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Part I. Supply Chain Management

Supply-Production-Distribution System

There are three phases to the flow of materials:

Raw materials flow into a manufacturing company from a physical supply system.

Raw materials are processed by manufacturing.

Finished goods are distributed to the end consumer through a physical distribution system.

What happens in any one of the above phases will affect the others.

Conflicts in Traditional Systems

In the past, supply, production, and distribution systems were organized into separate functions that reported to different departments of a company.

Often policies and practices of the different departments maximized objectives of the departments without much thought being given to the effect they would have on other parts of the system.

Because the three systems were interrelated, usually there were conflicts.

While each system made decisions that were best for itself, overall company objectives suffered.

Distribution would tend to ship in the largest quantities possible so it could minimize shipping costs. However this increased inventory and resulted in higher inventory-carrying costs.

Other “Suboptimizing” can take place in the overall system.

There are four main ways to maximize profit:

1. Provide best customer service.
2. Provide lowest production costs.
3. Provide lowest inventory investment.
4. Provide lowest distribution costs.

Objectives and Departments are often in conflict.

Marketing, production, and finance have conflicting objectives.

Marketing's objective is to maintain and increase revenue. To do so it must provide the best customer service possible. It can:

- Have high inventories so goods are always available for the customer.
- Interrupt production runs so a noninventoried item can be supplied quickly.
- Have an extensive and costly distribution system so goods can be shipped to the customer quickly.
Finance will want to keep investment and costs low. This can be done by:

- Reducing inventory so inventory investment is at a minimum.
- Reducing the number of plants and warehouses
- Producing in large quantities using long production runs
- Producing only to customer order.

Production will want to keep its production costs as low as possible. This can be done by:

- Making long production runs of relatively few products. This means there would be few changeovers to make to the processes and specialized equipment can be used, thus reducing the cost of making the product.
- Maintaining high inventories of raw materials so production is not disrupted by shortages.

These conflicts between marketing, Finance, and Production center on customer service disruption of production flow and inventory levels.

Today the concepts of Just-In-Time (JIT) manufacturing stress the need to supply customers with what they want and when they want it and to keep inventories at a minimum. These objectives put further stress on the relationship between production, marketing, and finance.

**Conflict Resolution Strategy**

One important way to resolve these conflicting objectives is to provide close coordination of the supply, production, and distribution functions.

To do so requires a type of integrated materials or logistics organization responsible for supply, production, and distribution.

Rather than having the planning and control of these functions spread between marketing, production, and distribution, they should occur in a single area of responsibility.

**What is Materials Management?**

The concept of having one department responsible for the flow of materials, from supplier through production, is relatively new.

While many companies have adopted this type of organization, there are still a number that have not.

If companies wish to minimize total costs in this area and provide a better level of customer service, they will move in this direction.

The name usually given to this function is materials management.

*The management of materials from production to the customer is normally called distribution management, while the entire materials and distribution process is called logistics management (old name) or supply chain management (new name).*
Materials management is a coordinating function responsible for the planning and controlling of materials flow. Its objectives are to maximize the use of the firm's resources and provide the required level of customer service.

Profit Maximization

Reducing material flow costs contributes directly to profit.

*Materials management and distribution management (which together make up supply chain management), can reduce costs by being sure that the right materials are in the right place at the right time and the resources of the company are properly used.*

Components of Supply Chain Management

Manufacturing Planning and Control

This function is responsible for the planning and control of the flow of materials through the manufacturing process. Primary activities include:

- Production planning, including forecasting and master planning.
- Material requirements planning.
- Capacity planning.
- Implementation Control

Responsible for putting into action and achieving the plans made by production planning. Accomplished by:

- Production activity control (often called shop floor control).
- Purchasing.

Inventory Management

Inventories are materials and supplies carried on hand either for sale or to provide material or supplies to the production process.

Inventories are part of the planning process and provide a buffer against the differences in demand rates and production rates.

A convenient measure of how effectively inventories are being used is inventory turns. Inventory turns: defined as annual cost of goods sold divided by average inventory in dollars. The calculation of average inventory can be complicated and is more a subject for cost accounting.
Inputs to the Manufacturing Planning and Control System

- Product Description: Tells how the product will appear at some stage of production.
- Engineering drawings and specifications.
- Bill of material (describes the components used to make the product, and the subassemblies at various stages of manufacture).

- Product Specification: Describes the steps necessary to make the end product. A step-by-step set of instructions describing how the product is made. Usually recorded on a route sheet or in a routing file. Gives information such as Operations required to make the product; Sequence of operations; Equipment and accessories required; and Standard time to perform each operation (time taken by an average operator working at a normal pace to perform a task).

Physical Supply and Distribution

Includes all the activities involved in the movement of goods from the supplier to the beginning of the production process and from the end of the production process to the consumer.

Activities include:

- Transportation
- Distribution inventory
- Warehousing
- Packaging
- Materials handling
- Order entry

Supply Chain Management Concerns

The overall concern is the balance between priority and capacity.

The marketplace sets demand. Supply Chain Management must plan the firm's priorities (what goods to make and when) to meet that demand.

Capacity is the ability of the system to produce or deliver goods.

Priority and capacity must be planned and controlled so customer demand can be met at minimum cost.

Manufacturing Systems (Three Types)

1. Line flow manufacturing
2. Intermittent (batch) manufacturing
3. Project manufacturing

The system used depends on demand for the item, output rate, range of products, and ease or difficulty of moving material.
All three systems can be used to make discrete items such as automobiles or textbooks or nondiscrete products such as gasoline, paint, or fertilizer.

**Line Flow Manufacturing**

All the work stations required to make a product or family of similar products, are grouped together into one department.

Each work station is located in the sequence needed to make the product.

Examples are assembly lines, cafeterias, oil refineries, and steel-rolling mills. Work flows from one work station to the next at a relatively constant rate and with no delays.

In addition, there will be some mechanical methods of moving goods between work stations.

Line flow systems only produce a limited range of similar products.

An assembly line produces a certain type of car or refrigerator. If designed to make refrigerators, it cannot be used to assemble washing machines. The operations used to make one are different and in a different sequence than those used for the other

Because line flow systems are limited in the variety of products they make, there has to be a large enough demand for the products to economically justify setting up the line.

If sufficient demand exists, line flow systems are extremely efficient for the following reasons:

- They are designed specifically for the tasks required.
- They are usually designed to minimize the labor needed.
- Because work flows from one work station to the next, there is little buildup of inventory between work stations.

Work flows down a line and parts must flow to the work stations on the line at a rate equal to their use.

Where the line makes some variety, such as in the automotive industry, the various parts must flow together so a four-door car in fact gets four doors.

The Flow and the coordination of variety must be planned.

The manufacturing planning and control system is called flow control.

**Intermittent Manufacturing**

Goods are not made continuously as in a line flow system but are made at intervals in lots or batches.

Work stations must be capable of processing many different parts.

It is necessary to use general-purpose work stations and machinery that can perform a variety of tasks.

General-purpose work stations do not produce goods as quickly as special-purpose work stations used in line flow manufacturing.

Usually work stations are organized into departments based on similar types of skills or equipment.
All welding and fabrication operations are located in one department, machine tools in another, and assembly in yet another department.

Work moves only to those work stations needed to make the product and skips the rest.

Intermittent operations are flexible.

Intermittent operations can change from one part or task to another quicker than flow operations. This is because they use general-purpose machinery and highly skilled labor. Skilled labor must be used so they can perform the variety of operations needed.

Control of the flow of work is managed through individual work orders for each lot or batch being made.

Because of this and the jumbled pattern of work flow, manufacturing planning and control problems are severe.

Often there are many work orders in existence, each of which can be processed in different ways.

**Comparison: Intermittent and Line Flow Manufacturing**

Line flow manufacturing is less costly than intermittent manufacturing. Reasons include:

- Set up costs are low. Once the line is established, it will be changed over to run another product very infrequently.
- Since work centers are designed for specific products, run costs will be low.
- Because products move continuously from one work station to the next, work-in-process inventory will be low.
- Costs associated with controlling production are low because work flows through the process in a fixed sequence.

**Project Manufacturing**

Sometimes called Fixed Position Manufacturing.

Usually used for large complex projects such as locomotives, ships, or buildings.

The product may remain in one location for its full assembly period, as with a ship, or it may move from location to location after considerable work and time is spent on it.

Large aircraft are made this way.

Has little advantage except it avoids the very high costs of moving the product from one work station to another.

**Combination of Types**

Manufacturing companies try to find the best combination to make their products.

In any one company it is not unusual to see examples of all three being used.

Each of the manufacturing systems requires planning for the flow of materials so the right material arrives at the right time and in the right quantities.
Techniques for planning and controlling the flow vary somewhat in each. But the basic need is the same.

Summary

Manufacturing creates wealth by adding value to goods.

To improve productivity and wealth, a company must first design efficient and effective systems for manufacturing.

It must then manage these systems to make the best uses of our resources of labor, capital, and material.

One of the most effective ways of doing this is through the planning and control of the flow of materials into, through, and out of manufacturing.

A planning and control system must answer four questions:

1. What are we going to make?
2. What does it take to make it?
3. What do we have?
4. What do we have to get?

Questions of priority and capacity

Priority relates to what products are needed, how many are needed and when are they needed. The marketplace establishes the priorities. It is manufacturing’s responsibility to devise plans to satisfy the market demand if at all possible.

Capacity is the capability of manufacturing to produce goods and services. It depends on the resources of the company (the machinery, labor, and financial resources), and the availability of material from suppliers.

For our purposes capacity is the quantity of work that labor and equipment can perform in a given period of time.

In the long and short run manufacturing must devise plans to balance the demands of the marketplace with its resources and capacity.

For long-range decisions such as the building of new plants or the purchase of new equipment. The plans will have to be made for several years. For planning production over the next few weeks the time span will be days or weeks.

There are five levels in the manufacturing planning and control (MPC) system:

1. Business planning
2. Production planning
3. Master production scheduling
4. Material requirements planning
5. Production activity control

Changes in Levels
In general, as we move from business planning to production activity control, the purpose will change from overall direction to detailed planning; the time span will decrease from years to a day; and the level of detail will increase from general categories to individual components and work stations.

**Levels Differ With Respect To:**

- Purpose of the plan
- Planning horizon
- Level of detail
- Planning cycle

**Three Appropriate Questions at Each Level**

1. What are the priorities (how much of what is to be produced and when)?
2. What is the available capacity?
3. How can differences between priorities and capacity be resolved?

**The Business Plan**

It is a statement of the major goals and objectives the company hopes to achieve over the next 2-5 years or more.

It is also a statement of the broad direction of the firm and shows the kind of business—product lines, markets, and so on the firm wants to do in the future. The business plan gives general direction as to how the company hopes to achieve these objectives.

It is based on long-range forecasts and includes inputs from marketing, finance, and production. In turn, the plan provides direction and coordination between the marketing, production, and financial plans.

**Business Plan Development**

Responsibility of senior management.

Using inputs from marketing, finance, and production, the business plan provides a framework that sets the goals and objectives for further planning by the marketing, finance, and production departments.

Each department produces its own plans to achieve the objectives set by the business plan.

Usually business plans are reviewed every 6 months to a year.

**Production Plan**

The quantities of each product group to produce in each time period.

The desired inventory levels.

The resources of equipment, labor, and material needed in each time period.
The availability of the resources needed.

**The Master Production Schedule**

A plan for the production of individual end items.

It breaks down the production plan to show, for each time period, the quantity of each end item to be made.

Level of detail if higher than for the production plan.

**Material Requirements Plan (MRP)**

A plan for the production and purchase of the components used in making the items in the master production schedule.

It shows the quantities needed and when manufacturing intends to make or use them.

The MRP will be used by purchasing and production activity control to decide the purchase or manufacture of specific items.

The level of detail is high. The MRP establishes when the components and parts are needed to make each end item.

The planning horizon is at least as long as the combined purchase and manufacturing lead times.

As with the master production schedule, it usually extends from 3 to 18 months.

**Purchasing and Production Activity Control**

The implementation and control phase of the production planning and control system.

Purchasing is responsible for establishing and controlling the flow of raw materials into the factory.

Production activity control is responsible for planning and controlling the flow of work through the factory.

The planning horizon is very short, perhaps from a day to a month.

The level of detail is high since it is concerned with individual components, work stations, and orders.

Plans will be reviewed and revised daily.

**Capacity Management**

The basic process is one of determining the capacity needed to manufacture the priority plan and of finding methods for making that capacity available.

A valid, workable production plan cannot be made unless this is done.

If the capacity cannot be made available when it is needed, then the plans will have to be changed. Determining the capacity required, comparing it to available capacity, and making adjustments (or changing plans) must occur at all levels of the manufacturing planning and control system.
Manufacturing Resource Planning (MRP II)

Because of the large amount of data and the number of calculations needed, the system will usually have to be computer-based.

The time and labor required to do calculations manually is extensive and forces a company into compromises.

Instead of scheduling requirements through the planning system, the company may be forced to extend lead times and build inventory in order to compensate for the inability to quickly schedule what is needed and when.

The system is intended to be a fully integrated planning and control system that works from the top down and has feedback from the bottom up.

Business planning integrates the plans and activities of marketing, finance, and production to produce plans that are intended to achieve the overall goals of the company.

In turn, master production scheduling, material requirement planning, production activity control, and purchasing are directed toward achieving the goals.

There must be feedback throughout the system. This is called closed-loop MRP.

The manufacturing planning and control system, as described here, forms a master game plan for all departments in the company. This fully integrated planning and control system is the manufacturing resource planning, or MRP II, system.

MRP II provides coordination between marketing and production.

Marketing, finance, and production agree on an overall workable plan that is expressed in the production plan.

Marketing and production must work together on a weekly and daily basis to make adjustments to the plan as changes occur.

Order sizes may need to be changed, orders canceled, and delivery dates adjusted.

Ordering changes are made through the master production schedule.

Marketing managers and production managers may change master production schedules to meet changes in forecast demand.

Senior management may adjust the production plan to reflect overall changes in demand or resources. But they all work through the MRP II system. It provides the mechanism for coordinating the efforts of marketing, finance, production, and other departments in the company.
Enterprise Resource Planning (ERP)

ERP = Process of planning & managing all resources & their use in the entire enterprise.


Main objective of ERP is to integrate all departments & functions across a company onto a single computer system.

Enterprise resource planning (ERP) further integrates the transaction processing as well as other routine activities in the entire enterprise.

*Integration continues along several paths:

- Functional areas
- Combining transaction processing and decision support
- Business intelligence
- CRM software

ERP or enterprise systems control all major business processes with a single software architecture in real time. It is comprised of a set of applications that automate routine back-end operations such as:

- Financial management
- Inventory management
- Scheduling
- Order fulfillment
- Cost control
- Accounts payable and receivable,
- Front-end operations such as POS, Field Sales, and Service

It also increases efficiency, improves quality, productivity, and profitability.

Making the Production Plan

Based on the market plan and available resources, the production plan sets the limits or levels of manufacturing activity for some time in the future.

The production plan integrates the capabilities and capacity of the factory with the market and financial plans to achieve the overall business goals of the company.

The production plan sets the overall levels of production and inventories over the planning horizon.

Its prime purpose is to establish production rates that will achieve the objectives of the business plan. These include inventory levels, backlogs (unfilled customer orders), market demand, customer service, low-cost plant operation, labor relations, and so on.

The plan must extend out in time far enough to plan for the labor, equipment, facilities, and material needed.

Typically, this is a period of 6-18 months.

The plan is done in weekly or monthly time periods.
Establishing Product Groups

Firms who make a single product or products that are similar can measure their output directly by the number of units they produce.

Many companies, however, make several products that are quite different, and a common denominator for measuring total output may be difficult, or impossible, to find.

These firms need to establish product groups based on the similarity of manufacturing processes.

Manufacturing must provide the capacity to produce the goods needed.

It is therefore not so much concerned with the demand for product as the demand for the specific kinds of capacity needed to make the products.

Importance of Capacity

Capacity is the ability to produce goods and services.

It can be expressed as the time available or, sometimes, as the number of units that can be produced in a given period.

The demand for goods must be translated into the demand for capacity.

At the production planning level, where little detail is needed, this requires identifying product groups, or families, of individual products based on the similarity of manufacturing process.

Over the time span of the production plan, large changes in capacity are usually not possible.

Additions or subtractions in plant and equipment are impossible or very difficult to accomplish in this time period.

Variations Possible

Some things can be altered, and manufacturing management must identify and assess them. People can be hired and laid off, overtime and short time can be worked, and shifts can be put on and removed; inventory can be built up in slack periods and sold or used in periods of high demand; and work can be subcontracted or extra equipment leased.

Manufacturing management must find the least cost alternative consistent with the goals and objectives of the business.

Production Planning Characteristics

A time horizon of 12 months with periodic updating perhaps every month or quarter.

Production demand consists of one or a small number of product families or common units.

Demand is fluctuating or seasonal.

