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LOGISTICS SYSTEMS:
DESIGN AND OPTIMIZATION

Edited by
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Springer
GERAD celebrates this year its 25th anniversary. The Center was created in 1980 by a small group of professors and researchers of HEC Montréal, McGill University and of the École Polytechnique de Montréal. GERAD’s activities achieved sufficient scope to justify its conversion in June 1988 into a Joint Research Centre of HEC Montréal, the École Polytechnique de Montréal and McGill University. In 1996, the Université du Québec à Montréal joined these three institutions. GERAD has fifty members (professors), more than twenty research associates and post doctoral students and more than two hundreds master and Ph.D. students.

GERAD is a multi-university center and a vital forum for the development of operations research. Its mission is defined around the following four complementarily objectives:

- The original and expert contribution to all research fields in GERAD’s area of expertise;
- The dissemination of research results in the best scientific outlets as well as in the society in general;
- The training of graduate students and post doctoral researchers;
- The contribution to the economic community by solving important problems and providing transferable tools.

GERAD’s research thrusts and fields of expertise are as follows:

- Development of mathematical analysis tools and techniques to solve the complex problems that arise in management sciences and engineering;
- Development of algorithms to resolve such problems efficiently;
- Application of these techniques and tools to problems posed in related disciplines, such as statistics, financial engineering, game theory and artificial intelligence;
- Application of advanced tools to optimization and planning of large technical and economic systems, such as energy systems, transportation/communication networks, and production systems;
- Integration of scientific findings into software, expert systems and decision-support systems that can be used by industry.

One of the marking events of the celebrations of the 25th anniversary of GERAD is the publication of ten volumes covering most of the Center’s research areas of expertise. The list follows: Essays and Surveys in Global Optimization, edited by C. Audet, P. Hansen and G. Savard; Graph Theory and Combinatorial Optimization,
I would like to express my gratitude to the Editors of the ten volumes, to the authors who accepted with great enthusiasm to submit their work and to the reviewers for their benevolent work and timely response. I would also like to thank Mrs. Nicole Paradis, Francine Benoît and Louise Letendre and Mr. André Montpetit for their excellent editing work.

The GERAD group has earned its reputation as a worldwide leader in its field. This is certainly due to the enthusiasm and motivation of GERAD’s researchers and students, but also to the funding and the infrastructures available. I would like to seize the opportunity to thank the organizations that, from the beginning, believed in the potential and the value of GERAD and have supported it over the years. These are HEC Montréal, École Polytechnique de Montréal, McGill University, Université du Québec à Montréal and, of course, the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Fonds québécois de la recherche sur la nature et les technologies (FQRNT).

Georges Zaccour
Director of GERAD
Avant-propos

Le Groupe d'études et de recherche en analyse des décisions (GERAD) fête cette année son vingt-cinquième anniversaire. Fondé en 1980 par une poignée de professeurs et chercheurs de HEC Montréal engagés dans des recherches en équipe avec des collègues de l'Université McGill et de l'École Polytechnique de Montréal, le Centre comporte maintenant une cinquantaine de membres, plus d'une vingtaine de professionnels de recherche et stagiaires post-doctoraux et plus de 200 étudiants des cycles supérieurs. Les activités du GERAD ont pris suffisamment d'ampleur pour justifier en juin 1988 sa transformation en un Centre de recherche conjoint de HEC Montréal, de l'École Polytechnique de Montréal et de l'Université McGill. En 1996, l'Université du Québec à Montréal s'est jointe à ces institutions pour parrainer le GERAD.

Le GERAD est un regroupement de chercheurs autour de la discipline de la recherche opérationnelle. Sa mission s'articule autour des objectifs complémentaires suivants :

- la contribution originale et experte dans tous les axes de recherche de ses champs de compétence ;
- la diffusion des résultats dans les plus grandes revues du domaine ainsi qu'au-delà des différents publics qui forment l'environnement du Centre ;
- la formation d'étudiants des cycles supérieurs et de stagiaires post-doctoraux ;
- la contribution à la communauté économique à travers la résolution de problèmes et le développement de coffres d'outils transférables.

