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Information Technology

Chapter Outline

Supply chain technology systems initiate activities and track information regarding processes, facilitate information sharing both within the firm and between supply chain partners, and assist in management decision making. This chapter describes comprehensive information systems as a combination of transaction, decision support, and communication systems. The chapter begins by describing the role of information systems functionality in supply chain competitiveness. Then the chapter describes the major modules and external interfaces of supply chain information systems. The remaining sections discuss enterprise integration and administration, enterprise operations, enterprise planning and monitoring, and communication technology applications respectively. The final chapter section discusses the movement to offering **software as a service (SaaS)** rather than requiring each firm to have their own copy of each application.

Information System Functionality

From its inception, logistics focuses on product storage and flow through the supply chain. Information flow and accuracy was often overlooked because it was not viewed as being critical to customers. In addition, information transfer rates were limited to manual processes. There are four reasons why timely and accurate information has become more critical in logistics system design and operations. First, customers perceive information regarding order status, product availability, delivery tracking, and invoices as necessary dimensions of customer accommodation. Customers demand real-time information. Second, with the goal of reducing total supply chain assets, managers realize that information can be used to reduce inventory and human resource requirements. In particular, requirements planning based on current information can reduce inventory by minimizing demand uncertainty. Third, information increases flexibility with regard to how, when, and where resources may be utilized to achieve competitive advantage. Fourth, enhanced information transfer and exchange utilizing the Internet is facilitating collaboration and redefining supply chain relationships.

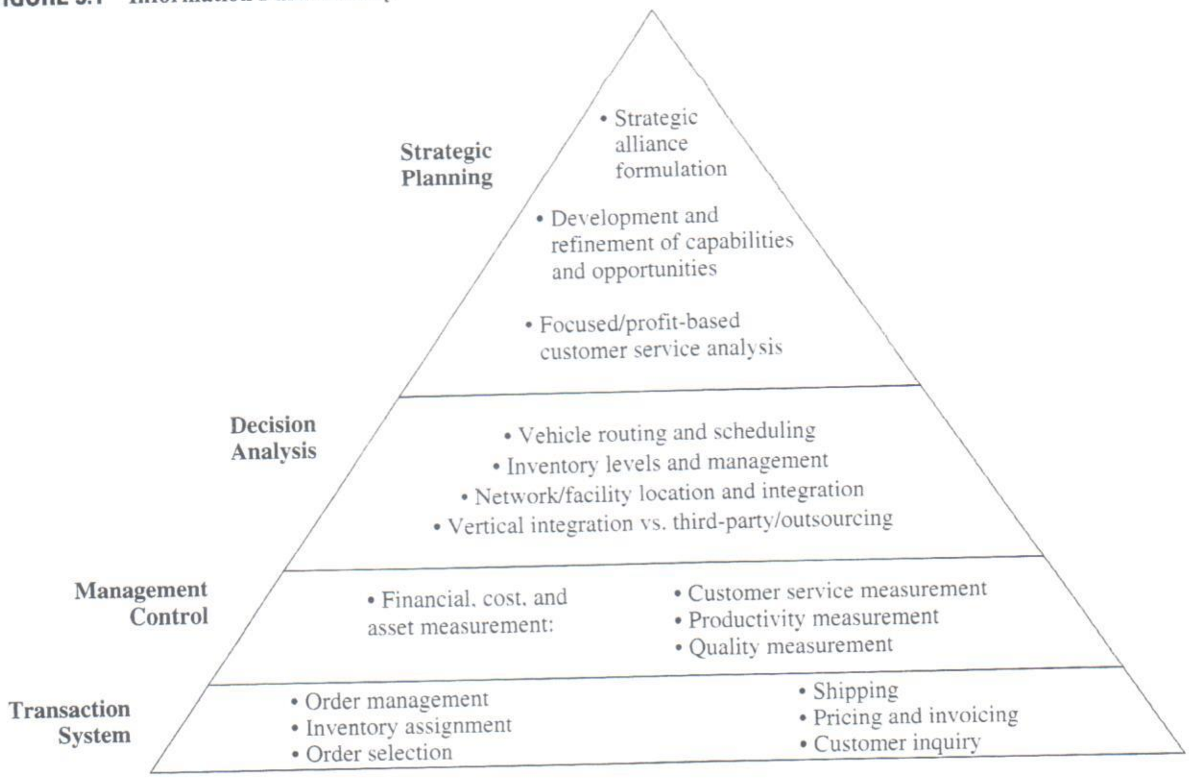
Supply chain information systems (SCIS) are the thread linking logistics activities into an integrated process. The integration builds on four levels of functionality: (1) transaction systems, (2) management control, (3) decision analysis, and (4) strategic planning. Figure 5.1 illustrates logistics activities and decisions at each level of information functionality. As the pyramid shape suggests, management control, decision analysis, and strategic planning enhancements require a strong transaction system foundation.

A **transaction system** is characterized by formalized rules, procedures, and standardized communications; a large volume of transactions; and an operational, day-to-day focus. The combination of structured processes and large transaction volume places a major emphasis on information system efficiency. At the most basic level, transaction systems initiate and record individual logistics activities and their outcomes. Typical transaction functionality includes order entry, inventory assignment, order selection, shipping, pricing, invoicing, and customer inquiry. For example, the customer order entry transaction enters a customer request for products into the information system. The order entry transaction initiates a second transaction as inventory is assigned to the order. A third transaction is then generated to direct warehouse operations to accumulate the order. A fourth transaction initiates order shipment to the customer. The final transaction creates the invoice and a corresponding account receivable. Throughout the process, the firm and customer expect real-time information regarding order status. Thus, the customer order performance cycle is completed through a series of information system transactions.[1]

The second SCIS level, **management control,** focuses on performance measurement and reporting. Performance measurement is necessary to provide feedback regarding supply chain performance and resource utilization. Common performance dimensions include cost, customer service, productivity, quality, and asset management measures. As an example, specific performance measures include transportation and warehousing cost per hundredweight, inventory turnover, case fill rate, cases per labor hour, and customer service perception.

[1] For a review of performance cycle structure and dynamics, see Chapter 2.

FIGURE 5.1 **Information Functionality**



While it is necessary that SCIS report historical system performance, it is also necessary for the system to identify operational exceptions. Exception information is useful to highlight potential customer or operational problems. For example, proactive SCIS should be capable of identifying future inventory shortages based on forecast requirements and planned inventory. Exception reporting should also identify potential transportation, warehouse, or labor constraints. While some control measures, such as cost, are well defined, other measures, such as service and quality, are less specific. For example, customer service can be measured internally, from the enterprise's perspective, or externally, from the customer's perspective. While internal measures are relatively easy to track, information concerning external measures is more difficult to obtain, since it involves the customer or other external partners.

The third SCIS level, **decision analysis,** focuses on software tools to assist managers in identifying, evaluating, and comparing strategic and tactical alternatives to improve effectiveness. Typical analyses include supply chain design, inventory management, resource allocation, transportation routing, and segmental profitability. Decision analysis SCIS should ideally include database maintenance, modeling, analysis, and reporting. Like management control, decision analysis may include operational considerations such as vehicle routing and warehouse planning. Decision analysis is also being used to manage customer relationships by determining the trade-offs associated with having satisfied and successful customers.

Strategic planning, the final SCIS level, organizes and synthesizes transaction data into a relational database that assists in strategy evaluation. Essentially, strategic planning focuses on information to evaluate and refine supply chain and logistics strategy. Examples of strategic planning include the desirability of strategic alliances, development and refinement of manufacturing capabilities, and opportunities related to customer responsiveness.

The relative shape of Figure 5.2 illustrates SCIS development characteristics and justification. Development and maintenance costs include hardware, software, communications, and human resources. In the past, most systems development focused on improving transaction system efficiency. While these investments originally offered returns in terms of speed and lower operating costs, there are now fewer improvement opportunities. Most SCIS development and implementation is now focused on enhanced supply chain system integration and improved decision making.

Supply Chain Information System Modules

A comprehensive SCIS initiates, monitors, assists in decision making, and reports on activities required for completion of logistics operations and planning. The major system modules and their interfaces as illustrated in Figure 5.3 are: (1) Enterprise Resource Planning **(ERP)**, (2) communication systems, (3) execution systems, and (4) planning systems. While Figure 5.3 provides a software-oriented perspective, Figure 5.4 illustrates a more application-oriented perspective. This application perspective is used to discuss each module's specific characteristics and functionality.

The ERP systems in Figure 5.4 are the backbone of most firms' logistics information system. This backbone maintains current and historical data and processes to initiate and monitor performance. During the 1990s, many firms began to replace legacy systems with ERP systems designed as integrated transaction modules and processes with a common and consistent database. The database includes information storage capability for both operations (i.e., product and activity based) and financial (i.e., monetary based) transactions. ERP systems facilitate integrated operations and reporting to initiate, monitor, and track critical activities such as order fulfillment and replenishment. ERP systems

FIGURE 5.2 **SCIS Usage, Decision Characteristics, and Justification**

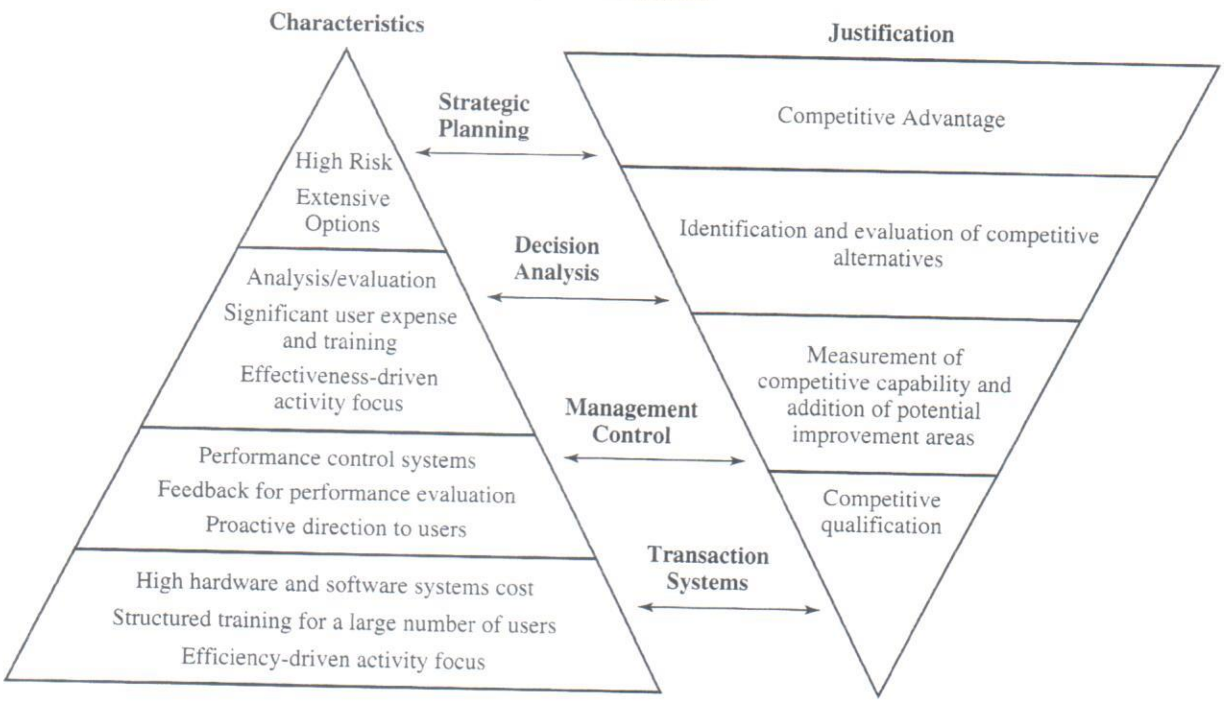
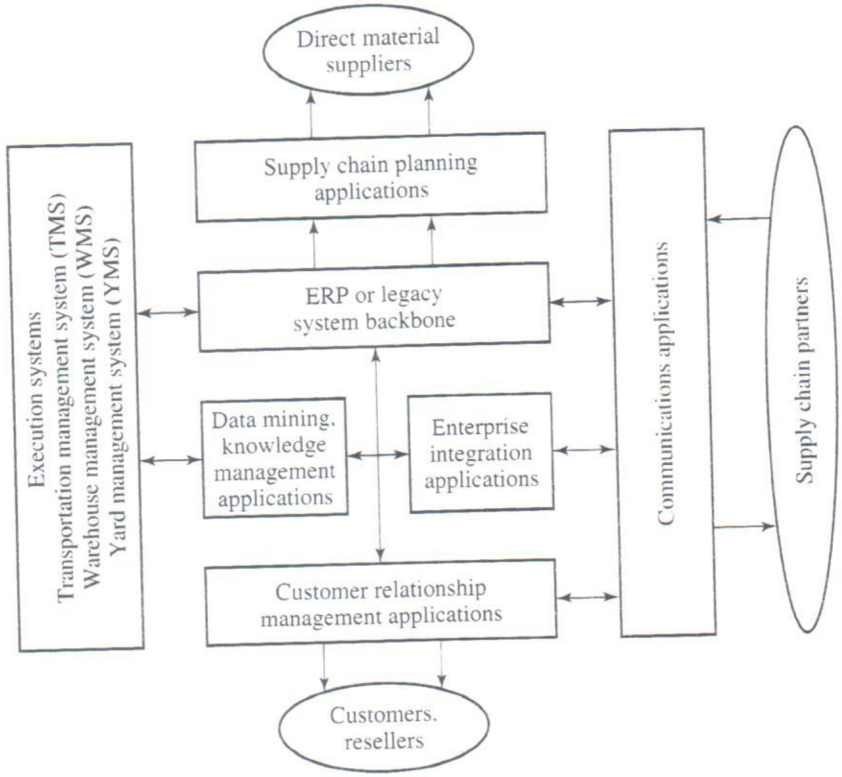


FIGURE 5.3
SCIS: Integrated Modules



also incorporate an integrated corporatewide database, sometimes referred to as a data warehouse, along with appropriate transactions to facilitate logistics and supply chain planning and operations. Supply chain transactions facilitated by ERP systems include order entry and management, inventory assignment, and shipping. Beyond these supply chain applications, ERP systems typically include financial, accounting, and human resource capability. Table 5.1 lists the traditional and emerging capabilities of ERP systems. Data mining, knowledge management, and other enterprise integration applications operate using the ERP backbone to develop and organize insight regarding customers, products, and operations.

