been significant growth for these logistics service providers, the companies using them do so sparingly. Eighty-five percent of the companies using outside services spend less than 20 percent of their logistics budgets on them.[19]

Compared with alliances, contract logistics companies (3PLs) are often viewed as selling services rather than forming partnerships that benefit from the synergism between the members of the alliance. However, because there can be information sharing and close working relationships, the relationship between a company and its outside logistics provider is frequently referred to as a partnership. The contract logistics companies hold themselves out to provide high-level solutions to logistics problems and excellent performance in the execution of logistics operations. A primary motivation for a company to outsource some or all of its logistics activities is that the third-party provider is more efficient because logistics is its primary business, while logistics is not the core competency of the buying firm.

The potential benefits of partnering were previously noted. On the other hand, there are some possible disadvantages, as well. From a survey by J. P. Morgan Securities, Inc., the most noted negatives to using a 3PL were the lack of understanding the client's business and overpromising service capabilities.[20] Barriers to maintaining a successful long-term relationship include (1) misalignment of company cultures; (2) change in leadership at either the 3PL or the user; (3) unreasonable expectations of the outsourced relationship; and (4) lack of good information.[21]

Failures in 3PL relationships have sometimes been spectacular. They have resulted in lawsuits and negative press, perhaps because expectations for the benefits were so high. Now that several years have passed since 3PLs became an option for logistics managers, practitioners having experience with outsourcing have the following 12 suggestions that can lead to a company's successful long-term relationship with a 3PL:[22]

1. Determine your current supply chain costs and service levels as a baseline for comparing performance with that of the 3PL.
2. Develop the necessary metrics and invest in the proper technology to accept and evaluate the information received from the 3PL.
3. Invest the time to make sure that you and the 3PL are in strategic alignment.
4. Establish trust by meeting promises, owning up to and working through mistakes, and accepting responsibility as appropriate.
5. Develop relationship management capabilities, especially strategic and organizational change management skills, necessary to manage relationships with 3PLs.
6. Measure performance of the 3PL in terms of costs, but also attempt to measure the 3PL's contribution to increased sales.
7. Be a good customer by treating the 3PL as a partner rather than a vendor.
8. Communicate openly and honestly.
9. Share both risk and reward.
10. Recognize the 3PL's team who is working on your behalf.

[19]Robert Lieb, "The Use of Third-Party Logistics Services by Large American Manufacturers," *Journal of Business Logistics*, Vol. 13, No. 2 (1992), pp. 29–42.
[20]"Shippers Slam Ignorance of Many 3PLs," *American Shipper* (December, 2001), pp. 30–31.
[21]"Making a Long Term Commitment," *Inbound Logistics* (July 2002), pp. 98–104.
[22]Ibid.

11. Work through the difficult situations rather than quickly changing providers.
12. Explore the frontiers for performance improvement as the relationship matures.

Example

With nearly 400 suppliers in 14 states shipping materials to 30 assembly plants on a call-and-demand basis, General Motors found its inventory and distribution costs rising and its facilities congested with less-than-truckload (LTL) truck traffic. GM turned to Penske Logistics, a third-party provider, for a customized solution. GM had three objectives: reduce costs, improve inbound material management and information processing, and reduce its carrier base.

Penske evaluated the automotive manufacturer's distribution processes and recommended the use of a cross-dock distribution center strategically located in Cleveland. Staffed and managed by Penske Logistics personnel, this facility receives, processes, and consolidates inbound materials. Penske Logistics also implemented a dedicated fleet of 60 tractors and 72 trailers and handled route development and scheduled supplier pickups and JIT deliveries.

Penske schedules supplier pickups based on parts usage levels communicated via EDI from GM. Once received, a shipment crosses the dock for immediate staging and is labeled with in-plant routing instructions designed to expedite delivery at the proper location within the facility. The freight is then loaded on outbound trailers. The process involves 5 million pounds of freight each week.

Penske Logistics uses dynamic routing to increase the frequency of supplier pickups, thus reducing inventory levels and improving outbound material flow. Onboard computers using satellite technology allow continuous two-way communication between drivers and dispatchers.

By consolidating inbound shipments at the distribution center and shipping full truckloads to the plants, Penske was able to lower LTL trucking costs and reduce GM's carrier base. Penske Logistics selects and manages those carriers necessary to supplement the dedicated fleet. This has reduced GM's administrative costs by processing "one bill" for LTL services and has cut transit times by 18 percent.[23]

Partnering Through Collaboration

The benefits of organization need not result from formal or informal designs where relationships are defined between people within an organization. As information technology has evolved, a new dimension to organization has emerged—partnering through collaboration. Partnerships among the supply channel members occur as information is shared among them for their mutual benefit. These partners collaborate to achieve their own organizational objectives, usually lowered cost from reduced inventories and improved customer service from higher fill rates.

Partnering with members across echelons in the supply channel has seen success when retail point-of-sale information was shared with suppliers who were better able to plan inventory levels at the retail level (vendor managed inventory control or

[23]"Logistics' New Customer Focus," *Business Week*, March 10, 1997.

VMIC) and with requirements plans shared with suppliers in just-in-time systems. There were early successes with collaborative planning and an organization called the voluntary inter-industry commerce standards (VICS) created collaborative planning, forecasting, and replenishment (CPFR).[24] CPFR is a program of information sharing that involves forecasts, production schedules, order replenishment quantities and their timing, and lead times. VICS established guidelines for explaining underlying business processes, supporting technology, and change-management issues.

Collaboration among channel members has the potential for improving supply chain performance by reducing the uncertainty associated with demand and lead times. Recall the "bull whip" effect on demand forecasting that arises when each channel member forecasts demand based on information derived from the order patterns of an immediate downstream member. Sharing information about end customer demand is known to improve forecasting accuracy for all members. Improved forecasting reduces inventory levels in the supply channel.

However, a program such as CPFR encourages collaboration beyond forecasting. Although sharing information among partners reduces demand-estimating variability, decisions also need to be made about order quantities, shipment sizes, delivery methods, and production or supplier response times. In a partnering environment, information about these issues will be shared and the outcomes negotiated. Compared with traditional approaches in which each member makes his or her own decisions, early results from pilot tests have been impressive. From a VICS survey, retail participants have reported

- An 80 percent increase in business with a CPFR partner
- A $9 million increase in sales
- Simultaneous sales growth and inventory reductions of at least 10 percent
- Improved fill rates with less inventory
- Service level of 100 percent, with almost 40 turns per year[25]

However, collaborative partnerships are being adopted slowly. The greatest impediment to mass adoption appears to be *trust*. Companies remain reluctant to share vital data with firms outside their control and who may have business relationships with competitors. Formal agreements between partners may reduce distrust, but it is likely to remain a hurdle to overcome for some time. Yet, the potential for collaborative partnerships remains high.

Observations

The concepts of collaborative planning, forecasting, and replenishment have been pilot tested in a number of cases with the following results:

- Wal-Mart collaborated with Warner Lambert on the mouthwash Listerine and found that in-stock levels increased to 98 percent from 87 percent, lead times were

[24]www.cpfr.org

[25]Walter McKaige, "Collaborating on the Supply Chain," *IIE Solutions*, Vol. 33, No. 11 (March 2001), pp. 34–37.

reduced from 21 days to 11 days, on-hand inventory was cut by two weeks, orders were more consistent, and production cycles were smoothed. Listerine's sales increased by $8.5 million. Similarly, sales for Sara Lee items in Wal-Mart's CPFR pilot increased 32 percent, while inventories fell 14 percent. In-stock performance improved by 2 percent and gross margin return on investment was up 6 percent.

- For two unnamed chains and their trading partners, post-collaboration results showed for one retail participant an average sales gain of 12 percent, and a distribution center inventory reduction averaging 33 percent for the other retail participant.
- One of Kmart's pilots with Kimberly Clark resulted in a 14 percent increase in sales as well as in-stock improvements that went from 86 to 94 percent without increasing inventory.
- Walgreen's CPFR with Schering-Plough for a laxative product showed a forecasting accuracy improvement of 25 percent.
- In Ace Hardware's CPFR pilot with Manic, a tape supplier, sales were up 20 percent, freight costs were down 14 percent, and Manic's distribution costs were down 28 percent.

Concluding Comments

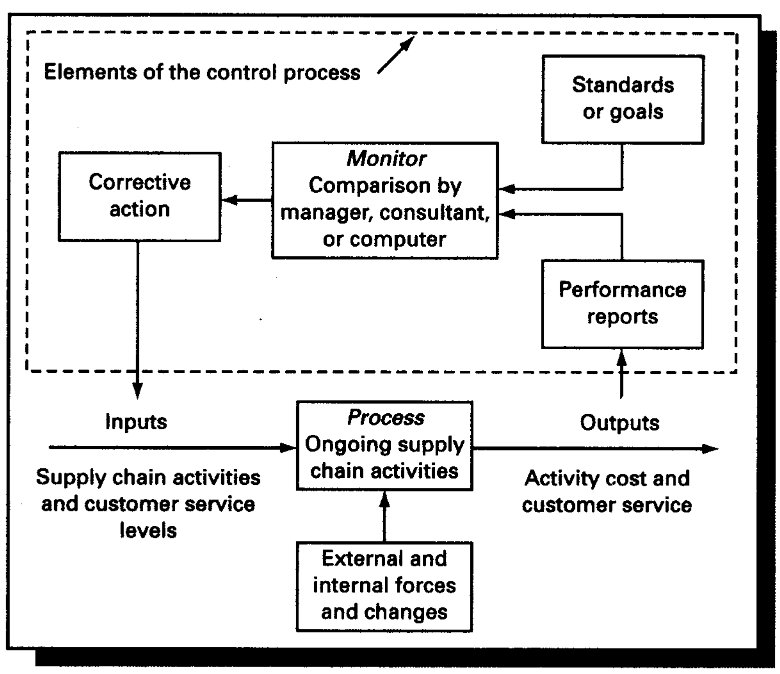
This chapter has shown the basic issues in logistics/SC organization and how to achieve coordination and cooperation among activities, functions, and firms so that logistics plans can be implemented effectively. Guided by the total cost concept, organization facilitates optimum logistics performance, except when customer service or information strategies are dominant. The organization should be considered on three levels. Grouping relevant activities together and managing them collectively as a logistics function has received the greatest attention. In certain cases, the payoffs have been great because of this activity realignment. Much less consideration has been given to the problems of interfunctional and interorganizational cooperation, coordination, and collaboration. The potential benefits may far exceed those from direct activity management. However, achieving cooperation among functions within the firm and among firms beyond their legal boundaries, when cooperation is likely to be largely voluntary, is a highly complex organizational problem. Undoubtedly in the future, logistics/SC organization at all levels will choose cooperation as a general theme for organizational effectiveness rather than simply selecting formalized organizational structures that create as many coordination problems as they resolve.

As an alternative to performing all logistics tasks in-house and, therefore, needing extensive logistics/SC organizations, many firms have sought to outsource logistics activities or to form logistics partnerships and share their logistics systems with other firms. Advocates have argued that such a strategy can lead to reduced costs and improved customer service, while allowing the firm to focus in its core competencies. Those opposing the strategy cite loss of control of the logistics activities and a resulting deterioration in customer service.