Les principaux axes de recherche du GERAD, en allant du plus théorique au plus appliqué, sont les suivants :

- le développement d'outils et de techniques d'analyse mathématiques de la recherche opérationnelle pour la résolution de problèmes complexes qui se posent dans les sciences de la gestion et du génie ;
- la confection d'algorithmes permettant la résolution efficace de ces problèmes ;
- l'application de ces outils à des problèmes posés dans des disciplines connexes à la recherche opérationnelle telles que la statistique, l'ingénierie financière, la théorie des jeux et l'intelligence artificielle ;
- l'application de ces outils à l'optimisation et à la planification de grands systèmes technico-économiques comme les systèmes énergétiques, les réseaux de télécommunication et de transport, la logistique et la distributique dans les industries manufacturières et de service ;
l'intégration des résultats scientifiques dans des logiciels, des systèmes experts et dans des systèmes d'aide à la décision transférables à l'industrie.


Je voudrais remercier très sincèrement les éditeurs de ces volumes, les nombreux auteurs qui ont très volontiers répondu à l'invitation des éditeurs à soumettre leurs travaux, et les évaluateurs pour leur bénévolat et ponctualité. Je voudrais aussi remercier Mmes Nicole Paradis, Francine Benoît et Louise Letendre ainsi que M. André Montpetit pour leur travail expert d'édition.

La place de premier plan qu'occupe le GERAD sur l'échiquier mondial est certes due à la passion qui anime ses chercheurs et ses étudiants, mais aussi au financement et à l'infrastructure disponibles. Je voudrais profiter de cette occasion pour remercier les organisations qui ont cru dès le départ au potentiel et la valeur du GERAD et nous ont soutenus durant ces années. Il s'agit de HEC Montréal, l'École Polytechnique de Montréal, l'Université McGill, l'Université du Québec à Montréal et, bien sûr, le Conseil de recherche en sciences naturelles et en génie du Canada (CRSNG) et le Fonds québécois de la recherche sur la nature et les technologies (FQRNT).

Georges Zaccour
Directeur du GERAD
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Preface

Logistics is an integral part of our every day life. Today it influences more than ever a large number of human and economic activities. The term logistics, which comes from the French word “logis” meaning dwelling, originally designated the art of organizing the transportation, resupplying, and housing of the troops of an army (that of Napoleon). From the 1960s on, the term logistics has been used in the business field to refer to the means and methods related to the physical organization of a company, and specially the flow of materials before, during, and after production. Logistics includes what is now known as supply chain management. Logistics also includes service activities.

In a context of global competition, the optimization of logistics systems is inescapable. This book falls within this perspective and presents twelve chapters that well illustrate the variety and the complexity of logistics activities. The chapters were written on invitation by recognized researchers and constitute either a summary of a particular topic, or an outline of an emerging field of logistics. The first chapter, by Riopel, Langevin, and Campbell, proposes a reference framework and allows placing the context accordingly of each of the other chapters. It classifies logistics decisions and highlights the relevant linkages among them. The intricacy of these linkages demonstrates how thoroughly the decisions are interrelated and highlights the complexity of managing logistics activities. All the other chapters focus on quantitative methods for the design and optimization of logistics systems.

In Chapter 2, Daskin, Snyder, and Berger outline the importance of facility location decisions in supply chain design. They summarize more recent research aimed at expanding facility location decisions to various supply chain contexts. Higginson and Bookbinder in the following chapter analyze logistics operations in distribution centers. They highlight the specific functions of a distribution center in comparison to those of a classical warehouse. The design and operation of a warehouse entail many challenging decision problems. Cormier presents in Chapter 4 a taxonomy of warehousing decision models and an overview of representative operations research models and solution methods for efficient warehousing.

The next chapter, by Marcoux, Riopel, and Langevin, presents a survey of operations research models and methods for facilities layout and handling system design. The focus is on the applicability of those models and methods to real-life problems. Bostel, Dejax, and Lu review in Chapter 6 applications, case studies, models and techniques proposed
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for facility location, inventory management, and the transportation and production planning of reverse logistics systems. They consider both cases of separate and integrated handling of original products and return flows throughout the logistics network. In the following chapter, Kim classifies and reviews models and methods for various operations in port container terminals. Considering the large amount of investment needed and the costly time spent by vessels at the terminals, it is important to improve the productivity of the handling activities.

