have to be made for a third party to discharge the organization's legal obligations in this regard. The choice of transport system will have to be carefully considered because of the adverse effects of transport fuel emissions, noise and congestion. Congestion and fuel emissions apply particularly in the case of road transport, but the other modes of transport are not immune from these problems. The location of manufacturing and distribution sites will have to pay due regard to environmental issues.

THE EUROPEAN UNION AND ENVIRONMENTAL LEGISLATION

In January 2001 the European Union laid out its priorities and objectives for environmental policy up to 2010 and beyond in the Sixth Environment Action Programme of the European Community, 'Environment 2010: our future, our choice'. This communication included measures to be taken to implement the EU's sustainable development strategy and built on the previous Fifth Environmental Action Programme, 'Towards sustainability'.

The Sixth Environment Action Programme suggests five strategic approaches, which are:

1. improving the implementation of existing legislation;
2. integrating environmental concerns into other policies;
3. working closer with the market;
4. empowering people as private citizens and helping them to change behaviour;
5. taking account of the environment in land-use planning and management decisions.

Specific action is proposed in the programme for each of these approaches.

Further to this, the programme focuses on four priority areas for action, which are:

1. climate change;
2. biodiversity;
3. environment and health;
4. sustainable management of resources and wastes.

In previous communications the EU identified five areas of economic activity that may affect the environment. They are:

1. tourism;
2. energy;
3. transport;
4. agriculture;
5. industry.

These declarations by the EU, which are supported by both current and impending legislation, will affect those involved in logistics to a greater or lesser extent. For example, locating manufacturing or distribution sites may be restricted by some of the above issues. Similarly the choice of transport mode for trunking (line-haul) and final delivery could be affected. Almost certainly the packaging used and provisions for its recycling or disposal will have to be considered.

Areas of EU environmental legislation, both current and under consideration, are concentrated in the following areas:

- *Waste management*. The EU's policy for waste management involves:
  eliminating waste at source by improving product design;
  encouraging the recycling and reuse of waste;
  reducing pollution caused by waste incineration.

  For example, EU Directive 2000/53/EC introduced provisions requiring the collection of all end-of-life vehicles. Member states are required to establish collection systems for end-of-life vehicles. This includes the transfer of these vehicles to authorized treatment facilities and a system for deregistration of the vehicles.

  Other EU legislation covers waste from electrical and electronic equipment, packaging waste, batteries and mineral oils. Waste treatment such as incineration and the use of landfill sites has also been the subject of legislation.

- *Noise pollution.* The EU has set maximum permissible noise levels from machines such as trucks, aircraft, lawnmowers and motorcycles.
- *Water pollution.* Water quality standards have been imposed, which cover drinking water, bathing water and water for fish farms. During the 1980s and 1990s the EU focused on establishing emission limits, but since 1995 the focus has expanded to include a more global approach, including the promotion of sustainable use of water resources.
- *Air pollution.* EU legislation is primarily designed to reduce emissions from industrial activities and road vehicles. The strategy for transport is:
  - to reduce polluting emissions through the use of catalytic converters and vehicle roadworthiness testing;
  - in collaboration with car manufacturers to reduce the fuel consumption of private cars;
  - to promote the use of clean vehicles through tax incentives.

  Standards have been set on the amount of carbon monoxide, oxides of nitrogen and hydrocarbon emissions that new vehicles over 3.5 tonnes gross vehicle weight can produce. These have come to be known as Euro 1, Euro 2, Euro 3, Euro 4 and Euro 5. Standards relating to fuel quality and exhaust after treatment complete the picture.
- *Nature conservation.* The EU has taken steps to conserve wildlife and natural habitats. The promotion of biodiversity in the fields of natural resources, agriculture, fisheries, and development aid and economic co-operation are the subject of action plans.
- *Natural and technological hazards.* The EU has taken action regarding civil protection from natural and technological hazards and the prevention of major industrial accidents. It has also signed the United Nations Convention on the Transboundary Impacts of Industrial Accidents.

  Nuclear safety measures cover protection against radiation and the management of radioactive waste. Genetically modified organisms (GMOs) have also been covered.