Plant and equipment are fixed within the time horizon.
A variety of management objectives such as low inventories, efficient plant operation, good customer service, good labor relations, and so on.

**Production Planning Strategies**

- Demand matching
- Production leveling
- Subcontracting

**Demand Matching**

Demand matching is producing the amounts demanded at any given time.

The firm manufactures just enough at any one time to meet demand, no more no less. Examples are farmers, the post office, and restaurants.

These industries cannot stockpile or inventory their product or service and must be capable of meeting user demand as it occurs.

The company must have enough capacity to be able to meet the peak demand.

The advantage to demand matching is that inventories can be kept to a minimum.

Goods will be made when demand occurs and not stockpiled.

The costs associated with carrying inventories are avoided.

**Production Leveling**

Producing continually an amount equal to the average demand.

Companies determine their total demand over the time span of the plan and, on the average, produce enough to meet it.

Sometimes demand is less than the amount produced and an inventory builds up.

At other times demand is greater and inventory is used up.

The advantage of a production leveling strategy is that it results in a smooth level of operation that avoids the costs of changing production levels.

Firms do not need to have excess capacity to meet peak demand.

They do not need to hire and train workers and lay them off in slack periods. They can build a stable work force.

The disadvantage is that inventory will build up in low demand periods. This inventory will cost money to carry.
Subcontracting

Means always producing at the level of minimum demand and meeting any additional demand through subcontracting.

The major advantage is cost--costs associated with excess capacity are avoided, and because production is leveled, there are no costs associated with changing production levels.

The main disadvantage is that the cost of purchasing (item cost, purchasing, transportation, and inspection costs) may be greater than if the item were made in the plant.

Few companies make everything or buy everything they need.

In addition to cost are a number of other needs which may operate in a given decision:

- To keep confidential processes within the company.
- To maintain quality levels and maintain a work force.
- To buy from a supplier who has special expertise in design and manufacture of a component.
- To allow the firm to concentrate in its own area of expertise.
- To provide known and competitive prices.

Hybrid Strategy

The three strategies discussed so far are pure strategies--each has its own set of costs: equipment hiring/layoff; overtime; inventory; and subcontracting.

In reality there are an infinite number of possible hybrid or combined strategies--each will have its own set of cost characteristics.

It is production management's job to find the combination of strategies that minimizes the sum of all costs involved, provides the level of service required, and meets the objectives of the financial and marketing plans.

Developing a Make-to-Stock Production Plan

In a make-to-stock environment products are made and put into inventory before an order is received from a customer.

Sale and delivery of the goods are made from inventory.

Off-the-rack clothing, frozen foods, and bicycles are examples of this kind of manufacturing.
Situations Favoring Make-to-Stock.

- When demand is fairly constant and predictable.
- When there are few product options.
- When delivery times demanded by the marketplace are much shorter than the time needed to make the product.
- When product has a long shelf life.

Information needed to make a production plan

- Forecast by time period for the planning horizon
- Opening inventory
- Desired ending inventory
- Any past due customer orders--orders that are late for delivery and are sometimes called back orders

Production Plan Objectives

Minimize the costs of carrying inventory; changing production levels; and stocking out.

Level Production Plan Steps

1. Total Forecast demand for plan horizon.
2. Determine opening inventory and desired ending inventory.
3. Calculate total production required as follows: Total Production = total forecast + back orders + ending inventory - opening inventory.
4. Calculate production required each period by dividing total production by number of periods.
5. Calculate ending inventory for each period.
Developing a Make-to-Order Production Plan

In a make-to-order environment, manufacturers wait until an order is received from a customer before starting to make the goods.

Firms generally make to order when:

- Goods are produced to customer specification.
- Customer is willing to wait while the order is being made.
- Product is expensive to make and store.
- Several product options are offered.

Assemble to Order

Where several product options exist, such as in automobiles; and where the customer is not willing to wait until the product is made, manufacturers produce and stock standard component parts.

When manufacturers receive an order from a customer, they assemble the component parts from inventory according to the order.

Since the components are stocked, the firm only needs time to assemble before delivering to the customer.

Examples of assemble-to-order products include automobiles, computers, and appliances.

Assemble to order is a subset of make to order.

A production plan for assemble-to-order needs the following information:

- Forecast by time period for the planning horizon
- Opening backlog of customer orders
- Desired ending backlog

A firm does not build an inventory of finished goods.

Instead it has a backlog of unfilled customer orders.

This backlog normally will be for delivery in the future and does not represent orders that are late or past due.

Level Production Plan Development

1. Total Forecast Demand.
2. Determine Opening backlog and desired ending backlog.
3. Calculate total production:  Total production = total forecast + opening backlog – ending backlog.
4. Calculate production required/period by dividing total production by number of periods.
5. Spread the existing backlog over the planning horizon according to due date per time period.
Resource Requirements Planning

Once the preliminary production plan is established it must be compared to the existing resources of the company.

This step is called resource requirements planning.

There are two questions that have to be answered:

1. Are the resources available to meet the production plan?
2. If not, how will the difference be reconciled?

If enough capacity to meet the production plan cannot be made available then the plan must be changed.

A tool often used is the resource bill. This shows the quantity of critical resources (material; labor and bottleneck operations) needed to make one average unit of the product group.

Summary

Production planning is the first step in a manufacturing planning and control system.

The planning horizon usually extends out for a year.

The minimum horizon depends on the lead times to purchase materials and make the product.

The level of detail is not high.

Usually the plan is made for families of products that are based on the similarity of manufacturing process or on some common unit.

There are three basic strategies that can be used to develop a production plan: demand matching; leveling production; and subcontracting.

Each strategy has its operational and cost advantages and disadvantages.

It is the responsibility of manufacturing management to select the best combination of these basic plans so total costs are minimized and customer service levels are maintained.

A make-to-stock production plan determines how much to produce in each period so as to meet the following objectives:

To achieve the forecast
To maintain the required inventory levels

While demand must be satisfied, the plan must balance the costs of maintaining inventory with the cost of changing production levels.
Master Production Scheduling

After production planning, the next step in the manufacturing planning and control process is to prepare a master production schedule (MPS).

The MPS is an extremely important planning tool and forms the basis for communication between sales and manufacturing.

Importance of MPS

The MPS forms the link between production planning and what manufacturing will actually build.

It forms the basis for determining capacity and the resources that will be needed and the basis for material requirements planning.

The MPS and bills of material determine what components will be needed from manufacturing and purchasing. The MPS drives the material requirements plan.

MPS keeps priorities valid. The MPS is a priority plan for manufacturing.

MPS Characteristics

While the production plan deals in families of products, the MPS works with end items.

It breaks down the production plan into the requirements for individual end items in each of the families by date and quantity.

The production plan limits the MPS.

The total of the items in the MPS should not be different from the total shown on the production plan.

Within this limit, its objective is to balance the demand (priorities) set by the marketplace with the availability of materials, labor, and equipment (capacity) of manufacturing.

The end items made by the company are assembled from component and subcomponent parts. These must be available in the right quantities at the right time to support the master production schedule.

The material requirements planning system plans the schedule for these components based on the needs of the MPS. The MPS thus drives the material requirements plan.

The MPS reflects the needs of the marketplace and the capacity of manufacturing, and forms a priority plan for manufacturing to follow.

The MPS forms a vital link between sales and production as follows:

It makes possible valid order promises
It plans what is to be produced and when. As such, it tells sales and manufacturing when goods will be available for delivery.
It is a contract between marketing and manufacturing

The MPS forms a basis for sales and production to determine what is to be manufactured.

It is not meant to be rigid.
It is a device for communication and a basis to make changes that is consistent with the demands of the marketplace and the capacity of manufacturing.

Information needed to develop an MPS

- The production plan
- Forecasts for individual end items
- Actual orders received from customers and for stock replenishment
- Inventory levels for individual end items
- Capacity restraints

Objectives in developing an MPS

1. To maintain the desired level of customer service.
2. To make the best use of material, labor, and equipment.
3. To maintain inventory investment at the required levels.
4. (To achieve these objectives, the plan must satisfy customer demand, be within the capacity of manufacturing, and be within the guidelines of the production plan.)

Three steps in preparing an MPS

1. Develop a preliminary MPS.
2. Check the preliminary MPS against available capacity.
3. Resolve differences between the preliminary MPS and capacity availability.

Preliminary Master Production Schedule

The process of building an MPS occurs for each item in the family.

If the total planned production of all the items in the family and the total ending inventory does not agree with the production plan, then some adjustment to the individual plans must be made so the total production is the same.

Once the preliminary MPS are made, they must be checked against the available capacity--This process is called rough-cut capacity planning.
Rough-Cut Capacity Planning

Checks whether critical resources are available to support the various preliminary MPS.

Critical resources include "bottleneck" operations, labor, and critical materials (perhaps material that is in short supply or has a long lead time).

The process is similar to resource requirements planning used in the production planning process.

The difference is that now we are working with a product and not a family of products.

Resolution of Differences

The next step is to compare the total time required to the available capacity of the work center.

If available capacity is greater than the required capacity, then the MPS is workable.

If not, then ways of increasing capacity have to be investigated.

Is it possible to adjust the available capacity with overtime, extra workers, routing through other work centers, or subcontracting? If not, then it will be necessary to revise the master production schedule.

Three Criteria for Judging the MPS

1. Resource Use--Is the MPS within capacity restraints in each of the time periods of the plan? Does it make the best use of resources?

2. Customer service--Will due dates be met and will delivery performance be acceptable?

3. Cost--Is the plan economic or will excess costs be incurred for overtime, subcontracting, expediting, or transportation?

Which Items to Master Schedule?

The MPS should represent what manufacturing will make.

It should do so as efficiently as possible.

If too many items are included, it will lead to difficulties in forecasting and managing the MPS.

In each of the manufacturing environments, make to stock, make to order, and assemble to order, master scheduling should take place where the smallest number of product options exists.

Make to Stock

A limited number of standard items are assembled from many components.

Television is an example.

The MPS is usually a schedule of finished-goods items.
Make to Order

Many different end items are made from a relatively small number of components.

Custom-tailored clothes is an example.

The MPS is usually a schedule of the actual customer orders.

Assemble to Order

Many end items can be made from combinations of basic components and subassemblies.

This last step, assembly to customer order, is usually planned using a final assembly schedule (FAS).

The FAS is a schedule of what will actually be assembled. It is used when there are many options and it is difficult to forecast the combination customers will want.

Master production scheduling is done at the component level.

The FAS schedules customer orders as they are received and is based on the components planned in the MPS.

It is responsible for scheduling from the MPS through final assembly and until shipment to the customer.

Planning Horizon

The planning horizon is the time span for which plans are made.

It must cover a period at least equal to the time required to accomplish the plan.

For master production scheduling the minimum planning horizon is the longest cumulative or end-to-end lead time (LT).

The planning horizon is usually longer for a number of reasons.

The longer the horizon, the greater the "visibility" and the better management's ability to act to avoid future problems or to take advantage of special circumstances.

Firms might be able to take advantage of economical purchase plans, to avoid future capacity problems, or manufacture in more economical lot sizes.

As a minimum, the planning horizon for a FAS must include time to assemble a customer's order. It does not need to include the time necessary to manufacture the components. That time will be included in the planning horizon of the MPS.
Production Planning, Master Production Scheduling, and Sales

The production plan reconciles total forecast demand with available resources.

It takes information from the business plan and market forecasts to produce an overall plan of what production intends to make to meet forecast.

It is dependent on the forecast and, within capacity limits, must plan to satisfy the forecast demand.

It is not concerned with the detail of what will actually be made.

It is intended to provide an overall plan, or framework, in which detailed plans can be made in the MPS.

The MPS is built from forecasts and actual demands for individual end items.

It reconciles these demands with the production plan and with available resources to produce a plan that manufacturing can fulfill.

It is concerned with what items will actually be built, in what quantities, and when, in order to meet expected demand.

The production plan and the MPS uncouple the sales forecast from manufacturing by establishing a manufacturing plan.

They attempt to balance available resources of plant, equipment, labor, and material with forecast demand.

The MPS is a plan for what production can and will do.

The MPS must be realistic in terms of what manufacturing can and will do.

If it is not, it will result in overloaded capacity plans, past due schedules, unreliable delivery promises, surges in shipments, and lack of accountability.

The MPS is a plan for specific end items or "buildable" components that manufacturing expects to make over some time in the future.

THE MPS is where manufacturing and marketing agree on end items to be produced.

Manufacturing is committed to make the goods and marketing to their sale.

The MPS is not meant to be rigid--Demand changes, problems in production, and sometimes components in short supply may make it necessary to alter the MPS.

Changes must be made with agreement of sales and production. The MPS provides the basis for making changes and a plan on which all can agree.

The MPS and Delivery Promises

The MPS provides a plan by which delivery promises can be made to customers.

As orders are received, they "consume" the available MPS.

Any part of the plan that is not consumed by actual customer orders is available to promise to customers.
In this way the MPS provides a realistic basis for making delivery promises.

Using the MPS, sales and distribution can determine the available to promise (ATP).

Available to promise is that portion of a firm’s inventory or production that is not already committed and is available to the customer. This allows delivery promises to be made and customer orders and deliveries to be scheduled accurately.

The ATP is calculated by adding scheduled receipts to the beginning inventory and then subtracting actual orders that are scheduled before the next scheduled receipt. A scheduled receipt is an order that has been issued either to manufacturing or to a vendor.

**Time Fences**

Changes to the master production schedule will occur. For example:

- Customers cancel or change orders.
- Machines break down or new machines are added, changing capacity.
- Vendors have problems and miss delivery dates.
- Processes create more scrap than expected.

A company wants to minimize the cost of manufacture and at the same time be flexible enough to adapt to changing needs.

Changes to production schedules can result in the following:

- Cost increases due to rerouting, rescheduling, extra setups, expediting, and buildup of work-in-progress inventory.
- Decreased customer service. A change in quantity of delivery can disrupt the schedule of other orders.
- Loss of credibility for the MPS and the planning process.

Changes far out in the planning horizon can be made with little or no cost or disruption to manufacturing, but the nearer to delivery, the more disruptive and costly changes will be.

To help in the decision-making process, companies establish zones divided by time fences.
Time Fence Zones

Frozen zone. Capacity and materials are committed to specific orders. Since changes would result in excessive costs, reduced manufacturing efficiency, and poor overall customer service, senior management approval is usually required to make a change.

Slushy zone. Capacity and material are committed to a reduced extent. This is an area for trade-offs that must be negotiated between marketing and manufacturing. If material and capacity are available, then changes can be made. If not, then perhaps other orders can be shifted.

Liquid zone. Any change can be made to the MPS as long as it is within the limits set by the production plan. Changes are routine and often are made by the computer program.

Summary

The master production schedule (MPS) is a plan for the production of individual end items.

The MPS must match demand for the product in total, but it is not a forecast of demand.

The MPS must be realistic. It must be able to be achieved and must reflect a balance between required and available capacity.

The MPS is the meeting ground for sales and production.

The MPS provides a plan from which delivery promises can be made to customers.

If adjustments have to be made in deliveries or the booking of orders, they are done through the MPS.

Major MPS functions include:

To form the link between production planning and what manufacturing builds.
To plan capacity requirements. The master production schedule determines the capacity that is required.
To plan material requirements. The MPS drives the material requirements plan.
To keep priorities valid. The MPS is a priority plan for manufacturing.
To aid in making order promises. The MPS is a plan for what is to be produced and when.
To be a contract between marketing and manufacturing. It is an agreed-upon plan.

The MPS must be realistic and based on what production can and will do. If it is not, the results will be as follows:

Overload or underload of plant resources
Unreliable schedules resulting in poor delivery performance
High levels of work-in-process (WIP) inventory
Poor Customer Service
Loss of credibility of the planning system
Material Requirements Planning

Manufactured end items are fabricated or assembled from components that must be available in the right quantities and at the right time to meet the requirements of the MPS.

If any component is missing, the product cannot be built and shipped on time.

A system is needed to plan the requirements for these components.

Material Requirements Planning (MRP) does this.

MRP establishes a schedule (priority plan) showing the components required at each level of the assembly and, on the basis of lead times, calculates the time when these components will be needed.

We will discuss bills of material (the major building block of MRP), the MRP process, and how the material requirements plan is used

Nature of Demand

There are two types of demand, independent and dependent.

Independent demand is not related to the demand for any other product. For example if a company makes wooden tables the demand for the tables is independent. Master production schedule items are independent demand items.

The demand for the sides, ends, legs, and top depends on the demand for the tables, and these are dependent demand items.

Since independent demand is not related to the demand for any other assemblies or products, it must be forecasted.

Items shown on an MPS are independent demand.

Since dependent demand is derived or directly related to the demand for higher level assemblies or products, it can be calculated.

Material requirements planning is designed to do this calculation.

An item can have both a dependent and an independent demand.

A service or replacement part has both.