In Chapter 8, Campbell reviews operations research models for strategic design of road transport networks, including network configuration and terminal location. This includes networks for less-than-truckload or truckload transporters, and postal carriers that serve many origins and destinations in large geographic regions. This chapter analyses several shipping strategies. Cordeau, Gendreau, Hertz, Laporte, and Sormany review in Chapter 9 some of the best metaheuristics proposed in recent years for the vehicle routing problem. These are based on local search, population search, and learning mechanisms.

In Chapter 10, Dror, through the description of the practices of a propane distribution company, analyses inventory routing problems and summarizes the literature on that topic. These problems include a family of hard problems of considerable practical significance. Martel, Rizk, D’Amours, and Bouchriha examine next the short-term production, transportation, and inventory planning problems encountered in the fine-paper industry. After placing the problems in the context of a general supply chain planning system, a comprehensive synchronized production-distribution model is gradually developed. The last chapter, by Moutreuil, analyses the impact of customer centricity and personalization as well as collaboration and agility of network stakeholders on the operational optimization modeling of demand and supply chains. This chapter deals with the demand and supply chain of manufacturers of high-value products such as vehicles, computers and equipment, which are sold to consumers in a large geographical region through a network of dealers. It introduces a comprehensive operations planning optimization model applicable in such a context. It then demonstrates its application specificities as a function of the characteristics of the demand and supply chain.

This book well illustrates the diversity of logistics. We are aware that its contents do not cover all the richness of the scientific community’s contribution. Our choices necessarily omitted a number of relevant topics, but we are convinced that the reader can acquire in a condensed way the knowledge of several important areas of logistics. We hope that this book will be useful both to researchers and to practitioners. We
would like to sincerely thank each of the authors for the quality of their contribution. We express our gratitude towards the GERAD personnel and more particularly towards Ms. Nicole Paradis and Francine Benoît, and Mr. André Montpetit of the CRM for their important contribution to the editing of this book.

André Langevin and Diane Riopel
École Polytechnique and GERAD
La logistique fait partie intégrante de notre quotidien. Elle influence aujourd'hui plus que jamais un grand nombre d'activités humaines et économiques. Le terme logistique, qui vient du mot 'logis', est apparu à l'origine pour désigner l'art de combiner tous les moyens de transport, de ravitaillement et de logement des troupes d'une armée (celle de Napoléon). À partir des années 1960, le terme logistique a été utilisé dans le domaine des affaires pour désigner l'ensemble des moyens et des méthodes concernant l'organisation physique d'une entreprise et spécialement les flux de matières avant, pendant et après une production. La logistique englobe ce que plusieurs appellent maintenant la chaîne logistique ou la chaîne d'approvisionnement. La logistique touche aussi les entreprises de service.

Dans un contexte de compétition planétaire, que l'on parle de globalisation ou de mondialisation, l'optimisation des systèmes logistiques est incontournable. Ce livre s'inscrit dans cette optique et présente douze chapitres qui illustrent bien la grande diversité et la complexité des activités logistiques. Les chapitres ont été écrits, sur invitation, par des chercheurs reconnus et constituent soit une synthèse d'un domaine particulier, soit une présentation d'un champ en émergence de la logistique. Le premier chapitre, écrit par Riopel, Langevin et Campbell, propose un cadre de référence et permet de situer chacun des chapitres. Il classifie les décisions logistiques et met en relief les liens entre celles-ci. La complexité de ces liens montre à quel point ces décisions sont inter-reliées et la difficulté de gérer l'ensemble des activités logistiques. Tous les autres chapitres du livre focalisent sur les méthodes quantitatives pour la conception et l'optimisation des systèmes logistiques.

Au chapitre 2, Daskin, Snyder et Berger relèvent l'importance des décisions de localisation des installations dans la conception de chaînes logistiques. Ils résument les recherches récentes sur l'extension des modèles de localisation à divers contextes de chaînes logistiques. Higginsson et Bookbinder analysent dans le chapitre suivant les opérations logistiques des centres de distribution. Ils comparent les fonctions d'un centre de distribution à celles d'un entrepôt classique. La conception et la conduite des opérations d'un entrepôt sont la source de plusieurs problèmes décisionnels difficiles. Cormier présente au chapitre 4 une taxonomie des modèles de décision en entreposage et un survol des modèles et méthodes les plus représentatifs.