The above list does not make any mention of the huge amount of health and safety legislation that mainly covers the internal environment. The main thrust of this legislation has moved in recent years from descriptive to prescriptive legislation. The principles of managing health and safety through risk assessment force management to create an agenda for corrective actions. Risk assessments are undertaken for given work activities. In the course of conducting the risk assessment, hazards are identified and an evaluation made of the likelihood of that hazard creating an accident. Having identified both the hazard and the risk, management are then obliged to undertake corrective actions.

In many ways, following best environmental and health and safety practices can make good business sense. After all, is it not the objective of logisticians to optimize the performance of the whole organization? Elimination of wasteful activities can be environmentally friendly and beneficial to the company. Maintaining a safe and healthy internal environment for its workforce will ultimately benefit the organization. Time lost to industry is breathtaking in its scale due to accidents, illness and management time in dealing with these issues.

Hand in hand with lost time go the additional costs created by accidents, associated with consequential loss, and replacement assets and people. Criminal and civil legal actions will also be avoided by following best practice.

LOGISTICS AND ENVIRONMENTAL BEST PRACTICE

This section is designed to highlight some of the key areas that should be considered when dealing with the management of environmental issues. Given the complexity of many environmental issues and their ability to generate intense public interest, this section should be seen as only an introduction to the area. Specialist help should always be sought by management if any doubt exists as to the proper course of action in a given set of circumstances.

Environmental management systems

As we have seen, logistics and transport activities have been identified as having a major impact on the environment in which we all live. Consequently they have attracted significant legislation at both the national and the international level. Targets for improving environmental performance have been set by part of the international community via the Rio, the Kyoto and the Montreal summit meetings on climate change. At the level of the organization it has been recognized that a formal system for the management of environmental matters would be useful. The ISO 14000 series of standards outlines such a system.

This standard provides a framework for managing environmental issues rather than establishing performance requirements. The approach is defined in the introduction of the standard's specification. It is seen as an iterative process that starts with the creation of an environmental policy by the organization. This leads on to planning how the organization will meet its legal obligations as well as any targets it wishes to set, which in turn leads to implementing and operating the plan. Implementation will pay due regard to the organizational structure and allocation of responsibilities. Training and communicating with staff, control of relevant documentation and operational controls must all be covered in the implementation.

Once the system has been set up, it is then formally monitored through an auditing process, which will identify corrective actions that will need to be taken. Top management is required to review the performance of the system formally on a regular basis. This review may lead to the policy or objectives being changed or updated in the light of auditing reports or changing circumstances. This process should encourage a commitment to continuous improvement in environmental management as well as ensuring that the organization is not exposed by failing to meet its legal and moral obligations.

Environmental checklist

The following checklist was published in 1991 by the UK Department of Trade and Industry in a useful document entitled Environment: A challenge for business. In a series of questions, it helps focus attention on the key areas for consideration and is still very relevant:

- What environmental risks do your firm's activities pose?
- Do your processes and materials pose any danger?
- Do you know what impact your products (including their disposal) and services have on the environment?
- Do you know what quantity and type of waste you produce?
- Do you know how it is disposed of and what the cost is?
- Is your firm operating the most cost-effective method of controlling or eliminating pollution risk?
- Are there hidden benefits (for example, greater production efficiency) - or even straight business opportunities (for example, commercial utilization of waste) - from adopting alternative methods of controlling or eliminating the pollution risk?
- Can you meet the consumer demand for environmentally improved products?
- Are you aware of existing environmental standards and legislation in the UK and overseas?
- What arrangements do you have for monitoring compliance with environmental legislation?
- Is senior management actively involved in ensuring that proper weight is given to environmental considerations throughout the firm?

- Could you improve your environmental image to the public and your employees?
- Are you highlighting your environmental performance to private investors, financial institutions and shareholders?