FIGURE 5.4
Application-Oriented SCIS Framework

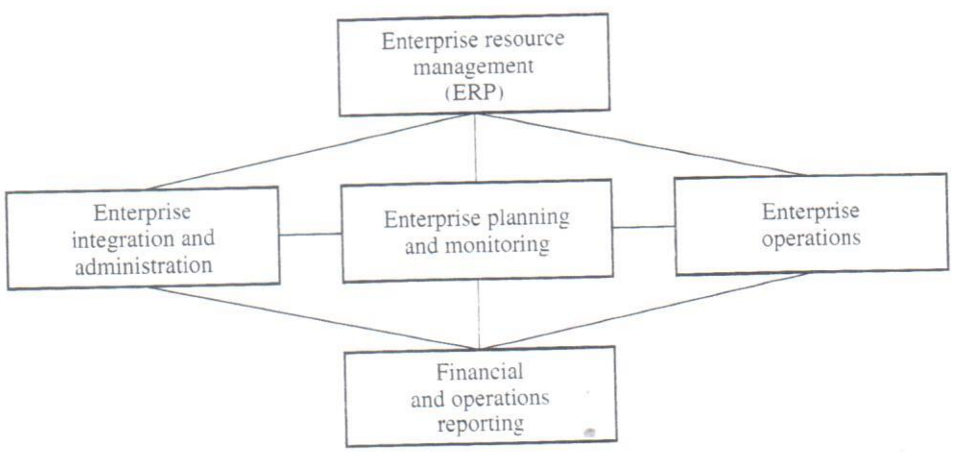


TABLE 5.1
ERP System Capability

Typical	Advanced
Accounts payable and receivable	Collaborative planning, forecasting, and replenishment
General ledger	Customer relationship management
Human resource management	Supply chain event management
Bill of materials	Web-enabled applications
Inventory control	Advanced planning and scheduling
Routings	
Order management	
Project requirements planning	
Execution systems	

The application-oriented modules include: (1) ERP data warehouse, (2) enterprise integration and administration, (3) enterprise operations, (4) enterprise planning and monitoring, and (5) communications technology. Each is briefly described.

ERP Data Warehouse

The core of an ERP system is the central database or information warehouse where all information is maintained to facilitate access to common and consistent data by all modules. Surrounding the database are the functional modules that initiate and coordinate business activities. Although total ERP benefits can best be achieved when all functions are integrated into a common application, many firms elect to implement systems using a modular approach to spread resource requirements and minimize risk, so a limited number of firm functions are in transition at any time.

The **central database** is the relational information repository for the entire ERP system. The central database is described as **relational** because it relates or links information regarding operational entities so that there is minimal information redundancy. Over time, information redundancy usually leads to inaccuracy because one reference to a data item is eventually changed without a comparable change in the other reference. For example, if a customer address is contained in two different locations in the database, it is likely that eventually one reference will be changed if the customer moves but the second reference may be forgotten. At that point, the database would no longer be consistent and all references to the second address would be incorrect. Although the central database is extensive and can contain millions of data items in numerous files, eight major data files are critical to logistics operations: (1) customer file, (2) product-price file, (3) supplier file, (4) order file, (5) bill-of-materials file, (6) purchase order file, (7) inventory file, and (8) history file.

The **customer file** contains information describing the firm's customers. Each entry defines one customer, including name, address, billing information, ship-to location, company contact, price list, terms of sale, and special instructions. A common customer file is helpful particularly when multiple divisions of the firm serve the same customer.

The **product-price file** contains the information describing the products and services offered by the firm. Specific entries include product number, description, physical characteristics, purchase source or manufacturing location, references to equivalent products or updates, and standard cost data. The product-price file or related file also contains information regarding prices and quantity breaks. Product-price file maintenance is increasingly challenging because of shorter product life cycles and more frequent price changes.

The **supplier file** lists the firm's suppliers for materials and services. Specific entries include supplier number, supplier name, address, transportation and receiving information, and payables instructions. A common supplier file is critical to achieve purchasing economies through supplier rationalization and consolidation.

The **order file** contains the information regarding all open orders in some stage of processing or fulfillment by the firm. Each order represents a current or potential request by a customer to ship product. The order file contains the customer number and name, requested receipt date, and the list of products and quantities that are being ordered. The order file is increasingly being required to include special shipping and packaging requests for unique customers. The system must also increasingly accept orders from multiple sources, including EDI and the Internet, as well as by internal order entry.

The **bill-of-materials file** describes how raw materials are combined for finished products. For example, a simple bill-of-materials for an automobile would indicate that one car requires one body, one chassis, four seats, one engine, one transaxle, and four tires. Although these product relationships are typically used in manufacturing, it is becoming increasingly important for logistics as well. Logistics operations are beginning to use bills of materials to facilitate packaging, customization, and kitting in distribution center operations.

The **purchase order (PO) file** is similar to the order file except that it contains the records of purchase orders that have been placed on suppliers. The purchase order may be for raw material to support product or for MRO (Maintenance, Repair, and Operating) supplies necessary to support operations and administration. MRO items are not directly included as finished products sold by the firm. Specific purchase order file information includes purchase order number, supplier number and name, request date, ship-to location, transportation mode and carrier, and a list of the items to be purchased and the corresponding quantity. Other critical requirements of the PO file are the product specifications, delivery requirements, and contracted price.

The **inventory file** records the physical inventory or quantity of product that the firm has available or may be available in the future according to current production schedules. The file also tracks the physical location of the product within the material storage system and facility; the product status in terms of available to ship, damaged, quality hold, or on-hold for a key customer; and lot numbers for products that must be tracked. Specific inventory file information includes product number, facility location, storage location, and inventory quantity for each product status.

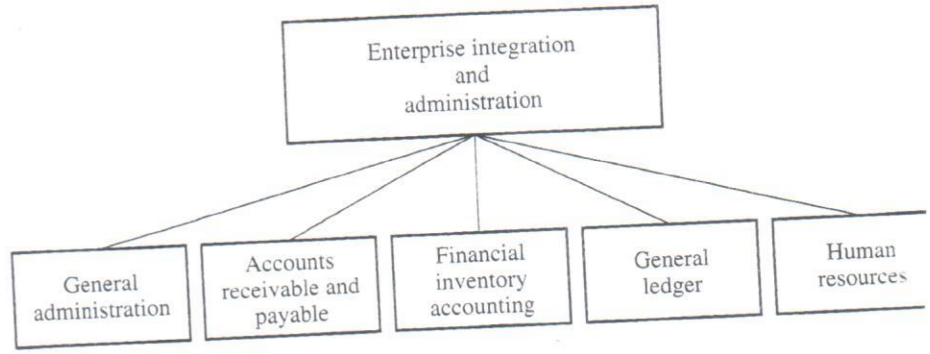
The **history file** documents the firm's order and purchase order history to facilitate management reporting, budget and decision analyses, and forecasting. In essence, this file contains summaries of the customer orders that have been filled and the purchase orders that have been received.

Enterprise Integration and Administration

Enterprise integration and administration applications are the ERP modules that are not specifically supply chain applications but do have substantial interactions. Figure 5.5 illustrates the major enterprise integration and administration components. The specific components include (1) general administration, (2) accounts receivable and payable, (3) financial inventory accounting, (4) general ledger, and (5) human resources.

General administration includes the various transactions to structure the firm and define firm process flows. Supply chain operations use these modules to define reporting, functional, and organizational structures as well as to define process flows such as customer and replenishment order fulfillment. Accounts receivable and payable represent the functions for invoice collection from customers and invoice payment to suppliers. While these

FIGURE 5.5
Enterprise Integration and Administration Components



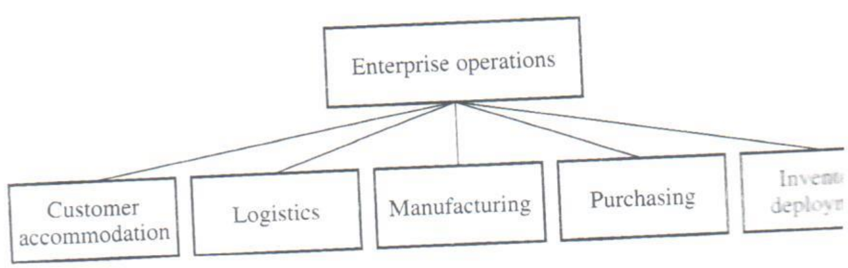
are typically acknowledged as accounting functions, there is a significant interaction supply chain operations since accounts payable is influenced by materials and ser acquisition and accounts receivable is influenced by delivery and invoicing of com orders. Financial inventory accounting relates to the tracking of value-added proc through the supply chain to facilitate financial and tax reporting. The timing and loc of supply chain value-added processes (e.g., production, inventory control, and pa ing) can have a significant influence regarding what can be reported to the treasur taxation purposes) and the financial markets (for stock valuation purposes). Gener ger relates to the structure of the detailed accounts for monitoring and reporting rev and accounts. Since supply chain involves substantial interaction with firm and ex processes, the structure of the general ledger accounts significantly influences the chain's ability to measure, monitor, and report cost related to delivering product o ing customers. The human resource module of the ERP systems tracks personnel p and their activity levels. Since most firms have a large number of individuals invo supply chain operations (e.g., manufacturing, distribution, and purchasing) and c different global environments, the ability to track pay scales and activity levels is to make effective supply chain personnel decisions.

Enterprise Operations

Enterprise operations include the SCIS modules required to support day-to-day chain operations. Figure 5.6 illustrates the specific modules including: (1) customer modation, (2) logistics, (3) manufacturing, (4) purchasing, and (5) inventory depl Enterprise operations systems work in conjunction with the firm's ERP system vide specific functionality to support supply chain operations. While some ERP support required supply chain functionality, others lack some functionality suc required to support warehouse and transportation operations.

Customer accommodation systems, also known as **customer relationship ment (CRM)** systems, are relatively new applications designed to facilitate tion sharing between customers, sales force, and operations management. The

FIGURE 5.6
Enterprise Operations Modules



module directs and monitors logistics activities including finished goods inventory management, warehouse management, transportation management, and yard management. The manufacturing module schedules and allocates production resources and determines component requirements. The purchasing module initiates and tracks procurement activities including purchase order initiation, expediting, and supplier management. The inventory deployment system module schedules and monitors material flows to meet production and deployment requirements. Each module is discussed in more detail later in this chapter.

Enterprise Planning and Monitoring

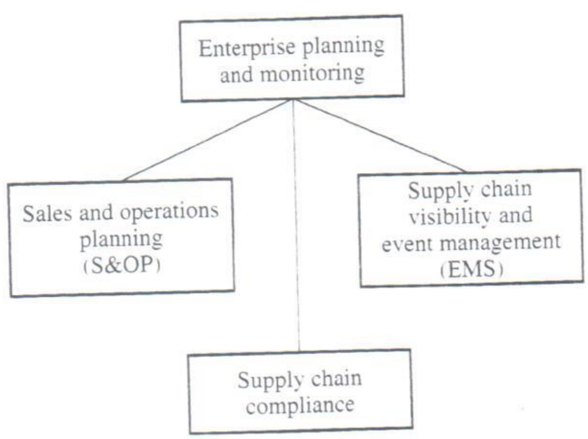
Enterprise planning and monitoring are the processes and technologies that facilitate exchange of planning and coordinating information both within the firm and between supply chain partners. Figure 5.7 illustrates the major enterprise planning and monitoring components. The specific modules include (1) sales and operations planning, (2) supply chain visibility and event management, and (3) supply chain compliance. Since many of these activities involve interaction with other members of the supply chain, effective applications require substantial standardization with other firm functions and supply chain partners.