QUESTIONS

1. Explain why a firm would want to develop an organization chart for a logistics/SC.
2. If a firm does not wish to establish a separate, identifiable logistics function, how might the coordination, which is necessary for effective management of logistics activities, be achieved?
3. Explain the difference between a line and a staff organization structure for logistics.
4. What criteria would you use to determine whether a logistics/SC organizational structure should be centralized or decentralized?
5. What responsibilities, skills, and experiences would you want to include in a job description for the position of vice president of logistics/SC for a consumer products manufacturer (say, of housewares)? How would your description change, if at all, if the position were for a large medical clinic?
6. Indicate the firm's activities, such as purchasing, transportation, and inventory control, that should be included in a logistics/SC organization, if the company is one of the following:
   a. Miller Coal Mining Company (extractive firm)
   b. Titusville Community Hospital (service firm)
   c. March Department Stores (retailing firm)
   d. Romac Appliance Company (manufacturing firm)
7. If a firm is in Stage II of its logistics/SC organizational development, what would be required for it to move to Stage III? To Stage IV? To Stage V?
8. Why are customer service, packaging, and production scheduling considered interfunctional management activities? How can they be managed effectively within a functionally organized firm? What organizational structure would you propose for managing the superorganization? Contrast the structure with that for managing logistics activities that are strictly within the legal boundaries of the firm.
9. What is a superorganization? How does managing the superorganization compare with managing the logistics function within the firm?
10. Table 15-1 indicates that distribution channel profits can be higher if individual channel members cooperate in deciding purchase order quantities and pricing policies than if they act alone. Because the benefits of cooperation may tend to "pool" with one of the members, how might the members enjoy the increased benefits and be encouraged to continue to cooperate?
11. Describe the situation within a company where it is suggested that
    a. Some or all of the logistics activities be outsourced.
    b. The company seeks a partner to share its logistics system.
    c. The company actively takes the lead in forming a logistics alliance.
    d. All logistics activities be managed in-house.
12. Suggest the type of information that should be shared among supply channel partners to encourage cooperation and to maintain trust.
13. What methods are available for distributing the benefits of channel member collaboration?
14. Briefly describe CPFR.

Figure 16-1
A Schematic Representation of the Logistics/SC Control Process



Inputs, the Process, and Output

The focus of the control system is on the process to be regulated. This process may be a single activity, such as filling orders and supplying inventories, or it may be a combination of all activities in the logistics function, both internal and external. There are inputs into the process in the form of plans. Plans indicate how the process should be designed. Examples are plans for transportation modes to use, for the safety stock to maintain, for the order processing system design, or a combination of all of these, depending on the goals for the control system.

Environmental influences are a second type of process input. The environment broadly includes all factors potentially affecting the process and that are not accounted for in the plans. These represent the uncertainties that alter the process output from the planned activity levels. Examples of some of the important environmental influences would be uncertainties in the actions of customers, competitors, suppliers, and government.

The process output is what we may, in general, call performance. Performance is the state of the process at any particular time. For example, if the process is the transportation activity, then the performance might be measured in terms of direct costs, such as transportation rates, indirect costs, such as loss and damage, or delivery performance.

The process, with its input plans and resulting performance, is the object of the control process. These factors result from the planning and implementation processes, and they are shown in relation to the control function in Figure 16-1.

Standards and Goals

The control function requires a reference standard against which logistics activity performance can be compared. The manager, consultant, or a computer program strives to match process performance with this standard. Typically, this standard is a cost budget, a customer service target level, or a contribution to profit.

In addition to standards set by company plans and policies, some firms have chosen to conform to external standards. The heightened interest in quality has led to firms setting their performance standards high enough to compete for quality awards, such as the Malcolm Baldridge National Quality Award, the Deming Prize, or the J. D. Powers & Associates Quality Award. Perhaps the most popular standards for quality assurance are those of the International Organization for Standardization,[1] referred to as ISO 9000.[2] For the logistician, quality may mean filling orders accurately, having few stockouts, or delivering product on time. Companies around the world seek to become certified and promote that they meet the certification criteria. Customers expect it from their suppliers, since this gives assurances that the products or services they receive will be as they expect. For the provider of products or services, the criteria for these quality awards or ISO 9000 certification may become the logistics process goal.

The Monitor

The monitor is the nerve center of the control system. It receives information about process performance, compares it with the reference goal, and initiates corrective action (see Figure 16-1). Compared with the thermostat in a heating and air-conditioning system, the information inputs to the logistics control system monitor are often not as electronically sophisticated. Information received by the monitor is primarily in the form of periodic reports and audits. Such information typically includes reports concerning inventory status, resource utilization, activity cost, and customer service level.

The monitor in the system is the manager, consultant, or a computer program. The monitor interprets and compares the performance reports with the activity goals. It decides whether performance is out of control and, if it is, chooses the corrective steps that must be taken to bring performance in line with objectives. For example, if customer service is too low compared with the desired service level, the manager might call for additional safety stock to be maintained in the warehouses. The exact nature of the corrective action depends on the degree of control process error and how permanent the manager hopes the correction to be. If the "error" between actual and desired performance is within acceptable limits, no corrective action is likely to be taken. On the other hand, if the error exceeds acceptable limits, the manager may choose immediate and possibly temporary tactical solutions to reduce the error, or he or she may initiate strategic planning that will alter the system design. It is a matter of judgment whether the manager seeks a tactical or strategic solution. That individual's understanding of the error's cause influences judgment,

[1]A worldwide federation of national standards bodies from some 100 countries, one from each country.
[2]A set of five universal standards for a quality assurance system accepted around the world.

for example, whether there is random variation or fundamental change in performance, whether the benefits to be gained from major replanning outweigh the costs involved, or whether there is a need for quick error correction.

Types of Control Systems

Control systems vary in design. They are generally categorized as open loop, closed loop, or modified feedback types.

Open-Loop Systems

The most common system for controlling logistics activities is the open-loop system as illustrated in Figure 16-2(a). The important feature of the open-loop system is the human intervention between the action of comparing actual and desired performance and the action to reduce the process error. The manager must intervene in a positive way before any corrective action can occur. Thus, the control process is said to be open.

Major advantages of the open-loop control system are its flexibility and low initial cost. The manager, at his or her discretion, can prescribe the type of information needed for control, the error tolerance that is acceptable at any particular time, and the form of the corrective action. This flexibility is particularly beneficial when goals, plans, and environmental influences are subject to frequent changes and when automated control procedures are expensive and constraining. To date, most individual logistics activities, plus the function as a whole, are under open-loop control systems.

Closed-Loop Systems

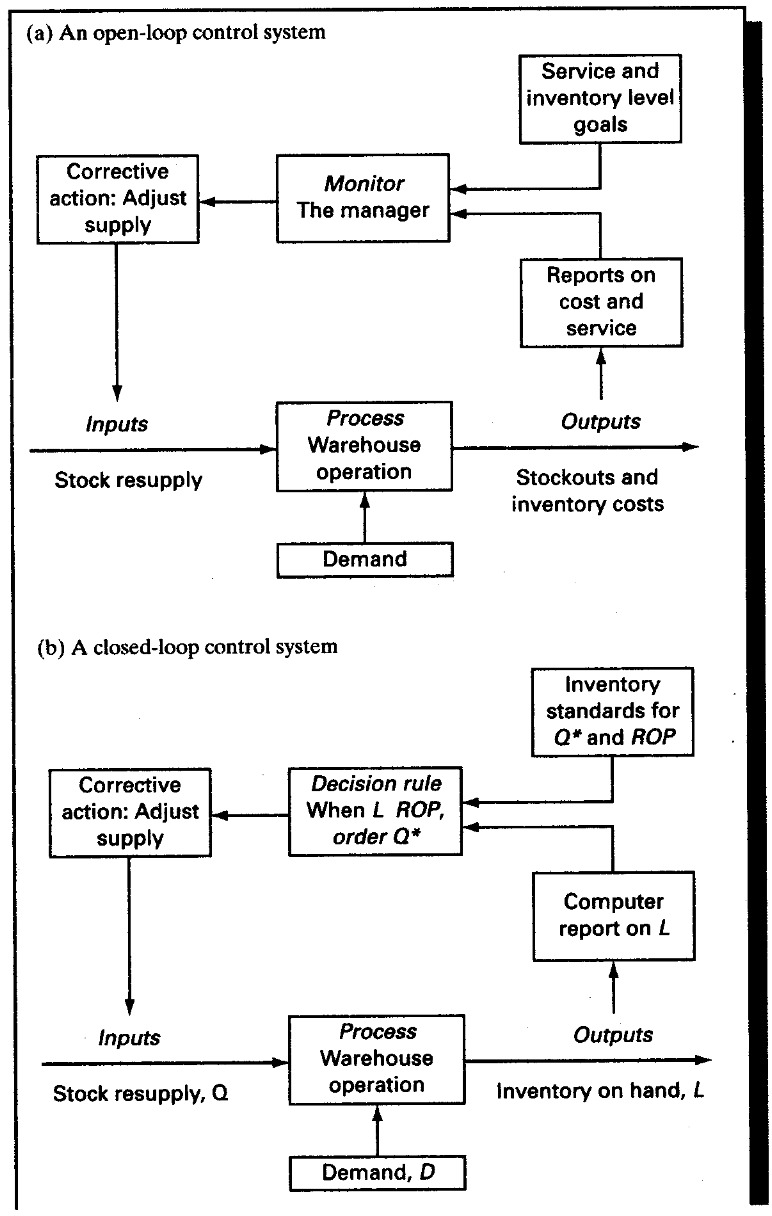
Much work has been done in recent years to find ways of reducing the need for the human element in control processes. A good deal of this work has centered on physical processes, such as controlling temperatures, voltages, pressures, speed, and position. Such control devices are broadly referred to as servomechanisms, regulators, and controllers. However, only recently has attention been given to similar control of logistics activities. The automatic control of inventories is the outstanding success to date.

In controlling logistics activities, the decision rule is used as a manager surrogate in closed-loop systems. The decision rule acts as the manager would if he or she had observed the performance error. Because the manager can be removed from the control process and control will be maintained by the decision rules, the control system is said to be closed.

Currently, the best example of a closed-loop control system in logistics management is the inventory-control system. As early as 1952, Simon suggested that servomechanism theory could be taken from its electrical and mechanical context and applied to the problems of business concerns, especially inventory-control problems.[3] It was not until the computer became useful as a business tool that inventory systems could be successfully controlled automatically. The importance of good inventory

[3]Herbert A. Simon, "On the Application of Servomechanism Theory in the Study of Production Control," *Econometrica*, Vol. 20 (April 1952), pp. 247–268.