Packaging

Packaging is important to logisticians for a number of reasons. Its shape may define how effectively the products may be loaded into transport containers such as cartons or vehicles. For example, a cylindrical-shaped product is unlikely to fill a given cubic capacity as well as a rectilinear shape. This has implications for how much product can be stored or transported in a given space and, as all storage and transport resources have a finite size and weight restriction, filling these spaces effectively is extremely important. The more product stored or transported in a given cubic capacity, the more the associated unit costs, as well as the environmental impact, may be reduced.

Packaging is also important in protecting the products from damage in transit and even pilferage. Packaging in the form of unitized containers, whether they are pallets or reusable containers, will often require return transportation to the point of origin to facilitate reuse.

Many industries have developed forms of packaging that do all that is required of them whilst in transit between the point of origin and the end user but that do not warrant the expense of returning them to the point of origin. Therefore the packaging is used only once and then consigned to the rubbish tip. This principle goes all the way down to the level of the single tin or carton of food. In this case the consumer transports the container from the retail outlet to the point of use and then simply discards the container.

It is this type of packaging, in all its forms, that environmental legislation aims to control. For logisticians, the problem manifests itself in the form of reverse logistics. Waste packaging needs to be returned up the supply chain, or at least the obligation to do this needs to be dealt with. It is possible under the UK regulations to join a compliance scheme that helps discharge the organization's obligations in this regard.

The Producer Responsibility Obligations (Packaging Waste) Regulations (1997) came into force in March 1997. These regulations implemented the EU Directive 94/62/EC on packaging and packaging waste and required each member state to set targets for recovery and recycling of packaging waste. The responsibility for executing these regulations is shared by all the parties in the packaging chain, described as the 'producers'. These 'producers' are legally obliged to do the following:

1. Register with the relevant Environmental Regulator in the UK and submit data on packaging handled.
2. Arrange for the recovery and recycling of specified tonnages of packaging waste.
3. Certify that their obligations have been met.
4. If their main activity is that of a seller of packaging or products in packaging they are required to inform customers of their role in increasing recovery and recycling as well as the return, collection and recovery systems available to them.

'Producers' may either discharge their responsibilities themselves or register with a 'compliance scheme', which will discharge their obligations on their behalf.

Companies covered by these regulations are defined as those with a turnover of greater than £2 million *and* that handle more than 50 tonnes of packaging annually *and* that are involved in any of the following activities:

- manufacture of packaging raw materials;
- converting materials into packaging;
- using packaging to pack products;
- selling packaging to the final consumer;
- importing packaging or packaging materials into the United Kingdom.

Waste transport and disposal

The UK Environmental Protection (Duty of Care) Regulations 1991 created responsibilities for all those involved in the import, production, keeping, treatment, transport, transfer and disposal of waste. All parties involved are charged with a 'duty of care', which covers the escape of waste, the transfer of waste only to persons authorized to receive it and documentation describing the waste and parties involved in its disposal. Waste management licences are required by those involved in keeping, treating or disposing of waste. Waste transfer notes must accompany the waste on its journey from producer to final disposal.

The Waste Electrical and Electronic Equipment (WEEE) Directive

The objective of this EU directive is to reduce the amount of WEEE being produced and to encourage reuse, recycling and recovery. Businesses that manufacture, supply, use, recycle and recover electrical and electronic equipment (EEE) are all covered by this legislation.

EU member states are required to minimize the amount of unsorted WEEE in municipal waste. This directive is planned to come into force in the UK in mid-2006.

The key requirements are:

- Targets must be established for the amount of WEEE to be collected separately from private households.
- The UK must establish and maintain a register of EEE producers.
- Distributors and retailers are responsible for establishing systems to accommodate WEEE being returned by customers that are free of charge and convenient.
- Recycling and recovery targets for WEEE are introduced.
- EEE products are required to be marked with a 'crossed-out wheelie bin' symbol.
- All separately collected WEEE is required to be treated.

This directive will have significant implications for businesses. They will have to establish reverse logistics systems to comply with these requirements.

Performance measures

As with any management exercise, performance measures are useful for evaluating the progress or otherwise of a given initiative. Most business managers will be concerned with costs and benefits because businesses are concerned with making a healthy return on investment. Very often, best environmental practice will result in financial benefits in return. For example, investment in driver training may deliver savings through reduced accident figures and better fuel consumption.