The manufacturer of vacuum cleaners uses flexible hose in the assembly of the units. In the assembly of the vacuums the hose is a dependent demand item. However, the hose has a nasty habit of breaking and the manufacturer must have replacement hoses available. Demand for replacement hoses is independent since demand for them does not depend directly upon the number of vacuums manufactured.
Objectives of MRP

Determine requirements

The main objective of any manufacturing planning and control system is to have the right materials in the right quantities available at the right time to meet the demand for the firm's products.

The MRP's objective is to determine what components are needed in order to meet the master production schedule and, on the basis of lead time, to calculate the time periods when the components must be available. It must then determine What to order, How much to order, When to order, and When to schedule delivery.

It is a constant chore to keep priorities current

- The demand for and supply of components change daily.
- Customers enter or change orders.
- Components get used up.
- Vendors are late with delivery.
- Scrap occurs.
- Orders are completed.
- Machines break down.

In this everchanging world, an MRP must be able to reorganize priorities to keep plans current.

AN MRP must be able to add and delete, expedite, delay, and change orders.

Linkages to Other MPC Functions

The MRP is driven by the MPS.

The MRP is a priority plan for the components needed to make the products in the MPS.

The MRP will be a valid plan if the capacity is available when needed to make the components.

The MRP must be checked against capacity. The process of doing so is called capacity requirements planning (discussed later).

MRP in turn drives, or is input to, production activity control (PAC) and purchasing.

MRP plans the release and receipt dates for orders.

It is the job of PAC and purchasing to plan and control the performance of the orders to meet the job dates.
The Computer

If a company makes a small number of simple products, it might be possible to perform material requirements planning manually.

However, most companies need to keep track of thousands of components in a world of changing demand, supply, and capacity.

In the days before computers it was necessary to maintain extensive manual systems and to have large inventories and long lead times.

These were needed as a cushion due to the lack of accurate and up-to-date information and the inability to perform the necessary calculations quickly.

Somehow, someone in the organization figured out what was required sooner, or very often later, than needed.

"Get it early and get lots of it!!" was a good rule then

Computers are incredibly fast and accurate and ideally suited for the job at hand.

With their ability to store and manipulate data and produce information rapidly, manufacturing now has a tool to use modern manufacturing planning and control systems properly.

There are many application programs available that will perform the calculations needed in MRP systems.

**Inputs to the MRP System**

1. Master Production Schedule
2. Inventory Records
3. Bills of Material

**Master Production Schedule**

A statement of which end items are to be produced, the quantity of each, and the dates they are to be completed.

Drives the MRP system by providing the initial input as to what components are required to the MRP system can produce orders for manufactured and purchased parts and raw materials.
**Inventory Records**

A major input to the MRP system is inventory.

When a calculation is made to find out how many are needed, the quantities on hand must be taken into account.

There are two kinds of information needed.

1. Planning Factors—order quantities, lead times, safety stock, and scrap.
2. Status of Each Item---MRP needs to know how much is on hand, how much is allocated, and how much is available for future demand.

These data are maintained in an inventory record file (also called a part master file or item master file).

Each item has a record and all the records together form the file.

**Bills of Material**

If we want to make something, the first question to ask is "What is it Made of?"

Recipes, formulas, and parts lists tell us what is needed to make the end product—all are bills of material.

A bill of materials is a listing of all the components and parts required to make one of an assembly.

**Bills of Materials—Important Points**

The Bill of Material shows all the parts required to make one of the items.

Each part of items has only one part number. A particular number is unique to one part and is not assigned to any other part. Thus, if a particular number appears on two different bills of material, then the part so identified is the same.

**Product Tree**

The bill of material can more conveniently be shown as a product tree (sometimes called a family tree)

A bill of material is one of the most widely used documents in a manufacturing (or construction) company.

**Bills of Material—Uses**

*Product Definition.* The bill specifies the components needed to make the product.

*Engineering Change Control.* Product design engineers sometimes change the design of a product and the components that are used. These changes must be recorded and controlled. The bill provides the method for doing so.

*Service Parts.* Replacement parts needed to repair a broken component are determined from the bill of material.
Planning. Bills of material define what materials have to be scheduled to make the end product. They define what components have to be purchased and made to satisfy the master production schedule.

Order Entry. Where a product has a very large number of options (e.g., cars), the order entry system very often configures the end product bill of materials. The bill can also be used to price the product.

Manufacturing. The bill provides a list of the parts needed to make or assemble a product.

Costing. Product cost is usually broken down into direct material, direct labor, and overhead. The bill provides not only a method of determining direct material but also a structure for recording direct labor and distributing overhead.

Bills of Material—Importance

There is hardly a department of the company that will not make some use of the bill at some time. Maintaining bills of material and their accuracy is extremely important.

The computer is an excellent tool for centrally maintaining bills and for updating them.

Types of Bills of Material

Parts list. It lists all the parts that are needed to make one of the assembly. The parts list is produced by the product design engineer and does not necessarily reflect the way the parts go together or any subassemblies that might be made.

Multilevel BOM. This BOM reflects the way in which the product will be manufactured. It shows the grouping of parts into subassemblies and components. It is the responsibility of manufacturing engineering to decide how the product is to be made, the operations to be performed, their sequence, and their grouping. The subassemblies that have been created are the result of this.

Indented bill of material. A multilevel bill of material can also be shown as an indented bill of material. This bill uses indentations as a way of differentiating parents from components.

The components of the parent are listed in the first column, the components of those components are listed in the second column, etc.

Components are linked to their parents by indenting the columns and by listing them immediately below the parent.

Single-level BOM. A single-level bill of material contains only the parent and its immediate components, which is why it is called a single-level bill.

The computer stores information describing the product structure as a single-level bill.

A series of single-level bills is needed to completely define a product.
"Where-Used" and "Pegging" Reports

"Where-used" report. A component may be used in making several parents. Wheels on an automobile, for example, might be used on several models or cars. A listing of all the parents in which a component is used is called a "where-used" report. This has several uses, such as in implementing an engineering change, or when materials are scarce, or in costing a product.

"Pegging" report. A "pegging" report is similar to a "where-used" report. However, while the where-used report shows all parents for a component, the "pegging" report shows only those parents for which there is an existing requirement.

"Pegging" Reports-Contents

1. The parents creating the demand for the components.
2. The quantities needed.
3. When items are needed.

MRP Process

Each component shown on the bill of material is planned for by the material requirements planning system. For convenience it is assumed that each component will go into inventory and be accounted for.

Whether the components actually go into a physical inventory or not is not important. However, it is important to realize that planning and control take place for each component as they appear on the bill.

Raw material may go through several operations before it is processed and ready for assembly, or there may be several assembly operations between components and parent.

These operations are planned for, and controlled, by production activity control and not material requirements planning.

The purpose of MRP is to determine the components needed, their quantities, and when they will be needed so items in the master production schedule are made in time.

Exploding and Offsetting

The process of multiplying the requirements by the usage quantity and recording the appropriate requirements throughout the product tree is known as exploding the requirements, or simply exploding.

The process of placing exploded requirements in their proper time periods on the basis of lead times is known as offsetting. (Lead time is the time from when an order is placed until the part is available for use. It includes all times for ordering, processing the part, queueing, moving, and expected delays).

Planned orders

Planned order receipt is the date when components must be received.

Planned order release is the date when the order for the components must be issued.
Gross and Net Requirements

If inventory is available, it must be taken into account.

Gross requirements minus inventory equal net requirements.

The planned order release of the parent becomes the gross requirement of the component.

Released Orders

So far we have looked at the process of planning when orders should be released so work is done in time to meet requirements.

Requirements change, and in many cases on a daily basis.

A computer-based material requirements planning system automatically recalculates the requirements for subassemblies and components and recreates planned order releases to meet the shifts in demand.

Planned order releases have not been released. They must be released by a material planner.

Since the objective of the MRP id to have material available when it is needed and not before, orders for material should not be released until the planned order release date arrives.

This means that an order is not normally released until the planned order is in the current week.

Before a manufacturing order is released, component availability must be checked.

The computer program checks the component inventory records to be sure that enough material is available and, if it is, allocates the necessary quantity to that work order.

When the authorization to purchase or manufacture is released, the planned order receipt is canceled and a Scheduled receipt is created in its place.

Scheduled receipts

Scheduled receipts are orders placed on manufacturing or on a vendor and represent a commitment.

For an order in a factory necessary materials are committed and capacity at work centers allocated to that order.

For purchased parts similar commitments are made to the vendor.

The scheduled receipts row shows the quantities that have been ordered and when they are expected to be completed and available.
Open orders

Scheduled receipts on the MRP record are open orders on the factory or a vendor.

They are the responsibility of purchasing and of production activity control.

When the goods are received into inventory and available for use, the order is closed out and the scheduled receipt disappears to become part of the on-hand inventory.

Net requirements

The calculation for net requirements can now be modified to include scheduled receipts: Net requirements = gross requirements - scheduled receipts - available inventory

Basic MRP Record Components

The current time is the beginning of the first period.

Time periods are called time buckets. They are often a week but can be any length of time convenient to the company. Some companies are moving to daily time buckets.

The number of periods in the record is called the planning horizon which shows the number of future periods for which plans are being made. It should be at least as long as the cumulative product lead time; otherwise the MRP system is not able to release planned orders of items at the lower level at the correct time.

An item is considered to be available at the beginning of the time bucket in which it is required.

The quantity shown in a projected on-hand row is the projected on-hand balance at the end of the period.

The immediate or most current period is called the action bucket. A quantity in the action bucket means that some action is needed now to avoid a future problem.

Capacity Requirements Planning

As occurred in the previous planning levels, the MRP priority plan must be checked against available capacity.

At the MRP planning level the process is called capacity requirements planning (CRP).

If the capacity is available, then the plan can proceed. If not, then either capacity has to be made available or the priority plans have to be changed.
Low-Level Coding and Netting

A component may reside on more than one level in a bill of material.

If this is the case, it is necessary to make sure that all gross requirements for that component have been recorded before netting takes place.

The process of collecting the gross requirements and netting can be simplified by using low-level codes. The low-level code is the lowest level on which an item resides in all bills of material. Every item has only one low-level code.

Low-level codes can be determined by starting at the lowest level of a bill of material and, working up, recording the level against the item.

If an item occurs on a higher level, its existence on the lower level has already been recorded.

Once the low-level codes are obtained, the net requirements for each item can be calculated using the following procedure.

Netting Procedure

STEP 1: Starting at level 0 of the tree, determine if any of the items on that level have a low-level code of 0. If so, those items occur at no lower level and all the gross requirements have been recorded. These items can therefore be netted and exploded down to the next level, that is, into their components. If the low-level code is greater than zero, then there are more gross requirements and the item is not netted.

STEP 2: Move down to level 1 on the product tree and repeat the routine followed in step 1.

STEP 3: Move down to level 2 on the product tree and repeat the routine in steps 1 and 2.

Multiple Bills of Material

Most companies make more than one product and often use the same components in a number of their products.

The material requirements planning system will gather the planned order releases from all the parents and will create a schedule of gross requirements for the components.

The same procedure used for a single bill of material can be used where there are multiple products being manufactured.

All bills must be netted and exploded level by level as was done for a single bill.

Using the Material Requirements Plan (MRP)

The MRP software will perform all the calculations we have done so far.

- It will net, offset, and explode requirements and create planned order releases.
- It will keep priorities current for all planned orders according to changes in gross requirements for the part.
- It will not issue a purchase or manufacturing order or reschedule open orders.
- It will print action or exception messages suggesting that the planner should act and what kind of action might be appropriate.
It is the planner's responsibility to issue orders and to reschedule existing orders as required.

Planners are also responsible for working with other planners, master production schedulers, production activity control, and purchasing to solve problems as they arise.

**Types of Orders**

*Planned Orders*

Automatically scheduled and controlled by the computer.

As gross requirements, projected available inventory, and scheduled receipts change, the computer will recalculate the timing and quantities of planned order releases.

The MRP program will recommend to the planner the release of an order when the order enters the action bucket but will not of itself release the order.

*Released orders*

Releasing a planned order is the responsibility of the planner.

When that is done the order becomes an open order to the factory or to purchasing and appears on the MRP and appears on the MRP record as a scheduled receipt.

It is under control of the planner who may expedite, delay or even cancel the order.

*Firm Planned Orders*

The computer-based MRP system automatically recalculates planned orders as the gross requirements change.

At times the planner may wish to hold a planned order firm against changes in quantity and time despite what the computer may calculate.

This might be necessary because of future availability of material or capacity or to handle special demands on the system.

The planner can tell the computer that the order is not to be changed unless the planner advises the computer to do so.

The order is "firmed" against the logic of the computer.

Material Requirements Planners must manage the parts for which they are responsible—this means not only releasing orders to purchasing and the factory, rescheduling due dates of open orders, and reconciling differences and inconsistencies but also finding ways to improve the system and removing the causes of potential errors.
Capacity Management

So far we have been concerned with planning priority, that is, determining what is to be produced and when

The system is hierarchical, moving from relatively long planning horizons and little detail (production plan) through medium time spans (master production schedule) to a high level of detail and relatively short time spans (material requirements plan).

At each of the levels manufacturing has developed priority plans to satisfy demand, and it has had to balance priority and capacity to get a workable plan.

Capacity management is responsible for determining the capacity needed to achieve the priority plans and with providing, monitoring, and controlling that capacity so the priority plan can be met

**Capacity Management consists of two phases:**

1. Capacity planning
2. Capacity control

**Capacity Planning**

The process of determining the resources required to meet the priority plan and with methods of making that capacity available.

Takes place at each level of the priority planning process.

Production planning, master production scheduling, and material requirements planning determine priorities: what is wanted and when

Capacity planning links the various production priority schedules to manufacturing resources.

Concerned with determining the capacity needed to achieve the priority plan and with the ways of making that capacity available.

If the capacity cannot be made available, then the priority plans have to be changed.

Priority plans are usually stated in units of product or some standard unit of output.

Capacity can sometimes be stated in the same units, for example, tons of steel or yards of cloth.

At other times there is no common unit, and capacity has to be stated as the hours available.

In these cases the priority plan must be translated into hours of work required and then compared to the hours available.
For these cases, the process of capacity planning is as follows:

- Determine the capacity available at each work center.
- Translate the priority plan into the hours of work required at each work center in each time period.
- Sum up the capacities required for each item on each work center to determine the load on each work center in each time period.
- Adjust available capacity, if possible, to match the load. Otherwise change the priority plans to match the available capacity Planning Levels.

**Capacity Control**

The process of monitoring production output, comparing it with the capacity plans, and taking corrective action as needed.

Discussed under the subject of production activity control.

**Planning Levels**

**Resource Planning**

Concerned with long-range capacity resource requirements and is directly linked to production planning.

Typically it involves translating monthly, quarterly, or annual product priorities from the production plan into some total measure of capacity such as gross labor hours.

It involves changes in manpower, capital equipment, product design, or other facilities that take a long time to acquire and dispose of.

If a resource plan cannot be devised to meet the production plan, then the production plan has to be changed.

The two plans set the limits and levels for production, and if they are realistic, then it should be possible to carry out the master production schedule.

**Rough Cut Capacity Planning**

Takes capacity planning to the next level of detail.

The master production schedule is the primary information source.

The purpose of rough-cut capacity planning is to check the feasibility of the MPS, provide warning of any bottlenecks, ensure utilization of work centers, and advise vendors of capacity requirements.

**Capacity Requirements Planning**

Directly linked to the material requirements plan.

Since it is concerned with component parts, it is in greater detail than rough-cut capacity planning.

It is concerned with individual orders at individual work centers and calculates work center loads and labor requirements for each time period at each work center.
Available Capacity

Capacity is the ability to produce work.

The American Production and Inventory Control Society (APICS Dictionary, 6th ed.) defines capacity as "the highest reasonable output rate which can be achieved with current product specifications, product mix, work effort, plant and equipment."

This definition can be applied to an individual work center, a department, or a plant--emphasis is on the number of units of product that can be produced in a given time.

Factors Affecting Available Capacity

- Product specification--If the product specifications change, the work content (work required to make the product) will change, thus affecting the number of units that can be produced.
- Product mix--Each product has its own work content measured in the time it takes to make the product. If the mix of products being produced changes, then the total work content (time) for the mix will change.
- Work effort—this relates to the speed or pace at which the work is done. If the work force changes pace, for example, produces more in a given time, then the capacity will be altered.
- Plant and equipment--This relates to the methods used to make the product. If the method is changed, for example, a faster machine is used, then the output will change. Similarly, if more machines are added to the work center, the capacity will change.

Unit of Measurement

Where the variety of products produced at a work center or in a plant are not large, it is often possible to use a unit common to all products.

Paper mills speak of capacity in tons of paper, breweries in barrels of beer, and automobile manufacturers in numbers of cars.

However, where a variety of products is made, it may be that a good common unit does not exist. In this case the unit common to all products is time.

The work content of a product is expressed as the time required to make the product using a given method of manufacture.