Figure 16-2
Examples of Various Control Systems for Inventory Control



(c) A modified control system

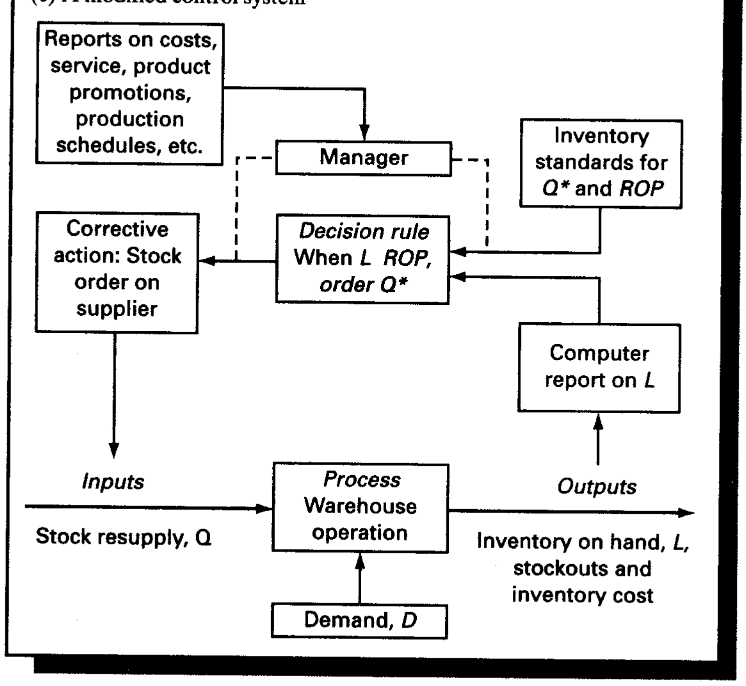


Figure 16-2 *(cont.)*

management to many firms and the quantifiable nature of inventory problems have made it one of the first activities of the firm to be controlled by closed-loop methods.

Figure 16-2(b) shows a closed-loop control system for inventory control based on the fixed order quantity–variable order interval inventory control model with constant demand and lead time. It is contrasted with an open-loop control system for the same problem in Figure 16-2(a). The process is one of maintaining an inventory in a warehouse from which demand is served. Demand continually depletes the stock, and positive action must be taken to replenish it. In the simple system that we are examining, process output is the inventory on hand. Recalling the reorder point inventory model from Chapter 9, we can develop the performance standard and the decision rule for corrective action. That is, the decision rule would be, when the inventory on hand drops below the reorder point quantity *(ROP)*, place a stock order for Q^* units. If conditions remain the same as those assumed when the decision rule was developed, the control system will ensure optimum performance. Implementing the decision rule, reporting on inventory on hand at all times, and issuing the stock order can all be handled by a computer.

In contrast with the open-loop control system of Figure 16-2(a), closed-loop control systems have a great capacity for controlling numerous product inventories with speed and accuracy. However, the closed-loop system tends to be rigid in terms of meeting changing conditions outside its design parameters. It also may provide control over a portion of the total process and, therefore, may lack some of the scope of the open-loop system. Thus, automation may have reduced flexibility, more limited scope of control, and higher initial cost, but it offers increased speed and accuracy of control.

Modified Control Systems

In real-world applications, few things are implemented in their purest form, including control systems. Managers are reluctant to transfer extensive control of an activity or a group of activities to a set of decision rules. Environmental influences are too unpredictable to expect that an automatic control system will remain relevant for all time. Managers may even have a degree of distrust for computers and mathematical models. A combination open-loop, closed-loop (modified) control system is, in fact, what is most frequently used for logistics activity control. The modified system will generally appear as shown in Figure 16-2(c).

In a modified control system, the manager may at times substitute for the decision rules. In the case of the inventory-control problem of Figure 16-2(c), the logistics/SC manager is in a position to *override* the automatic decisions of when and how much to order. He or she generally has access to a much broader information base than the automatic control system and is in a position to judge the performance of the control system. Such information might include customer service complaints, inventory cost reports, marketing promotional announcements, transportation service changes, and production schedule changes. Because the automatic control system usually does not respond to this type of information, it may no longer ensure optimal inventory performance. Thus, the logistician may intervene in the control process either to make minor adjustments in the decision rule, the reference standard, or the information base, or he or she may make major changes in the control system and process design. If the control system is well designed, only infrequent minor adjustments will be necessary. For example, a higher-than-ordinary level of inventory may be needed for temporary item promotion, and the logistician would override the automatic control system by calling for a higher order quantity for the item than the automatic system would suggest.

The manager in a modified control system not only adds flexibility and scope to the system but also acts as a safety valve when the automatic system breaks down. In effect, the modified control system offers advantage in controlling complex activities without requiring the manager to relinquish managerial command over the system. This undoubtedly is the reason for its use over purely open loop or closed loop control systems.

Control System Details

Once the type of control system for controlling single activities in the entire logistics function has been broadly defined, several system details need to be considered. These include the tolerance of the system for "error," the nature of system response, the setting of goals, and the nature of control information.

Error Tolerance

How great must the performance error be before corrective action is initiated? Just because the logistics activity costs are too high and the customer service level is too low may not mean that corrective action should be initiated. Corrective action does consume managerial time, especially if the control system is of the open-loop type, so that to take corrective steps to reduce the error when it is unnecessary leads to unneeded expense. Corrective action is unnecessary when the error is due to ordinary random events, and no fundamental changes in average process performance have occurred. In effect, a control system that tends to follow every slight performance error can have the characteristic of being "nervous." In general, a control system should not be designed to respond to random errors.

In contrast to too little tolerance for error is the control system that has too much tolerance for error. If the control monitor, say, the logistics/SC manager, is quite insensitive to performance errors, it is possible for him or her to miss fundamental changes in customer service and activity costs until some time after they have occurred. To bring the process back under control may require drastic alterations in activity levels, even in cases where minor adjustments may have proved satisfactory if the fundamental changes had been detected earlier. Thus, excess control expense can result from the control system designed to be too insensitive to error.

The best control system design is obviously the one that lies between these two extremes. That is, the best system is one that will detect fundamental errors but will not respond to random errors.

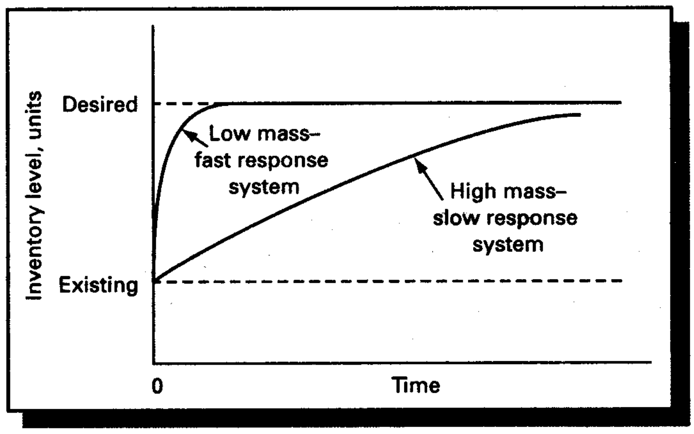
Response

When the error in a control system is no longer tolerable, corrective action must be taken. How the system responds to corrective action affects control costs. Response is a function of the characteristics of the system and the form in which corrective action is taken.

Logistics control systems are much like mechanical control systems in that they have varying degrees of mass. System mass governs how quickly actual error correction will occur and the pattern of process response. In a logistics system, mass determines the rate at which the needed change can be made. For example, if inventory levels are to be raised, the time required for realizing the desired levels will be a function of the rate at which production levels can be changed or the necessary quantities obtained from suppliers. The more mass there is in the system, the longer it will be before desired levels are reached, and the longer the out-of-control situation will prevail. Figure 16-3 illustrates the effect of mass on system response.

Information time lags are a second important factor in the pattern of response. In general, when there is a time lag between when a change in process occurs and when that change is detected in the control monitor, the system will tend to "hunt," as shown in Figure 16-4. That is, the control system can never stabilize at the desired level. If information lags, as well as system mass, are not too great, the variation around the desired level will remain within acceptable limits. If not, a more

Figure 16-3 Speed of Response in an Inventory-Control System, Depending on the Mass of the System

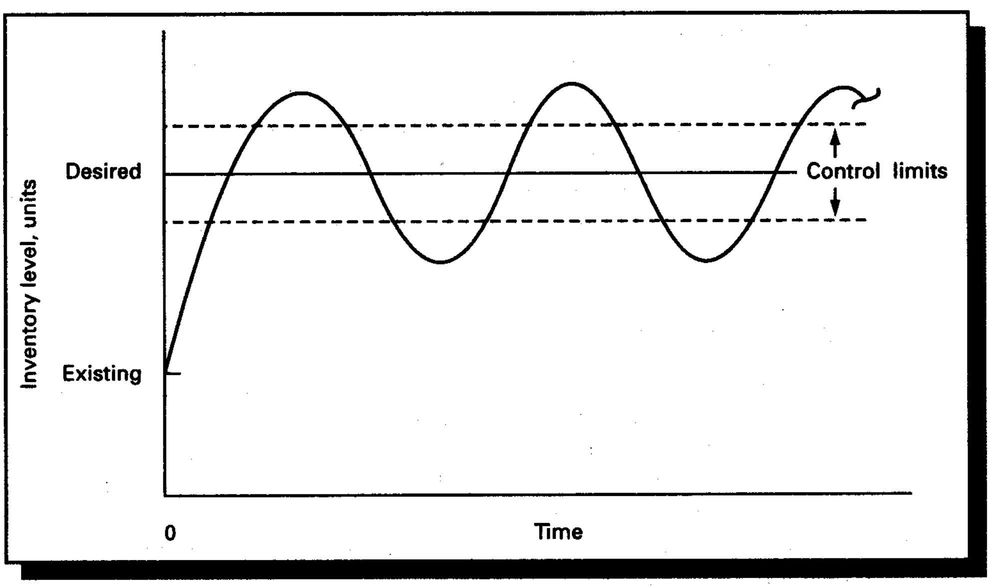


responsive information system, or possibly a more responsive production and delivery system, will need to be designed.

Process response is also influenced by the form in which corrective action is taken. Two modes of control are common. The most popular is the on-off, or two-position, mode. When an error is detected, full and constant corrective action is taken until it is observed by the monitor that the desired level has been reached. If the mass of the system and information lags are great, the on-off control mode promotes "overshooting" of the desired process performance level.

The *proportional* control system is the second familiar control mode. Corrective action here is in direct proportion to the observed error. When the error is great, so is

Figure 16-4 Control System Hunting Caused by Informational Time Lags



the change in the input level to the process to reduce the error. As the error is reduced, so is the change in process inputs. Such a system is more sophisticated and more expensive than an on-off system, but it may be justified in terms of more rapid system response without a loss in process performance stability.

Control in Practice

Logistics control systems have been aided by the use of budgets, service targets, and even the profit center concept. There is increasing use made of the computer to aid in the control process through what is known as decision support systems.

Budgets

The most widely used aid for controlling logistics activities is the budget. Budgets are cost goals set by top management in concert with the logistics/SC manager to guide the cost performance of activities. Budgets serve as the reference standard in the control process and, it is hoped, ensure the profitability of the company through cost control. They also serve as a device for measuring the performance of the logistics/SC manager.

Budgets must be realistically set if the profit objectives of the firm are to be met. Nearly any budget can be met if customer service is reduced to low enough levels. However, if it is assumed that the firm desires long-run survival, the logistics service level should be set high enough to at least ensure a competitive service level.

Service Targets

Opposite to the budget is the customer service target. The customer service target focuses on the revenue side of the profit equation. The philosophy of control by setting the control reference standard equal to the service target is that costs will tend to follow revenues. This approach would be reasonable in cases where product sales are highly service-sensitive (e.g., low-valued, highly substitutable products). However, there is an important deficiency in using service targets as a control device. Often, too little is known about the effect of physical distribution service changes on revenues.

Profit Center Concept

An appealing approach for controlling logistics is to treat the logistics function as a separate business entity within the firm, that is, as a profit center. This makes sense because the logistics function employs capital, incurs cost, and adds value by distribution. It even contributes to sales through the customer service level provided. All the prerequisite elements exist for establishing a profit center. Control of the logistics function is in terms of the broader concept of profit and avoids the narrow control features of either budgets or service targets.