Sales and operations planning (S&OP), which is discussed further in Chapter 6, describes the process used to balance demand requirements and supply capabilities of the firm and its supply chain partners. While S&OP itself is a process requiring functional coordination and integration, it requires information technology to evaluate the demand, supply, and resource trade-offs. This technology is generally characterized as planning and scheduling applications. Supply chain visibility and event management tracks shipments while they are in-transit and are increasingly capable of proactively suggesting changes in supply chain flows to minimize the potential of manufacturing shutdowns or service failures. Supply chain compliance systems monitor component and product flow information to make sure they comply with government and regulatory requirements for label, taxation, and security restrictions.

Communication Technology

Communication technology is the hardware and technical software that facilitates information exchange between the systems and physical infrastructure within the firm and between supply chain partners. The real-time information interchange between

FIGURE 5.7
Enterprise Planning and Monitoring Modules



functions and supply chain partners facilitate coordination of inbound material, production, inventory, customer orders, and customer shipment. From a supply chain perspective, the availability of common and consistent requirements, activity, and performance information between supply chain partners enhances both effectiveness and efficiency. These technologies include electronic bar coding and scanning, exchange portals, product codes, radio frequency, and XML. Each is discussed in detail later in the chapter.

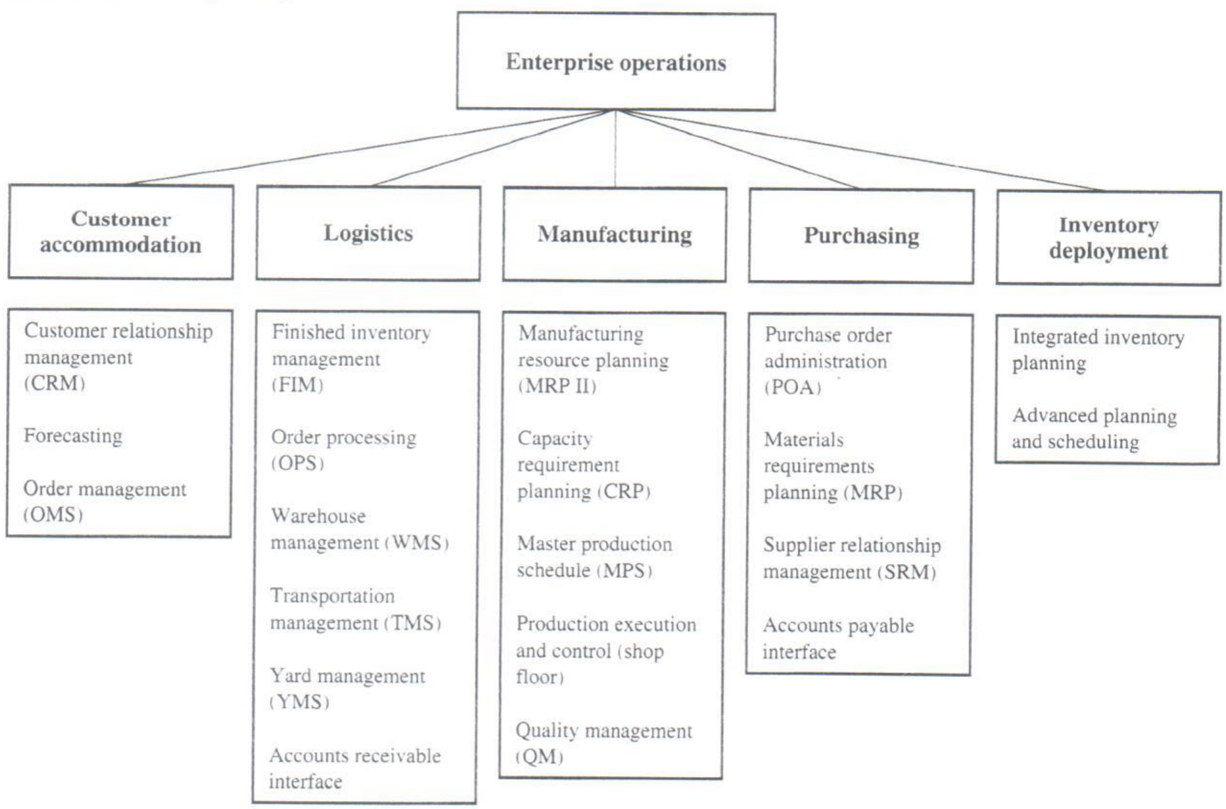
Enterprise Operations

Enterprise operations include customer accommodation, logistics, manufacturing, purchasing, and inventory deployment modules. Figure 5.8 lists the major elements of each module, which are discussed in detail below.

Customer Accommodation

Customer accommodation systems facilitate the synthesis and exchange of relevant and accurate information regarding order history, status, and demand generation information between a firm and its customers. The major system components include (1) customer relationship management (CRM), (2) forecasting, and (3) order management.

FIGURE 5.8 Enterprise Operations Modules

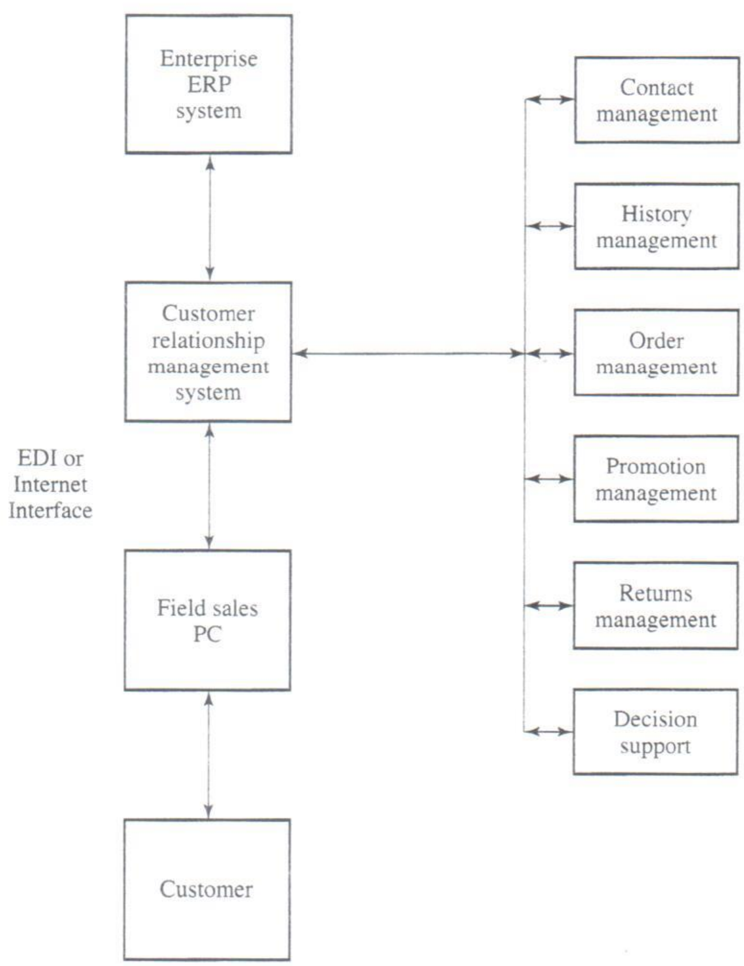


Customer Relationship Management

CRM is designed to extend the functionality of the ERP sales and delivery applications. CRM provides sales representatives and customers with current information regarding sales history, shipment history, order status, promotional summaries, and shipment information. The history and current status information, combined with product development, pricing, and promotion information, allow firms to better create and manage customer orders. Such timely and accurate information exchange between a firm and its customers increases the likelihood that the product sales and promotion plans will be supported with required product. Figure 5.9 illustrates the flow and elements of a CRM system.

While traditional ERP applications focus on efficiently taking customer orders, firms are finding it necessary to transition from treating customers as income sources to be exploited to treating customers as assets to be nurtured. While the traditional sales and delivery technology is configured to accept customer orders in a wide range of formats and allow those orders to be managed throughout the fulfillment process, a broader range of capabilities is necessary to manage the overall customer relationship. An integrated CRM system includes a combination of a server-based common database, remote PCs carried by

FIGURE 5.9
Typical Customer Relationship Management Extension System



sales representatives, and a global synchronization process to ensure that both corporate and sales representative data are timely and consistent. Beyond this base functionality, CRM today requires sales tracking, sales history analysis, pricing management, promotion management, product mix management, and category management. In some cases, customers expect their supplier's sales force to manage the entire category of products at the customer's facility. For example, it is becoming more common for grocers to expect their suppliers to manage both the product mix and shelf quantities for major product categories such as beverages and specialty products. This practice, termed **category management,** requires substantial information support from the manufacturer but also facilitates information sharing.

Forecasting

While the CRM system facilitates collaboration between the firm and its customers, the other customer accommodation modules focus on synthesizing the available information into a forecast that best reflects the combined information of the firm and its customers. While all these elements generate forecasts to drive supply chain activity, they represent increasing degrees of sophistication. Using primarily historical data, a basic forecast system projects anticipated demand using the formulae discussed in Chapter 6 with minimal information exchange with the customer. Demand management systems use the historical data but also work proactively with the customer to shift demand timing or product requirements to develop a plan that is achievable within the firm's constraints. CPFR is even more interactive and proactive as the firm and its key customers develop a joint plan that meets their combined objectives within their operating constraints.

Order Management

Once the individual or joint forecast is developed and the planned orders are created, the order management system (OMS) places the orders in the ERP system and allows for their maintenance, processing, and tracking. An effective OMS allows both the firm and its customers to have the most up-to-date status of current orders.

Logistics

Coordinated, integrated logistics operations are essential for supply chain competitiveness. Coordination and integration facilitate smooth and consistent customer and replenishment order information flow throughout the firm and offer current order status visibility. Integrated information sharing reduces delays, errors, and resource requirements. The logistics processes required for customer order fulfillment and to coordinate receipt of purchase orders are (1) order processing, (2) order assignment, (3) warehouse operations, (4) transportation, (5) yard management, and (6) purchasing.

Order Processing

Order processing is the entry point for customer orders and inquiries. It allows entry and maintenance of customer orders by using communication technologies such as mail, phone, fax, EDI, and the Internet. As orders or inquiries are received, order processing enters and retrieves required information, edits for appropriate values, and retains acceptable orders for assignment. Order processing can also offer information regarding inventory availability and delivery dates to establish and confirm customer expectations. Order processing, in conjunction with customer service representatives, forms the primary interface between the customer and the ERP or legacy system.

Table 5.2 lists primary order processing functionality. It includes entry for blanket, electronic, and manual orders. Blanket orders are large orders that reflect demand over an extended time period such as a quarter or year. Future shipments against blanket orders are triggered by individual order releases. Order processing creates and maintains the customer and replenishment order base that initiates remaining operations components.

Order Assignment

Order assignment allocates available inventory to open customer and replenishment orders. Assignment may take place in real time, as orders are received, or in a batch mode. Batch mode means that orders are grouped for periodic processing such as by day or shift. While real-time allocation is more responsive, a batch process provides the firm with more control over situations when inventory is low. For example, in a batch process, order assignment can be designed to allocate stock from current inventory only or from scheduled production capacity. The operational system is more responsive if it allows inventory assignment from scheduled production quantities or capacity. However, there is a trade-off, since assigning

TABLE 5.2 Operations System Functionality

Order Processing	Order Assignment	Inventory Management	Warehouse Operations	Transportation and Shipping	Yard Management	Purchasing
Order entry (manual, electronic, blanket)	Create blanket order	Forecast analysis and modeling	Assign and track storage locations	Carrier selection	Initiate trailer movement to and from docks	Match and pay
Credit check	Generate invoice	Forecast data maintenance and updates	Inventory cycle counting	Carrier scheduling	Initiate trailer movement to and from other yards	Open order review
Inventory availability	Generate order selection documents	Forecast parameter selection	Labor scheduling	Dispatching	Yard control and trailer tracking	Purchase order entry
Order acknowledgement	Inventory allocation	Forecast technique selection	Equipment scheduling	Document preparation	Appointment scheduling	Purchase order maintenance
Order modification	Process blanket order	Inventory parameter selection	Lot control	Freight payment	Carrier performance tracking	Purchase order receipt
Order pricing	Release reserved inventory	Inventory simulation and testing	Order selection, location, replenishment	Performance measurement		Purchase order status
Order status inquiry	Reassign order source	Inventory requirements planning	Receiving	Shipment consolidation and routing		Quote request
Price and discount extension	Release blanket order	Promotion data integration	Putaway	Shipment rating		Requirements communication
Promotion check	Verify shipment	Replenishment order build, release, and scheduling	Storage	Shipment scheduling		Schedule receipt appointment
Returns processing		Define service objectives	Performance measurement	Shipment tracing and expediting		Supplier history
Service management				Vehicle loading		

scheduled production capacity reduces the firm's ability to reschedule production. The best order assignment applications operate interactively in conjunction with order processing to generate an order solution that satisfies customer requirements within enterprise resource constraints. In this type of operational environment, the customer service representative and the customer interact to determine the combination of products, quantities, and performance cycle length that is acceptable for both parties. Possible solutions when there is conflict in order assignment include delivery date adjustments, product substitutions, or shipment from an alternative source.