Using time study techniques, the standard time for a job can be determined. This is the time we would expect a qualified operator working at a normal pace to take to do the job. It provides a yardstick for measuring work content and a unit for stating capacity. It is also used in talking about loading and scheduling.

Levels of Capacity

1. Machine or individual worker
2. Work center--A work center is composed of a number of machines or workers capable of doing the same work
3. Plant--A plant can be considered as a group of different work centers.
Determining Available Time

The available time of a work center is dependent on the number of machines, the number of workers, and the hours of operation.

If a work center has three machines and is operated for 8 hours a day 5 days a week, then available time = $3 \times 8 \times 5 = 120$ hours per week

**Utilization**

Available time is the maximum actual hours we could expect from the work center.

However, it is unlikely this will be achieved all the time.

Downtime can occur due to machine breakdown, absenteeism, lack of material, and so on, all those things that cause unavoidable delays.

The percentage of time that the work center is active compared to the available time is called work center utilization:

$$\text{Utilization} = \frac{\text{hours actually worked}}{\text{available hours}} \times 100\%$$

For example, suppose that a work center has available time of 120 hours but actually produced goods for 100 hours:

$$\text{Utilization} = \frac{100}{120} = 83.3\%$$

Utilization can be determined from historical records or by a work sampling study.

**Efficiency**

It is possible for a work center to utilize 100 hours a week but not produce 100 standard hours of work.

Workers might be working at a faster or slower pace than the standard working pace, causing the efficiency of the work center to be more or less than 100%:

$$\text{Efficiency} = \frac{\text{std hours of work produced}}{\text{hours actually worked}} \times 100\%$$
Rated Capacity

Rated capacity is calculated by taking into account work center utilization and efficiency.

Rated capacity = available time x utilization x efficiency

For example, suppose a work center consists of four machines and is operated 8 hours per day for 5 days a week. Historically the utilization has been 85% and the efficiency 110%. What is the rated capacity?

Available time = 4 x 8 x 5 = 160 hours per week
Rated capacity = 160 x 0.85 x 1.10 = 149.6 standard hours

Demonstrated Capacity

Capacity can also be measured.

Measured, or demonstrated, capacity is determined from historical data.

For example, suppose that over a 4-week period a particular work center produced 220 standard hours of work. The demonstrated capacity is 220/4 = 55 standard hours of work per week.

Required Capacity

Capacity requirements are generated by the priority planning system and involve a translation of the priorities, given in units of product or some common unit, into the hours of work required at each work center in each time period.

This translation must take place at each of the priority planning levels from production planning to master production scheduling to material requirements planning.

There is thus a direct link between the various levels of priority planning and capacity planning.

Capacity Requirements Planning

The Capacity Requirements Plan (CRP) occurs at the level of the MRP.

It takes planned orders from the MRP and open-shop orders (scheduled receipts) and converts these into demand for time in each work center in each time period.

It takes into consideration lead times for operations and offsets the operations at work centers accordingly.

In considering open-shop orders, it accounts for work already done on a shop order.

The most detailed, complete, and accurate of the capacity planning techniques.

This accuracy is most important in the immediate time periods.

Because of the detail, the data and computation required are great.
Inputs

Inputs needed for a CRP are open-shop orders, planned order releases, routings, time standards, lead times, and work center capacities. This information can be obtained from:

- Open order file
- Material requirements plan
- Routing file
- Work center file

Open Order file

An open-shop order appears as a scheduled receipt on the MRP.

It is a released order for a quantity of a part to be manufactured and completed on a specific date.

It shows all relevant information such as quantities, due dates, and operations.

The open-order file is a record of all the active shop orders.

It can be maintained manually or as a computer file.

Planned Order Releases

Planned orders are determined by the computer's MRP logic based upon the gross requirements for a particular part.

They are inputs to the CRP process in determining the total capacity required in future time periods.

Routing File

A routing is the path that work follows from work center to work center as it is completed.

Routing is specified on a route sheet or, in a computer-based system, in a route file.

One should exist for every component manufactured and contain the following:

- Operations to be performed
- Sequence of operations
- Work centers to be used
- Possible alternate work centers
- Tooling needed at each operation
- Standard times: setup times and run times per piece.
Work Center File

A work center is a particular production facility of one or more machines and/or people each of which performs the same functions and has the same capacity.

A work center file contains information on capacity and move, wait, and queue times.

Move time is time taken to move material from one work station to another.
Wait time is time a job is at a work center after completion and before being moved.
Queue time is time a job waits at a work center before being worked on.
Lead time is sum of queue, setup, run, wait, and move times

Shop Calendar

Another piece of information that is needed is the number of working days available.

The Gregorian calendar (which is the one we use every day) has some serious drawbacks for manufacturing planning and control.

The months do not have the same number of days, holidays are spread unevenly throughout the year, and it does not work on a decimal base.

Julian (or other calendars) are generally preferred.

Scheduling Orders

The first step in capacity requirements planning is to determine when orders must be started and completed on each work center so the final due date can be met.

This process is called scheduling.

The usual process is to start with the due date and, using the lead times, to work backward to find the start date for each operation. This process is called backward scheduling.

Information needed for backward scheduling is obtained from the following:

1. Order file--Quantities and due dates
2. Route file--Sequence of operations, work centers needed, setup time, and run time
3. Work center file--Queue, move, and wait times and work center capacity

You can calculate the work (time) to be done at each work center for a particular order: Setup time + run time = total time (standard hours)

We schedule back from the schedule due date to get the completion and start dates for each operation.

To do so, we need to know not only the operation times but also the queue, wait, and move times, which are in the work center file.

Calculate the work (time) to be done at each work center for a particular order.

We can now back-schedule from the due date to get the completion and start dates for each operation.
A scheduling rule should be established to convert the operation times in standard hours into days, the same units as the other times.

**Load Profiles**

We have developed a schedule of start and finish dates for each work center.

The next task is to develop a load profile for each work center showing the capacity requirements based on planned and released orders for each time period of the plan. To do this, we determine the standard hours of operation time for each order for each work center by time periods, and then add all the standard hours together for each work center in each time period.

The result is the total required capacity (load) on that work center for each time period of the plan.

**Making the Plan**

The next step is to compare the load to available capacity to see if there are imbalances and, if so, to find possible solutions.

In general, there are two ways of balancing available capacity and load: alter the load or change the available capacity.

**Alter the load**

Means shifting orders ahead or back so the load is leveled.

If orders are processed on other work stations, the schedule and load on the other work stations have to be changed as well.

It may also mean that other components should be rescheduled and the master production schedule changed.

Changing the load may not be the preferred course of action.

- Change the Available Capacity (In the Short Run)
- Schedule overtime or undertime.
- Adjust the level of the work force by hiring or laying off workers.
- Shift work force from underloaded to overloaded work centers.
- Use alternate routings to balance load over work centers.
- Subcontract work when more capacity is needed or bring in previously subcontracted work to increase required capacity.

**Production Activity Control**

The time comes when plans must be put into action.

Production Activity Control (PAC) is responsible for executing the master production schedule and the material requirements plan.

While doing so it must make good use of labor and machines, minimize work-in-process inventory, and maintain customer service.
The material requirements plan authorizes production activity control to release work orders to the shop for manufacturing.

Production activity control is responsible for taking control of the work order and making sure that it is completed on time.

It is responsible for the very short-term detailed planning of the Flow of orders through manufacturing, implementing the plan, and controlling the work as it progresses to final completion.

It must manage the day-to-day activity and the detail needed to do so.

PAC activities include planning, implementation, and control.

Planning

The flow of work through each of the work centers has to be planned so the delivery dates can be met. This will require PAC to do the following:

Ensure that the required materials, tooling, personnel, and information are available to manufacture
Schedule start and completion dates for each shop order at each work center so the scheduled completion date of the order can be met. To do this will involve the planner in developing a load profile for the work centers

Implementation

Once the plans are made, they must be put into action by advising the shop floor as to what is to be done.

This is usually done through some form of shop order. Production activity control will:

1. Gather together the information needed by the shop floor to make the product.
2. Release orders to the shop floor as authorized by the material requirements plan. This is called dispatching.

Control

Once plans are made and shop orders released, the process must be monitored to see what is actually happening.

This is then compared to the plan to determine whether corrective action is necessary.

Production Activity Control Functions

Rank shop orders in desired priority sequence by work center and, on this basis, establish a dispatch list.
Track actual performance of work orders and compare to planned schedules
Where necessary, PAC must take corrective action by replanning, rescheduling, or adjusting capacity to meet final delivery requirements
Monitor and control work in process, lead times, and work center queues.
Report work center efficiency, operation times, order quantities, and scrap.
Manufacturing Systems

The particular type of production control system used will vary from company to company, but all should perform the preceding functions.

The relative importance of these functions will vary depending on the type of manufacturing process:

1. Line Flow manufacturing
2. Intermittent manufacturing
3. Project manufacturing

Line Flow Manufacturing

Routings are fixed and work centers are arranged according to the routing. Time taken to perform work at one work center is almost the same as any other work center in the line.

Work centers are dedicated to produce a limited range of similar products. Machinery and tooling are especially designed to make the specific products.

Material flows from one work station to another using mechanical transfer. There is little buildup in work-in-progress inventory and throughput times are relatively low.

Capacity is fixed by the line.

Production activity control concentrates on planning the flow of work and making sure that the right material is fed to the line as determined by the planned schedule.

Since work flows from one work station to another automatically, implementation and control are relatively simple.

Intermittent Manufacturing

Flow of work through the shop is varied and depends on the design of a particular product. The time an order takes at any one work center is different from another and the work flow is not balanced.

Machinery and workers must be flexible to do the variety of work. Machinery and work centers are usually grouped according to the function they perform (e.g., all lathes in one department).

Throughput times are generally long. It is difficult to schedule work to arrive just when needed, the time taken by an order at each work center is the same, and work tends to queue up before work centers, causing long delays in processing. Work-in-Process inventory is often large.

The capacity required depends on the particular mix of products being built and is difficult to predict.

Production activity control in intermittent manufacturing is complex.

Because of the number of products made, the variety of routings, and scheduling problems, PAC is a major activity in this type of manufacturing.

Planning and control are typically exercised using shop orders for each batch being produced.
**Project Manufacturing**

Associated with the manufacture of one or a small number of units. Large-ship building is an example. Because the design of the product is often modified, or done, as the project moves along, there is close coordination between manufacturing, marketing, purchasing, and engineering.

The production plan, often using network analysis, is the most important function and determines when activities are to be performed.

**Data Requirements**

To plan the processing of materials through manufacturing, PAC must know the following:

- What and how many to produce.
- When parts are needed so the final completion date can be met.
- What operations are needed to make the product and the times the operations will take.
- Available capacities of the various work centers.

The PAC must have a data or information system from which to work.

The data needed to answer these questions is organized into a data base. The files contained in the data base are of two types, planning and control.

- Planning Files
- Item master file
- Product structure
- Routing file
- Work center master file

**Item Master File**

There is one record in this file for each part number, consisting of:

- Part number, a unique number assigned to a component
- Part description
- Manufacturing lead time, the normal time needed to make this part
- Quantity on hand
- Allocated quantity, quantities assigned to specific work orders but not yet withdrawn from inventory
- On-order quantities, the balance due on all outstanding orders
- Lot size quantity, the quantity normally ordered at one time
Product Structure File (Bill of Material File)

Contains a list of the single-level components and quantities needed to assemble a parent.

Forms a basis for a pick list to be used by storeroom personnel to collect the parts required to make the assembly.

Routing File

There is a record in this file for each part manufactured.

The routing consists of a series of operations required to make the item.

For each product this file contains a step-by-step set of instructions describing how the product is made. It includes:

1. The operations required to make the product and the sequence in which those operations are to be performed.
2. A brief description of each operation.
3. Equipment, tools, and accessories needed for each operation.
4. Setup times: the standard time required for setting up the equipment for each operation.
5. Run times: the standard time to process one unit through each operation.
6. Lead times for each operation.

Work Center Master File

The purpose of this file is to collect all the relevant data on a work center. For each work center it gives details on the following.

- Work center number
- Capacity. a. Number of shifts worked per week. b. Number of machine hours per shift. c. Number of labor hours per shift
- Efficiency
- Utilization
- Queue time, the average time that a job waits at the work center before work is begun
- Alternate work centers: work centers that may be used as alternatives

Control in Intermittent Manufacturing

Exercised through shop orders and control files that contain data on these orders.

Generally two kinds of files:

1. Shop order master file.
2. Shop order detail file.
Shop Order Master File

Each active manufacturing order has a record in this file. Normally contains:

- Shop order number: a unique number identifying the shop order
- Order quantity
- Quantity completed
- Quantity scrapped
- Quantity of material issued to the order
- Due date, the date the order is expected to be finished
- Priority, a value used to rank the order in relation to others
- Balance due, the quantity as yet not completed
- Cost information

Shop Order Detail File

Each shop order has a detail file, and that file contains a record for each operation needed to make the item. Each record contains the following information:

- Operation number
- Setup hours, planned and actual
- Run hours, planned and actual
- Quantity reported complete at that operation
- Quantity reported scrapped at that operation
- Due date or lead time remaining

Order Preparation

Once authorization has been received to process an order, it is the responsibility of PAC to plan and prepare its release to the shop floor.

The order should be reviewed to be sure that the necessary tooling, material, and capacity are available. If they are not, the order cannot be completed and should not be released

Tooling is not generally considered in the MRP program, and at this stage its availability must be checked.

The MRP software program will have checked the availability of material and allocated it to a shop order so it may not be necessary to check.

If MRP has not been used, Then PAC will have to manually check material availability.

If a capacity requirements planning system has been used, then it is expected that capacity is available.

At this stage there may be some differences between planned capacity and what is actually available.

When CRP is not used it is necessary to check to see if capacity is available.

Checking capacity availability is a two-step process

1. The order must be scheduled to see when the capacity is needed
2. The load on work centers must be checked in that time period
Scheduling

Objective is to meet delivery dates and to make the best use of manufacturing resources.

It involves establishing start and finish dates for each operation required to complete an item.

To develop a reliable schedule, the planner must have information on routing, required and available capacity, competing jobs, and manufacturing lead times (MLTs) at each work center involved.

Manufacturing Lead Time

This is the time normally required to produce an item in a typical lot quantity. Typically MLT is made up of five elements:

1. Queue time, time the job is waiting at a work center before operation begins
2. Setup time, time required to prepare the work center for operation
3. Run time, time to run the order through the operation
4. Wait time, time the job is at the work center before being moved to the next work center
5. Move time, transit time between work centers

The total MLT is the sum of the MLTs for each operation

Setup time and run time are fairly straightforward, and determining them is the responsibility of the industrial engineering department.

Queue, wait, and move times are under the control of manufacturing and PAC.

Queue Time

The largest of the five elements is queue time.

Typically, in an intermittent manufacturing operation, it accounts for 85-95% of the total lead time.

The queue can be managed by regulating the flow of work into and out of work centers, and it is generally the responsibility of PAC to do so.

If the number of orders waiting to be worked on (load) were reduced, so would the queue time, the lead time, and the work in process.

Increasing capacity would also reduce queue.

It is the job of production activity control to manage both the input of orders to the production process and the capacity available so queue and work in process are controlled.

There are many techniques to schedule shop orders through a plant, but all of them require an understanding of forward and backward scheduling and of finite and infinite loading.
Scheduling Techniques

Forward Scheduling

Assumes that material procurement and operation scheduling for a part starts as soon as the order is received regardless of the due date, and that operations are scheduled forward from this point.

Backward Scheduling

The last operation on the routing is scheduled first, and it is scheduled for completion at the due date. Previous operations are scheduled back from the last operation.

This schedules items to be available as needed and is the same logic as used in the MRP system.

Work-in-process inventory is reduced, but because there is little slack time in the system, customer service may suffer.

Backward scheduling is the most common in industry because it reduces inventory.

Infinite loading

The assumption is made that the work stations on which operations are done will have the capacity available when required.

It does not consider the existence of other shop orders competing for capacity at these work centers.

It assumes infinite capacity will be available.

Finite Loading

Assumes there is a defined limit to available capacity at any work station.

If there is not enough capacity available at a work station because of other shop orders, then the order has to be scheduled in a different time period.

Operation Overlapping

A technique used to reduce the total MLT by cutting out the queue and transit times between operations

An order is divided into at least two lots. As soon as the first lot is completed on operation A it is transferred to operation B. While operation A continues with the second lot, operation B starts on the first lot. When operation A finishes the second lot it is transferred to operation B. If the lots are sized properly there will be no idle time at operation B. The total MLT is reduced by the overlap time and the elimination of queue time.
Operation Splitting

Operation splitting is a second method of reducing MLT.

The order is split into two or more lots and run on two or more machines at the same time.

If the lot is split in two the run time component of lead time is effectively cut in half even though an additional setup is incurred.

Load Leveling

The load profile for a work center can be constructed by determining the standard hours of operation for each order in each time period and adding them together by time period.