Au chapitre suivant, Marcoux, Riopel et Langevin présentent une synthèse des modèles et des méthodes de recherche opérationnelle pour la
conception d’implantations et de systèmes de manutention. Cette synthèse est centrée sur l’applicabilité de ces modèles et méthodes en entreprise. Bostel, Dejax et Lu passent en revue au chapitre 6 les applications, cas d’entreprise, modèles et techniques qui ont été proposées pour la localisation d’installations, la gestion des stocks, le transport et la planification de la production pour les systèmes de logistique inverse. Ils prennent en compte les mouvements de façon séparée ou intégrée des flux de produits originaux et des flux de retours dans tout le réseau logistique.

Au chapitre suivant, Kim classe et passe en revue les modèles et les méthodes pour diverses opérations dans les installations portuaires pour conteneurs. Compte tenu des investissements requis et des coûts relatifs au temps à quai des bateaux, il est primordial d’optimiser la productivité des opérations de manutention des conteneurs.

Au chapitre 8, Campbell passe en revue les modèles de recherche opérationnelle pour la conception stratégique de réseau de transport routier, incluant la configuration des réseaux et la localisation des installations. Ceci inclut les réseaux de transporteurs à charges partielles ou de chargements complets, ou transporteurs de courrier postal qui desservent plusieurs origines et plusieurs destinations sur de larges territoires. Ce chapitre analyse plusieurs stratégies de transport. Cordeau, Gendreau, Hertz, Laporte, et Sormany présentent au chapitre 9 une synthèse des meilleures métaheuristiques élaborées ces dernières années pour le problème de tournées de véhicules. Ces métaheuristiques sont basées sur les méthodes de recherche locale, de recherche sur populations et sur des mécanismes d’apprentissage.

Au chapitre 10, Dror, au travers de la description des pratiques d’une compagnie de distribution de propane, analyse les problèmes combinés de tournées de véhicules et de gestion des stocks et présente une synthèse de la littérature sur ces problèmes. Ces problèmes comportent une famille de problèmes difficiles, d’une grande importance pratique. Martel, Rizk, D’Amours et Bouchriha examinent ensuite des problèmes de production, transport et gestion des stocks à court terme dans l’industrie de production de papiers fins. Après avoir situé le problème dans le contexte d’un système général de chaîne logistique, ils développent graduellement un modèle complet de production et distribution synchronisées. Le dernier chapitre, par Montreuil, analyse l’impact du centrage client et de la personnalisation ainsi que de la collaboration et de l’agilité des partenaires d’un réseau, sur la modélisation de l’optimisation des opérations d’une chaîne de demande et d’approvisionnement. Le chapitre traite de chaînes de demande et d’approvisionnement de manufacturiers de produits de grande valeur, comme des véhicules, des ordinateurs et équipements informatiques, vendus au moyen d’un large réseau de concessionnaires à
des consommateurs géographiquement dispersés. Il introduit un modèle générique d'optimisation de la planification des opérations dans un tel contexte et en démontre les spécifications d’application en fonction des caractéristiques de la chaîne de demande et d’approvisionnement.

Ce livre illustre bien la diversité du domaine de la logistique. Nous sommes conscients que son contenu pourra paraître bien peu pour apprécier la richesse des travaux effectués par la communauté scientifique. Nos choix ont forcément omis un certain nombre de sujets pertinents. Mais nous sommes convaincus que les lecteurs pourront acquérir de façon condensée les connaissances sur plusieurs domaines importants de la logistique. Nous espérons que ce livre sera utile tant aux chercheurs qu’aux praticiens. Nous voulons remercier chaleureusement chacun des auteurs pour la qualité de leur contribution. Nous exprimons notre gratitude envers le personnel du GERAD, et particulièrement Mmes Nicole Paradis et Francine Benoît, et M. André Montpetit du CRM pour leur apport important à l’édition de ce livre.