Table 5.2 lists typical order assignment functionality, including inventory allocation, back-order creation and processing, order selection document generation, and order verification. Order selection documents, in paper or electronic form, direct distribution operations to select an order from the distribution center or warehouse and pack it for shipment. The customer or replenishment order, with its allocated inventory and corresponding order selection material, links order assignment with distribution center physical operations.

Warehouse Operations

Warehouse operations, also known as Warehouse Management Systems (WMS), incorporate processes to guide physical activities, including product receipt, material movement and storage, and order selection. For this reason, they are often termed inventory control or warehouse management systems and sometimes warehouse locator systems, referring to the capability to track inventory storage locations in warehouses. Warehouse operations direct all material handling activities using a combination of batch and real-time assignments. In a batch environment, the warehouse operations system develops a "to do" list of instructions or tasks to guide each material handler in the warehouse. Material handlers are the individuals who operate equipment such as forklifts. In a real-time environment, information-directed technologies such as bar coding, radio-frequency communication, and automated handling equipment operate interactively to reduce the elapsed time between decision and action. The real-time information-directed materials handling technologies, discussed in detail in Chapter 11, also must interface directly with the warehouse operations process to provide operational flexibility and reduce internal performance cycle time requirements.

Table 5.2 lists typical warehouse operation functionality. In addition to directing warehouse operations and activities, the functionality must also plan operating requirements and measure performance. Operations planning includes personnel and resource scheduling, including staff, equipment, and facility. Performance measurement includes developing personnel and equipment productivity reports.

Transportation and Shipping

A Transportation Management System (TMS) plans, executes, and manages transport and movement functions. The TMS includes shipment planning and scheduling, shipment consolidation, shipment notification, transport documentation generation, and carrier management. These processes facilitate efficient transport resource utilization as well as effective carrier management.

Table 5.2 lists transportation and shipping functionality. The TMS generates the documentation to release the order for shipment and measures the firm's ability to satisfactorily deliver the order. Historically, the TMS focused on document generation and rate tracking. Transport documents include manifests and bills of lading, specifically discussed in Chapter 9, and the carrier charges incurred for product movement. The large numbers of shipments made by most enterprises require an automated and exception-driven TMS that can reduce errors and report performance. With the increased opportunity to enhance performance through better transport management, contemporary TMS functionality emphasizes performance monitoring, rate auditing, routing and scheduling, invoicing, reporting, and decision analyses. Advanced TMS applications incorporate increased planning and performance measurement capability and are being termed enterprise execution systems.

A unique characteristic of the TMS is that it often involves three parties—shipper, carrier, and consignee (recipient). To effectively manage the process, a basic level of information integration must exist. Information sharing requires standardized data formats for transport documents.

Yard Management System

A yard management system (YMS) manages full and empty trailers in the parking lot or yard at manufacturing plants and distribution centers. In many operations, there may be hundreds or more trailers in the yard and they move in and out daily. The trailers and containers may represent inbound receipts, outbound orders, or may be empty. For the trailers that are full, the contents may represent a single shipment or a combination of orders. It is clear that the accuracy of a manual system would quickly decline, resulting in lost trailers and inventory.

The objective of a YMS is to make the yard an extension of the plant, distribution center, or warehouse by being able to quickly find a specific trailer and its contents. The system should also be able to sequence receipts, unloads, and loads to replenish desired inventory and to meet customer shipping requirements. Thus, the YMS enhances service by accessing the necessary inventory, even if it is on a trailer in the yard, and makes sure that customer shipments are loaded and dispatched in time to meet the delivery schedule. Table 5.2 lists specific YMS functionality.

Manufacturing

Manufacturing systems form the information system foundation to plan and control manufacturing planning and operation. These components define core activities that guide enterprise resource allocation and performance from procurement to product delivery. The Manufacturing module includes (1) Manufacturing Resource Planning II (MRP II), (2) Capacity requirement planning, (3) Master production scheduling (MPS), (4) Shop floor control, and (5) Quality management.

MRP II is the system that time-phases manufacturing schedules with procurement requirements. The MRP system (discussed below under Purchasing) explodes the bill of materials of the scheduled products to the required raw materials and communicates the requirements to the appropriate suppliers. For example, if an automotive assembly plant is scheduled to make 1,000 cars in the next week, the MRP system would communicate to the tire supplier that 4,000 regular tires would be required next week (assuming that the spares would not be regular tires). The MRP II system extends that capability by coordinating demand management with procurement scheduling. The MRP II system typically operates in more aggregate time buckets such as weeks.

Capacity requirement planning (CRP) maps the schedule developed by the MRP II system to a daily production schedule while considering equipment and personnel capacity constraints. The result is a day-to-day schedule that fits within the capacity constraints of the manufacturing process.

The **master production schedule (MPS)** further maps the capacity constrained sched ule developed by CRP to specific equipment sequences and timing. The result is a produc tion thread or sequence that defines precisely how a production order is to flow throug the manufacturing process while minimizing waste, delays, and capacity. An integrate MRP II, CRP, and MPS is critical to operating a lean manufacturing system.

The production shop floor control and quality systems control the production equip ment and processes to monitor equipment operations for effective operations and quality.

Purchasing

Purchasing manages **purchase order (PO)** preparation, modification, and release ar tracks vendor performance and compliance. The specific elements of the purchasing sy tem include administering purchase orders, sharing materials requirements with supplier and managing the overall supplier relationship. Although purchasing systems have not tr ditionally been considered part of logistics systems, the importance of integrating purcha ing with logistics schedules is critical to facilitate the coordination of material recei facility capacity, and transportation backhaul.

For integrated supply chain management, purchasing must track and coordinate recei ing and shipping activities to optimize facility, transport, and personnel scheduling. F example, since loading and unloading docks are often a critical facility resource, an eff tive purchasing system should coordinate the use of the same carrier for both deliver and shipments. This capability requires the enterprise system to have both receipt a shipment visibility. Supply chain system integration can be further enhanced through el tronic integration with suppliers. Table 5.2 lists purchasing functionality. A state-of-the- purchasing system provides plans, directs activities, and measures performance, coordin ing inbound and outbound activity movement.

Inventory Deployment

Inventory deployment represents one of the major enterprise integrators of sa marketing, and financial goals. The inventory deployment activity can be comple independently by individual supply chain functions, in an integrated manner by sup chain overall, or in a coordinated manner by the entire firm. When it is done in a coo nated manner by the entire firm, it is often referred to as **Sales & Operations Plann (S&OP).**

These strategic objectives are typically developed for a multiyear planning hori that often includes quarterly updates. Sales and marketing's strategic objectives de target markets, product development, promotions, other marketing mix plans, and role of logistics value-added activities such as service levels or capabilities. The ob tives include customer scope, breadth of products and services, planned promotions, desired performance levels. Sales and marketing goals are the customer service pol and objectives that define logistics and supply chain activity and performance targets. performance targets include service availability, capability, and quality elements discu earlier. Financial strategic objectives define revenue, financial and activity levels, and responding expenses, as well as capital and human resource constraints.

The combination of sales, marketing, and financial objectives defines the scop markets, products, services, and activity levels that logistics and supply chain man must accommodate during the planning horizon. Specific goals include projected ar or quarterly activity levels such as revenue, shipments, and case volume. Events that be considered include product promotions, new product introductions, market roll and acquisitions. Ideally, the marketing and financial plans should be integrated consistent, as inconsistencies result in poor service, excess inventory, or failure to meet financial goals.

The inventory deployment process must include both long- and short-term elements. The long-term element focuses on annual and quarterly plans with the objective of coordinating the marketing and financial plans to achieve enterprise goals. While supply chain and logistics operations are not the major focus, they do merit some consideration, as planners must ensure that there is enough aggregate production, storage, and movement capacity available. The short-term element focuses on weekly and daily plans with the objective of coordinating supply chain and logistics resources to ensure that specific customer requests can be satisfied. The key objective of an inventory deployment system is an integrated inventory plan through what is increasingly being termed an **Advanced Planning and Scheduling (APS)** system.

APS System Overview

To correspond with the planning and execution of effective logistics and supply chain strategies, supply chain planning systems incorporate both spatial and temporal considerations. The spatial considerations include movement between raw material providers, manufacturing plants, warehouses, distributors, retailers, and the end customer. The temporal considerations include moving timing and scheduling.

The APS system in Figure 5.10 is a network including plants, warehouses, and customers as well as transportation flows. This network reflects the resource status and allocation at a point in time, for example, on the first day of the month. Effective planning requires a process that can time-phase and coordinate resource requirements and constraints through time. For example, if product X is needed by the customer in period 3, its movement through the supply chain must be time-phased for arrival by period 3. Assuming a one-period performance cycle between each stage in the supply chain, this means that the APS must plan for the shipment of X from the plant during period 1 and shipment from the distribution center during period 2.

More specifically, suppose a firm is facing the situation summarized in Table 5.3. Customers require 200 units of product during each of the next five periods with the exception of period 4, when a special promotion increases demand to 600 units. The firm's production

FIGURE 5.10
Advanced Planning and Scheduling Overview

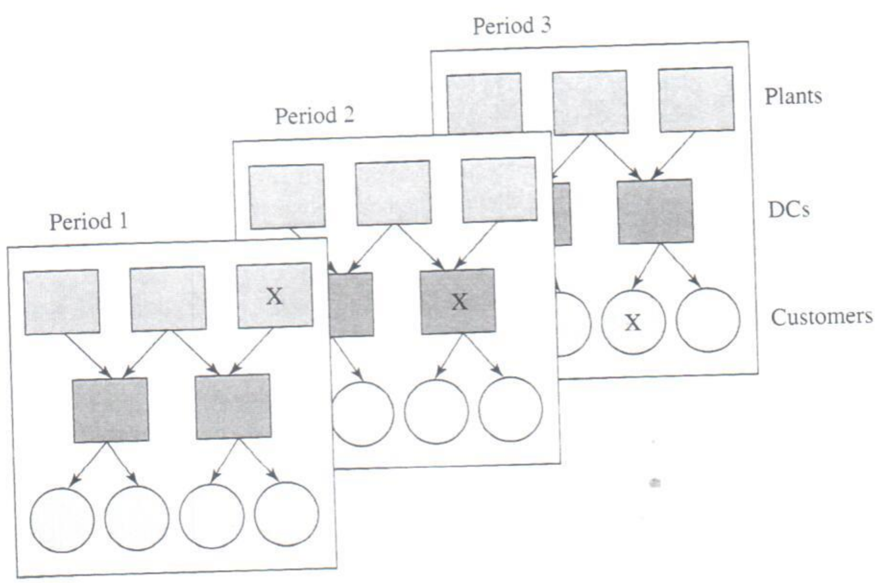


TABLE 5.3
Sample APS Planning Situation

	Time Period				
	1	2	3	4	5
Requirement	200	200	200	600	200
Production Capacity	300	300	300	300	300
Alternative 1 (overtime):					
Production	200	200	200	600	200
Inventory Carryover	—	—	—	—	—
Alternative 2 (build ahead):					
Production	300	300	300	300	200
Inventory Carryover	100	200	300	—	—

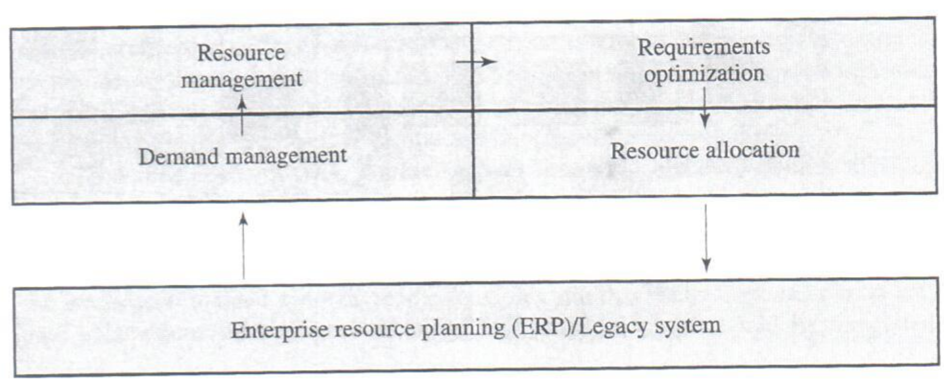
capacity is 300 units per week. On the extremes, the firm can select between two approaches to satisfy customer requirements given the production constraints. Alternative 1 is to wait until the fourth time period and then run production overtime to meet customer requirements. This alternative results in higher production cost but no cost to carry or store inventory. Alternative 2 is to build ahead using the extra 100-unit capacity in the time prior to period 4. With this alternative, an extra 100 units is built and added to inventory each period until it is required during period 4. This alternative does not require overtime production but does require increased inventory carrying and storage costs. There are, of course, intermediate alternatives to these two extremes. The ideal option is to select the combination resulting in the lowest combined cost of manufacturing and storage. Using linear optimization techniques, APS identifies the most cost-effective trade-offs considering all relevant costs. While firms have wanted to consider these trade-offs previously, analysis capabilities only allowed for evaluation of two or three major trade-offs to minimize problem complexity. Supply chain planning tools like APS offer the ability to thoroughly evaluate complex trade-offs involving a large number of alternatives.