Scheduling Bottlenecks

In intermittent manufacturing it is almost impossible to balance the available capacities of the various work stations with the demand for their capacity.

This means that some work stations are overloaded and some underloaded.

The overloaded work stations are called bottlenecks, and by definition are those work stations where the required capacity is greater than the available capacity.

Bottlenecks control the throughput of all products that are processed by them.

Work centers that feed the bottlenecks are capable of producing more than the bottleneck can process.

- If scheduled to their capacity, they build up excess work in process inventory
- They should be scheduled to feed the bottleneck at the rate that the bottleneck can process
- Work centers that are fed by bottlenecks have their throughput controlled by the bottleneck, and their schedules should be determined by that of the bottleneck

“Theory of Constraints”

Eliyahu Goldratt and Robert Fox of the Avraham Y. Goldratt Institute have developed the "Theory of Constraints," which explores the problems of constraints (bottlenecks), their effect on a company's performance, and how they can be analyzed and overcome.

They call a bottleneck a "Capacity Constraint Resource" (CCR)

In the race they state "that such a constraint will dictate the rate of production of the entire plant".
To effectively schedule the constraint, two things must be done.

STEP ONE is to establish a "time buffer" inventory (queue) before each CCR. This buffer should contain only enough inventory to keep the CCR busy for a predetermined time. Since it is of the utmost importance to keep the CCR working at all times, it must never be starved for material. It can only be starved if the flow from feeding work stations is disrupted. The time buffer should be only as long as the time of any expected delay caused by feeding work stations. In this way the time buffer ensures that the CCR will not be shut down for lack of work and that this queue will be held at a predetermined minimum quantity.

STEP TWO is to control the rate of material being fed to the CCR. It must be fed at a rate equal to the CCR's available capacity so the time buffer neither increases nor decreases but is maintained constant. The first operation in the sequence of operations is called a "gating operation." Since this operation controls the work being fed to the CCR, its operation must be sequenced at a rate equal to the output of the CCR so the time buffer queue is maintained.

Another name for this system is "Synchronized Manufacturing".

Implementation

Orders that have tooling, material, and capacity have a good chance of being completed on time and can be released to the shop floor.

Those orders that do not should not be released.

If released, they only cause excess work-in-process inventory and perhaps work centers to work on orders that cannot be completed instead of those that can.

Implementation is achieved by issuing a shop order to manufacturing authorizing them to go ahead and make the item.

Contents of a “Shop Packet”

- Shop order showing the shop order number, the part number, name, and description and quantity.
- Engineering drawings.
- Bills of material.
- Route sheets showing the operations to be performed, equipment and accessories needed, materials to use, and the setup and run times.
- Material issue tickets that authorize manufacturing to get the required material from stores.
- Tool requisitions authorizing manufacturing to withdraw necessary tooling from the tool crib.
- Job tickets for each operation to be performed. As well as authorizing the individual operations to be performed, they also can function as part of a reporting system. The worker can log on and off the job using the job ticket, and it then becomes a record of that operation.
- Move tickets that authorize and direct the movement of work between operations.

Control

Once the work orders have been issued to manufacturing, their progress has to be controlled.

To control progress, performance has to be measured and compared to the plan.
If what is actually happening (what is measured) varies significantly from that planned, then either the plans have to be changed or corrective action has to be taken to bring performance back to plan.

Control of orders in a manufacturing system is achieved by the following:

Controlling the work going into and coming out of a work center. This is generally called input-output control.

Setting the correct priority of orders to run at each work center.

**Input/Output Control**

Production activity control must balance the work going to and coming from different work centers. This has to be done so queue, work-in-process and lead times are controlled.

The input/output control system is designed to balance the input rate in hours with the output rate so these will be controlled.

The input rate is controlled by the release of orders to the shop floor.

If the rate of input is increased queue work-in-process and lead times increase.

The output rate is controlled by increasing or decreasing the capacity of a work center.

Capacity change is a problem for manufacturing but it can be achieved by over- or undertime shifting workers and so forth.

To be able to control input/output there must be a plan and a way of comparing what is actually happening to the plan.

**Input/Output Report Contents**

- Planned and actual inputs monitor the flow of work coming to the work center.
- Planned and actual outputs monitor the performance of the work center.
- Planned and actual backlogs monitor the queue and lead time performance.

**Priority Control**

The Material Requirements Planning system establishes proper need dates and quantities.

Over time these dates and quantities change.

Customers want deliveries changed
There are changes in deliveries of component parts either from vendors or internally as well as scrap, shortages, overages, and so on.

Priorities change and the PAC system must be able to react to these changes by changing the priorities of shop orders.
Dispatch Lists

Control of priorities is exercised through dispatch lists.

The dispatch list is the instrument of priority control.

It is a listing by operation of all the jobs available to be run at a work center with the jobs ranked by rules involving relative priorities.

Contents of Dispatch List

It normally includes the following information and is updated and published at least daily:

- Plant, department, and work center
- Part number, shop order number, operation number, and operation description of jobs at the work center
- Standard hours
- Priority information
- Jobs coming to the work center

Priority Rules

Ranking of jobs for the dispatch list is created through the application of priority rules.

There are many rules, some attempting to reduce work-in-process inventory, others attempting to minimize the number of late orders or maximize the output of the work center.

None is perfect or will satisfy all objectives.

Two that are commonly used are due date by operation and critical ratio.

Due Date by Operation and Critical Ratio

*Due Date by Operation* implies that orders at a work center will be run in sequence of the operation due dates.

*Critical Ratio (CR)* is an index of the relative priority of an order to other orders at a work center. It is based on the ratio of time remaining to work remaining and is usually expressed as:

\[
CR = \frac{\text{due date} - \text{present date}}{\text{lead time remaining}} = \frac{\text{actual time remaining}}{\text{lead time remaining}}
\]

Lead time remaining includes all elements of manufacturing lead time

Production Reporting

Production reporting provides feedback of what is actually happening on the plant floor.

It allows PAC to maintain valid records of on-hand and on-order balances, job status, shortages, scrap, material shortages, and so forth.
Production activity control needs this information to establish proper priorities and to answer questions regarding deliveries, shortages, and the status of orders.

Manufacturing management needs information to assist them in operating the plant.

Payroll needs information with which to pay the employees.

Data must be collected, sorted, and reported.

The particular data collected depends upon the needs of the various departments.

The methods of data collection vary.

In some cases the operator reports the start and completion of an operation, order, movement, and so on, using an on-line system directly reporting events as they occur via data terminals.

In other cases the operator, supervisor, or timekeeper reports this information on an operation reporting form included in the shop packet.

Information about inventory withdrawals and receipts must be reported as well.

**Information Needed in Reports**

- Order status
- Weekly input/output by department or work center
- Exception reports on such things as scrap, rework, and late shop orders
- Inventory status
- Performance summaries on order status, work center and department efficiencies, and so on

**Forecasting**

Forecasting is a prelude to planning.

Before making plans, an estimate must be made of what conditions will exist over some future period.

How estimates are made, and with what accuracy, is another matter, but little can be done without some form of estimation.

Forecasting must be done if one wishes to be in a position to meet the demands of the future.

Most firms cannot wait until orders are actually received before they start to plan what to produce.

Customers usually demand delivery in reasonable time, and manufacturers must anticipate future demand for products or services and make plans to provide the capacity and resources to meet that demand.

Firms must have the resources of labor and equipment available to meet demand.
Factors Influencing Demand

- General business and economic conditions.
- Competitive factors.
- Market trends such as changing demand.
- The firm's own plans for advertising, promotion, pricing, and product changes.

What Should Be Forecast?

- Business plan
- Production plan
- Master production schedule

Business Plan

Concerned with overall markets and direction of the economy over the next 2-10 years or more.

Purpose is to provide time to plan for those things that take long to change.

For production the business plan should provide sufficient time for resource planning: plant expansion, capital equipment purchase, and long lead time purchase items.

Level of detail is not high, and usually forecasts are in sales units, sales dollars, or capacity. Forecasts and planning will probably be reviewed quarterly or yearly.

Production Plan

Concerned with manufacturing activity for the next 1-3 years.

For manufacturing it means forecasting those items needed for production planning, such as budgets, manpower planning, long lead time procurement items, and overall inventory levels.

Forecasts are made for groups or families of products rather than specific end items.

Forecasts and plans will probably be reviewed monthly.

Master Production Schedule

Concerned with production activity from the present to a few months ahead.

Forecasts are made for individual items, as found on a master production schedule, individual item inventory levels, raw materials and component parts, manpower planning, and so forth.

Forecasts and plans will probably be reviewed weekly.
Characteristics of Demand (Demand Patterns)

If historical data for demand is plotted against a time scale, it will show any shapes or consistent patterns that exist.

A pattern is a general shape of the time series, and although some individual data points do not fall on the pattern, they tend to cluster around it.

Actual demand typically varies from period to period. There are four reasons for this: trend, seasonality, random variation and cycle.

**Trend**

A trend may be linear, but in other cases it may be of different shapes, such as geometric or exponential.

The trend can also be level, having no change from period to period, or it can rise or fall.

**Seasonality**

Seasonal fluctuations may be the result of the weather, holiday seasons, or particular events that take place on a seasonal basis.

While seasonality is usually thought of as occurring on a yearly basis, it can also occur on a weekly or even daily basis. A restaurant's sales vary with the hour of the day, and supermarket sales vary with the day of the week.

**Random Variation**

Many factors affect demand during specific periods and occur on a random basis.

The variation may be small, with actual demand falling close to the trend, or it may be large, with the points widely scattered. The pattern of variation can usually be measured, and this will be discussed in the section on tracking the forecast.
**Cycle**

Over a long time span of several years and even decades wavelike increases and decreases in the economy influence demand.

Forecasting of cycles is beyond the scope of this Study Guide.

**Stable versus Dynamic**

The shape of the demand patterns for some products or services change over time while others do not.

Those that retain the same general shape are called stable and those that do not are called dynamic.

Dynamic changes can affect the trend, seasonality, or randomness of the actual demand.

The more stable the demand, the easier it is to forecast.

**Dependent vs Independent Demand**

Demand for a product or service is independent when it is not related to the demand for any other product or service.

Dependent demand for a product or service occurs where the demand for the item is derived from that of a second item.

Requirements for dependent demand items need not be forecast but can be calculated from that of the independent demand item.

*Only independent demand items need be forecast. These are usually end items or finished goods.*

**Principles of Forecasting**

*Forecasts are usually wrong.* Forecasts attempt to look into the unknown future and, except by sheer luck, will be wrong to some degree. Errors are inevitable and one must live with them.

Every forecast should include an estimate of error. Since forecasts are expected to be wrong, the real question is, "By how much?" Every forecast should include an estimate of error expressed as a percentage (plus and minus) of the forecast or as a range between maximum and minimum values. Estimates of this error can be made statistically by studying the variability of demand about the average demand.

Forecasts are more accurate for families or groups. The behavior of individual items in a group is random even when the group has very stable characteristics. For example, the marks for individual students in a class are more difficult to forecast accurately than the class average. High marks average out with low marks.

Forecasts are more accurate for nearer periods of time. The near future holds less uncertainty than the far future. Most people are more confident in forecasting what they will be doing over the next week than a year from now. As someone once said, tomorrow is expected to be pretty much like today.
Principles of Collection and Preparation of Data

Record data in the same terms as needed for the forecast. This is a problem in determining the purpose of
the forecast and what is to be forecast. There are three dimensions to this:

If the purpose is to forecast demand on production, then data based on demand, not shipments, is required.
Shipments show what production was able to do in response to incoming orders. But if demand exceeds
capacity, shipments will not give a true indication of demand.

The forecast period, by weeks, months, or quarters for instance, should be the same as a schedule period.
If schedules are made up on a weekly basis, the forecast should be for the same time interval.

The items forecast should be the same as those controlled by manufacturing. For example, if there are a
variety of options that can be supplied with a particular product, then the demand for the product and for
each option should be forecast.

Record the circumstances relating to the data.

Demand is influenced by particular events, and these should be recorded along with the demand data.

For instance, artificial bumps in demand can be caused by sales promotions, price changes, changes in the
weather, or a strike at a competitor's factory.

It is vital that these factors be related to the demand history so they may be included or removed for future
conditions.

Record the demand separately for different customer groups.

Many firms distribute their Goods through different channels of distribution each having its own demand
characteristics.

A firm may sell to a number of wholesalers that order relatively small quantities regularly and sell to a
major retailer that buys a large lot twice a year.

Forecasts of average demand would be meaningless and each set of demands should be forecast separately.

Forecasting Techniques

1. Qualitative

2. Causal

3. Quantitative
Qualitative Techniques

Projections based on judgment, intuition, and informed opinions.

By their nature, they are subjective.

Qualitative techniques are used to forecast general business trends and the potential demand for large families of products over an extended period of time.

They are used mainly by senior management.

Production and inventory forecasting is usually concerned with the demand for particular end items, and in most cases qualitative techniques are not appropriate.

When attempting to forecast the demand for a new product, there is no history on which to base a forecast.

In these cases the techniques of market research and historical analogy might be used.

Market research is a systematic, formal, and conscious procedure for testing to determine customer opinion or intention.

Historical analogy is based on a comparative analysis of the introduction and growth of similar products in the hope that the new product behaves in a similar fashion.

*The most frequently used Qualitative Technique is “The Delphi Method”.*

Causal Techniques

Projections based on external indicators for which forecasts or actual data are available.

Examples of such data would be housing starts, birth rates, and disposable income.

The theory is that the sales of a product group are directly proportional or correlate to activity in another field.

Examples of correlation are as follows:

Sales of bricks are proportional to housing starts.

Sales of automobile tires are proportional to gasoline consumption.

Economic Indicators

Housing starts and gasoline consumption are called economic indicators.

Economic Indicators describe economic conditions prevailing during a given time period.
Commonly used economic indicators:

- Construction contract awards
- Automobile production
- Farm income
- Steel production
- Gross National Product (GNP)

Data of this kind are compiled and published by various government departments, financial papers and magazines, trade associations, and banks.

The problem is to find an indicator that correlates with sales and one that preferably leads sales, that is, one that occurs before the sales do.

The number of construction contracts awarded in one period may determine the building material sold in the next period.

When it is not possible to find a leading indicator, it may be possible to use a nonleading indicator for which the government or an organization forecasts.

In a sense it is basing a forecast on a forecast.

Causal forecasting is most useful in forecasting the total demand for a firm's products or the demand for families of products.

It is used most often in conjunction with business and production planning rather than the forecasting of individual end items.

**Quantitative Techniques**

Quantitative forecasting techniques are based on the assumption that what happened in the past will happen in the future.

Historical data is usually recorded in the company and is readily available.

The assumption that what happened in the past will happen in the future has been likened to driving a car by looking out the rear-view mirror.

While there is some obvious truth to this, it is also true that in the absence of any other "crystal ball," the best guide to the future is what has happened in the past.

Since quantitative techniques are so important, we will discuss some of the more important ones.

They are usually used as input to master production scheduling where end-item forecasts are needed for the planning horizon of the plan.
Some Important Quantitative Techniques

Use of Simple Projections

You may assume sales this month will be the same as those last month:

This may appear too simple.

If there is little change in sales month to month, it probably will be quite accurate.

You might assume sales this month will be the same as sales the same month last year:

This rule is adequate if sales are seasonal.

It would be valid if there is little up or down trend.

Averages are Often Better

Rules such as these, based on a single month or period in the past, are of limited use when there is much random fluctuation in demand.

Usually methods that average out history are better because they dampen out some of the effects of random variation.

As an example, the average of last year's sales can be used as an estimate for January sales. Such a simple average would not be responsive to trends or changes in level of sales. A better method would be to use a moving average.

Moving Averages

One simple way to forecast is to take the average demand for, say, the last three or six periods and use that figure as the forecast for the next period.

At the end of the next period the first-period demand is dropped and the latest period demand added to determine a new average to be used as a forecast.

This forecast would then always be based on the average of the actual demand over the specified period.

Moving Average Example

Suppose it was decided to use a 3-month moving average. Our forecast for January would take the historical data for October, November, and December preceding and divide by three as follows:

\[
63 + 91 + 84 = 79 \\
(O) \,(N) \,(D)
\]

Now suppose that January sales turned out to be 90 instead of 79. The forecast for February would be calculated as:

\[
91 + 84 + 90 = 88 \\
(N) \,(D) \,(J)
\]
Notice how the forecast rises to reflect the higher recent values.

If a longer period, such as 6 months, is used, the forecast does not react as quickly.

The fewer months included in the moving average, the more weight is given to the latest information, and the faster the forecast reacts to trends or seasonal variation.

However, the forecast will always lag behind a trend or seasonality.