Making the profit-center concept work is more difficult than the use of budgets or service targets. The major problem centers on pricing the services provided by the logistics function. Pricing would not be a problem if there were some way of relating the customer service level provided and the contribution made to logistics function profits. If such a relationship were known, the logistics/SC manager would balance revenue against costs incurred in providing the service. Such a relationship generally does not exist. Even if it did, another problem would remain before the profit center concept could be effectively applied. That is, prices for incoming products to the logistics function have to be determined.

Pricing of logistics services and the prices paid for products to be handled by the logistics function are generally not serious problems. Transfer prices can be established in much the same way as goods are priced that move from one division to another in a multidivisional company. Production would price goods to logistics and logistics, after adding value, would price goods to marketing. The price to marketing might be the price paid to production plus logistics costs incurred in supply and distribution plus a markup equivalent to the company's overall return on investment. Once prices are fixed, the logistics/SC manager is free to improve profits in any way he or she wishes. Top management measures the logistics/SC manager through profit performance and periodically reviews the setting of transfer prices.

Decision Support Systems

Decision support systems (DSSs) involve the use of a computer, database systems, and decision, or control, models. An on-line database is maintained of the important data elements needed for control purposes. These might include transportation rates, demand forecasts, lead times, inventory levels, warehousing costs, and service targets. The computer is used to interrogate this database on command of the user. Integrated into the DSS are a number of models and report-generating programs useful for monitoring ongoing activities. These programs interrogate the database for information when activity levels are to be reviewed. In addition to generating activity reports, the DSS has the capability of determining the best level of performance, which serves as a standard against which current performance can be compared. This latter capability distinguishes the DSS from a manual system.

Application

When Xerox found it necessary to cut costs in order to compete in markets with rapidly falling prices, the company needed to know how to motivate personnel in the lower administrative levels to seek the desired cost goals. Logistics and Distribution (L&D) was a cost center of Xerox's Business Systems Group. Steps were taken to get this group to emulate the behavior of a profit center by providing services for a fee and incurring the costs associated with the services provided. L&D was permitted to offer its services to other units of Xerox on a competitive basis. In effect, L&D's 1,200 employees were to act as "intrapreneurs."

Four steps were necessary to realize the profit center status for the L&D group.

1. Establish Benchmarks Since the L&D profit center must furnish services at competitive prices, it was necessary to know established norms for expenses and service levels relative to its competition. Data were gathered from vendors and companies with both similar and dissimilar operations. The data were represented in the form of indexes in order to neutralize the differences among the data sources.

2. Negotiate Service Levels L&D contracted with the captive customers within its own group to establish level-of-service targets. L&D set up a fee schedule of expenses for various service levels that aided the selection process.

3. Bid for Business L&D was permitted to bid for business in other business groups. Since each group had its own distribution organization, any business won was a clear savings to Xerox.

4. Vend to Outsiders L&D could also sell its services to outside customers. The services offered were a complete network of services or elements of distribution such as transportation or warehousing.

Enhancement of employee morale, initiative, and professionalism were clear benefits of a profit center. In addition, Xerox was able to average a 12 percent productivity improvement over the three-year period following the introduction of the profit center concept to L&D.[4]

Control Information, Measurement, and Interpretation

An effective logistics control system requires accurate, relevant, and timely information about activity or function performance. The major sources of this information are audits and various reports of logistics activities.

Audits

The logistics audit is a periodic examination of the status of logistics activities. Because of potential errors in reporting systems and the lack of reports about certain activities, it becomes necessary to periodically take stock of the situation. A control system may lose its effectiveness if the information available to it is inaccurate. Audit information is used to establish new reference points against which reports are generated and to correct errors resulting from the performance of certain logistics activities due to misinformation.

[4]Paraphrased from Frances G. Tucker and Seymour M. Zivan, "A Xerox Cost Center Imitates a Profit Center," *Harvard Business Review* (May–June 1985), pp. 168ff.

Total Function Audit

From time to time, management will find it necessary to take stock of how well the logistics function as a whole is being managed. Management needs to convince itself that the logistics activities are being performed effectively and efficiently. Such an audit might include an evaluation of all personnel, of the organizational structure, and of the overall network design. Network design can be effectively audited by analyzing the general determinants of logistics system design. Substantial changes in demand, customer service, product characteristics, logistics costs, and pricing policies can indicate the need for strategy revision.

Demand. Geographic dispersion and level of demand greatly determine the configuration of distribution networks. Firms may project disproportionate growth or decline in one region of the country compared to a general growth or decline overall. The latter may require only expansion or recession at current facilities. However, shifting demand patterns may require that new warehouses be located in rapidly growing markets while facilities in slow-growth areas experience little or no expansion. Disproportionate growth of only a few percentage points a year indicates that replanning may be economically beneficial.

Customer service. This usually includes inventory availability, speed of delivery, and order-filling speed and accuracy. The costs of transportation, warehousing, inventory carrying, and order processing rise disproportionately as service levels are increased. Therefore, logistics costs will be sensitive to the level of customer service provided, especially if the service level is already high.

Replanning is usually needed when service levels are changed due to competitive forces, policy revisions, or arbitrary service goals different from those on which the logistics strategy was originally based. Conversely, minor changes in service levels, when levels are already low, probably will not trigger the need for replanning.

Product characteristics. Logistics costs are sensitive to product weight, volume, value, and risk. In the channel, these characteristics can be altered through package design or finished state of the product during shipment and storage. For example, shipping a product in a knocked-down form can considerably affect the weight-bulk ratio of the product and the associated transportation and storage rates. However, altering a product characteristic can substantially change one cost element of logistics without affecting others. This will create a new cost balance point for the distribution system. If so, replanning would be indicated.

Logistics costs. The amount of money a firm spends on logistics often determines how often its strategy should be replanned. All other factors being equal, a firm producing highly engineered goods (such as machine tools and computers), with total distribution costs of 1 percent of sales or less, may give little attention to a logistics strategy. On the other hand, companies producing packaged industrial chemicals or food products may have physical distribution costs as high as 20 to 30 percent of sales. When costs are as high as this, even small changes in inventory-carrying costs and transportation rates can make reformulation of logistics strategy worthwhile.

Pricing Policy

Some suppliers transfer the responsibility and cost of transportation to the buyers, thus taking decisions on important logistics cost elements out of their own hands. Many firms do this through pricing policies such as f.o.b. factory, prepaid transportation charges, and invoice add-ons. Because these firms do not pay for transportation, there is little incentive to include it as an economic force in setting logistics strategy. If the price policy is changed to a delivered arrangement (transportation cost included in the price), the supplying firm directly incurs the transportation charges. This can add warehouses and inventory to the logistics system. Shifting the terms of the price policy, especially shipment routing and quantities, and shifting the responsibility for the transportation decision can signal a need for strategy reformulation.

Inventory Audits

Inventory audits are essential in inventory systems. A typical inventory-control system makes adjustments to inventory records due to demand depletions, replenishments, returns to plant, and product obsolescence. However, the occurrence of other events may cause disparities between inventory records and the actual inventories maintained in the warehouses. Theft, customer returns, damaged goods, and errors in various inventory reports can lead to substantial errors in the level of inventories believed to be on hand. A physical count of the inventories, from time to time, determines the true level of all product items. Adjustments are then made to inventory records so that once again the control system will provide more accurate tracking of inventory levels.

Taking a physical count of every item in an inventory can be quite time-consuming and disruptive to operations. Some firms may shut down operations annually while the item count is taken. As an alternative to the once-a-year count of all items, only a fraction of the items will be counted at a particular time, with the times for a count being staggered throughout the year. The frequency with which an item is counted can be set according to its criticality. This *cycle counting* process spreads the auditing workload throughout the year and causes fewer disruptions in operations.

Freight Bill Audits

Human mistakes commonly cause the extra expense of performing audits. In the control of transportation costs, many firms have found it worthwhile to audit their freight bills. Errors in rates, product description, weights, and routing are just a few of the ways that errors can creep into billing. It is common for a large company to have up to 750,000 freight bills a year, and even infrequent errors can result in sizable overcharges. There is a 3 to 5 percent overcharge to freight bills on an annual basis.

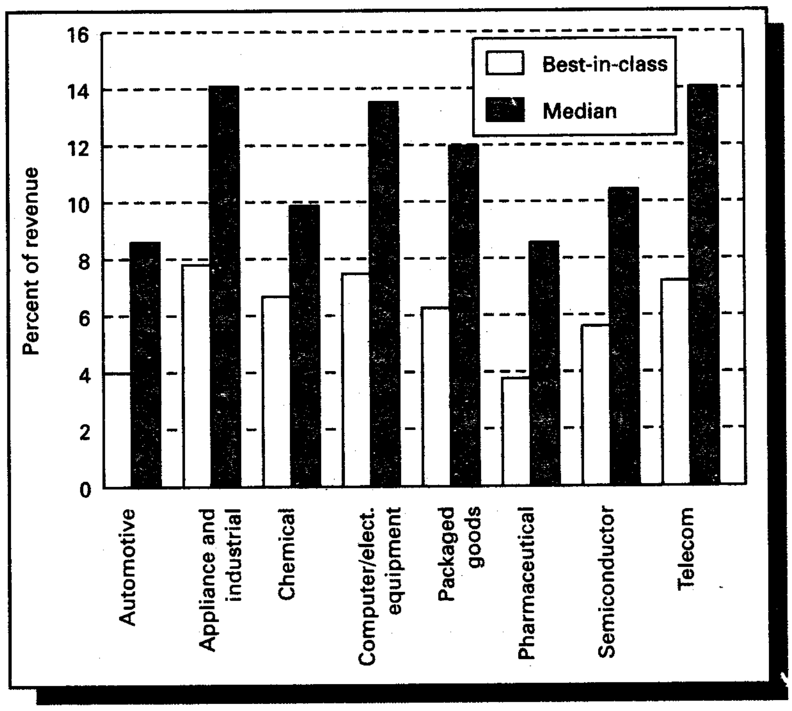
Checking freight bills can be handled by a company's traffic department; however, many firms prefer to have this audit performed outside the firm by freight bill auditing firms. These firms offer this service on a commission basis. That is, the audit firm receives a percentage of the claims that are recovered. Contracting with an outside agency is particularly beneficial to the small firm that cannot efficiently provide a staff for this activity. So common are errors that freight bill auditing is often carried out on a regular basis. The cost to have freight bills audited is typically about 50 percent of the amount recovered.

Maruti Udyog Limited (MUL) introduced Challenge 50, a program for continuous benchmarking of performance across its production-facilities, in 2001. The program targeted at improving productivity by 50 percent in three years. The program yielded 54 percent reduction in manhours per vehicle produced and cut down inventory level from 30 days to 19 days. Manhours per vehicle declined from 100 in April 2001 to 46.1 in March 2004. MUL has adopted Global Customer Audit model for quality checks. It has achieved 73.7 percent decline in warranty claims, and improved inventory turnover from 9.8 in 2002–2003 to 15.2 in 2003–2004.[5] Similarly, the management of Mitsui OSK Lines Maritime (India) (MOL) has decided to conduct surveillance audit after every six months, after the company got ISO 9001:2000 certification for its liner and logistics divisions in Mumbai, New Delhi, and Chennai from Bureau veritas (BVQI).[6]

Benchmarking to Other Firms

When audits are conducted, it is common to wonder how well a firm's logistics/SC is performing compared with its competition. Costs and customer service performance data are sought for firms in similar businesses. Such data are made available through surveys. Typically, universities, trade associations, or consulting firms become repositories for such data submitted by many firms. The anonymity of the data from an individual firm is protected when the results are presented as averages and ranges. For example, Figure 16-5 shows total supply chain costs as a percent of

Figure 16-5
Total Supply Chain Costs As a Percent of Revenue for Selected Industries
Source: Pittiglio, Rabin, Todd, & McGrath, "The Keys to Unlocking Your Supply Chain's Competitive Advantage: Integrated Supply-Chain Benchmarking Study" (1997), p. 4.