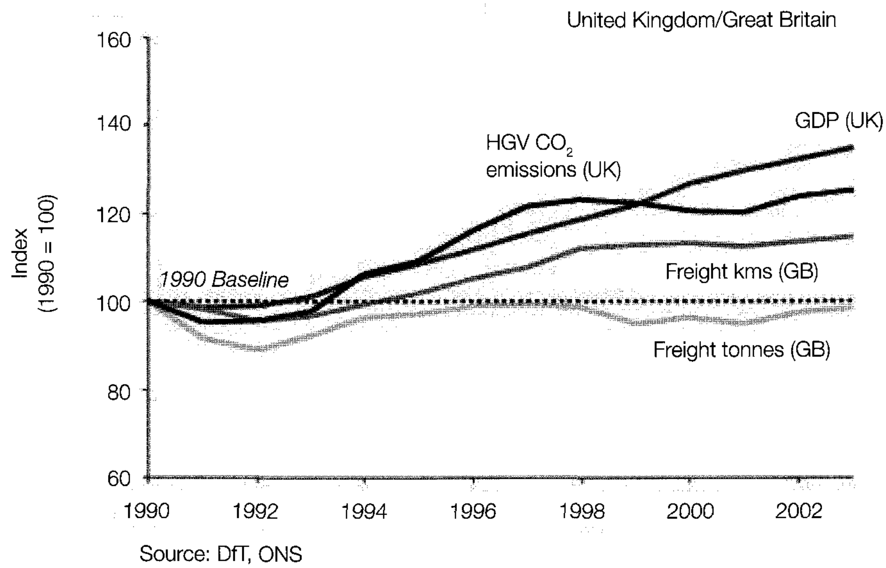
However, some environmental projects may have to be undertaken because of legal requirements and will not generate commensurate cost savings for the business. For example, a noise abatement order generated because local residents have objected to the noise emanating from a distribution centre at night may result in the installation of noise screens, landscaping or restrictions on operating hours. Clearly, any of these measures will simply add cost and no financial benefit to the business concerned, although some public relations benefits may accrue. Obviously, it would be desirable to avoid this kind of problem by selecting operating sites carefully, but some sites, through no fault of their own, have over time been slowly surrounded by residential dwellings. Unfortunately, being there first is not enough to make them immune from this kind of issue.

Organizations with environmental management systems, whether formal or informal, will attempt to monitor their performance in certain areas of their operation. Simple measures might include:

- miles per gallon or litres per kilometre of fuel used;
- percentage of fleet using less polluting fuels;
- percentage of truck fleet in the Euro 1, Euro 2, Euro 3, Euro 4 and Euro 5 emission regulation bands;
- average life of tyres expressed in miles or kilometres;
- percentage of tyres remoulded or regrooved;
- amount of waste lubrication oils generated by the operation;
- utilization of vehicle load space expressed as a percentage;
- percentage of empty miles or kilometres run by vehicles;
- targets for reducing waste packaging;
- targets for reducing noise levels.

The contribution of road vehicles to the production of harmful emissions has generated a great deal of attention from governments, the press, environmental pressure groups and many other concerned parties. For those organizations operating very large fleets of vehicles, the following formula may prove useful in measuring performance: *1 litre of diesel fuel produces 3 kilograms of* CO_2*, or 1,000 litres of diesel fuel produces 3 tonnes of* CO_2*.* This formula may be used in practice by simply identifying the number of litres of diesel fuel saved through the implementation of a given initiative and multiplying the saved fuel figure by 0.003 to arrive at the number of tonnes of CO_2 emissions that have been avoided. Figure 32.1 illustrates the relationship between the increase in freight kilometres travelled and the commensurate increase in HGV CO_2 emissions in the UK.

Noise levels are measured using decibels (dB (a)). The problem with measuring improvements in noise levels is that sound waves are reflected by different surfaces. Measurement of the effect of noise attenuation on, say, a piece of vehicle ancillary equipment - such as the blower used in the discharge of powder tankers - would be affected by any surrounding buildings or the position of the person in relation to the blower itself. However, providing that these limitations are recognized and accounted for then it is possible to compare different blowers in the same location and arrive at an indication of improvement.