APS System Components

While there are many conceptual approaches to designing supply chain planning applications like APS, the major components are fundamentally the same: demand management, resource management, resource optimization, and resource allocation. Figure 5.11 illustrates how these modules relate to each other and to the corporate ERP or legacy system.

The **demand management** module develops the requirement projections for the planning horizon. In effect, it generates sales forecasts based on sales history, currently scheduled orders, scheduled marketing activities, and customer information. In the case

FIGURE 5.11
APS System Modules



of requirements planning, the forecasts are in terms of orders while it would be shipments in the case of transportation planning. Ideally, demand management works collaboratively and interactively both internally across the firm's functional components and externally with supply chain partners to develop a common and consistent forecast for each time period, location, and item. The forecast must also incorporate feedback from customers to integrate the influence of combined demand generation activities such as advertising and promotion.

The **resource management** component defines and coordinates supply chain system resources and constraints. Since APS systems use the resource and constraint information to evaluate the trade-offs associated with supply chain decisions, information accuracy and integrity are critical to provide optimal decisions and enhance planning system credibility. Obviously, incorrect planning decisions not only suboptimize supply chain performance but also severely reduce management credibility in the planning system itself. In addition to the requirements definition developed by the demand management module, APS requires four other types of information: product and customer definitions, resource definitions and costs, system limitations, and planning objective.

The product and customer definitions provide constants regarding the firm's products and customers to support the planning process. The product definitions provide the product descriptions and physical characteristics, such as weight and cube, standard costs, and bill of material. The customer definitions provide the ship-to location and distribution assignments, along with special service requirements. The combination of both defines what is being manufactured, what is being distributed, where it is being delivered, and the performance cycles involved in distribution.

The resource definitions specify the physical resources used to accomplish supply chain activities such as manufacturing, storage, and movement. The resources include manufacturing equipment and process rates, storage facilities, and transportation equipment and availability. In addition to defining the existence of specific resources, the database must include the cost and performance characteristics and costs associated with resource usage.

System limitations define major supply chain activity constraints. These include the capacity limitations associated with production, storage, and movement. Production capacity defines how much product can be produced within a specific time period and what are the trade-offs associated with making various mixes of products. Storage capacity defines the amount of product that can be stored in a specific facility. Movement capacity defines the volume of product that can be transported between facilities or to customers within a given time frame.

The planning function defines criteria for developing a solution. Typical objective functions include minimizing total cost or any of its subcomponents, meeting all customer requirements, or minimizing the number of instances when capacity is exceeded.

This combination of demand management and resource management information provides the basis for the APS evaluation of alternative supply chain strategies. The module includes the databases to store the definitions, resources, constraints, and objectives as well as the processes to validate and maintain it. Users are finding that one of the major challenges to effective supply chain planning systems is the ability to develop and maintain accurate and consistent data.

The **resource optimization** module is the computational engine or "black box" of the supply chain planning system. Using the requirements from the demand management module and the definitions, resources, limitations, and objectives from the resource management module, resource optimization uses a combination of mathematical programming and heuristics to determine how to most effectively meet customer requirements while optimizing resource utilization. Mathematical programming is a combination of linear programming and mixed-integer programming, which is used to minimize the specified objective function; heuristics are computational rules of thumb or shortcuts that reduce the time or computational resources required to develop an integrated plan. In effect, the resource optimization module evaluates multiple planning alternatives and systematically completes the trade-offs to identify the best alternatives until a near-optimal result is achieved. The resource optimization module also determines when requirements cannot be met and which resources are the most constraining on supply chain performance. The resource optimization module results are supply chain plans projected into future time periods that minimize overall costs while attempting to operate within major resource constraints. The plan specifies which products should be produced when and determines movement and storage requirements across the supply chain.

The resource optimization module can also be used to conduct sensitivity or what-if analyses to determine the impact of changes in market requirements or constraints. These analyses allow the supply chain planner to isolate the impact of demand and performance uncertainty on supply chain capabilities and operations. Using the insight regarding the trade-offs and the impact of uncertainty, the supply chain planning resource optimization module guides the planner in establishing the most effective sourcing, production, movement, and storage strategy.

Following planner review and evaluation of the resource optimization module results, the **resource allocation** module specifies the resource assignments and communicates them to the ERP system to initiate appropriate transactions. The results include requirements for procurement, production, storage, and transport. The specific requests can be communicated to the ERP system in the form of transactions or instructions to complete a specific activity. Each transaction includes detailed instructions regarding type of supply chain activity, suppliers, customer, products involved, and required timing, along with a list of relevant products and quantities. The resource allocation module also provides information regarding when product is available to promise (ATP) or capable to promise (CTP). ATP is used to designate that even though actual inventory is not currently available, it will be available for shipment or promise at a specific date in the future. In effect, the ATP designation allows firms to commit scheduled production to customers. CTP is used to designate when requested product can be promised for future delivery. CTP requires a much broader analysis, as it determines whether there is future specific capacity or capability, given current and projected supply chain demands. ATP and CTP can dramatically enhance supply chain performance and effectiveness by allowing commitments against future production and capacity. The result is more rapid commitments to customers, fewer customer surprises, and enhanced resource utilization.

Supply Chain Planning Benefits

While some supply chain planning system benefits were discussed earlier, there are three broad benefits that accrue from planning system utilization. These are responsiveness to changes, comprehensive perspective, and resource utilization.

First, logistics and supply chain managers have used extended lead times and schedule freezes to plan for future supply chain activity. For example, production would be scheduled three to four weeks into the future and then frozen to minimize uncertainty and allow for effective resource utilization. Long lead times and freeze periods were necessary since the planning process was complex and required substantial analyses. While this approach reduced uncertainty, it also substantially reduced flexibility and responsiveness. Today's customer requires more responsiveness to market needs, and demand for lower inventory levels rules out long cycle times. Marketplace and firm changes can be quickly made in the demand management and resource management modules, allowing for the planning process to use the most current and accurate information. The requirements optimization module then solves the allocation, allowing daily and single week planning cycles rather than multiple weeks or months. Supply chain planning thus results in a process that can be much more responsive to marketplace or firm changes.

Second, effective supply chain management requires planning and coordination across firm functions and between supply chain partners. The process must consider the trade-offs associated with shifting activities and resources across functions and organizations. Such a comprehensive perspective increases planning process complexity substantially. The complexity follows from the number of organizations, facilities, products, and assets that must be considered when coordinating activities and resources across an entire supply chain. Supply chain planning systems offer the capability to consider the extended supply chain and make the appropriate trade-offs to achieve optimal performance.

Third, supply chain planning typically results in substantial performance improvements. While more comprehensive planning and reduced uncertainty usually result in improved customer service, another major planning system benefit is enhanced resource utilization. More effective and responsive planning allows a more level assignment of resources for existing sourcing, production, storage, and transportation capacity. The result is that existing capacity is used more effectively. Firms also report that supply chain planning systems have significantly reduced asset requirements by smoothing resource demands. The decreases include estimates of 20 to 25 percent reductions in plant, equipment, facilities, and inventory.

Supply Chain Planning Considerations

While comprehensive supply chain planning is a relatively new capability, the future outlook is bright as the technology and capacity to effectively evaluate and manage integrated supply chains are developed. Supply chain planning can take a comprehensive and dynamic perspective of the entire supply chain and focus on reducing the supply chain asset requirements as demanded by financial markets. Prior to the actual implementation, there are many considerations for supply chain planning system adoption. Managers cite their major considerations to be (1) integrated versus bolt-on application, (2) data integrity, and (3) application education.

The first consideration concerns the level of integration with other supply chain applications. Technically, there are three options for acquiring and implementing planning applications. The first is development using internal firm resources. This is not very common, as planning system development requires substantial expertise and most firms without substantial software competency could not effectively design, develop, or maintain such complex planning systems. In addition, the planning process of individual industries or firms is not usually different enough to be able to achieve any significant competitive advantage. Options two and three are to use a supply chain planning application that is integrated with the firm's ERP system or one from a third-party that **bolts on** to the firm's ERP system. Some ERP providers, such as SAP, offer an APS that is designed to be closely integrated with their ERP system. The obvious benefits of such integration include data consistency and integrity, as well as reduced need to transfer data between applications, which results in delays and potential errors. The alternative is to use a **bolt-on** or **best-of-breed** approach that seeks to identify the best supply chain planning system for the firm on the basis of features and functionality and then attach it to the firm's ERP system. The result is a planning system that better meets the firm's specific requirements or offers improved performance but at a probable cost of reduced integration. While providers of both integrated and bolt-on supply chain planning applications are attempting to enhance their integration with ERP system providers, operational integration between execution and planning systems remains a challenge.

Data integrity is a second major consideration for supply chain planning system impl mentation. Planning systems rely on absolute data integrity for effective decision makin While data integrity has always been important, it is more critical for planning systems sin missing and inaccurate data can dramatically impact decision reliability and stability. O often-cited data integrity problem concerns product level detail such as cube and weig While this is basic data, accuracy is not easy to maintain when there are a large number products with constant changes and new product introductions. Managers cite that in t process of implementing supply chain planning applications, it is not uncommon to fin few hundred products with incorrect or missing physical characteristics. While it may r be a large percentage of products in number, the inaccuracy can substantially impact pl ning system decision making. For example, missing or inaccurate cube can result in a tra portation planning system making a recommendation to overload a transportation vehic Specifically, the planning system will think that a large amount of product can be loa into a truck when the product data contains an incorrect or zero cube. While the decisi errors resulting from data integrity problems can be significant, the larger problem is t such errors substantially reduce the credibility of planning systems in general. A few hig visible errors such as overloading transportation vehicles or storage facilities cause m agement and planners to question the integrity of the entire planning system and proc The result is that management and operations personnel don't trust the results and prefe return to the old tried and true methods of planning and scheduling. Thus, the potential improved planning is reduced until the trust can be redeveloped. A strong focus on devel ing and maintaining data integrity is critical to effective planning system implementatio

Education regarding planning system application is a third major consideration. U training for supply chain execution and planning systems has usually focused on mechanics to initiate the transactions. So, the user would be trained in data or param entry where the system would provide quick feedback regarding the acceptability of entry. Supply chain planning systems are relatively more complex, as the feedback is immediate and the impact may be extensive. For example, changing the requirement forecast for one item in a time period may shift production schedules for related item the other side of the world. Understanding planning system dynamics is critical to succ ful application. Such understanding requires thorough knowledge of APS system mec ics and system interactions. Although such knowledge can be initiated through trainin must be refined and extended through education and experience. Planning system ed tion must focus on the characteristics and relationships between supply chain man ment activities and processes both internal and external to the firm. The education pro must be much broader than existing training approaches. Planning system experience be developed by using job shadowing experience and simulations. The shadowing e ronment provides actual on-the-job experience in a real-time environment. The simu environment provides a laboratory where inexperienced planners can see or observ results of their planning environment at low risk to the firm. The combination of these educational experiences provides a solid foundation for implementing successful su chain planning applications.

Supply Chain Planning Summary

The major objective of an integrated inventory deployment or APS system is integ and coordinated capacity management of relevant supply chain resources including m facturing plants, distribution centers, and transportation resources. Capacity manage planning balances the market demands with the production resources. On the ba the activity levels defined by the forecasting system, these constraints determine rial bottlenecks and guide resource allocation to meet market demands. For each pr capacity constraints influence the where, when, and how much for production, storage, and movement. The constraints consider aggregate limitations such as periodic production, movement, and storage capacities.

Capacity problems can be resolved by resource acquisition or speculation/postponement of production or delivery. Capacity adjustments can be made by acquisition or alliances such as contract manufacturing or facility leasing. Speculation reduces bottlenecks by anticipating production capacity requirements through prior scheduling or contract manufacturing. Postponement delays production and shipment until specific requirements are known and capacity can be allocated. It may be necessary to offer customer incentives such as discounts or allowances to postpone customer delivery. The capacity limitations time-phase the enterprise's S&OP by taking into account facility, financial, and human resource limitations. These constraints have a major influence on logistics, manufacturing, and procurement schedules.