[5]*Financial Express* (September 7, 2004), p. 5.
[6]*Times Shipping Journal* (June 30, 2006), p. 34.

revenue for a variety of industries. Since the best-in-class is given, this performance level may be used as a reference against which to compare. Other data besides costs may also be available, such as inventory turnover ratios, on-time delivery statistics, and logistics activity costs.

While appealing, benchmarking in this manner must be used with caution. A firm that is not performing as well as the best in class, or even as well as the average firm in its industry, must recognize that it may have chosen to balance its trade-offs differently. For example, a firm with low inventory turnover may be saving on transportation by shipping in large quantities. Transportation cost performance may be quite good, but inventory-carrying costs may be high. Similarly, logistics costs may be high, but exceptional customer service is given. Unless customer service is compared with costs, the firm with the high logistics costs may appear to be underperforming.

Example

Premier Industrial distributes lubricants to construction sites that may be up to 600 miles from a warehouse. Premier has found a profitable niche in the marketplace by supplying its customers lubricants in small quantities and with quick response. Compared with the major oil companies used as a benchmark, Premier's logistics costs appear quite high. When customer service is brought into the comparison, logistics has been used as a key to its marketing strategy. Premier has been one of the most consistently profitable Fortune 500 companies for many decades.

Benchmarking has been referred to as a process with definable steps. It is a continuous process of measuring and evaluating supply chain performance and practices against others in the industry. The purpose is to identify differences that can lead to improvement. Benchmarking is conducted at the performance metrics, processes, or strategies level. Although the type of performance measurement using metrics has been previously discussed, benchmarking processes and strategies involves comparing such elements as information technologies used, methods for filling customer orders, transportation and inventory-management policies, make-to-stock or make-to-order strategies, and network configuration. Five steps for conducting a benchmark analysis have been suggested:

1. Collect and analyze baseline data
2. Identify and gather data on best practice companies
3. Identify and analyze performance gaps
4. Develop a plan to close process performance gaps
5. Implement the plan[7]

Collecting and analyzing baseline data involve mapping (describing) and reviewing the current supply chain. Data are assembled on key performance measures, and processes are described using maps, flow diagrams, figures, and tables.

[7]Sandor Boyson, Thomas M. Corsi, Martin E. Dresner, and Lisa H. Harrington, *Logistics and the Extended Enterprise* (New York: John Wiley & Sons, 1999), pp. 168–170.

Data gathering should focus on identifying symptoms of underperformance and causes for the performance problems. Preparing a data collection form that lists key questions and data items can be useful.[8]

Gathering data about best practice may be the most challenging part of the benchmarking process. Competitors are unlikely to share their data, and survey data may not separate best practice information from the generalized results. Nevertheless, the data sought should parallel that of the baseline information and problem causes noted in step 1. High-performing companies need to be identified that reflect characteristics similar to those of the baseline.

The third step is to compare the baseline data with that of the benchmark and best practice firms to note differences and measure the extent of the gap. Gaps may appear in performance measures such as transportation costs or item fill rates. In addition, the base company may be outsourcing logistics activities to a 3PL, whereas the best practice firm is managing its own transportation, which shows a difference in strategy.

Next, a plan is needed to close the gaps observed in step 3. Not all of the observed gaps will be of equal importance, so prioritize them. Many criteria can be used, such as greatest impact on revenue, greatest cost reduction, greatest customer service improvement, and ease of implementation for quick return. Top management approval of the initiatives may be needed whereby criteria important to these managers should be presented. Evaluating the plans on (1) the amount of cash flow generated, (2) the cost reduction, and (3) the return on investment will interest this level of management.

The final step is to implement the plans. A champion of the plan or an organizational structure to oversee implementation should be considered. A schedule for timing the various phases is needed to coordinate training, time resource availability, and so forth. Measuring performance change against the baseline is also useful.

In the Indian context, CONCOR started benchmarking the centers internally in 2005. It monitors data on various parameters from the centers and studies parameters like equipment deployed per wagon, wagon movement per hour, and staff used for moving a wagon over a certain distance.[9]

Other Audits

Any number of other audits might also be carried out on an irregular basis. Warehouse space utilization, customer service levels, transportation fleet utilization, and inventory policy performance represent specific areas that might be audited. All provide basic information necessary for effective logistics control.

Observation

Technology is playing a major role in providing data for measurement and controlling operations. Take the control of trucking costs and on-time delivery. Just-in-time practices require that progress of truck deliveries be known precisely, since delayed shipments to customers can shut down their operations that have little or no backup inventory. With the high cost of trucking, it is imperative to carefully control

[8]For an example, see Boyson et al., op. cit., pp. 201–219.
[9]Available at http://www.concorindia.com.

costs. On many rigs, there now is a tiny data-beaming antenna that monitors the truck's location at all times—good for projecting arrival times. In addition, other electronic equipment helps with cost control. A special credit card helps the company check that the driver gets fuel only from approved stops. Electronic engine monitoring controls top speed, gear shifting, and maximum idling times. If the driver steps out of the truck, the engine shuts off. Cellular phones are common in many trucks so that the driver can be in constant contact with headquarters and can avoid long waits for phones at truck stops. Report preparation time is significantly reduced.[10]

Regular Reports

Many reports are generated in the normal course of business operations. A number of these are routinely available to the logistician. These include stock status reports, warehouse and truck fleet utilization reports, and warehouse and transportation cost reports. To achieve overall logistics function control, three key measurement reports are suggested: the cost-service statement, the productivity report, and the performance chart.

Cost-Service Report

Cost-service reports are similar to the profit-and-loss reports that are popular for financial accounting in most firms. They are intended to show total physical supply and physical distribution costs as well as the corresponding customer service levels achieved over time. The most important physical supply and distribution activities are presented, namely, transportation, handling, storage, inventory-carrying, and order processing costs. Total annual costs levels are given in this report, as shown in Table 16-1.

Costs for the various elements of the report can be determined from traditional accounting procedures. However, contemporary thinking is that *activity-based costing* gives a more accurate representation of logistics costs than traditional accounting practices.[11] The reason is that historically, process overhead costs were allocated to the process based on direct labor hours or machine hours. This was appropriate when operations were more focused, less automated, and more labor intensive, but as process improvements reduced volume-related costs in logistics activities, the traditional methodology has been questioned. Alternately, activity-based costing traces resource consumption to the consuming process and then to specific products, customers, and activities. Ultimately, cost drivers that influence costs are identified so that costs can be better managed.

It should be noted that the cost-service report includes opportunity costs, notably for inventories. This permits the proper comparison of these activities with those such as transportation and materials handling for which direct expenditures are made.

Ideally, the revenues associated with the physical distribution activity levels represented by the costs should be presented as well. Because it is impractical to

[10]"New Gadgets Trace Truckers' Every Move," *Wall Street Journal*, July 14, 1997, B1.
[11]Binshan Lin, James Collins, and Robert K. Su, "Supply Chain Costing: An Activity-Based Perspective," *International Journal of Physical Distribution & Logistics Management*, Vol. 31, No. 10 (2001), pp. 702–713.

Table 16-1 An Example of a Logistics Cost-Service Report

	THIS YEAR	LAST YEAR	BUDGET/TARGET
Physical Distribution			
Transportation of finished goods			
Freight charges inbound to warehouses	$ 2,700,000	$ 2,500,000	$ 2,800,000
Delivery charges outbound from warehouses	3,150,000	2,950,000	3,000,000
Freight charges on stock returns to plant	300,000	250,000	275,000
Extra delivery charges on back orders	450,000	400,000	400,000
Subtotal	$ 6,600,000	$ 6,100,000	$ 6,475,000
Finished goods inventories			
Inventories in transit	$ 280,000	$ 260,000	$ 250,000
Storage costs at warehouses[a]	1,200,000	600,000	1,000,000
Materials handling costs at warehouses	1,800,000	1,600,000	1,700,000
Costs of obsolete stock	310,000	290,000	300,000
Storage costs at plants[a]	470,000	460,000	460,000
Materials handling costs at plants	520,000	510,000	510,000
Subtotal	$ 4,580,000	$ 3,720,000	$ 4,220,000
Order-processing costs			
Processing of customer orders	$ 830,000	$ 840,000	$ 820,000
Processing stock replenishment orders	170,000	165,000	160,000
Processing of back orders	440,000	300,000	300,000
Subtotal	$ 1,440,000	$ 1,305,000	$ 1,280,000
Administration and overhead			
Proration of unallocated managerial expenses	$ 240,000	$ 220,000	$ 230,000
Depreciation of owned storage space	180,000	180,000	180,000
Depreciation of materials handling equipment	100,000	100,000	100,000
Depreciation of transportation equipment	50,000	70,000	50,000
Subtotal	$ 570,000	$ 570,000	$ 560,000
Total distribution costs	$13,190,000	$11,695,000	$12,535,000
Physical Supply			
Transportation of supply goods			
Freight charges inbound to plant	$ 1,200,000	$ 1,400,000	$ 1,115,000
Expedited freight charges	300,000	250,000	350,000
Subtotal	$ 1,500,000	$ 1,650,000	$ 1,465,000
Supply goods inventories			
Storage costs on raw materials	$ 300,000	$ 375,000	$ 275,000
Materials handling cost on raw materials	270,000	245,000	260,000
Subtotal	$ 570,000	$ 620,000	$ 535,000
Order processing			
Processing of supply orders	$ 55,000	$ 50,000	$ 50,000
Costs of expedited orders	10,000	10,000	10,000
Subtotal	$ 65,000	$ 60,000	$ 60,000

Table 16-1 *(cont.)*

	This Year	Last Year	Budget/Target
Administration and overhead—supply goods			
Proration of unallocated managerial expenses	$ 50,000	$ 60,000	$ 40,000
Depreciation of owned storage space	30,000	30,000	30,000
Depreciation of materials handling equipment	40,000	40,000	40,000
Depreciation of transportation equipment	25,000	25,000	25,000
Subtotal	$ 145,000	$ 155,000	$ 135,000
Total supply costs	$ 2,280,000	$ 2,485,000	$ 2,195,000
Total distribution costs	$13,190,000	$11,695,000	$12,535,000
Total logistics costs	**$15,470,000**	$14,180,000	**$14,730,000**
Customer Service			
Percentage of warehouse deliveries within one day	92%	90%	90%
Average in-stock percentage[b]	87%	85%	85%
Total order-cycle time[c]			
(a) Normal processing	7 ± 2	6 ± 2	6 ± 2
(b) Back order–split delivery processing	10 ± 3	10 ± 3	10 ± 3
Back orders and split deliveries			
(a) Total number	503	490	490
(b) Percentage of total orders	2.5%	2.7%	2.5%
Orders filled complete	90%	86%	87%
Line item fill rate	95%	91%	95%
Customer returns due to damage, dead stock, order processing errors, and late deliveries[d]	1.2%	2.6%	1.0%
Percentage of available production time shutdown due to supply out-of-stocks	2.3%	2.4%	2.0%

[a]Includes space, insurance, taxes, and capital costs
[b]Percentage of individual product items filled directly from warehouse stocks
[c]Based on the distribution of order-cycle times at the 95th percentile
[d]Percentage of gross sales

determine accurately the relationship between sales and logistics service levels, revenues are not included in the report. Rather, measures of the customer service level itself are reported. No single customer service measure typically prevails. Therefore, many measures may be presented to provide a complete view of logistical performance (see Table 16-1).