- The total weight of goods carried by road has remained at about the same level as in 1990. However, freight traffic (kilometres travelled) increased in line with economic growth (gross domestic product) between 1993 and 1998 and since then has remained 12 to 15 per cent higher than in 1990.
- Carbon dioxide (CO_2) emissions from heavy goods vehicles (HGV) rose broadly in line with economic growth until 1998 and overall emissions were 25 per cent higher in 2003 than in 1990, compared with economic growth of 39 per cent.

Source: http://www.sustainable-development.gov.uk/performance/9.htm

Figure 32.1 Heavy goods vehicle (HGV) CO_2 emissions, kilometres, tonnes and gross domestic product, 1990 to 2003

Possible areas *for improvement*

For the distribution centre, consider these areas for improvement:

- location;
- vehicle access/egress;
- noise reduction by:
  — landscaping,
  erecting noise screens,

moving noisy operations away from local residents,
restricting noisy activities to certain hours,
restricting visiting vehicles to certain hours,
using noise-attenuated equipment where possible,
- turning vehicle engines off when not in use,
insisting on drivers turning off radios when working in the distribution centre at night;

- reduction of visual intrusion through landscaping and a generally neat and tidy approach;
- reduction of water wastage by the use of water recycling on vehicle washes;
- avoidance of pollution of the watercourse with run-off from fuel dispensing areas through the use of interceptor tanks;
- consideration of the use of a computerized fuel dispensing system;
- careful management and monitoring of other hazardous chemicals on-site (paying due regard to the UK Control of Substances Hazardous to Health (COSHH) Regulations);
- keeping pallet stacks tidy and out of sight if possible;
- fitting particulate traps to diesel fork-lift trucks to reduce emissions;
- consideration of the use of electric- or gas-powered fork-lift trucks;
- better management of the production, collection and disposal of waste.

For the vehicles, consider these possible areas for improvement:

- Driver training reduces accidents and improves fuel consumption. Use on-board vehicle technology to monitor driver performance. Computerized engine management can provide a wealth of information.
- Consider less polluting fuels.
- Monitor fuel consumption.
- Monitor vehicle utilization in terms of both payload and empty running.
- Use speed limiters on smaller commercial vehicles that don't require them by law.
- Follow preventative maintenance programmes, because slipping clutches, blocked air filters, fuel leaks, poorly inflated tyres and binding brakes all use fuel unnecessarily.
- Consider the use of aerodynamic kits on the vehicles to improve fuel consumption.
- Specify the most appropriate driveline (engine, gearbox and drive axle) for a given vehicle duty cycle.

- Consider the use of synthetic oils, as their use may reduce the overall use of oil in the vehicles.
- Lubrication oils in the engine, gearbox and driving axles all impose drag on the driveline. Consider using different oils to produce fuel savings.
- Use computerized routeing and scheduling packages to reduce overall vehicle distances travelled.
- Instigate better tyre management through the increased use of recutting and remoulding of tyres to extend useful life.
- Dispose of used tyre casings responsibly.
- Use low rolling resistance tyres to improve fuel economy.
- Muffle vehicle body noise where possible.
- Use self-tracking (or positively steered) steering axles on trailers to reduce tyre wear and tear.
- Specify attenuated ancillary equipment such as refrigeration units, discharge blower units and tail-lifts.
- Specify air brake silencers.
- Use quiet floor materials in vehicle bodies.
- Use asbestos-free brake linings and clutch plates.
- Use air suspension on vehicles to reduce road damage and prolong the life of vehicle components.
- Use chlorofluorocarbon-free body insulation materials.

A further area of consideration for possible improvement is the transfer of some freight to rail or other modes of transport.

Reverse *logistics*

For the most part, logistics management is about moving materials from raw materials through production and onward to the end customer. Usually going in the opposite direction from the end customer through production planning to raw material suppliers is information about customer requirements. However, there are occasions when it is necessary to move materials in the other direction as well. These circumstances are usually:

1. product recall for quality or safety reasons;
2. the return of unwanted goods;
3. used packaging or products for recycling or disposal.