Consider the following demand history for the past five periods:

<table>
<thead>
<tr>
<th>Period</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>2000</td>
</tr>
<tr>
<td>3</td>
<td>3000</td>
</tr>
<tr>
<td>4</td>
<td>4000</td>
</tr>
<tr>
<td>5</td>
<td>5000</td>
</tr>
</tbody>
</table>

There is a rising trend to demand. If a five-period moving average is used, the forecast for period six is 

\[(1000 + 2000 + 3000 + 4000 + 5000)/5 = 3000\]

**Moving Average Example #2**

This project does not look very accurate since the forecast is lagging actual demand by a great amount.

However, if a 3-month moving average is used, the forecast is 

\[(3000 + 4000 + 5000)/3 = 4000\]

This is not perfect, but somewhat better.

The point is that a moving average always lags a trend and the more periods included in the average, the greater the lag will be.

**Moving Average Example #3**

On the other hand, if there is no trend but actual demand fluctuates considerably due to random variation, a moving average based on a small number of periods reacts to the fluctuation rather than forecasts the trend. Consider the following demand history:

<table>
<thead>
<tr>
<th>Period</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2000</td>
</tr>
<tr>
<td>2</td>
<td>5000</td>
</tr>
<tr>
<td>3</td>
<td>3000</td>
</tr>
<tr>
<td>4</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>4000</td>
</tr>
</tbody>
</table>

The demand has no trend and is random.

If a 5-month moving average is used, the forecast for the next month is 3000--This reflects all the values.
If a 2-month average is taken, the forecasts for the third, fourth, fifth, and sixth months are:

Forecast for 3rd month = (2000 + 5000)/2 = 3500
Forecast for 4TH month = (5000 + 3000)/2 = 4000
Forecast for 5TH month = (3000 + 1000)/2 = 2000
Forecast for 6TH month = (1000 + 4000)/2 = 2500

**Moving Average Major Points**

Moving averages are best used for forecasting product with stable demand where there is little trend or seasonality.

Moving averages are best used to filter out random fluctuations.

This has some common sense since periods of high demand are often followed by periods of low demand.

One drawback to using moving averages is the need to retain several periods of history for each item to be forecast.

This will require a great deal of computer storage or clerical effort.

In addition, the calculations are somewhat cumbersome.

A common forecasting technique that gives the same results as a moving average but without the need to retain so much data and with easier calculations is called exponential smoothing.

**Exponential Smoothing**

It is not necessary to keep months of history to get a moving average because the previously calculated forecast has already taken into account this history.

Therefore, the forecast can be based on the old calculated forecast and the new data.

Exponential smoothing assumes the most recent data should be given either more or less weight than previous data.

The weight given to the latest actual data is called a smoothing constant and is represented by the Greek letter alpha (a). It is always expressed as a decimal from 0 to 1.0.

**Formula for Calculating a New Forecast**

In general, the formula for calculating a new forecast is:

New forecast = (a)(latest Historical Data) + (1 - a)(previous forecast)

Exponential smoothing provides a routine method for regularly updating item forecasts.

It works quite well when dealing with fairly stable items.

Generally it has been found satisfactory for short-range forecasting.

It is not satisfactory where the demand is low or intermittent.
Exponential smoothing will detect trends although the forecast will lag actual demand if a definite trend exists.

**Double Exponential Smoothing**

If a trend exists, it is possible to use a slightly more complex formula called double exponential smoothing.

This technique uses the same principles but notes whether each successive value of the forecast is moving up or down on a trend line.

Double exponential smoothing is beyond the scope of this Study Guide.

**Selection of Best “Alpha” Factor**

A problem exists in selecting the "best" alpha factor.

If a low factor such as 0.1 is used, the old forecast will be heavily weighted and changing trends will not be picked up as quickly as might be desired.

If a larger factor such as 0.4 is used, the forecast will react sharply to changes in sales and will be erratic if there is a sizable random fluctuation.

A good way to get the best alpha factor is to use computer simulation.

**Seasonality**

Many products have a seasonal demand pattern:

- Skis
- Lawnmowers
- Bathing suits
- Christmas tree lights

Less obvious are products whose sales vary by the time of day, week, or month:

Electric power usage during the day  
Grocery shopping during the week  

Power usage peaks between 4 and 7 p.m., and supermarkets are most busy toward the end of the week.

**Seasonal Index**

A useful indication of the degree of seasonal variation for a product is the seasonal index.

This index is an estimate of how much the demand during the season will be above or below the average demand for the product.

Swimsuit sales might average 100 per month, but in July the average is 175, and in September it is 35. The index for July sales would be 1.75 and for September sales 0.35.
The seasonal index can be based on daily, weekly, monthly, or quarterly sales. The formula is:

\[
\text{Seasonal index} = \frac{\text{period average sales}}{\text{average sales for all periods}}
\]

The period can be daily, weekly, monthly, or quarterly depending on the basis for the seasonality of sales.

**Seasonal Index Example**

Suppose a product is seasonal based on quarterly sales and the sales for the past 3 years are given.

Assume no trend, with flat sales over the 3 years but assume definite seasonality.

Assume average quarterly sales of 100 units and average sales for quarter 1 of 128 units, for quarter 2 of 102 units, and for quarter three of 75 units, and for quarter four of 95 units.

The seasonal indices can now be calculated as follows:

\[
\begin{align*}
\text{Seasonal index} & = \frac{128}{100} = 1.28 \text{ (quarter 1)} \\
& = \frac{102}{100} = 1.02 \text{ (quarter 2)} \\
& = \frac{75}{100} = 0.75 \text{ (QUARTER 3)} \\
& = \frac{95}{100} = 0.95 \text{ (QUARTER 4)}
\end{align*}
\]

Total \[= 4.00\]

Note that the total of all the seasonal indices equals the number of periods. This is a good way to check whether the calculations are correct.

Suppose that this company forecast sales for next year to be 420,000 units. How many units could it expect to sell in each of the quarters?

Forecast quarterly sales = \[\frac{420,000}{4} = 105,000\] 

Expected quarter sales = seasonal index \times forecast quarterly sales

Expected first-quarter sales = 1.28 \times 105,000 = 134,400 units

Expected second-quarter sales = 1.02 \times 105,000 = 107,100 units

Expected third-quarter sales = 0.75 \times 105,000 = 78,750 units

Expected fourth-quarter sales = 0.95 \times 105,000 = 99,750 units
Deseasonalized Demand

Assume a company sells tennis rackets. Sales are usually best in the summer, but some people play indoor tennis and there are sales in the winter months. If sales in January were 5200 units and June sales were 24,000 units, how could January sales be compared to June sales to see which was the better sales month? If there is seasonality, comparison of actual sales would be meaningless. Deseasonalized data are needed to make a comparison. Deseasonalized data show the average or base for sales:

\[
\text{Deseasonalized demand} = \frac{\text{actual demand}}{\text{seasonal Index}}
\]

If the seasonal indices based on history for June were 2.5 and for January 0.5, then:

Deseasonalized June demand = \( \frac{24,000}{2.5} = 9600 \)

Deseasonalized January demand = \( \frac{5200}{0.5} = 10,400 \)

June and January sales can now be compared.

On a deseasonalized basis January sales are greater than June sales.

Deseasonalized data must be used for forecasting.

Suppose that a smoothing constant of 0.1 was used and that the April and May seasonal indices were 1.2 and 0.7, respectively. The previous deseasonalized forecast for April was 1000 and actual sales in April were 1250.

To forecast May sales:

Deseasonalized April sales = \( \frac{1250}{1.2} = 1042 \)

Deseasonalized forecast for May = 0.1(1042) + (0.9)1000 = 1004

Seasonal forecast for May = 1004(0.7) = 703

Rules for Seasonal Adjustment

- Keep the base forecast deseasonalized by using only deseasonalized data.
- Seasonalize the base forecast to predict actual demand for future periods.

Tracking the Forecast

Forecasts are usually wrong.

There are several reasons for this, some of which are related to human involvement and others to the behavior of the economy.

We must make some determination as to the validity of our forecasts. We use this to improve our forecasting methods and to replan around the error.

Continuing with a plan based on poor forecast data is not good.
Tracking the forecast is the process of comparing actual demand with the forecast.

**Forecast Error**

Defined as the difference between actual demand and forecast demand.

Error can occur in two ways:

- Bias
- Random Variation

**Bias**

Cumulative actual sales may not be the same as forecast.

Bias exists when the cumulative variance is not zero.

Bias is a systematic error where the actual demand is consistently above or below the forecast demand.

When bias exists, the forecast can be changed to improve its accuracy.

The purpose of tracking the forecast is to be able to react to forecast error by planning around it or trying to reduce it.

When unacceptably large error or bias is observed, it should be investigated to determine its cause.

Often there are exceptional one-time reasons for error:

- Machine breakdown
- Customer shutdown
- Large one-time orders
- Sales promotions

The above reasons relate to the discussion on collection and preparation of data and the need to record the circumstances relating to the data.

In any event, the demand history must be adjusted to consider the exceptional circumstances.

Errors can also occur because of timing. (an early or late winter will affect the timing of sales of snow shovels even though the cumulative sales will be the same).

Tracking cumulative demand will confirm timing errors or exceptional one-time events.
Random Variation

In a period (e.g., month), actual sales will vary plus and minus about the average sales.

The variability will depend upon the demand pattern of the product.

Some products will have a stable demand and the variation will not be large.

Others will be unstable and will have a large variation.

Variation = actual - forecast

Mean Absolute Deviation (MAD)

Forecast error must first be measured before it can be used to revise the forecast or to help in planning.

There are several ways to measure error, but one most commonly used is mean absolute deviation (MAD).

Determined by calculating the total error ignoring the plus and minus signs and taking the average.

\[ \text{MAD} = \frac{\text{sum of absolute deviations}}{\text{number of observations}} \]

Normal Distribution

The mean absolute deviation measures the difference (error) between actual sales and forecast

Usually actual sales are close to the forecast but sometimes they are not.

If a plot is done of the number of times (frequency) actual sales are of a particular value, we get a bell-shaped curve.

This distribution is called a normal distribution.

Normal Distribution Characteristics

The Central Tendency, or average (the forecast).

The Dispersion, or Spread, of the distribution (sometimes called the fatness or thinness of the normal curve). This is measured by the Standard Deviation. The greater the dispersion, the larger the standard deviation.

MAD as Measure of Dispersion

The Mean Absolute Deviation (MAD) is an approximation of the standard deviation.

From statistics we know that the error will be within + 1 MAD of the average about 60% of the time, within +2 MAD of the average about 90% of the time, and within +3 MAD of the average about 98% of the time.
MAD Uses

We can make some judgment about the reasonableness of the error. Under normal circumstances the actual period sales will be within $+3 \text{ MAD}$ of the average 98% of the time. If actual period sales vary from the forecast by more than 3 MAD, we can be about 98% sure that the forecast is in error.

The data can be used for contingency planning. Suppose a forecast is made that sales of door slammers will be 100 units and that capacity for making them is 110 units. Mean absolute deviation has been calculated at 10 units. This means there is a 60% chance that actual sales will be between 90 and 110 units and a 40% chance that they will not.

Perhaps manufacturing management can devise a contingency plan to cope with the possible extra sales.

The data can be used as a basis for setting safety stock.

Forecasting Handbook

The “Forecasting Handbook” (also available from ACI) contains many more forecasting techniques specifically appropriate for purchasing. In that Handbook, much emphasis is placed on the number 1 technique of quantitative analysis, which is Regression Analysis.

Summary

Forecasts should be tracked.

There should be a measure of reasonableness of error.

When actual exceeds the reasonableness of error, an investigation should be made to discover the cause of the error.

If there is no apparent cause of error, then the method of forecasting should be reviewed to see if there is a better way to forecast.
Inventory Fundamentals

Inventories are those materials and supplies carried on hand by a business or institution either for sale or to provide inputs or supplies to the production process.

All businesses and institutions require inventories.

The British refer to inventory as “Stock”.

Inventories are often a substantial part of total assets and are carried on the Balance Sheet of the firm.

Financially, inventories are very important to manufacturing companies (On the Balance Sheet they usually represent from 20 to 60% of total assets.

When inventories are reduced, their value is converted into cash, which improves cash flow and return on investment.

There is a cost to carrying inventories, which increases operating costs and decreases profits of the company.

Good inventory management is essential.

Inventory management in a firm is responsible for planning and controlling inventory from the raw material stage to the customer.

Since inventory either results from production or supports it, it is often not possible to manage the two separately. As a minimum, they must be coordinated.

Inventories must he considered at each of the planning levels and are thus part of production planning, master production scheduling, and material requirements planning.

Production planning is concerned with overall inventory, master planning with end items, and material requirements planning with component parts and raw material.

At the production planning level inventory management deals with total inventory.

This is called aggregate inventory management.

The concern here is managing inventories according to their classification:

1. Raw Material
2. Work in Process
3. Finished Goods

Aggregate inventory management is also concerned with function inventories perform rather than at the individual item level.
Aggregate Inventory Management

Financially oriented and concerned with the costs and benefits of carrying the different classifications of inventories.

Aggregate inventory management is involved with:

- The flow of materials and the kinds of inventory needed
- Supply and demand patterns
- The functions inventories perform
- The objectives of inventory management
- The costs associated with inventories

Item Level Inventory Management

Inventory must not only be managed at the aggregate level but also at the item level.

To do so, management must establish decision rules about inventory items so the staff responsible for inventory control can do its job effectively.

Inventory Management Decision Rules

1. Deciding on the importance of individual inventory items and how they are to be controlled.
2. How much to order at one time.
3. When to place an order.

Inventory Classifications

The classification system used often is related to the flow of materials into, through, and out of a manufacturing organization.

Raw Materials. These are purchased items that have been received but have not entered the production process. They include purchased materials, component parts and subassemblies.

Work In Process (WIP). Raw materials that have entered the manufacturing process and are being worked on or are waiting to be worked on.

Finished Goods. The finished products of the production process that are ready to be sold as completed items. They may be held at a factory or central warehouse or at various points in the distribution system.

Distribution Inventories. Finished goods that are located in the distribution system.

Maintenance, Repair and Operating (MRO Supplies). Items that are used in production but do not become part of the product. These include hand tools, spare parts, lubricants, cleaning supplies, and so on.
Classification Varies

Classification of an item into a particular inventory depends on the production environment.

Sheet steel or tires are finished goods to the supplier but are raw materials and component parts to the car manufacturer.

Supply and Demand Patterns

If supply were able to meet demand exactly there would be little need for inventory.

Goods could be made at the same rate as demand and no inventory need be built up.

For this situation to exist demand must be predictable, stable, and relatively constant over a long time period.

If this is so then manufacturing can produce goods on a line flow basis matching production to demand.

Raw materials can be fed to production as required work flow from one work station to another can be balanced so little work-in-process inventory is required and goods can be delivered to the customer at the rate the customer needs them.

Because line flow systems are so limited in the variety of products they can make demand has to be large enough to economically justify setting up the system.

Line Flow Systems

Characteristic of just-in-time manufacturing (JIT).

JIT is discussed later.

“Normal Demand Flow”

The demand for most products is not sufficient or constant enough to warrant setting up a line flow system and these products are usually made in lots or batches.

Work stations are organized by function.

All machine tools in one area all welding in another and assembly in another. Work moves in lots from one work station to another as required by the routing.

By the nature of the system, inventory will build up in raw materials work in process and finished goods.

Function of Inventory in Batch/Lot Manufacturing

In batch or lot manufacturing the basic purpose of inventories is to decouple supply and demand. The purpose of inventories is thus to serve as a buffer:

- Between customer demand and finished goods.
- Between finished goods and component availability.
- Between requirements for an operation and the output from the preceding operation.
- Between parts and materials to begin production and the suppliers of materials.
Classification of Inventories According to Function

- Anticipation Inventory
- Fluctuation Inventory
- Lot Size Inventory
- Transportation Inventory
- Hedge Inventory

Anticipation Inventory

These inventories are built up in advance of a peak selling season, a promotion program, vacation shutdown, or possibly the threat of a strike.

They are built up to help level production and to reduce the costs of changing production rates.

Fluctuation Inventory

Inventory is held to cover random, unpredictable fluctuations in supply and demand or lead time.

If demand or lead time is greater than forecast, then a stockout will occur.

Safety stock is carried to protect against the possibility of a stockout.

Its purpose is to prevent disruptions in manufacturing or deliveries to customers.

Lot Size Inventory

Items that are purchased or manufactured in quantities greater than needed immediately create lot size inventories.

Items will be ordered in lots or batches to get quantity discounts to reduce shipping, clerical, and setup costs, and in cases where it is impossible to make or purchase items at the same rate they will be used or sold.

Transportation Inventory

These inventories exist because of the time required to move stock from one location to another.

They are sometimes referred to as pipeline or movement inventories.

The only way to reduce the inventory in transit, and its cost, is to reduce the transit time.

Hedge Inventory

Some products such as minerals and commodities (e.g., grains or animal products) are traded on a worldwide market.

The price for these products fluctuates according to world supply and demand.
If buyers expect that prices will rise, they can purchase hedge inventory when prices are low.

The buying of these inventories is complex and beyond the scope of this Study Guide.