The cost-service report may also give comparisons against previous periods or against budget. This can indicate trends in absolute cost-service levels. It is particularly good at showing the relative importance of each activity.

The report might logically be organized according to physical distribution costs, supply costs, and customer service. Distribution costs can be separated from supply costs because of the degree of independence in the systems that generate the costs. Supply warehouses may be different from finished goods warehouses, different transportation services may be used on the supply versus the distribution side of the firm, and the order processing networks may be different as well. Because of the degree of independence, separate management of these systems is sometimes possible. Thus, it is useful to separate the costs into two categories.

Distribution costs might include transportation costs from plant to customer, finished goods inventory costs, order processing costs, and administrative and overhead expenses associated with the distribution system. In the example in Table 16-1, transportation costs include inbound costs to and outbound costs from a finished goods warehouse, expenses from stock returns to plant, and charges associated with back orders. Finished goods inventory costs include those costs for maintaining inventories in field warehouses and at the plant, as well as the cost of goods in transit from plant to warehouse and warehouse to customer. In addition, materials handling costs at the warehouse and at the plant are listed because they are often computed separately from storage costs, and the separate classifications are useful in evaluating the efficiency and effectiveness of each of these subsystems. Obsolete stock costs are listed because, in this case, they are significant relative to the other costs in the category. Order processing costs are the third major item in distribution costs. These costs would include customer and stock order processing as well as the costs for processing the back orders. Finally, distribution costs would include prorating various administration and overhead expenses.

Physical supply costs are divided into the same general categories as physical distribution costs (see Table 16-1). Because the supply system often is simpler than the distribution system for many companies, fewer cost categories are needed for effective management.

Customer service is the final category in the cost-service statement. Logistics costs mean little unless there is some measure of logistics service against which to compare them. Knowing how any particular logistics system would affect revenues would be ideal. This is rarely available, so some physical rather than economic measure is used as a substitute. For example, distribution service might be measured in terms of percentage of warehouse deliveries within one day, average in-stock percentage, total order cycle time for normal processing and for back orders, the number and percentage of back orders, and percentage of sales returned due to distribution problems. On the supply side, customer service might be measured as a percentage of the available production time that operations were shut down due to raw material stockouts.

In general, the cost-service statement provides the kind of aggregate data necessary for broad control of the logistics function. When further information is required for detailed control of a single cost or service category, the logistician should be able to "explode" the category to obtain the information that produced the aggregate figure. This helps to trace the reason for being out of control to fundamental causes.

Productivity Report

The cost-service statement may be the proper report for budgeting purposes, but it does little to indicate efficiency in logistics activities. Examples of some of the top

Productivity Measure	This Quarter	Last Quarter	This Quarter Last Year	Company Standard	Industry Average[a]
Transportation					
Freight costs as a percentage of distribution costs	31%	30%	32%	29%	31%
Damage and loss claims as a percentage of freight costs	0.5%	0.5%	0.6%	0.5%	0.5%
Freight costs as a percentage of sales	9.6%	9.2%	10.2%	9.0%	8.8%
Inventories					
Inventory turnover	4.5	4.4	5.0	4.7	6.0
Obsolete stock to sales	0.1	0.1	0.3	0.1	0.2
Order Processing					
Orders processed per labor hour	50	45	55	50	50
Percentage of orders processed within 24 hours of receipt	96%	92%	85%	95%	93%
Order processing costs to the total number of orders processed	$5.50	$4.95	$5.65	$5.00	—
Warehousing					
Percentage of cube utilized	75%	70%	70%	70%	70%
Units handled per labor hour	200	250	225	200	200
Customer Service					
Stock availability (percentage of orders filled from primary stock)	98%	92%	90%	90%	85%
Percentage of orders delivered within 24 hours of receipt	72%	70%	61%	85%	90%

[a]For comparable firms

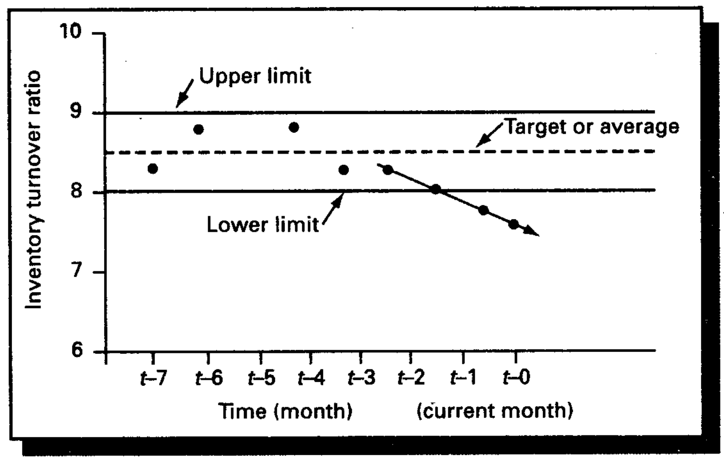
Table 16-2 An Example of a Logistics Productivity Report

logistics management evaluation ratios that could be used for control to improve productivity include the following:

- Logistics cost to sales
- Activity cost to total logistics cost
- Logistics cost to industry standard and/or average
- Logistics cost to budget
- Logistics resources budget to actual (dollars, labor, hours, and the like) adjusted for actual throughput versus forecast activity

A productivity report of the type illustrated in Table 16-2 attempts to put activity performance in a relative perspective. That is, a ratio is formed of output performance to the input resources that gives rise to the output performance level. For example, ratios are created of freight costs to sales, sales to the average inventory level needed to support them, and the number of items picked in a warehouse to labor hours. As sales of the company change, the ratio should either remain

Figure 16-6
Graphic Performance Chart for an Inventory-Turnover Ratio



constant or change in a predictable way. Deviation may indicate any activity that is out of control.

Productivity reports of the type shown in Table 16-2 are particularly meaningful when one firm's logistics performance is compared with that of another or with that of the industry as a whole. Differences in the size of firms are neutralized, which enhances comparability. In addition, comparisons made between different periods are facilitated, as the sales level variations between periods are again neutralized in most ratios.

Graphic Performance Chart

Control charts of the type that have been so popular in manufacturing quality control can be used in logistics performance control to provide better tracking of costs, customer service, or productivity ratios over time and to pinpoint when adverse trends are occurring. When sufficient data are available, statistical procedures may be used to give signals as to when corrective action should be taken. Performance charts provide a graphic picture of performance as well as comparing performance measures over multiple, consecutive periods.

Figure 16-6 illustrates the use of the graphic performance chart for an inventory-turnover ratio. Normal variation for the ratio is between eight and nine turns per year. Actual turnover ratios can be plotted for the current period, including a representative number of the most recent periods. The actual performance, or turnover ratios, is observed for their trend, and whether they have penetrated the control limit. In either case, actual performance is no longer tracking within the norms set for the ratio. Management review of the reasons for the change would be in order.

Example

An express package service promises that packages will be delivered within 24 hours of pickup. Practically, the company wants at least 90 percent of the deliveries to be within this time period. Samples of 100 deliveries have been collected for each of ten representative operating days. The results were as follows:

Sample	Deliveries Made Within 24 hr.
1	94
2	93
3	94
4	95
5	94
6	93
7	92
8	93
9	96
10	95
Total	939

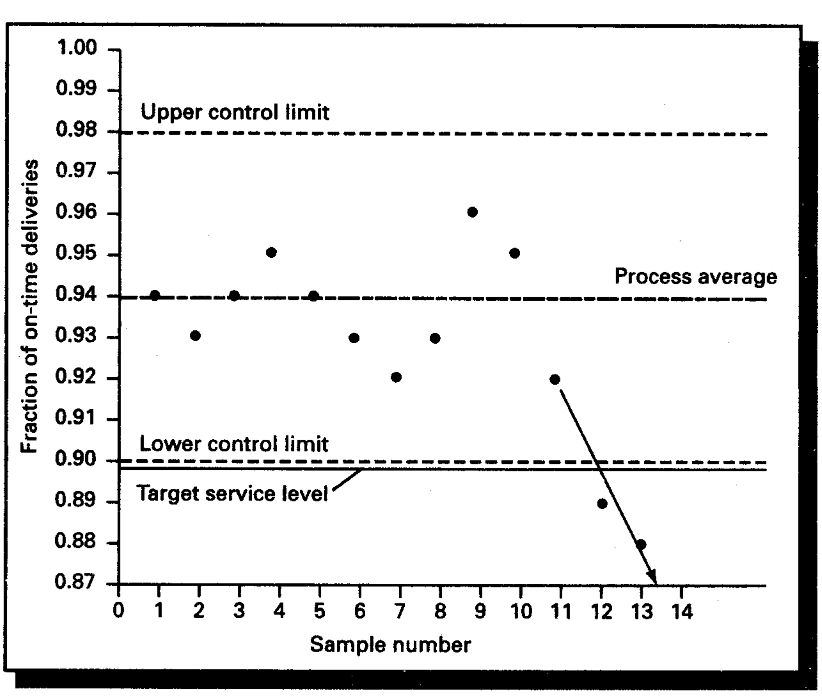
This process can be represented by a p-chart as shown in Figure 16-7. The process average $(\bar{p})$ is found by

$$\bar{p} = \frac{\text{Total number of on-time deliveries}}{\text{Total number of deliveries}} = \frac{939}{10(100)} = 0.94$$

The standard deviation of the sampling distribution for a sample size of $n = 100$ is

$$\hat{\sigma}_p = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \sqrt{\frac{0.94(1-0.94)}{100}} = 0.02$$

Figure 16-7
Graphic Performance Chart for On-Time Deliveries



The upper and lower control limits on this process for a $z = 1.96$ at 95 percent confidence (Appendix A) are

$$UCL_p = \bar{p} + z(\hat{\sigma}_p) = 0.94 + 1.96(0.02) = 0.98$$
$$LCL_p = \bar{p} - z(\hat{\sigma}_p) = 0.94 - 1.96(0.02) = 0.90$$

The next three samples of 100 each show 92, 89, and 88 deliveries were made on time. The average number of late deliveries appears to be increasing, and corrective action would seem to be indicated in order to preserve the promised customer service level. An unfavorable trend is seen in Figure 16-7.

CORRECTIVE ACTION

The final element in the control function is the corrective action that must be taken when the difference between the system goals and actual performance is no longer tolerable. Action to reduce the difference depends on the nature and extent of the out-of-control condition. In this section, three types of action are delineated: minor adjustments, major replanning, and contingency action.