Moving materials back through the distribution channel presents organizations with many challenges because the system is primarily designed to move goods in one direction only, ie from the organization to the customer and not the other way round. However, there are businesses where reverse logistics is a part of the fabric of their organizations. For example, the mail order/catalogue companies can experience return rates on dispatched goods of up to 50 per cent, especially where fashion items are concerned. The increase in shopping via the internet or other media will clearly affect this phenomenon. The postal services and parcels carriers also specialize in systems that both collect and deliver goods.

For those companies that are not set up to deal with reverse flows through their systems, there are many obstacles to overcome. The following is a brief outline of what should be considered:

1. Is there a strategy for reversing the flow of materials in the system? Responsibilities should be allocated in advance, and any resources unavailable internally should be identified in advance. Cost elements should also be identified in advance. Cost elements involved in a product recall fall under four headings: communication costs, documentation costs, replacement costs and disposition costs. Communication costs include:
    - registered and certified mail;
    - return receipts;
    - instructions;
    - telephone, telegrams (and faxes);
    - messenger (courier) service.

   Documentation costs include:
    - filing of receipts of notices for recall;
    - estimates for disposition and replacement;
    - plans of item recalled;
    - plans for replacement item;
    - instructions for replacement/repair;
    - authorizations for work to be performed;
    - receipts for items replaced/repaired.

   Replacement costs include:
    - manufacture and installation;
    - employee visits;
    - shipping, packing and warehousing;
    - testing and retesting;
    - identification of product;
    - identification of carton;

– identification of shipping carton;
– temporary personnel;
– invoicing;
overtime of employees.
Disposition costs include:
locating all items;
inventory of items;
removal from customer's property;
packaging and unpacking;
labelling;
shipping;
- inspection;
repair or replace;
– discard or salvage;
– instruction pamphlet;
refunding;
allowances for time used;
repurchase of item;
compensation for loss of use;
– warehousing: storage.

(*Source:* Gattorna, 1990: *470; NB:* item in brackets added by author)

2. What is the urgency associated with this reverse flow? Clearly, in the case of malicious contamination of food products, which usually are life-threatening in nature, speed is of the essence. These particular situations may be further complicated by police insistence on secrecy if blackmail is involved. Even if this is not the case, very often the perishable nature of the goods has ensured that they were distributed very quickly across a large geographical area. In these circumstances, hours and minutes can be critical to success or failure. If goods are defective in some way that is not life-threatening but the consumers' enjoyment of the products may tarnish the company's reputation in the market-place, then a rapid resolution of the matter may even enhance the standing of the company in the consumers' eyes. Naturally, the opposite is also true. Used packaging or unwanted goods need to be dealt with efficiently and professionally, but they will not attract the same level of urgency as either malicious contamination of food products or defective goods.
3. Having established the relative urgency of the reverse flow, it is then necessary to establish where the goods are in the distribution channels. It can be easily understood that the more links in the distribution channel that exist the more

complex and costly it will be to both locate and return the goods. This is where a good product traceability system will come into its own.

4. Assuming that the goods have been located, the next task is to collect them. If the goods are in the hands of the consumer then this is the most difficult situation of all, as the manufacturer's distributors may not know the identities of these consumers. This situation will require some form of publicity campaign, but even then consumers may not choose to respond. In this situation, limited success is very likely. Associated transport costs will be higher than usual because consignments are likely to be smaller and more widely dispersed.
5. When the goods are returned, care will have to be taken to isolate and quarantine them to avoid the possibility of their being inadvertently dispatched again. This is especially important where the reason for collection is not immediately obvious to the casual observer. The potential for salvage and reworking of the products will also need to be established.

This list has concentrated on product recalls, as they can be very complicated and costly and have disastrous results. In the case of material moving back up the distribution channel for recycling, the need for urgency is likely to be reduced unless the material is hazardous in some way. As stated earlier in this chapter, the disposal and handling of waste have attracted a great deal of legislation and media attention, which means that this process cannot be approached in a half-hearted way.