**Objectives of Inventory Management**

- Maximum customer service
- Low-cost plant operation
- Minimum inventory investment

**Customer Service**

The term Customer Service is used to describe the availability of items when needed and is a measure of inventory management performance.

The customer can be a purchaser, a distributor, another plant in the organization, or the work station where the next operation is to be performed.

**Management of Customer Service**

There are many different ways to measure customer service, each with their strengths and weaknesses, but there is no one best measurement.

- Percentage of orders shipped on schedule.
- Percentage of line items shipped on schedule.
- Order-days out of stock.

**Minimization of Uncertainty**

Inventories help to maximize customer service by protecting against uncertainty.

If we could forecast exactly what customers want and when, we could plan to meet demand with no uncertainty.

However, actual demand is uncertain and, as well, the lead time to get an item is often uncertain.

These can result in stockouts and customer dissatisfaction.

It may be necessary to carry extra inventory to protect against uncertainty.
Operating Efficiency

Inventories can help make a manufacturing operation more productive in four ways:

Inventories allow operations with different rates of production to be operated separately and thus more economically.

Level production and build anticipation inventory for sale in the peak periods, resulting in lower overtime costs; lower hiring and firing costs; lower training costs; lower subcontracting costs; lower capacity required; and operating efficiency.

Inventories allow longer production runs, which result in lower setup costs per item and an increase in production capacity due to production resources being used a greater portion of the time for processing as opposed to setup.

Inventories allow manufacturing to purchase in larger quantities which results in lower ordering costs per unit and quantity discounts.

Balance Needed Between Inventory Investment and Other Factors

Customer Service. The lower the inventory the higher the likelihood of a stockout and the lower the level of customer Service. (The higher the inventory level, the higher Customer Service will be).

Costs Associated With Changing Production Levels. Excess equipment capacity, overtime, hiring, training, and layoff costs will be higher if production must fluctuate with demand.

Costs of Placing Orders. Lower inventories can be achieved by ordering less more often, but this practice results in higher annual ordering costs.

Transportation Costs. Goods moved in small quantities cost more to move per unit than those moved in large quantities. However, moving large lots of goods implies higher inventory.

If inventory is carried, there has to be a benefit that exceeds the costs of carrying that inventory.

Inventory Costs

- Item Cost
- Carrying Costs
- Ordering Costs
- Stockout Costs
- Capacity-Related Costs

Item Cost

The price paid for a purchased item is the cost of the item and any other direct costs associated in getting the item into the plant.

These could include such things as transportation, custom duties, and insurance.
The all inclusive cost is often referred to as the (total) landed cost (TLC).

For an item manufactured in house the cost includes direct material, direct labor, and factory overhead.

These costs can usually be obtained from either purchasing or accounting.

**Carrying Costs**

Include all expenses incurred by the firm because of the volume of inventory carried.

As inventory increases, so do these costs.

**Three Categories of Carrying Costs**

**Capital Costs**

Money invested in inventory is not available for other uses and as such represents a lost opportunity cost.

The minimum cost would be the interest lost by not investing the money at the prevailing interest rate and may be much higher depending on the investment opportunities of the firm.

**Storage Costs**

Storing inventory requires space, manpower and equipment.

As inventory increases, so do these costs.

**Risk Costs (Examples)**

Obsolescence. loss of product value resulting from a model or style change or technological development

Damage, inventory damaged while being held or moved.

Pilferage. goods lost, strayed, or stolen.

Deterioration. inventory that rots or dissipates in storage or whose shelf life is limited.

**What Does it Cost to Carry Inventory?**

Actual figures vary from industry to industry and company to company.

Capital costs can vary depending upon interest rates; the credit rating of the firm; and the opportunities the firm may have for investment.

Storage costs vary with location and type of storage needed.

Risk costs can be very low or can be close to 100% of the value of the item for perishable goods.

The carrying cost is usually defined as a percentage of the dollar value of inventory per unit of time (usually 1 year).

Textbooks tend to use a figure of 20-30% in manufacturing industries--This is realistic in many cases but not with all products.
Possibility of obsolescence with fad or fashion items is high and the costs of carrying such items are greater.

**Ordering Costs**

These are costs associated with the placing of an order either *with the factory or a supplier.*

The cost of placing an order does not depend upon the quantity ordered.

Whether a lot of 10 or 100 is ordered, the costs associated with placing the order are essentially the same.

The annual cost of ordering depends upon the number of orders placed in a year.

**Factory Ordering Costs**

**Production Control Costs**

The annual cost and effort expended in production control depends on the number of orders placed, not on the quantity ordered.

The fewer orders per year, the less cost.

The costs involved are those of issuing and closing orders, scheduling, loading, dispatching, and expediting.

**Setup and Teardown Costs**

Every time an order is issued, work centers are involved in setting up to run the order and tearing down the setup at the end of the run.

These costs do not depend upon the quantity ordered; rather the annual cost depends upon the number of orders placed per year.

**Lost Capacity Costs**

Every time an order is placed at a work center, the time taken to set up is lost as productive output time.

This represents a loss of capacity and is directly related to the number of orders placed.

It is particularly important and costly with bottleneck work centers.
Purchase Order Costs

Every time a purchase order is placed, costs are incurred to place the order. These costs include:
- Order preparation
- Follow-up
- Expediting
- Receiving
- Authorizing payment
- The accounting cost of receiving and paying the invoice.

Annual cost of ordering depends upon the number of orders placed in a year.

This can be reduced by ordering more at one time, resulting in the placing of fewer orders.

However, this drives up the inventory level and the annual cost of carrying inventory.

Stockout Costs

If demand during the lead time exceeds forecast, then we can expect a stockout.

Potentially a stockout can be expensive because of back-order costs, lost sales, and possible lost customers.

Stockouts can be reduced by carrying extra inventory to protect against those times when the demand during lead time is greater than forecast.

Capacity-Associated Costs

When output levels must be changed, costs can be incurred for overtime, hiring, training, extra shifts, and layoff.

These costs can be avoided by leveling production by producing items in slack periods for sale in peak periods.

Summary

There are benefits as well as costs to having inventory.

The problem is to balance the cost of carrying inventory with the following:

Customer Service. The lower the inventory level, the higher the likelihood of a stockout and the potential cost of back orders, lost sales, and lost customers. The higher the inventory level, the higher the level of customer service.

Costs Associated With Changing Production Levels. Excess equipment capacity, overtime, hiring, training, and layoff costs are all higher if production fluctuates in response to changes in demand.

Transportation and Handling Costs. The more often goods have to be moved and the smaller the quantities moved, the greater the transportation and material handling costs.
Inventory management is influenced by a number of factors:

Classification of inventory, whether raw material, work in process, or finished goods.

Function the inventory serves (anticipation, fluctuation, lot size, or transportation).

The supply and demand patterns.

In addition to managing inventory at the aggregate level, it must also be managed at the item level.

Management needs to establish decision rules about inventory items so the inventory control staff can do their job effectively.
**ABC Inventory Management**

A system that can be used to decide the importance of items, and therefore the type of control needed, is the ABC inventory classification.

Most companies carry a tremendous number of items in stock.

To have better control of these items at a reasonable cost, it is helpful to be able to classify them according to their importance.

Usually this is based upon the annual dollar volume, but other criteria may be used.

The ABC principle is based on the observation that relatively few items often dominate the results achieved in any situation.

This observation was first made by an Italian economist, Vilfredo Pareto, and is sometimes referred to as Pareto's law or rule.

As applied to inventories, it is usually found that the relationship between the percentage of items and the percentage of annual dollar usage follows a pattern:

- About 20% of the items account for about 80% of the dollar usage
- About 30% of the items account for about 15% of the dollar usage
- About 50% of the items account for about 5% of the dollar usage

The percentages are approximate and should not be taken as absolute. This type of distribution can be used to help control inventories.

**Steps in ABC Management**

Establish the item characteristics that influence the results of inventory management,

Classify each item into groups based on the criteria established.

Apply a degree of control in proportion to the importance of the group.

(The Factors that affect the importance of the item include annual dollar usage, unit cost, and scarcity of material. For simplicity only annual dollar usage is used here.)
**ABC Development Procedure**

1. Determine the annual usage for each item in the group.
2. Multiply the annual usage of each item by its cost to obtain its total annual dollar usage.
3. List the items according to their annual dollar usage.
4. Calculate the cumulative annual dollar usage and the cumulative percentage of items.
5. Examine the annual usage distribution and group the items into A, B, and C groups on the basis of percentage of annual usage.

**Inventory Management/Control Based on ABC Classification**

Using the ABC approach, there are two general rules to follow:

1. Have plenty of low-value items.
2. Use the money and control effort saved to reduce the inventory of high-value items.

**Different Controls Used With Different Classifications**

"A" Items (high priority): Tight control, including complete accurate records, regular and frequent review by management, frequent review of demand forecasts, and close follow-up and expediting to reduce lead time. Perhaps use a perpetual inventory system.

"B" Items (medium priority): Normal controls involving good records, regular attention, and normal processing.

"C" Items (lowest priority): Simplest possible controls—make sure there are plenty; simple or no records; perhaps use a two-bin system or periodic inventory review system. Order large quantities and carry safety stock.

**Order Quantities**

The objective of inventory management is to provide the required level of customer service.

To do so, two basic questions must be answered:

How much should be ordered at one time?

When should an order be placed?

**Decision Rules Needed**

Management must establish decision rules to answer these questions so those working in inventory management know when to order and how much.

In the absence of any better knowledge, decision rules are often made on the basis of what seems reasonable.

Unfortunately, such rules do not always produce the best results.
We will attempt to answer these two questions in turn.

**Inventory Control**

Control is exercised through individual items in a particular inventory.

These are referred to as stock-keeping units (SKU).

Two white shirts in the same inventory but of different sizes or styles would be two different SKUs.

The same shirt in two different inventories would be two different SKUs.

**Techniques in Determining How Much to Order**

- Lot-For-Lot ordering rules
- Fixed-order quantity rules

**Lot-For-Lot Ordering Decision Rules**

Order the exact requirement for an item in each time period.

The order quantity changes whenever requirements change.

Requires time-phased information such as that provided by a material requirements plan or a master production schedule.

Since items are ordered only when needed, this system creates no unused lot size inventory.

It is the best method for planning "A" inventory items.
Fixed-order Quantity Lot Size Decision Rules

Specify the number of units to be ordered each time an order is placed for an individual item or SKU.

The quantity may be arbitrary, such as 200 units at a time, but is often based on an Economic Order Quantity (EOQ).

Determining how much to order at one time depends on the costs that will be affected by the quantity ordered.

Ideally the ordering decision rules that are established minimize the sum of all these costs.

Economic Order Quantity (EOQ)

At the heart of the EOQ principle are two key variable costs of inventory management: the "how much to order," and the "how often to order" (frequency of orders). EOQ is based on the following principles:

1. The range and depth of an inventory can be controlled by using statistical concepts to determine the size and frequency of replenishment orders over a given period of time;
2. Determining "how often to order" is based upon the quantity of stock required to last through an average order and shipping interval without "running out" of stock or exhausting the safety level;
3. The "how much to order" element is a separate problem from the "how often to order" element of the problem. It is based upon a formula designed to obtain the optimum order quantity that will result in the lowest sum of ordering and carrying/holding costs;
4. The application of these principles to selected segments of the inventory enables the supply or inventory manager to predict the trends in inventories and to manage supply effectiveness in terms of cost; and
5. The relationship between ordering and carrying/holding costs can be balanced to determine the most economical quantities to be ordered and held.

Economic Order Quantity (EOQ) is determined by finding that point where ordering and carrying costs are equal. At this point, total cost is the lowest (see graph below).

Additional explanation of EOQ can be found in the “CPP Study Guide”.
Economic Order Quantity

Ordering and Carrying Costs (Thousands)

Order Quantity
Independent Demand Ordering Systems

The Economic Order Quantity addressed the question of how much to order at one time.

Another important question is when to place a replacement order.

If stock is not reordered soon enough there will be a stockout and a potential loss in customer service.

But if stock is ordered earlier than needed there will be extra inventory carried.

The problem then is how to balance the costs of carrying extra inventory against the costs of a stockout.

No matter what the items are, some rules are needed to tell when to reorder.

They can be simple rules such as order when needed order every month or order when stock falls to a predetermined level.

We all use rules of some sort in our own lives and they vary depending on the importance placed on the item.

A homemaker uses some intuitive rules to make up the weekly shopping list.

"Order enough meat for a week; order salt when the box is empty; order vanilla extract if it will be needed over the next week; and so on.

In industry there are many inventories that involve a large investment and where stockout costs are high.

In order to control these inventories, effective reorder systems are needed.

Systems Used to Determine When to Order

1. Order Point System
2. Periodic Review System
3. Material Requirements Planning (MRP)

(The first two are for independent demand items and the last is for dependent demand items)

Order Point System

When the quantity on hand of an item in inventory falls to a predetermined level called an order point, an order is placed.

The quantity ordered is usually precalculated and based on economic order quantity concepts.

Using this system, an order must be placed when there is enough stock on hand to satisfy demand from the time the order is placed until the new stock arrives (called the lead time).

Suppose that for a particular item the average demand is 100 units a week and the lead time is 4 weeks.
If an order is placed when there are 400 units on hand, on the average there will be enough stock on hand
to last until the new stock arrives.

However, demand during any one lead time period probably varies from the average—sometimes more
and sometimes less than the 400.

Statistically the demand is greater than average half the time and there is a stockout, and the demand is
less half the time and there is extra stock.

If it is necessary to provide some protection against a stockout, safety stock can be added.

The item would then be ordered when the quantity on hand falls to a level equal to the demand during the
lead time plus the safety stock: \( OP = DDLT + SS \).

where
\( OP = \) order point
\( DDLT = \) demand during the Lead time
\( SS = \) safety stock

It is important to note that it is the demand during the lead time that is important.

If the lead time is reduced to zero, no safety stock is needed, but as the lead time is increased, more safety
stock is required to give the same level of protection against a stockout.

**Principles of Order Point System**

Order quantities are usually fixed.

The order point is determined by the average demand during the lead time. If the average demand or the
lead time changes and there is no corresponding change in the order point, then effectively there has been
a change in safety stock.

The intervals between replenishments are not constant but vary depending on the actual demand during
the reorder cycle.

Average inventory = Order Quantity/2 + safety stock.

Determining the order point depends on the demand during the lead time and the safety stock required.

Methods of estimating the demand during the lead time were discussed previously.

We now look at the problem of determining safety stock.

**Determining Safety Stock**

The safety stock required depends on the following:

- Variability of demand during the lead time
- Frequency of reorder
- Service Level desired
- Length of the lead time. The longer the Lead time the more safety stock has to be carried to provide a
given service Level. This is why it is important to reduce it at times as much as possible.
Variation in Demand During Lead Time

Actual demand varies from forecast for two reasons:

Bias error in forecasting the average demand.

Random variations in demand about the average.

It is the latter that we are concerned with in determining safety stock.

Variation in Demand About the Average-Normal Distribution

Everything in life varies, even identical twins to some extent.

The pattern of demand distribution about the average will be different for different products and markets.

What is needed is some method of describing the distribution—its shape, center, and spread.

Most demand patterns are stable and predictable.

The most common predictable pattern is called a normal curve, or bell curve, because its shape resembles a bell.

The normal distribution has most of the values clustered near a central point with progressively fewer results occurring away from the center.

It is symmetrical about this central point in that it spreads out evenly on both sides.

The normal curve is described by two characteristics. One relates to its central tendency, or average, and the other to the variation, or dispersion of the actual values about the average.

Average or Mean
This value is at the high point of the curve
It is the central tendency of the distribution
The symbol for the mean is \( \bar{x} \) (pronounced "x bar"). It is calculated by adding the data and dividing by the total number of data

The Variation, or Dispersion

Can be measured in a number of ways:

- As a range of the maximum minus the minimum value
- As a standard deviation. This is a statistical value that measures how closely the individual values cluster about the average
- As the mean absolute deviation (MAD), which is a measure of the average forecast error
Mean Absolute Deviation (MAD)

\[ \text{MAD} = \frac{\text{sum of absolute deviations}}{\text{number of observations}} \]

It is important to note that these deviations in demand are for the same time interval as the lead time.

If the lead time is 1 week, then it is the variation in demand over a 1-week period that is needed to determine safety stock.

Statistics Lessons Learned

The actual demand will be within + or - 1 MAD of the forecast average about 60% of the time.

The actual demand will be within + or - 2 MAD of the forecast average about 90% of the time.

The actual demand will be within + or - 3 MAD of the forecast average about 98% of the time.

Determining the Safety Stock and Order Point

Now that we have calculated the Mean Absolute Deviation we must determine how much safety stock is needed.

One of the properties of the normal curve is that it is symmetrical about the average.

This means that half the time the actual demand is less than the average and half the time it is greater.

Safety stocks are needed to cover only those periods when the demand during the lead time is greater than the average.