·prise Planning and Monitoring

As described previously, the enterprise planning and monitoring modules facilitate the collaboration and exchange of plans and performance data both across firm functions and between supply chain partners. The three modules are (1) sales and operations planning, (2) supply chain visibility and event management, and (3) supply chain compliance. The function and features of each are discussed.

Sales and Operations Planning

As further discussed in Chapter 6, S&OP is a process that coordinates demand and supply plans across the organization. The process includes information sharing and accountability to systematically develop a common and consistent plan. While S&OP is an organizational process, it also requires substantial information technology support. The technology support can range from something as simple as a few linked spreadsheets to a sophisticated APS system discussed previously.

In general, the S&OP technology integrates the firm's information regarding forecasts, inventory availability, production resources, and other resource constraints.

Requirements include time-phased facility, equipment, labor, and inventory resources necessary to accomplish the logistics mission. For example, the logistics requirement component schedules shipments of finished product from manufacturing plants to warehouses and ultimately to customers. The shipment quantity is calculated as the difference between customer requirements and inventory level. Future requirements are based on forecasts, customer orders, and promotions. Forecasts are based on sales and marketing input in conjunction with historical activity levels. Customer orders include current orders, future committed orders, and contracts. Consideration of promotional activity is particularly important in planning logistics requirements, since it often represents a large percentage of variation in volume and has a large impact on capacity. Current inventory status is product available to ship. Figure 5.12 illustrates the computation for determining periodic logistics requirements.

Specifically, for each planning period, day, week, or month, the sum of forecast plus future customer orders plus promotional volume represents period demand. It is not easy to determine the percentage of the forecasted volume that is accounted for by known customer orders, so some judgment is necessary. Typically, period demand is actually a combination of the three, since current forecasts may incorporate some future orders and promotional volume. In determining period demand, it is important that the overlap between forecast, future customer orders, and promotions be considered. Period logistics requirements are then determined as

FIGURE 5.12
Logistics Requirements

+	Forecasts (sales, marketing, input, histories, accounts)
+	Customer orders (current orders, future committed orders, contracts)
+	Promotions (promotion, advertising plans)
=	Period demand
−	Inventory-on-hand
−	Planned receipts
	Period logistics requirements

the period demand less inventory-on-hand plus planned receipts. Using this form, each period would ideally end with zero inventory available, so planned receipts would exactly equal period demand. While perfect coordination of demand and supply is desirable from an inventory management perspective, it may not be possible or the best strategy for the firm.

Supply Chain Visibility and Event Management

Supply chain visibility and event management systems are more sophisticated versions of what are typically termed "track and trace" systems. Over the last decade, customers ordering mail order increasingly expect the ability to "track and trace" their shipments online using the FedEx, Postal Service, or United Parcel Service Web sites. As such systems became more widely available, logistics managers now desire that similar track and trace capabilities be available from their carriers.

The specific capabilities desired include (1) track and trace, (2) notification, (3) reporting, (4) rerouting, and (5) simulation. Track and trace is the ability to determine where a shipment is currently and which carrier or firm is currently responsible for it. Notification is the capability to provide information to the shipper or customer regarding the status of the shipment. While the notification can be provided when the shipment is on time, it is particularly important to provide information when it is delayed and when it hasn't reached an expected waypoint. The notification capability should provide information in the form of an e-mail, voice-mail, or contact with a personal digital assistant. The reporting capability allows the logistics manager to measure the performance of individual carriers based on their history with actual shipments. The rerouting capability allows logistics managers to change the mode or flow of a shipment if it were to get delayed. For example, if a shipment is delayed arriving at a port, management may want to shift the final delivery mode to air rather than ground to reduce the possibility of shutting down the manufacturing process. The simulation capability allows management to complete "what if" analyses using various routes and shipment modes. For example, this capability would allow a manager to proactively compare a shipment routed through two different ports to determine which is more likely to arrive on time based on recent shipping history.

Given the capabilities that individuals experience with consumer track and trace systems, it may seem that this would be trivial for major corporations. However, most firms don't have the resources or time for event management for each shipment. They want to be notified when there is a problem or an exception rather than have to monitor the hundreds or thousands of shipments that they have in process at any point in time. A second problem is that many shipments, particularly internationally, use multiple carriers and even multiple modes. Major problems in global supply chain event management occur at the interfaces between carriers where there may be system or timing inconsistencies. The major global carriers such as FedEx and UPS have begun to make such a capability a critical dimension of their offerings.

Supply Chain Compliance

Since most firms either source or market globally, if not both, there is increasing need to track transactions from a legal and security perspective as well as to facilitate adequate reporting to relevant governmental agencies. Supply chain compliance systems provide these capabilities so that firms can meet the reporting requirements of local governments and so that the firm doesn't break any import or export laws. In some cases, failure to provide necessary information may result in criminal charges against firm executives.

Supply chain compliance systems include some combination of the following capabilities: (1) global classification, (2) authorized economic operator automation, (3) advance security filing, (4) processing under customs control, (5) C-TPAT compliance, (6) free trade agreements, and (7) export compliance. Global classification defines the nature of the goods for global reporting. For monitoring and reporting purposes, it ensures that the same or essentially similar item from two different suppliers or countries is classified the same for reporting and customs purposes. The authorized economic operator (AEO) automation function ensures that the firms involved in a transaction are authorized to engage in commercial exchanges. The major objective of AEO automation is to ensure that none of the firms involved have a history with illegal, black market, or gray market transactions. Advance security filing capability provides the required shipment documentation to the relevant customs organization with the appropriate leadtime. For example, U.S. Customs requires notification regarding shipment arrival at least 2 to 24 hours prior to arrival depending on transportation method. Processing under customs control provides the information support to track and monitor goods when supply chain value-added processes are completed under customs control. Firms sometimes complete final manufacturing or packing under customs control prior to formal arrival from an international source to reduce duty or to meet local content requirements. C-TPAT (Customs-Trade Partnership against Terrorism) compliance tracks the security authorizations of firms involved in a trade transaction. C-TPAT is further discussed in Chapter 17. Free trade agreement capability is to track and monitor international transactions between countries that have free trade agreements for the items involved. For example, for the North American Free Trade Act (NAFTA) and the European Union (EU) relationships, many transactions are treated as though they are domestic even though the goods cross international borders. Finally, the export compliance capability ensures that goods involved in a transaction can be traded between the countries involved. For example, for security reasons, there are many limitations on the trade of U.S. technology with firms in foreign countries. Failure to follow these restrictions could be embarrassing for the firm involved and in some cases even criminal for the firm's officers.

The increasing volume of international supply chain transactions along with a combination of agreements to motivate trade and restrictions on what can be traded results in an increasing need for information technology capability to monitor and track such transactions. Supply chain compliance systems are evolving to meet that requirement.

Communication Technology

Information-sharing technology is critical to facilitate logistics and supply chain planning and operations. Historically, logistics coordination has been difficult since essential work is typically performed at locations remote from information technology hardware. As a result, information was not available at the work location in terms of both time and content. The past decade has witnessed remarkable advances in logistical communication systems capability, including bar code and scanning, global data synchronization, the Internet, extensible markup language, satellite technology, and image processing.

Bar Code and Scanning

Auto identification (ID) systems such as bar coding and electronic scanning were developed to facilitate logistics information collection and exchange. Typical applications include tracking warehouse receipts and retail sales. These ID systems require significant capital investment but replace error-prone and time-consuming paper-based information collection and exchange processes. In fact, increased domestic and international competition is driving shippers, carriers, warehouses, wholesalers, and retailers to develop and utilize auto ID capability to compete in today's marketplace.

Auto ID allows supply chain members to quickly track and communicate movement details with high accuracy and timeliness, so it is fast becoming a fundamental service requirement for freight tracking by carriers. Both consumers and B2B customers expect to be able to track the progress of their shipment using the Web-based system offered by carriers such as United Parcel Service and FedEx.

Bar coding is the placement of computer-readable codes on items, cartons, containers, pallets, and even rail cars. Bar code development and applications are increasing at a very rapid rate. Table 5.4 summarizes the benefits of auto ID technologies. While the benefits are obvious, it is not clear which symbologies will be adopted as industry standards. Standardization and flexibility are desirable to accommodate the needs of a wide range of industries, but they also increase cost, making it more difficult for small- and medium-size shippers, carriers, and receivers to implement standardized technologies. Finally, while continued convergence to common standards is likely, surveys indicate that select industries and major shippers will continue to use proprietary codes to maximize their competitive position.

Another key component of auto ID technology is the scanning process, which represents the eyes of a bar code system. A scanner optically collects bar code data and converts it to usable information. There are two types of scanners: handheld and fixed position. Each type can utilize contact or noncontact technology. Handheld scanners are either laser guns (noncontact) or wands (contact). Fixed-position scanners are either automatic scanners (noncontact) or card readers (contact). Contact technologies require the reading device to actually touch the bar code. A contact technology reduces scanning errors but decreases flexibility. Laser gun technology is the most popular scanner technology currently in use, outpacing wands as the most widely installed technology.

TABLE 5.4
Benefits of Automatic Identification Technologies

Shippers	Warehousing
Improve order preparation and processing	Improved order preparation, processing, and shipment
Eliminate shipping errors	Provide accurate inventory control
Reduce labor time	Customer access to real-time information
Improve record keeping	Access considerations of information security
Reduce physical inventory time	Reduced labor costs
Carriers	**Wholesalers/Retailers**
Freight bill information integrity	Unit inventory precision
Customer access to real-time information	Price accuracy at point-of-sale
Improved record keeping of customer shipment activity	Improved register checkout productivity
	Reduced physical inventory time
Shipment traceability	Increased system flexibility
Simplified container processing	
Monitor incompatible products in vehicles	
Reduced information transfer time	

Scanner technology has two major applications in logistics. The first is point-of-sale (POS) in retail stores. In addition to ringing up receipts for consumers, retail POS applications provide accurate inventory control at the store level. POS allows precise tracking of each stockkeeping unit (SKU) sold and can be used to facilitate inventory replenishment. In addition to providing accurate resupply and marketing research data, POS can provide more timely strategic benefits to all channel members.

The second logistics scanner application is for materials handling, vehicle identification, and tracking. Through the use of scanner guns, materials handlers and gate operators can track product and vehicle movement, storage location, shipments, and receipts. While this information can be tracked manually, it is very time-consuming and subject to error. Wider usage of scanners in logistical applications will increase productivity and reduce errors. The demand for faster and less-error-prone scanning technology drives rapid changes in the marketplace for applications and technology.

Global Data Synchronization

While the phone, fax, and direct computer connection have enabled information exchange in the past, EDI and the Internet are quickly becoming the standards for effective, accurate, and low-cost information exchange. EDI is defined as direct computer-to-computer exchange of business documents in standard formats to facilitate high-volume transactions. It involves both the capability and practice of communicating information between two organizations electronically instead of via the traditional forms of mail, courier, or even fax.

Communication and information standards are essential for EDI. Communication standards specify technical characteristics necessary for the computer hardware to correctly accomplish the interchange. Communication standards deal with character sets, transmission priority, and speed. Information standards dictate the structure and content of the message. Standards organizations have developed and refined two general standards as well as numerous industry-specific standards in an effort to standardize both communication and information interchange.

EDI Transaction Sets

Communication standards are implemented using transaction sets. A transaction set provides a common standard to facilitate information interchange between partners in a specific industry and country. Table 5.5 lists the common logistics-related industry transaction standards. For each industry, the transaction set defines the documents that can be transmitted. Documents typically cover common logistics activities such as ordering, warehouse operations, and transportation. Table 5.6 lists the transaction set usage matrix. The transaction set consists of a transaction code (or ID) and is followed by the data. The transaction code, for example, indicates whether the electronic communication is a warehouse shipping order (code 940) or a warehouse stock transfer receipt (code 944). In addition to the transaction code, a transaction contains warehouse number, item number, and quantity.

TABLE 5.5 **Primary Logistics Industry EDI Standards**

UCS (Uniform Communication Standards): grocery
VICS (Voluntary Interindustry Communication Standards Committee): mass merchandisers
WINS (Warehouse Information Network Standards): warehouse operators
TDCC (Transportation Data Coordinating Committee): transportation operators
AIAG (Automotive Industry Action Group): automotive industry

TABLE 5.6
Transaction Set Usage Matrix

Source: Adapted from materials provided by Deborah Faragher, Uniform Code Council, Inc.