Many manufacturers are designing their products with recycling in mind. Scania AG, the Swedish truck manufacturer, is a case in point. It produces heavy trucks that are virtually completely constructed of materials that may be recycled. It also produces annually an environmental report, which lays out the company's progress against stated environmental objectives. In future, the challenge for manufacturers will be to retrieve and recycle their own products.

Instances of reverse logistics can also be seen in the service sector. For instance, a holiday tour operator may need to repatriate its clients at short notice due to disease, civil unrest or severe weather conditions. The principles are very similar.

ALTERNATIVE FUELS

With the increasing concerns about global warming, attention has inevitably been focused on the causes of this phenomenon. One of the major culprits identified by scientists has been the emissions created by burning fossil fuels in transport vehicles, with special emphasis on road vehicles.

This area of science is extraordinarily complicated in itself. However, it is made even more incomprehensible to the layperson when the scientists themselves do not seem to agree on the extent or the degree of this problem.

It is not just the macro-environment (global warming and greenhouse gases), but the effects of road vehicle emissions on human health in the micro-environment such as a city street, that concerns many people. Fossil fuels tend to produce what is called particulate matter (PM), which is, amongst other things, unburned fuel. Diesel engines are particularly prone to producing this type of emission. Medical studies have raised concerns about what has come to be known as PM10s and their effect on sufferers of respiratory illnesses such as asthma. PM10s are particulate matter smaller than 10 microns in size. An effective method for reducing these emissions is exhaust after-treatment. A device called a particulate trap is fitted to the vehicle exhaust system, which effectively prevents the PMs being discharged into the atmosphere. It is not a straightforward matter to fit this equipment to existing vehicles because of the effects it may have on engine performance and the space required to accommodate the equipment.

The internal combustion engine also produces other emissions that are a cause for concern. The main culprits and their effects are:

Emission	*Main effects*
Carbon monoxide	*Toxic*
Carbon dioxide	Implicated in global warming
Oxides of nitrogen	Photochemical smog and ozone formation
Volatile organic compounds	Photochemical smog
Sulphur dioxide	Acid rain
Particulate matter	Respiratory problems

It is little wonder, in view of the above, that attention has turned to finding an alternative fuel to power road vehicles. Before discussing alternative fuels, it is worth explaining that the quality of road fuels and engines has been dramatically improved in the last 15 years. In the main, this has been achieved by:

- reducing the sulphur content in diesel fuel;
- fitting catalytic converters to all new cars sold in the UK after 1 January 1993;
- high-pressure fuel injection systems;
- the use of computerized engine management systems.

Unfortunately, much of this good work has been nullified by the increase in road congestion and the number of private cars on the roads.

There are many alternative fuels being developed currently. This section will briefly outline some of the fuels and highlight any particular points of interest.

Compressed natural gas (CNG)

Natural gas is mainly methane and is to be found in most homes in the UK, where it is used for domestic purposes. Natural gas is used in a combustion engine in the same way as petrol, that is to say it requires a spark to ignite it rather than compression.

One obvious problem with this fuel is the lack of refuelling infrastructure; therefore vehicles will either have to return to their base at the end of their journey or at least go to another point where they may be refuelled. This is all the more frustrating when one understands that this gas is already widely distributed via the existing domestic gas infrastructure. Should the vehicle run out of fuel then it will have to be towed back to base, as currently there is no alternative.

CNG-powered trucks require roughly five times the volume of fuel storage that a diesel-powered truck requires. The weight of fuel tanks will obviously be increased and detract from the payload capacity of the vehicle. The actual process of refuelling can be achieved in two ways - either fast-fill or slow-fill. The fast-fill method requires a compressor to compress the gas after taking it from the main supply network. The compressed gas is then stored in tanks ready for vehicles to draw the fuel. Using this method, vehicles may achieve a refuelling time comparable with fuels such as diesel. The slow-fill method uses a smaller compressor and no intermediate storage tanks. This option is a low-cost alternative to fast-fill provided there is a gas supply to the vehicle's base. Its major drawback is that the vehicle will have to be coupled to the refuelling system overnight.