ANDRÉ LANGEVIN ET DIANE RIOPEL
École Polytechnique et GERAD
Chapter 1

THE NETWORK OF LOGISTICS DECISIONS

Diane Riopel
André Langevin
James F. Campbell

Abstract  This chapter provides a framework for business logistics decision-making by classifying logistics decisions and highlighting the relevant linkages among them. We focus on the precedence relationships among logistics decisions and on how each decision influences and is influenced by other decisions. We also identify the key information required for making various logistics decisions. The core of our framework is a three-part decision hierarchy consisting of a strategic planning level, a network level and an operations level for 48 fundamental logistics decisions. The intricacy of the linkages between the various decisions demonstrates how thoroughly the decisions are interrelated and highlights the complexity of managing logistics activities.

1. Introduction

Effective logistics management requires good decision making in a wide variety of areas. Because the scope of logistics is so broad across both the functional areas of an organization and the temporal span of control, and because of the inherent inter-relationships between logistics decisions, logistics decision-makers must contend with a daunting array of issues and concerns. In this chapter we seek to provide a coherent framework for business logistics decision-making by identifying logistics decisions and highlighting the relevant linkages between them. Our focus is on the precedence relationships among logistics decisions, and on how each decision influences, and is influenced by, other decisions. We also identify the key information required for making various logistics decisions.
In this chapter we adopt the Council of Logistics Management definition of Logistics (2003): “Logistics is that part of the supply chain process that plans, implements, and controls 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 customers’ requirements.” Our goal is to delineate the precedence network of logistics decisions to help organizations better understand the interrelationships between these decisions. The issues to address are usually distributed across several departments or services, and hence across several groups of personnel. The framework we provide emphasizes the multiple links and the complexity of the resulting decision network. This is aimed at helping managers improve the efficiency, agility, and coherence of their logistics systems. This work is in keeping with the contributions to establish and manage fully integrated supply chains.

The field of business logistics has evolved substantially over the past several decades. (See for example Miyazaki et al., 1999; Langley, 1986; Kent and Flint, 1997). In the 1960s, business logistics primarily concerned two groups of functions, materials management and distribution. As Bowersox indicates regarding the founding of the National Council of Physical Distribution Management (NCPDM, now CLM) in 1963: “We were beginning to pioneer educational courses in physical distribution in those days, and nobody was integrating the functions of transportation, warehousing, and inventory to study and discuss how they worked together.” (CLM web site, http://www.clml.org/aboutUs/aboutUs.History.asp 2003)

The 1970s brought an increasing focus on the interdependence of these functions (Heskett et al., 1973; Heskett, 1977; Bowersox, 1978), and logistics “expanded” in the following years to include a more integrated perspective (Hutchinson, 1987; Ballou, 1992; Blanchard, 1992; Langford, 1995). As a reflection of this change in focus, the NCPDM changed its name to the Council of Logistics Management (CLM) in the mid-1980s. Other contributors to the evolution of logistics in organizations in the 1980s were improvements in information technologies and communications, the emergence of third party firms offering varied logistic services, and new techniques such as DRP (Distribution Resource Planning) and JIT (Just-in-Time) (The Logistics Handbook, 1994).

Since the 1990s logisticians have given increased attention to integrating the activities of all the supply chain. Global operations and customer service have become key themes (Bowersox and Closs, 1996; Coyle et al., 2003; Ganesan et al., 1998; Kasilingam, 1999; Gattorna, 1998; Stock, 2001).
The evolution of logistics has entailed an increasingly comprehensive and global vision of logistics, and a corresponding expanding scope for logistics decision-making. The decision environment has become more complex, with new management strategies and business models (e.g., JIT and e-commerce), global markets and sourcing, new information technologies and communications, a renewed focus on customer satisfaction (e.g., 24-hour service), new transport service options (e.g., overnight delivery), and increasing environmental awareness (e.g., recycling), etc. Although the logistics decision environment changes as new services, technologies, markets, and operations arise, the fundamental logistics decisions still must be made (for example, “What mode of transportation should be used?”).