TS ID	Transaction Set Name	UCS	VICS EDI
102	Associated Data		√
180	Return Merchandise Authorization and Notification	√	√
204	Motor Carrier Load Tender	√	
210	Motor Carrier Freight Details and Invoice	√	
214	Transportation Carrier Shipment Status Message	√	
753	Request for Routing Instructions		√
754	Routing Instructions		√
810	Invoice	√	√
812	Credit/Debit Adjustment	√	√
816	Organizational Relationships	√	√
818	Commission Sales Report	√	
820	Payment Order/Remittance Advice	√	√
824	Application Advice	√	√
830	Planning Schedule with Release Capability	√	√
831	Application Control Totals	√	√
832	Price/Sales Catalog		√
846	Inventory Inquiry/Advice	√	√
850	Purchase Order	√	√
852	Product Activity Data	√	√
853	Routing and Carrier Instructions		√
855	Purchase Order Acknowledgment	√	√
856	Ship Notice/Manifest	√	√
857	Shipment and Billing Notice	√	
860	Purchase Order Change Request—Buyer Initiated		√
861	Receiving Advice/Acceptance Certificate		√
864	Text Message	√	√
867	Product Transfer and Resale Report	√	
869	Order Status Inquiry		√
870	Order Status Report		√
875	Grocery Products Purchase Order	√	
876	Grocery Products Purchase Order Change	√	
877	Manufacturer Coupon Family Code Structure	√	
878	Product Authorization/De-Authorization	√	
879	Price Information	√	
880	Grocery Products Invoice	√	
881	Manufacturer Coupon Redemption Detail	√	
882	Direct Store Delivery Summary Information	√	√
883	Market Development Fund Allocation	√	
884	Market Development Fund Settlement	√	
885	Store Characteristics	√	
886	Customer Call Reporting	√	
887	Coupon Notification	√	
888	Item Maintenance	√	
889	Promotion Announcement	√	√
891	Deduction Research Report	√	
893	Item Information Request	√	√
894	Delivery/Return Base Record	√	
895	Delivery/Return Acknowledgment and/or Adjustment	√	
896	Product Dimension Maintenance	√	
940	Warehouse Shipping Order	√	√
944	Warehouse Stock Transfer Receipt Advice	√	
945	Warehouse Shipping Advice	√	
947	Warehouse Inventory Adjustment Advice	√	√
997	Functional Acknowledgment	√	√

While applications are migrating toward common standards, there is still conflict regarding the ultimate goal. A single common standard facilitates information interchange between partners in any industry and country, but many firms believe that strategic advantage can be achieved only with proprietary EDI capabilities. Proprietary capabilities allow a firm to offer customized transactions that efficiently meet their unique information requirements.

Many firms resolve this dilemma through the use of value-added networks (VANs). A VAN, illustrated in Figure 5.13, is a common interface between sending and receiving systems. The VAN adds value by managing transactions, translating communication standards, and reducing the number of communication linkages. Transaction management includes broadcast of messages to subsets of suppliers, carriers, or customers and receipt of messages from customers using different communication standards.

The Uniform Code Council (UCC), in partnership with **European Article Numbering (EAN)** International, is the organization responsible for international numbering standards and is committed to developing common global standards for products and transaction sets. Information regarding the status of the council's current initiatives can be found on its Web site at **www.uc-council.org.** Another source documenting the evolving commercial standards is the Voluntary Interindustry Commerce Standards (VICS) at **www.vics.org.**

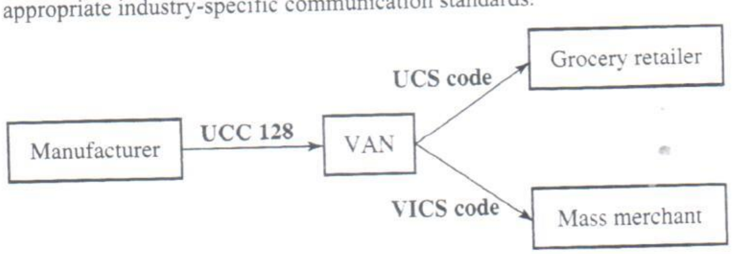
Electronic Product Code

EPC (electronic product code) is an emerging form of product identification. The Auto-ID Center at Massachusetts Institute of Technology, with support from both manufacturers and retailers, collaborated to develop an "intelligent tracking infrastructure" for supply chains. The two standards organizations EAN (European Article Number) and UCC (Uniform Code Council), which were developers of previous bar code standards, formed an organization called EPCglobal Inc., which is driving the adoption and implementation of the "EPCglobal Network."

As opposed to the widely used UPC bar codes, which contain only the product make (manufacturer) and model, the EPC contains a number that can be linked to an individual SKU in the form of a serial number. Each EPC is 96 bits in length and has the capability to represent all products now and into the reasonable future. In addition, EPC accommodates all existing EAN.UCC keys such as Serial Shipping Container Code (SSCC) and GTIN (Global Trade Identification Number).[2]

[2] For a more detailed vision regarding the future of EPC, see Sean Campbell and Sachin Shah, "EPC: A Shared Vision for Transforming Business Processes," in *Reshaping Supply Chain Management Vision and Reality* (IBM Global Business Services, 2007), pp. 252–285.

FIGURE 5.13
Value-Added Networks (VANs)
The VAN collects transaction messages and information from a manufacturer and then translates those messages and information into appropriate industry-specific communication standards.



Radio-Frequency Exchange

Radio-frequency data communication (RFDC) technology is used within relatively small areas, such as distribution centers, to facilitate two-way information exchange. A major application is real-time communication with mobile operators such as forklift drivers and order selectors. RFDC allows drivers to have instructions and priorities updated on a real-time basis instead of using a hard copy of instructions printed hours earlier. Real-time or Wi-Fi transmissions guide work flow, offer increased flexibility and responsiveness, and can improve service using fewer resources. Logistics RFDC applications also include two-way communication for warehouse picking, cycle counts, verification, and label printing.

Advanced RFDC capabilities in the form of two-way voice communication are finding their way into logistics warehouse applications. Instead of requiring warehouse operations personnel to interface with a mobile or handheld computer, voice RFDC prompts operators through tasks with audible commands and waits for verbal responses or requests. United Parcel Service uses speech-based RFDC to read zip codes from incoming packages and print routing tickets to guide packages through their sortation facilities. The voice recognition systems are based on keywords and voice patterns of each operator. The primary benefit of voice-based RFDC is an easier operator interface; since keyboard data entry is not required, two hands are available for order picking.

Radio-frequency identification (RFID) is a second form of radio-frequency technology. RFID can be used to identify a container or its contents as it moves through facilities or on transportation equipment. RFID places a coded electronic chip in the container or box. RFID chips can be either active or passive. Active chips continuously emanate radio waves so that product can be located in a warehouse or a retail store, using receivers located throughout the store. Active chip technology is good for locating product in a facility as well as for identifying when it is moving in and out of the facility. Passive chips respond only when they are electronically stimulated by having the product pass through a relatively small gateway or portal that has scanners built in. Since the product must be passed through a gateway for passive chips to operate, these can be used only for tracking product movement in, out, and around a facility. With current technology, the cost of active chips (GEN II) is approximately 10 times that of passive chips because of the need for a battery and larger antenna. As the container or box moves through the supply chain, it can be scanned for an identifying code or even for the list of contents. Retailers are beginning to use RFID to allow entire cartloads of merchandise to be scanned simultaneously. WalMart* and other major retailers began initiatives to require their major suppliers place RFID tags on their cases to facilitate processing in distribution warehouses, receipt at stores, and shelf restocking. While the benefits were apparent for the retailers, they were not so evident for the manufacturers, particularly since the retailers were not generally willing to pay for the chip and the technologies to employ it. While the initiatives to use RFID to track activity for consumer products have declined, there is significant activity investigating the use of RFID to enhance security and minimize counterfeiting. For example, there is increasing use of RFID for pharmaceuticals and expensive technology to reduce counterfeiting and enhance security. It is anticipated that the lessons learned through these applications will reduce the price of RFID and will lead to future logistics applications.

Typically, information on a bar code is captured via a fixed or handheld scanner device. The EPC-based identification system, on the other hand, can use RFID tags in conjunction with readers in order to collect more extensive product information. The RFID tags are miniature circuits that contain the EPC code. A reader can transmit a request for product identification that will stimulate the tag on a responding item to transmit the identification number on the tag back to the reader. The identification number on the reader can then be transmitted to a computer, which can identify both the unique item (SKU number as well as a unique serial number) as well as physical location. Information about a product in a warehouse, store, or any place within transmission range can then be shared and updated in real time across a network. EPC read speed and lack of requiring line-of-sight reading are major advantages over bar code scanners.

Internet

Widespread availability of the Internet and standardized communication interfaces offered through browsers such as Internet Explorer have substantially expanded the opportunities and capability to exchange information between firms of all sizes. The Internet is quickly becoming the supply chain information transmission device of choice for exchanging forecasts, orders, inventory status, product updates, and shipment information. In conjunction with a server and a browser, the Internet offers a standard approach for order entry, order status inquiry, and shipment tracking. An Ohio State University survey predicts the Internet will carry 5 percent of customer orders by the year 2010.[3]

The availability of the Internet has also enabled the development of the exchange portal, a communication medium that has significant supply chain implications. An exchange portal is an infomediary that facilitates horizontal and vertical information exchange between supply chain partners. Figure 5.14 illustrates an exchange portal designed to facilitate communication between supply chain participants. The facilitating firm can provide information regarding raw material requirements, product availability, and price changes and allow the marketplace to react by placing bids or orders.

A second type of exchange portal is industry based. It facilitates communication between all participants within an industry and can substantially reduce transaction costs. Figure 5.15 illustrates the exchange portal that the electronics industry has developed to facilitate communication between the original equipment manufacturers and their multiple tiers of suppliers. This portal offers a common framework for exchanging information, including design information, proposal requests, commodity availability, bids, and schedules. While the information can be made available to all interested parties, it is also possible to restrict information availability. There is increasing fear that industry portal collaborations might increase the potential for monopolistic practices and trade restraints.

[3] The Ohio State University, "Careers Patterns Survey," 2008; available under "careers" at the Council of Supply Chain Management Professionals Web site, **www.cscmp.org**.

RE 5.14
-Firm
ange Portal

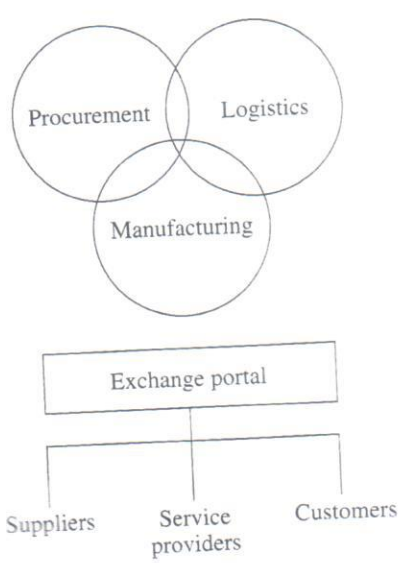
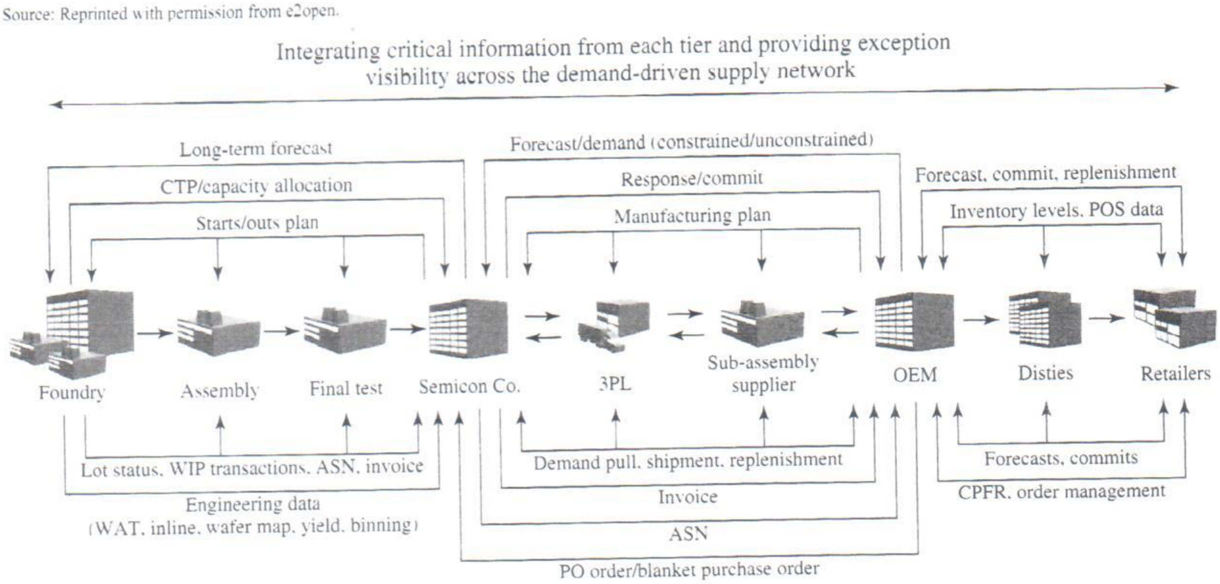


FIGURE 5.15 **Electronics Industry Exchange Portal**

Source: Reprinted with permission from e2open.