Minor Adjustments

Some variation of actual performance from desired performance will occur and can be anticipated, whether the control problem is one of managing the overall logistics function or a subactivity of the function. Just as the direction of an automobile must constantly be adjusted as it moves along a highway, so must the performance of a logistics activity. Activity performance is under constant change due to a dynamic and uncertain business environment that acts upon it. For example, the transportation activity of service selection, routing, and scheduling will vary over time in terms of its costs, due to changes in rates, available routes, equipment availability, loss and damage, and the like. Such dynamics usually do not require major changes in the way that the activity is performed. Minor adjustments to activity level mix, decision rules, and even system goals often suffice to maintain adequate control over the system. Most corrective action is of this type.

Major Replanning

Sweeping reevaluation of the logistics system, significant changes in logistics function goals, major changes in the logistics environment, and introduction of new products and dropping of existing ones, may necessitate major replanning for activity performance. Major replanning involves a recycling through the management planning process that generates new courses of action and, hence, a new activity performance level, control system reference standards, and error tolerance limits. Such replanning might result in a new warehouse configuration, alterations in order processing procedures, revision of inventory control procedures, and alterations to the product flow system within warehouses and plants.

The difference between corrective actions taken in the form of minor adjustments versus major replanning is that minor adjustments do not require any substantial changes to the control mechanisms. In fact, corrective action is often routine, as in the case of inventory control where action is initiated in the form of a stock order when stock is depleted to a predetermined level. Control adjustments are automatic through the application of a decision rule. In contrast, major replanning involves substantial changes to the process inputs in the form of new plans or major revision to old ones. There is no clear delineation as to when adjustments to maintain activity control should give way to major system revision. In theory, the optimal changeover point is when the incremental costs associated with continuing to use minor adjustments within the control system to maintain control over the process just equal the incremental benefits to be derived from major replanning. Finding this point is more a matter of managerial judgment than of precise mathematical calculation.

Contingency Plans

The third form of corrective action is that taken when there are possibilities of dramatic changes in the activity performance level. Such dramatic changes can occur when a warehouse is shut down due to fire, when computer failure renders the computerized inventory-control system inoperative, when labor strikes change the availability of transportation services, or when sources of raw materials suddenly become unavailable. The company's customer service may be severely jeopardized and/or the level of logistics costs to produce a given level of customer service may suddenly rise because of swift and dramatic changes in the conditions under which the process was operating. Minor adjustments to the process inputs often prove to be too little to restore control to a system that has suffered the shock of such an event. The pressures for continuing logistics operations put major replanning as a course for corrective action at a disadvantage, as good planning requires time.

Many companies have found that contingency plans developed in advance of their need are a good way of meeting the problem of shock changes to the system process.[12] Contingency plans represent predetermined courses of action to be implemented when a defined event occurs.

Application

Recall the previous illustration where the privately owned warehouse of a large and well-known manufacturer of office copier products was struck by fire on a Friday afternoon. The fire destroyed the warehouse and its contents. The warehouse served the entire West Coast area, and sales and customer service were jeopardized in this region. Because the company had the foresight to develop a contingency plan for just such an event, inventories were immediately shipped by airfreight to a public warehouse in the area to be ready for sales by Monday morning. Customers experienced no change in service

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[12]In a survey of the participants at an annual meeting of the Council of Logistics Management, 60 percent of the respondents claimed that their companies had contingency plans for logistics operations.

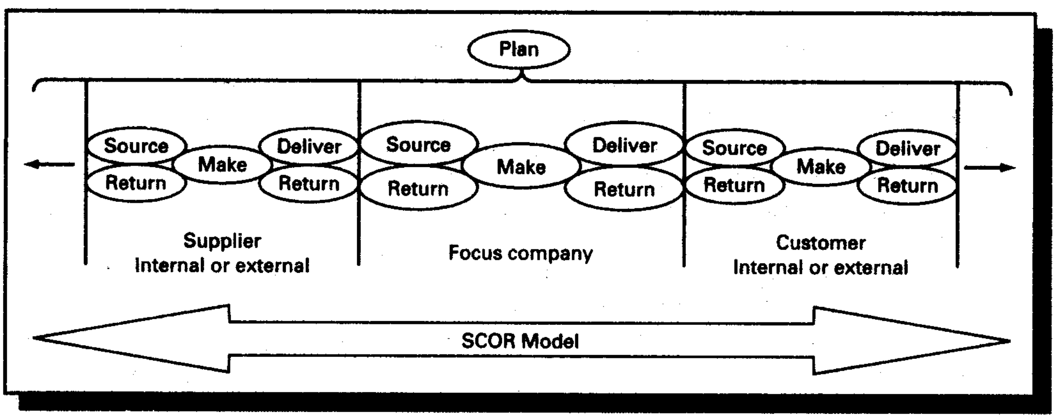
A Supply Chain Operations Reference (SCOR) Model[13]

To better measure supply chain performance and identify improvement opportunities, the Supply-Chain Council[14] in 1997 developed its first version of a business process reference model. The model attempts to link supply chain process, or activity, description, and definition to performance measures, best practices, and software requirements. The objectives of model design were to provide a *structure* for linking business objectives to supply chain operations (e.g., interpreting the effect of order fulfillment statistics on revenue and costs) and to develop a *systematic approach* for identifying, evaluating, and monitoring supply chain performance. In a word, the supply chain operations reference (SCOR) model provides a way of defining supply chain activities in a standardized format, analyzing the supply chain interorganizationally at the product level, and comparing performance with statistics derived from the council's membership companies.

The model achieves its objectives first by having a broad scope that includes all elements of demand, beginning with customer demand forecast or order placement and ending with the final invoice and payment, which can include the supply chain elements from multiple enterprises. Second, process descriptions can be product specific, although a general company infrastructure description is possible as well. Third, a framework is established for process description based on five components of plan, source, make, deliver, and return. Finally, five performance dimensions are used: reliability, responsiveness, flexibility, cost, and efficiency in asset utilization.

At the highest level in the model (Level 1), the five business processes of plan, source, make, deliver, and return are described for each echelon in the supply channel, as shown in Figure 16-8. *Plan* activities balance demand and resources, and provide

Figure 16-8 The Five Business Processes of the SCOR Model



[13]Based on a SCOR model description in Scott Stephens, "Supply Chain Operations Reference Model Version 5.0: A New Tool to Improve Supply Chain Efficiency and Achieve Best Practice," *Proceedings of a Workshop on Supply Chain Management Practice and Research: Status and Future Directions* (University of Maryland, Rockville, MD, April 18–19, 2001), pp. 7-1–7-11.

[14]The Supply-Chain Council is a nonprofit organization composed primarily of practitioners dedicated to advancing supply chain management systems and practices. More information about the council and the SCOR model can be found at www.supply-chain.org.

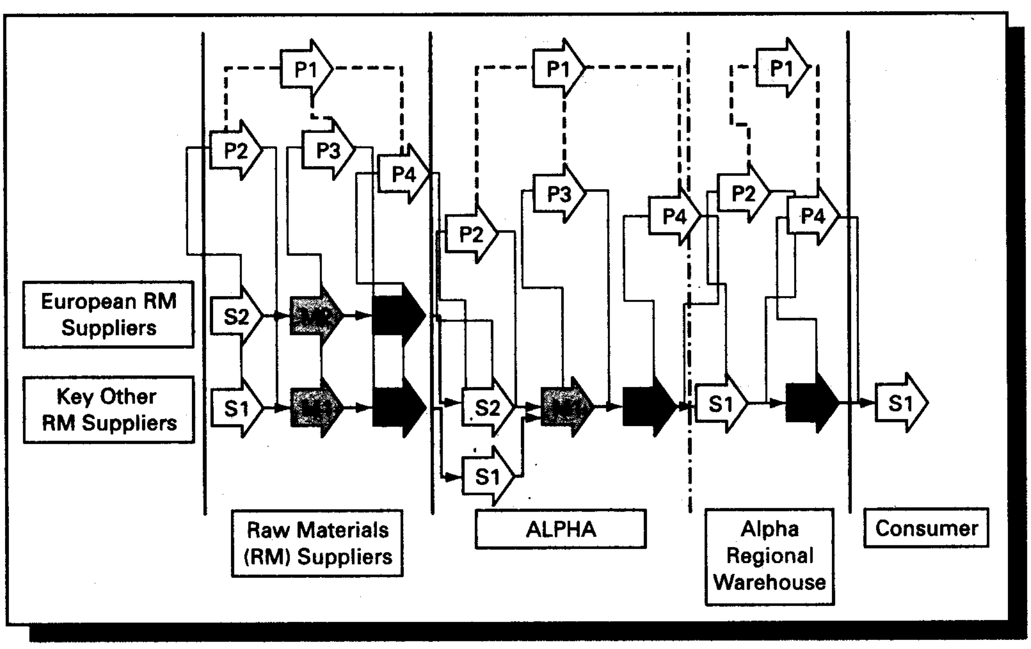


Figure 16-9 Process "Thread" Diagram for a Hypothetical Supply Chain, Where P = Plan, S = Source, M = Make, and D = Deliver

integration between activities and organizations. *Source* activities are those that are associated with acquiring raw materials and they connect organizations with their suppliers. *Make* activities transform raw materials into finished goods; however, some companies, such as distributors or retailers, do not perform make activities. *Deliver* activities are those associated with order management and delivery of finished goods. *Return* activities refer to those related to returning raw materials to suppliers or returning finished goods from customers. Whereas Level 1 is tied to the business objectives, the five processes may be decomposed in Levels 2 and 3 for further detail and greater insight into supply channel operation. Standard references are used. Decomposing to Level 4 allows specific management practices to be modeled.

To further describe the supply chain, a process map is created. Often starting with a network diagram, a product "thread" diagram is prepared, as shown in Figure 16-9. This type of mapping helps to visualize the supply chain, but it still has insufficient information for knowing whether the supply chain is performing in accordance with business objectives. To do this, the model provides a number of measurements grouped into five performance dimensions. An example of the metrics for Level 1 is given in Table 16-3. For each of the process elements, the SCOR model identifies best practice and technology. Figure 16-10 shows a first step in linking processes and metrics within the SCOR model.

Finally, a table showing the best practice and technology is presented by the model. From these representative lists, options can be derived for improvement and implementation. The SCOR model is primarily a tool for communicating among practitioners, which leads to improved control over the supply channel.

Supply Chain Performance Attribute	Performance Attribute Level Definition	Level 1 Metric
Delivery reliability	The supply chain's performance in delivering the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, and to the correct customer	• Delivery performance • Fill rates • Perfect order fulfillment
Responsiveness	The velocity at which a supply chain provides products to the customer	• Order fulfillment lead times
Flexibility	The supply chain's agility in responding to marketplace changes to gain or maintain competitive advantage	• Supply chain response time • Production flexibility
Costs	The costs associated with supply chain operations	• Cost of goods sold • Total supply chain management costs • Value-added productivity • Warranty/returns processing costs
Asset management efficiency	Organizational effectiveness in managing all assets to support demand fulfillment, including fixed and working capital	• Cash-to-cash cycle time • Inventory days of supply • Asset turns

Table 16-3 Level 1 Metrics for Supply Chain Performance Attributes

In the Indian context, Monsanto India (MI), a chemicals company which also uses the inventory, SCM, General Ledger (GL), payment, and manufacturing modules of the ERP is successfully implementing the SCOR model.[15]

Control Links to Artificial Intelligence

It has been common practice for the logistics/SC manager to judge performance from the regular reports and audits that he or she receives and to take corrective action as appropriate. Computer technology that makes computer-based planning and control practical is moving a step ahead by permitting the application of the emerging concepts of artificial intelligence (coincidentally referred to as expert systems) to the logistics control process. There are many interpretations of artificial intelligence. For purposes here, it refers to computer recognition of adverse patterns in the performance reports and the resulting suggestions about the courses of action that might be taken to correct the adverse performance patterns. In a sense, the artificially intelligent computer acts as a consultant or assistant to the manager.