Many authors have classified logistics activities into different functions, and most basic logistics or supply chain management textbooks include some form of categorization for logistics activities or decisions (see for example, Ballou, 2004; Bowersox et al., 2002; Chopra and Meindl, 2004; Coyle et al., 2003; Johnson et al., 1999; Simchi-Levi et al., 2003; Stock and Lambert, 2001). The preceding works generally enumerate the logistic functions, and indicate that many of the decisions are interdependent and should be made concurrently. Models for solving various problems (facility location, vehicle routing, inventory management) are often presented in detail, but the higher level view detailing the precedence relationships among all decisions is lacking. Our goal in this chapter is to provide the network of logistics decisions to clearly delineate the precedence relations. From such a network we can then examine the relative positioning of various logistics decisions to assess their influence on other decisions. In order to build a comprehensive network, we have consulted the logistics textbooks listed in Table 1.1.

The chapter is organized as follows: Section 2 presents, for each level of the hierarchy, the relevant logistics decisions. Section 3 discusses the linkages among the decision by depicting graphically their interrelationships. A conclusion follows.

2. Logistics decision

As indicated in the previous section, the activities of logistics can be divided and classified in several different ways. Many of the differences in the various classifications occur with the activities that span the interfaces between the different functional parts of an organization, such as those activities spanning logistics and production, marketing and/or finance. Although authors have adopted different approaches in defining the basic logistics activities, and have developed different frameworks for
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presenting and organizing the various logistics activities, they all address the same fundamental logistics decisions. These logistics decisions range from long-term strategic decisions involving customer service levels and network design, to short-term tactical or operational decisions, such as daily routing of vehicles. This section delineates the different logistics decisions required in each activity, and indicates linkages between these decisions. Our focus is specifically on the logistics decisions, rather than the logistics activities, and we attempt to indicate clearly the interdependence of decisions, as well as the additional information required as input for these decisions.

Logistics decisions may be divided or grouped in several dimensions based on various criteria. The common grouping into strategic, tactical and operational levels (as in Ballou, 2004) may be based on one or more of the following criteria associated with the decisions: the time frame, the resource requirements, or the level of managerial responsibility. These criteria are generally inter-related—for example, strategic decisions usually are made at high level in the organization and address long-term issues with significant resource implications, and these are made at a high level in the organization. While in reality the range of decisions may be better viewed as a continuum on all dimensions (time frame, resource requirements, and managerial responsibility), for ease of exposition and presentation these decisions are usually separated into distinct categories.

The core of our framework for this presentation is a three-part decision hierarchy consisting of a Strategic Planning level, a Network level and an Operations level. Table 1.2 lists the decision categories within each level of the hierarchy. (Alternate classification systems and hierarchies are possible, but the underlying decisions and inter-relationships between individual decisions would not change.)

The remainder of this section is divided into subsections for the Strategic Planning level decisions, Network Design level decisions, and Operations level decisions. Within each of the subsections we detail the individual decisions, and for each of these decisions we indicate the inputs needed in the form of any previous decisions, and the other information required. For example, the carrier selection decision ("Which transportation carrier(s) should be used?") requires a previous decision on the types of carriers to be used (for example, public vs. private trucks) and additional information on available carriers, and on the organization’s performance objectives. Each organization will not need to make every decision that we discuss; some organizations may contract or outsource large portions of their logistics activities, or the nature of the products and business may preclude certain decisions. Thus, our subsequent dis-
Table 1.2. Logistics decision categories

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<th>Strategic Planning level</th>
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<td><strong>Network level</strong></td>
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<td>- Physical Facility (PF) Network</td>
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<td>- Communication and Information (C&amp;I) Network</td>
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<tr>
<td><strong>Operations level</strong></td>
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<tr>
<td>- Demand Forecasting</td>
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<tr>
<td>- Inventory Management</td>
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<tr>
<td>- Production</td>
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<td>- Procurement and Supply Management</td>
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<td>- Transportation</td>
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<td>- Product Packaging</td>
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<td>- Material Handling</td>
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<td>- Warehousing</td>
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<td>- Order Processing</td>
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cussions are not focussed on one particular firm or industry, but are meant to provide general coverage of logistics decision-making. To help identify the discussion for each decision, we use an italic font for the decision name throughout this section.

All the decisions described in this section, along with their immediate predecessors and the additional information required are summarized in a table in the Appendix to assist the reader. To keep the table manageable, the additional information listed for each decision is only that information not included as input for a previous decision. It should be understood that each decision may depend on a cumulative collection of previous decisions and associated additional information.