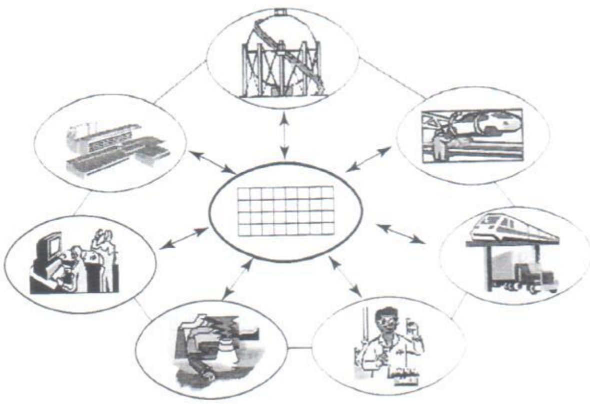
The Federal Trade Commission (FTC) can be expected to play an increasing role in the evolution of the exchange portals, particularly for B2B activities.[4]

A third type of exchange portal is cross-industry-based and is designed to facilitate communication between firms that have common interests in commodities and services. Figure 5.16 illustrates a cross-industry exchange portal for manufacturers, suppliers, service providers, and customers. When one of the member firms has a need for raw material, product, or service, it can access the exchange portal to determine availability and potential price. Similarly, when one of the member firms has excess product or service capacity, such availability can be posted on the portal to solicit interest or a possible bid by one of the exchange members. Reverse auctions can be used most effectively with cross-industry-based portals.

The Internet and the exchange portal have advanced supply chain communication from one-to-one or limited capability to a one-to-many environment capable of being extended to a many-to-many capability. The result is that extended Internet communication is a reality that offers substantial challenge in terms of exploiting widely available information.

One of the major challenges to the wide adoption of exchange portals is the definition and acceptance of online catalogs. Much like the paper version, an online catalog contains a listing of the products and services offered along with their descriptions and specifications. A catalog that is consistent across participating firms is critical to facilitate effective comparison of products and services across firms. For example, a firm desiring to purchase a simple T-shirt from a portal would like all the T-shirt suppliers on that portal to have a similarly formatted entry describing the shirt, its coloring, its content, as well as other minute details so that the customer can make an effective comparison. While customers prefer consistent catalogs, suppliers prefer to use a catalog as a differentiator and are thus reluctant to deviate from their proprietary format. To facilitate information sharing and exchange, the Voluntary Interindustry

[4] Kim S. Nash, "Really Check," *Computerworld,* June 5, 2000, pp. 58–59.



Commerce Standards (VICS) and Collaborative Planning, Forecasting, and Replenishment (CPFR) are actively promoting common and consistent catalog definitions and standards.

Extensible Markup Language

Extensible Markup Language (XML) is a flexible computer language that facilitates information transfer between a wide range of applications and is readily interpretable by humans. It was published in 1998 by the World Wide Web Consortium to facilitate information transfer between systems, databases, and Web browsers. Since EDI is very structured, the setup cost and required expertise are relatively high, limiting applications to situations involving high transaction volumes. XML is emerging as the information transfer medium between firms and service providers that do not have transaction volumes to justify EDI. XML facilitates communication by breaking down many information technology barriers that have constrained EDI adoption.

A basic XML message consists of three components: the actual information being transmitted, data tags, and a document type definition (DTD). The data tag is a key feature, as it defines the data being transmitted. For example, in a shipment XML, the tag for address would be address and might appear <address> 123 Main St.<address>. The tags indicate to all computer applications what the data between the brackets are and where the data should go in a database or Web page. The use of common terms and the lack of sequencing requirements make XML transactions much easier to use than EDI. The XML DTD tells the computer what document format to refer to when decoding a message. A DTD is essentially a template that maps out a standard form, its tags, and their relation in a database. For example, there would be separate schema for customer orders, advanced shipping notifications, or transportation documentation.

In situations characterized by low volume, XML is superior to EDI for three reasons. First, it is not expensive to install. It is easy to design an application and requires much less time to implement. Second, XML is easy to maintain because it can be easily converted to HyperText Markup Language (HTML), the language of Web browsers. This makes it much easier to modify and share data between applications. Finally, XML is more flexible, allowing for broad applications and quick definition and extension of standards.[5]

[5] For more detail, see Gordon Forsyth, "XML: Breaking Down IT Barriers in Logistics," *American Shipper*, June 2000, pp. 20–26.

Satellite

Satellite technology allows communication across an expansive geographic area such as a region or even the world. The technology is similar to that of microwave dishes used for home television in areas outside the reach of cable. Figure 5.17 illustrates two-way communication between corporate headquarters, vehicles, and remote operational locations.

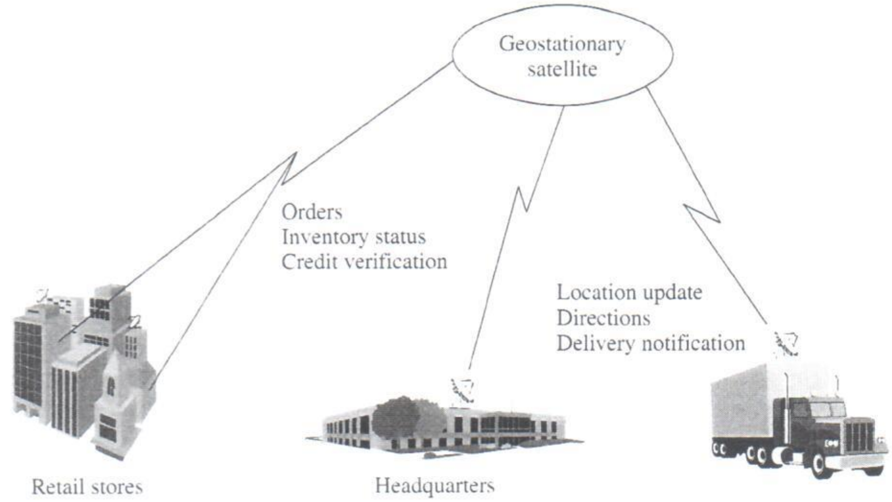
Satellite communication provides a fast and high-volume channel for information movement. Schneider National, a nationwide truckload carrier, uses communication dishes mounted on its trucks to enable two-way communication between drivers and their dispatchers. Such real-time interaction provides up-to-date information regarding location and delivery information, allowing dispatchers to redirect trucks according to need or congestion. Retail chains also use satellite communication to quickly transmit sales information back to headquarters. WalMart* uses daily sales figures to drive store replenishment and to provide input to marketing regarding local sales patterns.

Image Processing

Image processing utilizes facsimile (fax) and optical-scanning technology to transmit and store freight bill information, as well as other supporting documents such as proof of delivery receipts (POD) or bills of lading (BOL). The rationale for this service is that timely customer shipment information is almost as important as delivering the goods on time. As freight is delivered to customers, support documentation is sent to image processing locations, electronically scanned, and logged into the system.

Electronic images of the documents are then transmitted to a central database where they are stored. By the next day, customers can access the documents through computer linkages or a phone call to their service representative. Customer requests for a hard copy of a document can be filled within minutes by a facsimile transmission. Customer benefits include more accurate billing, faster response from carrier personnel, and easy access to documentation. The carrier also benefits because the system eliminates the need to file paper documents, reduces the chance of loss, and provides improved credibility with customers.

FIGURE 5.17
Logistics Satellite Communication Applications



Satellite technology, RF, and image processing require substantial capital investment prior to achieving significant returns. Experience has shown, however, the primary benefit of these communication technologies is not always lower cost but improved customer service. Improved service is provided in the form of more timely and accurate order entry, quicker shipment tracing, and faster transfer of sales and inventory information. There will be increased demand for these communication technology applications as customers observe the competitive benefits of real-time information transfer.

Software as a Service

Supply chain application software has traditionally been purchased by the firm using it or on behalf of the individual firm by a firm managing their information resources. This was comparable to the arrangement for other firm technology. Recently, some firms are effectively shifting toward software rental in what is being termed as **software as a service (SaaS).** SaaS is offered by a third-party information technology provider and is typically operated on the provider's hardware. This relieves the supply chain firm of the requirement to acquire and maintain either the software or hardware as well as the need to be trained on its internal integration and operation. Table 5.7 summarizes the primary benefits and considerations of SaaS relative to the firm purchasing and operating its own information technology.

Supply chain planning and operations is applying increasingly more sophisticated software and technology. Just as in the case of other logistics services such as transportation and warehousing, some firms are realizing that developing and maintaining a high level of competency in specific information applications is not core to their competitiveness. As a result, they are looking for SaaS providers to meet their technical and operating requirements. The applications that are particularly appropriate for SaaS include those that have significant potential for cross-firm synergies such as TMS and applications requiring a very high level of expertise such as APS.

TABLE 5.7
Benefits and Considerations Related to Software as a Service

Benefits	Considerations[6]
• Shifts much of the software and related hardware cost from fixed to variable based on time or number of transactions. • Reduces the need of the firm to develop and maintain specialized expertise. • Allows the firm to take advantage of economies of scale in software and hardware acquisition since costs can be shared across a number of user firms. • Since information is shared across firms, SaaS opens up the opportunity to share supply chain operations activities. • Access to the application can generally be from anywhere there is a personal computer with access to the Internet	• Who is providing the service? How long have they been providing it? And what guarentees are there that they will continue to provide it? • Are the servers and other hardware wholly owned or are they subcontracted to another supplier? • If hosting is outsourced, how secure is the data? • Are backups made regularly and where are they stored? • Who owns the data and who has access to it? • Does the supplier guarantee service and availability levels? • Who are the reference sites?

[6] Adapted from Alan Stevens, "Before You Sign up to a SaaS Solution," *Personal Computer World* (August 2008).

Summary

Supply chain information systems link logistics activities in an integrated process bas on four levels of functionality. The transaction system provides the foundation electronically taking the order, initiating order selection and shipment, and completi appropriate financial transactions. Management control systems record functional a firm operating performance and provide appropriate management reporting. Decisi analysis systems assist management in the identification and evaluation of logistics alt natives. Strategic planning systems provide top management with insight regarding t impact of strategic changes such as mergers, acquisitions, and competitive actions. Wh the transaction system provides the foundation, management control, decision analys and strategic planning systems are becoming critical for high-performance supply ch management.

ERP or legacy systems are the backbone of most SCIS because of their integrated da base capabilities and modular transactions. The communication systems facilitate inforr tion exchange internally within the firm's functions as well as externally across global s and with other supply chain partners. The execution systems are becoming more criti for controlling warehouse and transportation operations. The visibility systems mon product and information flow to reduce supply chain uncertainty and provide gove ment reporting information. Supply chain planning systems will likely become the crit competitive differentiator for the future as firms strive to improve their asset producti through reduced inventory and physical assets.

The foundation of any firm's supply chain information system is the ERP and execu systems that provide the database and transaction systems to initiate and track supply c activities. Firms continue to place a strong emphasis on ERP system implementatio achieve information consistency, economies of scale, and integration. These characteri are becoming basic requirements for global commerce. A broad-based ERP system de includes an integrated database along with modules to support supply chain, service, financial operations, and for human resource management. The supply chain exec system includes modules for customer accommodation, logistics, manufacturing, pur ing, and inventory deployment.

Remarkable advances have been made to facilitate logistical communication within a given firm and among its supply chain partners. EDI, satellite, and more rec XML continue to enable quicker and more consistent communication between su chain partners. Other technologies, such as bar coding, scanning, and radio frequenc substantially enhancing the communication effectiveness between logistics inform systems and the physical environment in which they must operate.

The increasing accessibility and capabilities of these information and communic systems substantially increase the availability and accuracy of supply chain inf tion. Communication technology advances have dramatically reduced the uncer between large firms, but substantial opportunities remain for improved communic between smaller firms, which make up the majority of supply chain participants. further communication system improvement will continue to reduce uncertainty likely that major opportunities for future performance enhancers will be through s chain analysis and strategic planning systems.

While firms still typically acquire and operate their own information technology cations, there is a trend toward application rental **(SaaS)** to reduce software and har assets and lower the cost of maintaining expertise. It is likely that this trend will co as supply chain software continues to become more specialized and critical to s operations.

enge
tions

1. Compare and contrast the role of ERP systems and planning systems in enhancing firm performance and competitiveness.
2. Compare and contrast the role of ERP systems and logistics execution systems.
3. Discuss the rationalization for ERP implementation by firms involved in supply chain management.
4. Discuss the major challenges a firm should expect when implementing an integrated ERP system, including financial, supply chain, service, and human resource applications.
5. Discuss the applications, benefits, and challenges related to the use of RFID to enhance supply chain performance.
6. Compare and contrast how enterprise operations systems differ for MTO and MTP firms.
7. Compare and contrast the role of enterprise operations applications in improving firm competitiveness.
8. Discuss the rationale and risks associated with using a common forecast to drive the firm's planning/coordination flow.
9. Discuss the role of the CRM system in enhancing the firm's competitiveness.
10. Discuss the trade-offs between information technology usage through acquisition versus access through SaaS.