From a financial point of view, CNG engines will cost more than standard diesel engines but there are currently grants available from the UK government to help with the additional cost. The excise duty on natural gas is also currently attractively lower than on traditional road fuels.

From an emissions point of view, natural gas performs very well and is increasingly seen as a viable alternative for commercial vehicles working in urban areas. This is mainly due to the range and refuelling limitations of the fuel but also because of its beneficial exhaust emission performance.

Liquefied natural gas (LNG)

This is the same fuel as CNG, the only difference being in the way it is stored and supplied. LNG is stored at a temperature of -162 degrees Celsius but in many other respects behaves like diesel fuel. Refuelling times are very similar, although the person refuelling will have to use protective equipment for safety reasons.

The use of both CNG and LNG has been steadily growing in recent years as operators of commercial vehicles, especially in urban areas, have become convinced of their advantages.

Bi-fuel or dual-fuel options

Bi-fuel systems are designed so that the vehicle is running exclusively on either one fuel or the other at any one time. Dual-fuel options are designed so that the vehicle can operate on a mixture of fuels at the same time or revert to operating on only one fuel if necessary.

These types of hybrid vehicles have been developed to overcome operating range or operational difficulties. Usually the vehicle will have a choice of fuel. This could be CNG and diesel or petrol and electric power. The problem with these vehicles is that they not only are more complex in design but also do not necessarily deliver the full benefits of one option or the other.

Liquefied petroleum gas (LPG)

This is a mix of propane and butane gas. It is a by-product of the petroleum and natural gas production process. It requires a spark ignition engine and is popular as an alternative to petrol. It benefits from an existing refuelling infrastructure, especially in continental Europe.

Bio-diesel

This is a fuel that is refined from various vegetable-based oils such as rapeseed oil. It performs much like diesel fuel and is currently used in a limited way.

Electric power

Vehicles powered by electricity have existed for many years. The use of electricity has been confined to smaller vehicles because of the weight and volume of batteries required. Recent developments in battery and fuel cell technology have made electric power for light transport a viable alternative. These vehicles benefit from low emissions and are very quiet.

Fuel cell technology is likely to provide the motive power for light transport in the future. This technology exploits the electricity produced by hydrogen and oxygen atoms when they combine together to form water. Fuel cells require a hydrogen-rich fuel such as methane. The resultant electricity drives an electric motor, which in turn provides the motive power. Fuel cells produce low emissions.

Dimethyl ether (DME)

DME is a synthetic fuel that can be substituted for diesel or LPG or as a hydrogen-rich source for fuel cells. It may be made from coal, natural gas, black liquor (a by-product of paper pulp manufacturing) or biomass. DME is a gas that becomes a liquid under low pressure similar to LPG. It is suitable for use in compression ignition engines due to its high cetane factor, which is equal to or greater than conventional diesel. Compared to diesel fuel, DME produces 90 per cent less NOx emissions. It is of particular interest to countries such as Sweden, Japan and China. In fact, at the time of writing the Swedish company Volvo Truck Corporation is testing a truck fitted with a 9.4-litre diesel engine adapted for DME use. In China, the Shanghai city authorities are testing buses fuelled by DME.

SUMMARY

This chapter has looked at the area of environmental law and best practice with specific reference to the impact on logistics management. Broadly, the subject matter was divided between the internal and the external environment. Environmental legislation tends to deal with the external environment, whilst the internal environment is covered by health and safety legislation.

The direction and content of EU environmental legislation was outlined, as was the environmental management system - ISO 14000. A useful environmental management checklist was reproduced.

Packaging was highlighted as an area singled out for special attention by the legislative authorities. The main requirements under these regulations were outlined. Waste transport was also covered. The WEEE Directive was described briefly.

Useful performance measures were suggested to aid the process of monitoring improvements in environmental best practice. Specific points regarding environmental best practice for both vehicles and distribution centres were listed. Reverse logistics and its implications for logistics management were briefly discussed.

Finally, the subject of alternative fuels was dealt with by outlining some of the issues and describing some of the major alternative fuels available or under research.

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