2.1 Strategic Planning level decisions

The Strategic Planning level includes high-level logistics decisions of a strategic nature. These types of decisions are likely to span functional areas beyond logistics. The key logistics decisions at this level concern performance objectives and the degree of vertical integration and outsourcing. One fundamental strategic decision is the definition of customer service and the associated metrics. This includes identifying the elements of customer service that are most important and most relevant for logistics, and defining exactly what will be measured and how it will be measured. This decision requires knowledge of the organizational mission and strategies, customer expectations, the competitive environment, financial resource availability and the existing logistics system (both the physical system and the information and communication system). Because financial resource availability and knowledge of the
existing logistics system are relevant for (nearly) every logistics decision, we will not discuss them in each subsection.

A subsequent decision related to defining customer service is setting the customer service objectives. This involves developing performance standards using the previously defined customer service elements and metrics, as well as the previously mentioned additional information.

Other fundamental strategic level decisions concern the degree of vertical integration and outsourcing within the supply chain. Decisions on vertical integration include the nature of the integration, the direction (forward towards customers and/or backward towards suppliers), and the extent of integration (for example, which activities, parts or components should be included). Decisions related to outsourcing determine which functions should be outsourced (for example, transportation, distribution, warehousing, order processing, or fulfillment) and the extent and nature of outsourcing agreements. These decisions may rely on the previously defined customer service objectives, the availability of financial, human, material and equipment resources (including production and distribution capabilities), and the additional information needed for the definition of customer service.

There are a variety of additional strategic level decisions that affect logistics, such as determining the organization's overall economic objectives and strategy, determining the range of products and services offered, determining the geographic scope (regional, national, multinational or global) of production, distribution, and marketing, and determining the marketing and information management objectives and strategy (including electronic commerce). However, because the scope of these strategic decisions extends considerably well beyond logistics, they are not included here.

2.2 Network level decisions

Logistics decisions at the Network level are divided into two groups corresponding to the physical facility network and to the communication and information network. These are generally long-range structural decisions and they often involve considerable expenditures. Because the cost of each decision alternative is used as an input in the decision, cost is not included explicitly in the table. Note that in the physical facility network and in the communication and information network, decisions may address both forward and reverse flows.

A key network decision for the physical facility (PF) network is determining the PF network strategy. This specifies the overall organization or structure of the network (for example, the degree of hierarchy and
number of echelons, and the degree of centralization/decentralization),
and depends on the previous decisions regarding customer service ob-
jectives and the degree of vertical integration and outsourcing (at the
strategic planning level), along with additional information about exist-
ing and potential suppliers, customers and markets.

Once the network strategy is determined, the physical facility net-
work design must be determined. Several key decisions that concern
the facilities are as follows: the type and number of facilities (for exam-
ple, warehouses, terminals, distribution centers), the size and location
of each facility, the activities and services provided from each facility, and
whether to use new or existing facilities. Additional decisions address
the linkages between facilities. These are all inter-dependent decisions
that can not be made in isolation. These decisions rely on a variety of ad-
ditional information used in the network strategy, customer service and
vertical integration and outsourcing decisions (the existing logistics sys-

tem, the competitive environment, resource availability and constraints,
etc.), along with information on capability and availability of labor and
support services, availability of sites and transportation, government in-
centives, community attitudes, environmental and zoning regulations,
utilities, and taxes.

Decisions in the communication and information (C&I) network ad-


dress the creation and maintenance of an effective system for communica-
tion and sharing of information throughout the supply chain. Similar to
design of the physical facility network, design of the communication and
information network relies on a C&I network strategy to define the net-
work organization and structure. C&I network strategy decisions include
the degree of centralization in information management and information
processing, (for example, centralized vs. distributed), the locus of appli-
cations development (centralized in-house, distributed in-house, rental,
purchase, etc.), the degree of systems integration, including the use of
enterprise resource planning (ERP) systems, and the role of e-commerce.
Other important C&I network strategy decisions concern the degree of
standardization for the hardware, software, operating system, develop-
ment environment, vendors, etc. These C&I network strategy decisions
depend on the previous decisions regarding the customer service objec-
tives, the degree of vertical integration and outsourcing and the physical
facility network strategy, along with additional information on the ex-
isting C&I systems of the organization, and the existing and potential
suppliers and customers.