[15]Available at http://www.monsantoindia.com.

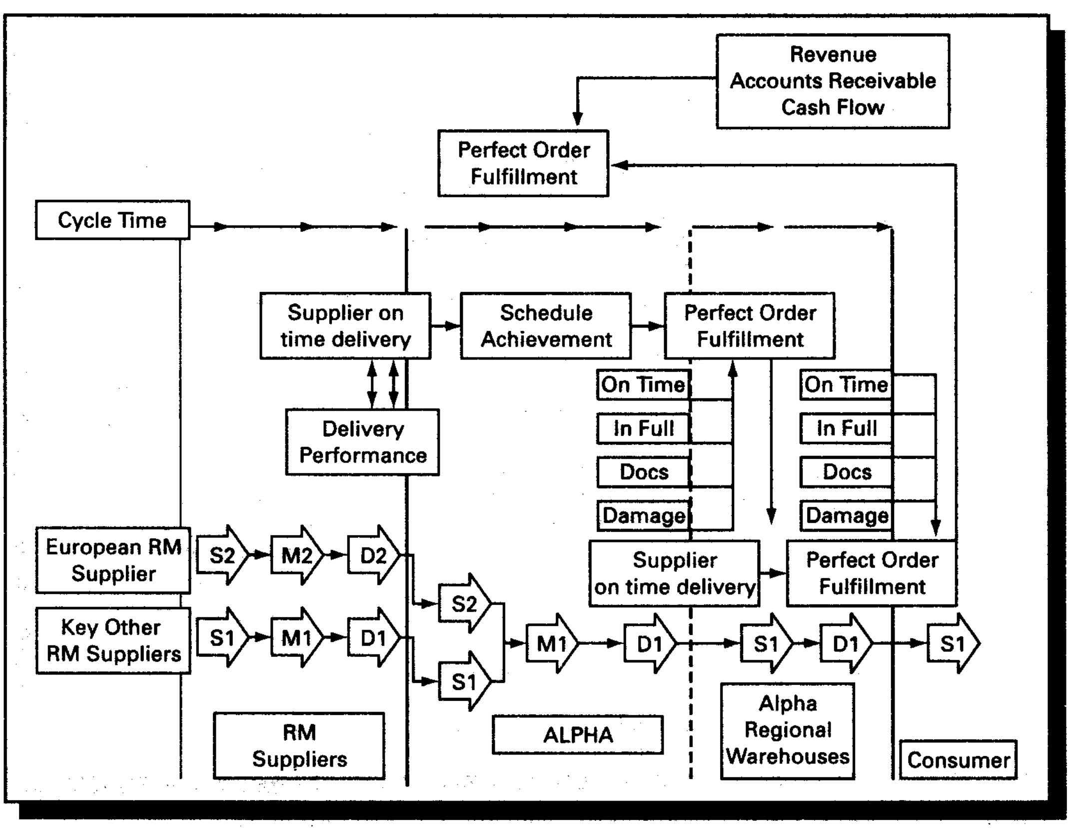


Figure 16-10 Linking Processes and Metrics Within the Model

Pattern Recognition

The key to taking performance measurement to its next level of sophistication is pattern recognition. Businesses frequently hire consultants to audit logistics operations. These consultants use experience, concepts and principles, and philosophy to judge performance (as do analysts and managers). Judgment is then applied to decide which courses of action might relieve actual or potential out-of-control situations. Capturing this process within a computerized management information or decision support system brings a new level of sophistication to the control process.

Artificial intelligence is not new. Significant research in the area dates back over 20 years, and a Nobel prize was given for research in the field; however, the technology is beginning to be applied to control problems in logistics, although not extensively at this time. Out of 105 applications of artificial intelligence to logistical problems, Allen and Helferich classified only five as related to control.[16]

[16]Mary K. Allen and Omar K. Helferich, *Putting Expert Systems to Work in Logistics* (Oak Brook, IL: Council of Logistics Management, 1990), p. 97.

Applications

- Santa Fe Railway uses an artificially intelligent system, called TRACKS, to handle basic supply and demand aspects of operations. It predicts railcar demand, anticipates customer preferences, and controls cars to meet shipper orders.
- Digital Equipment Corportation's MOVER program coordinates and drives two robots that deliver work-in-process inventories from storage areas to production. The transport system consists of a robot that picks bar code labeled totes from two carousels and moves them via one to three transporters to any of 75 production workstations. The robots deliver parts as needed by the plant six days per week, three shifts per day. MOVER has reduced materials handling labor costs $300,000 per year, decreased work in process (WIP) inventories 50 percent, and increased inventory account accuracy to 99 percent.[17]
- Tata Infotech launched an online answering system, Oasis, in 2001. It offers an interactive questioning and answering system on a specified topic using artificial intelligence. Oasis was developed following a research at Tata Infotech Cognitive Systems Research Lab.

Performance Patterns

Having the computer recognize performance trends or variations from standards is the first step toward an artificially intelligent control process. The basic concepts of logistics/SC management are the best guides to which performance information should be compared. Activities in significant cost conflict with each other (transportation with inventories and customer service levels with total distribution activity levels) are prime candidates to be monitored. Like the human as a monitor, we want the computer to recognize and interpret adverse logistics performance patterns.

The time when transportation and inventory costs are both rising yet customer service levels remain constant is an example of an adverse performance pattern. Because transportation and inventory costs typically show opposite, or conflicting, cost patterns, this trend is an indication that these two important performance factors are not moving in an expected manner and that inquiry and possible corrective action are needed.

Similarly, suppose that customer service levels are decreasing, yet total physical distribution costs are increasing. Alternatively, there is a decreasing item-fill rate on orders, but the inventory-turnover ratio is increasing. These comparisons reveal disturbing patterns that the artificially intelligent computer system should highlight.

Courses of Action

After recognizing performance patterns, the artificially intelligent control system will spell out appropriate courses of action that a manager should take to bring adverse performance patterns back in line with acceptable tolerance limits. This

[17]Ibid., Chapter 3.

assumes that a computer can be instructed to discern performance patterns with accuracy and match them with appropriate corrective responses. Knowledgeable observers can do this now, and perhaps computers can emulate the process. In the short term, computers can track the performance information as generated by such reports as previously presented in this chapter. With specified performance pattern norms, the computer can assess actual performance against these norms and offer a range of possible courses of action.

Consider how this might work. Suppose a logistics/SC manager identifies the fact that the inventory-turnover ratios have been decreasing over the past several periods and are now outside the acceptable tolerance limits. The next step is to check the factors that could be causing the inventory levels to increase. The following questions that relate to inventories might be asked by the computer:

- Has there been a sudden or seasonal drop in sales?
- Have production or purchase quantities increased from previous levels?
- Are inbound shipments being received in larger quantities than they had been previously?
- Has the sales forecast error increased significantly?
- Have supply lead times increased or become more uncertain?
- Have outbound shipments been delayed?

There may be inadequate or unavailable data to answer some of these questions. As an example, suppose the answer to the third question is found to be yes because the computer interrogated the appropriate database. The answers to the remaining questions are no. Once the out-of-control condition has been isolated, appropriate courses of action may be suggested. For example, based on current cost relationships, the computer might indicate that inbound transport shipments need to be reduced to a specific level if an average inventory-turnover ratio of a given level is to be achieved. The manager may follow this advice, or reset the inventory-turnover control limits to reflect a new level of cost-service trade-offs. The manager might also decide to utilize various computer-based models of the decision support system to evaluate different logistics options, thus changing the relationship of transportation costs and the inventory-turnover ratio.

All other performance factors would be treated similarly. The intelligent, or "expertlike," interpretation by a computer of cost-service relationships is artificial intelligence.

Concluding Comments

Logistics control helps to ensure that the goals around which logistics plans were developed are achieved after the plan is put into action. The dynamics and uncertainties of the logistics environment over time can cause deviations from planned process performance. To keep process performance in line with desired performance objectives, some form of managerial control is required. Control usually takes the form of an open-loop system, closed-loop system, or a system that combines both of these. All are used in practice.

The logistician is involved in the control activity on a daily basis. He or she often serves as the monitor of logistics activities by measuring the activity level through the various audits and reports that are received and comparing these with targets for performance, such as budgets, profit standards, and customer service goals. Based on this comparison, the decision is made to take corrective steps to bring the activity back under control. In many ways, control is just short-term or tactical decision making.

As there is greater concern with control of logistics activities across company boundaries, traditional control systems are lagging. Not only is sharing information among supply chain partners a problem of trust, but companies may have not developed the metrics and report structures needed to operate in the multienterprise environment. The SCOR model is a first attempt to evaluate and modify logistics activities of the entire supply chain using a standardized structure.

Finally, we have artificially intelligent computer programs and expert systems to aid in interpreting performance patterns and in selecting the correct courses of action. How rapidly they come into widespread use depends more on our ability to articulate the nature of the control process, so that it can be programmed into a knowledge base, than on the state of computer technology. This depends on our clear understanding of the principles and concepts on which logistics/SC management is based. It is hoped that some of these principles and concepts have been communicated throughout this text.

QUESTIONS

1. What role does control play in the management of logistics activities?
2. A common carrier trucking firm controls its delivery performance in terms of average delivery time, delivery-time variability, and loss and damage claims. Sketch a generalized open-loop feedback control model for this process to maintain a desired level of delivery performance.
3. What advantages does the modified control system have over either the open loop or the closed loop control system?
4. Which logistics activities might successfully be controlled by a closed-loop control system? Explain.
5. What effect do you think that a mail order transmittal (slow) mode compared with an electronic order transmittal (fast) mode would have on the performance of an inventory control system?
6. Of what value is the audit in the logistics control process? Which audits would be of particular value to the control of logistics activities?
7. Logistics/SC managers can suffer from too many reports and from reports of the wrong kind. Select a typical activity, such as transportation or inventory control, and suggest the type and frequency of reports needed to control the activity.
8. Suppose you are in charge of managing a common carrier trucking operation. How would you establish the tolerance for substandard performance (average delivery time, reliability, loss and damage) before initiating minor corrective action such as tighter standards on performance, personnel changes, and the like? When should major replanning take place?

9. An appliance manufacturer has a large regional warehouse in Utah to store and distribute major appliances to West Coast markets. If you were a logistics/SC manager in charge of the distribution operation, what contingency plans would you make to ensure continued good logistics performance in case disaster strikes?
10. If you were developing an artificially intelligent computer system to control overall logistics costs and service, suggest the questions that the computer might raise if it detected the following patterns:
    a. Inventory-carrying costs and inventory stock availability are dropping.
    b. Transportation costs and inventory-carrying costs are increasing and customer service levels are constant.
    c. Transportation costs are increasing while inventory-carrying costs and customer service levels have not changed.
11. As a logistics/SC manager, you would like to compare your company's logistics performance with that of similar companies. Where would you find such benchmarking information? How would you use it in the logistics control process?
12. Sketch a framework for controlling the inventory levels and deliveries of purchased product between a supplier and a buyer. Suggest the information to be shared and the measurement system that would need to be developed.