The design of the C&I network requires a host of decisions concerning
network architecture and capacities (decisions at nodes regarding the
capture, maintenance, storage, and analysis of data and information,
and decisions concerning information flows between nodes, and between functional groups at the same physical location). Other issues are the extent of information technology to be used (for example, manual paper filing systems, simple digital files, or relational databases), and hardware, software and vendor selection decisions. These decisions depend on the previous C&I network strategy and network design decisions, as well as a variety of additional information, including telecommunications regulations. Most of the C&I network design issues are beyond the scope of this chapter. See Bayles (2000), Edwards et al. (2001), Lewis and Talalayevsky (1997), Bowersox and Daugherty (1995), Nickles et al. (1998), Tilanus (1997) for details on logistics information systems.

2.3 Operations level decisions

Operations level decisions involve shorter time spans and smaller scopes than the Network level and Strategic Planning level decisions. We have divided these decisions into nine groups corresponding to fundamental logistics activities as follows: demand forecasting, inventory management, production, procurement and supply management, transportation, product packaging, material handling, warehousing, and order processing. Our primary interest is to identify these decisions and the linkages between them.

**Demand forecasting.** Short and long term demand forecasting are important activities that provide a basis for much logistics planning. The fundamental forecasting decisions are the magnitude, timing and location(s) of future demand. For existing products and markets these may be routine decisions made with the support of quantitative models. For new products and/or new markets, and for longer time horizons, more qualitative methodologies may be appropriate. These decisions are made primarily with information on historical sales, demand projections (e.g., population growth) and current/future environmental and economic outlooks, and marketing strategies.

**Inventory management.** Inventory management has a central role in logistics since many inventory decisions rely upon, and affect, other logistics decisions. The inventory management strategy (degree of centralization, push vs. pull, etc.) depends on the customer service objectives and on the availability of appropriate data via the C&I network, as well as on the fundamental nature of the products (for example, value or risk) and of the demand (patterns, dependent vs. independent, etc.). The relative importance of inventory items depends on the previous decisions regarding suppliers, which can influence the nature of the items
themselves, as well as on the item values and historical sales data. The methods for controlling inventories (quantitative methods such as EOQ, kanban, etc.) depend in turn on the relative importance of items, as well as on their nature and the nature of the demand. The desired inventory levels are driven by desired customer service levels, the magnitude of future demand, and the supplier selection, along with the characteristics of the production process and the delays in replenishing stocks. Finally, the safety stock decision depends on the previous decision regarding desired inventory levels, and on the item value and delays in replenishment.

Production. Several production decisions play an important role in logistics. Product routing determines where work is to be completed, and this depends on the characteristics of the products and the production equipment/personnel (such as capability and performance of equipment and personnel). The layout of production facilities depends on the previously determined customer service objectives, the activities and services provided from each facility (part of the network design), and the product routing, as well as the production equipment/personnel characteristics (such as size and weight). The master production schedule is a production plan for each product, usually derived from a higher level aggregate production plan. This depends on current levels of inventory and the capacities available for production and inventory (in the physical facility network). The master production schedule drives detailed production scheduling that also depends on product routing and facility layout.

Procurement and supply management. Fundamental logistics decisions in procurement and supply management involve the acquisition of raw materials, parts, components, products, supplies, equipment, etc. For each product or component to be procured, there is a procurement type decision of how best to acquire it (for example, by purchasing or subcontracting). This depends on the customer service objectives, PF network design, the costs, resource availability (capital, personnel, facilities and equipment), the availability of products on the market, and the nature and magnitude of risks involved. For each product, component, or raw material procured, the specifications of goods must be determined from the range of choices. For all goods and services procured, whether purchased or subcontracted, suppliers must be selected and a relationship established. This depends on the previous decisions regarding the PF network design, the inventory management strategy, and the specifications of the purchased goods, as well as a range of information on suppliers' performance and capabilities (quality, reliability, dependability, etc.), the characteristics of the products, organizational purchasing