Thus a service level of 50% can be achieved with no safety stock.

If a higher service level is needed then safety stock must be provided to protect against those times when the actual demand is greater than the average.

We know from statistics that the error is within + or - 1 MAD of the forecast about 60% of the time (30% of the time less and 30% of the time greater than the forecasts.

Suppose the Mean Absolute Deviation of demand during the lead time is 100 units and this amount is carried as safety stock.

This much safety stock provides protection against stockout for the 30% of the time the actual demand is greater than expected.

In total there is enough safety stock to provide protection for 50 + 30 = 80% of the time a stockout is possible.

The service level is a statement of the percentage of the time there is no stockout.

But what exactly is meant by supplying the customer 80% of the time?
It means being able to supply when a stockout is possible and a stockout is possible only at the time an order is to be placed.

If we order 100 times a year, there are 100 chances of a stockout.

With safety stock equivalent to one mean absolute deviation we would expect, on the average, no stockouts about 80 of the 100 times.

**Safety Stock & Order Point-Example**

Assuming a MAD of 160 units, we can calculate the safety stock and the order point for an 80% service level:

Safety Stock = 1 MAD
= 1 x 160
= 160 units

Order point = DDLT + SS = 1000 + 160 = 1160 units

Assuming a MAD of 160 units, we can calculate the safety stock and the order point for an 95% Service level:

Safety Stock = 2 MAD
= 2 x 160
= 320 units

Order point = DDLT + SS = 1000 + 320 = 1320 units

**Safety Factor**

The service level is directly related to the number of mean absolute deviations provided as safety stock and is usually referred to as the safety factor.

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<td>3.20</td>
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<td>99.99</td>
<td>5.00</td>
</tr>
</tbody>
</table>
Safety Factor-Example

Assume MAD is 200 units, service level is 90%, expected demand during lead time is 1500 units, what is the order point?

\[ SS = \text{MAD} \times \text{safety factor} = 200 \times 1.60 = 320 \]

\[ \text{OP} = \text{DDL} + \text{SS} = 1500 + 320 = 1820 \text{ Units} \]

Determining Service Levels

Theoretically we want to carry enough safety stock on hand so the cost of carrying the extra inventory plus the cost of stockouts is a minimum.

Stockouts cost money for the following reasons:

- Back-order costs
- Lost sales
- Lost customers

The cost of a stockout varies depending on the item, the market served, the customer, and competition.

Customer service is a major competitive tool, and a stockout can be very expensive.

In some industries, it may not be a major consideration.

Stockout costs are difficult to determine.

Usually the decision as to what the service level should be is a senior management decision and is part of the company's corporate and marketing strategy.

The only time it is possible for a stockout to occur is when stock is running low, and this happens every time an order is to be placed.

The chances of a stockout are directly proportional to the frequency of reorder.

The more often in a year that stock is reordered, the more often there is a chance of a stockout.

When the order quantity is increased, exposure to stockout decreases.

The safety stock needed decreases, but because of the larger order quantity, the average inventory increases.

What is needed is a statement from management as to the number of stockouts per year that are tolerable.

With this, the service level, safety stock, and order point can be calculated.
Different Forecast and Lead Time Intervals

There are usually many items in an inventory each with different lead times.

Normally we expect that records of actual demand and forecasts are made on a weekly or monthly basis for all items regardless of what the individual lead times are.

It is almost impossible to measure the variation in demand about the average for each of the lead times.

Some method of adjusting mean absolute deviation for the different time interval is needed.

If the lead time is zero, the mean absolute deviation of demand is zero, and as the lead time interval increases, the mean absolute deviation increases.

However, it will not increase in direct proportion to the increase in time.

For example, if the mean absolute deviation is 100 for a lead time of 1 week, then for a lead time of 4 weeks it will not be 400 since it is very unlikely that the deviation would be high for 4 weeks in a row.

As the time interval increases, there is a smoothing effect, and the longer the time interval, the more smoothing takes place.

The following adjustment can be made to the mean absolute deviation or the safety stock to compensate for differences between lead time interval (LTI) and forecast interval (FI). While not exact, the formula gives a good approximation:

\[ \text{MAD for LTI} = \text{MAD for Fi} \times \sqrt{\frac{\text{LTI}}{\text{FI}}} \]

**Example**

Suppose the forecast interval is 4 weeks, the lead time interval is 2 weeks, and MAD For the forecast interval is 150 units. Then:

\[ \text{MAD for LTI} = 150 \times \sqrt{\frac{2}{4}} = 150 \times 0.707 = 106 \]

The preceding relationship is also useful where there is a change in the LTI.

In this case it is probably more convenient to work directly with the safety stock rather than the mean absolute deviation.

**New Example**

Suppose the safety stock for an item is 150 units and the lead time 2 weeks.

If the lead time changes to 3 weeks, the new safety stock is calculated using the preceding relationship with slight modification:

\[ SS \ (NEW) = SS \ (OLD) \times \sqrt{\frac{\text{New Lead Time}}{\text{Old Lead Time}}} \]

\[ SS \ (new) = 150 \times \sqrt{\frac{3}{2}} = 150 \times 1.22 = 183 \text{ units} \]
Determining When the Order Point is Reached

There must be some method to show when the quantity of an item on hand has reached the order point.

In practice, there are a great many systems.

They all are inclined to be variations or extensions of two basic systems: the two-bin system and the perpetual inventory system.

Two-Bin System

A quantity of an item equal to the order point quantity is set aside (Frequently in a separate or second bin) and not touched until all of the main stock is used up.

When this stock is broken into, the production control or purchasing department is notified and a replenishment order is placed.

There are variations on this system, such as the red tag system, where a tag is placed in the stock at a point equal to the order point.

Book stores frequently use this system. A tag or card is placed in a book that is in a stack in a position equivalent to the order point. When a customer takes that book to the checkout, the store is effectively notified that it is time to reorder that title.

Two-Bin is often used for “C” inventory items.

Perpetual Inventory Record System

A continual account of inventory transactions as they occur.

At any instant it contains an up-to-date record of transactions—At a minimum it contains the balance on hand.

It may also contain the quantity on order but not received, the quantity allocated but not issued, and the available balance.

The accuracy of the record depends upon the speed with which transactions are recorded as well as the accuracy of the input.

Because manual systems rely on the input of human beings, they are more likely to have slow response and inaccuracies caused by human error.

Computer-based systems have a higher transaction speed and reduce the possibility of human error.

These systems are often used for “A” inventory items.
Inventory Records for a Perpetual Inventory System

Permanent Information typically includes part number, name, and description, storage location, order point, order quantity, lead time, safety stock, and suppliers.

Variable information is information that changes with each transaction and typically includes quantities ordered (dates, order numbers, and quantities), quantities received (dates, order numbers, and quantities), quantities issued (dates, order numbers, and quantities), balance on hand, allocated (dates, order numbers, and quantities), and available balance.

The information depends on the needs of the company and the particular situation.

Inventory Accuracy

The usefulness of the perpetual inventory record is directly related to its accuracy.

On the basis of the inventory record, a company determines net requirements for an item, releases orders on the basis of material availability, and performs inventory analysis.

If the records are not accurate, there will be shortages of material, disrupted schedules, late deliveries, lost sales, low productivity, and excess inventory (of the wrong things).

If inventory records are to be accurate, the movement of the goods must be processed properly.

There must be a good record-keeping system, the storeroom must be secure so no unauthorized withdrawals can be made, and there should be a good method of auditing inventory transactions and record accuracy.

Auditing Inventory Records

There are two basic methods of checking the accuracy of inventory records.

1. Periodic (usually annual) counts of all items.
2. Cyclic (usually daily) counts of specified items.

It is important to audit record accuracy, but it is more important to audit the system to find the causes of record inaccuracy and eliminate them. Cycle counting does this; periodic audits tend not to

Cycle Counting

A system of counting inventory continually throughout the year.

The idea is to count selected items each day.

Depending on their importance, some items are counted frequently throughout the year while others are not.

The number of times an item is counted in a year is referred to as its count frequency.

Ideally the frequency increases as the number of transactions increases (more chance of error) and as the value of the item increases.

There are a number of systems used to select items; one of the more popular is the ABC method.
Inventories are classified according to the ABC system--Some rule is then established for count frequency.

A items might be counted weekly or monthly, B items bimonthly or quarterly, and C items biannually or once a year.

On this basis a count schedule can be established.

**Periodic Review System**

In the order point system an order is placed when the quantity on hand falls to a predetermined level called the order point.

The quantity ordered is usually predetermined on some basis such as the economic order quantity.

The interval between orders varies depending on the demand during any particular cycle.

Using the periodic review system, the quantity on hand of a particular item is determined at specified, fixed time intervals and an order is placed.

The review period is fixed and the order quantity is allowed to vary.

The quantity on hand plus the quantity ordered must be sufficient to last until the next shipment is received.

The quantity on hand plus the quantity ordered must equal the sum of the demand during the lead time plus the demand during the review period plus the safety stock.

**Target Level or Maximum-Level Inventory**

The quantity equal to the demand during the lead time plus the demand during the review period plus safety stock is called the target level or maximum-level inventory.

The order quantity is equal to the maximum inventory level minus the quantity on hand at the review period.

**Periodic Review System Useful**

If there are many small issues from inventory, and posting transactions to inventory records are very expensive (supermarkets and retailers).

If ordering costs are small--This occurs when many different items are ordered from one source (A regional distribution center may order its stock from a central warehouse).

If it is desirable to order a number of items together so a production run is made up (A good example of this is a regional distribution center that orders a truck load once a week from a central warehouse).
Valuing Inventory

There are four different ways to value inventory

1. Specific Identification
2. FIFO (First In, First Out)
3. LIFO (Last In, First Out)
4. Average Cost

Specific Identification

Used when each the cost of each individual unit is tracked. Example: Buildings, Land, Heavy Equipment, Automobiles. Usually very few items are sold for a high price. Why wouldn't specific identification work for a company that sells paper clips? Cost of goods sold is simply to total of the actual cost of each item sold during the year.

Other Inventory Assumptions

When it isn't practical to track the cost of every item individually, then you have to make an assumption about which units are sold first and thus constitute cost of goods sold. This assumption doesn't necessarily reflect the physical flow of inventory.

FIFO (First In, First Out)

Assume that the first items that are purchased are the first to be sold.
Cost of Goods Sold are the oldest units.
Ending Inventory are the newest units.

LIFO (Last In, First Out)

Assume the last items purchased are the first to be sold.
Cost of Goods Sold are the newest units.
Ending Inventory are the oldest units.

Average Cost Flow

As goods are purchased, an average unit price is calculated.
When goods are sold, the cost of goods sold is the units sold times the average cost.

Conceptual Comparison

LIFO gives a better reflection of current inventory costs with current sales.
FIFO gives a better inventory value on the balance sheet because the most recently purchased items are included on the balance sheet.
**Physical Distribution**

Physical distribution is responsible for the movement or flow of materials from the producer to the consumer.

It is part of the supply-production-distribution system and as such is part of an integrated materials management or logistics system.

Movement of materials is divided into two functions

1. Physical supply
2. Physical distribution

**Physical Supply**

The movement and storage of goods from suppliers to manufacturing (a function of Materials Management).

Depending on the conditions of sale it is the responsibility of either the supplier or the customer but in either case it will ultimately be a cost to the customer.

**Physical Distribution**

The movement and storage of finished goods from the end of production to the customer (a function of Distribution Management).

The particular way that the goods move through warehouses, wholesalers, and retailers is referred to as the distribution channel.

While it can be argued that one firm's physical supply is another firm's physical distribution, frequently there are important differences, particularly as they relate to the bulk and physical condition of raw materials and finished goods.

The transportation and logistics problems involved in moving and storing iron ore are quite different from those that occur in moving sheet steel.

These differences influence the design of a logistics system and are important in deciding the location of warehouses and factories.

Both physical distribution and physical supply shall be covered together here under the discussion of physical distribution.

**Importance of Physical Distribution**

Physical distribution is vital in our lives.

Usually manufacturers, customers, and potential customers are widely dispersed geographically.

If manufacturers serve only their local market, they restrict their potential for growth and profit.

By extending its market, a firm is able to gain economies of scale in manufacturing, reduce the cost of purchases by volume discounts, and improve its profitability.

To accomplish these ends requires a well-run distribution system.
Manufacturing adds form value to a product by taking the raw materials and creating something of more use.

Distribution adds place value and time value by placing goods in markets where they are available to the consumer at the time the consumer wants them.

Factors Influencing Material Movement

- The channels of distribution that the firm is using. For example, producer to wholesaler to retailer to consumer.
- The types of markets served. Market characteristics such as the geographical dispersion of the market, the number of customers, and the size of orders.
- The characteristics of the product, such as weight, density, fragility, and perishability.
- The type of transportation available to move the material.

Physical Distribution System

Physical distribution is responsible for delivering to the customer what is wanted on time and being able to do so at a minimum cost.

The objective of distribution management is to design and operate a distribution system that achieves the required level of customer service and does so at least cost.

To do this, all activities involved in the movement and storage of goods must be organized into an integrated system.

Activities in the Physical Distribution System

A system is a set of components or activities that interact and affect each other.

A car engine is a system and if any part malfunctions, the performance of the whole engine is affected.

In a distribution system six interrelated activities affect customer service and the cost of providing it.

1. Transportation

Involves the various methods of moving goods outside the firm's buildings.

For most firms transportation is the single highest cost in distribution, usually accounting for one-third to two-thirds of distribution costs.

Transportation adds place value to the product.
2. **Distribution Inventory**

Includes all finished goods inventory at any point in the distribution system.

In terms of cost it is the second most important item in distribution, accounting for about 25-30% of the cost of distribution.

Inventories create time value by placing the product close to the customer.

3. **Warehousing**

Used to store and manage inventory.

The management of warehouses involves such problems as site selection number of warehouses in the system layout and methods of receiving, storing, and retrieving goods.

4. **Materials Handling**

Concerned with the movement and storage of goods inside the warehouse.

The type of materials handling equipment used affects the efficiency and cost of operating the warehouse.

Materials handling represents a capital cost and a trade-off exists between this capital cost and the operating costs of the warehouse.

5. **Protective Packaging**

Goods moving in a distribution system must be contained, protected and identified.

In addition, goods are moved and stored in packages and must fit into the dimension of the storage spaces and the transportation vehicles.

6. **Order Processing**

Includes those activities involved in filling customer orders.

They represent a time element in delivery and are thus an important part of customer service.

**Total-Cost Concept**

The objective of distribution management is to provide the required level of customer service at the least total system cost.

This does not mean that transportation costs or inventory costs or any one activity cost should be a minimum but that the total of all cost should be a minimum.

What happens to one activity has an effect on other activities, total system cost, and the service level.

Management must treat the system as a whole and understand the relationships between the activities.
Example

Consider the interaction between inventory and transportation costs.

The cost of inventory in transit for a particular shipment is $100 per day.

Transport by rail costs $200 and the transit time is 10 days. However, the goods can be moved by air at a cost of $1000 and will take 1 day to deliver.

<table>
<thead>
<tr>
<th></th>
<th>Rail</th>
<th>Air</th>
</tr>
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<tr>
<td>Inventory-carrying cost</td>
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<td>100</td>
</tr>
<tr>
<td>Total</td>
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Two Related Principles

Cost trade-off

The cost of transportation increased with the use of air transport but the cost of carrying inventory decreased.
There was a cost trade-off between the two.

Total cost

By considering all the costs involved and not suboptimizing on any one cost, the total system cost has been reduced.

Other Costs Must be Considered

Note also that while no cost has been attributed to it, customer service has potentially been improved by reducing the transit time.

The total cost should also reflect the effect of the decision on other sections of the firm such as production and marketing.

The preceding example does not mean that there will always be a saving by moving to faster transport.

For example, if the goods being moved are of low value and inventory carrying cost is only $10 per day, then rail is cheaper.

Trade-Offs

Most of the decisions in distribution, and indeed much of what is done in business and in our own lives, involves trade-offs and an appreciation of the total costs involved.

The emphasis is on the costs and trade-offs that will be incurred and on maximizing customer service.

Generally, but not always, an increase in customer service requires an increase in cost, and this in itself is a major trade-off required in the system.
Interfaces

By taking the goods produced by manufacturing and delivering them to the customer, physical distribution provides a bridge between marketing and production.

As such, there are a number of important interfaces between physical distribution and production and marketing.

Marketing

While physical distribution interacts with all departments in a business, the closest relationship is probably with marketing.

In many cases it is thought of as a marketing subject and not as part of materials management or logistics.

The "marketing mix" is made up of product, promotion, price, and place, and the latter is created by physical distribution.

Marketing is responsible for transferring ownership.

Ownership transfer is accomplished by such methods as personal selling, advertising, sales promotion, merchandising, and pricing

Physical distribution is responsible for giving the customer possession of the goods and does so by operating warehouses, transportation systems, inventories, and order processing systems.

It has the responsibility of meeting the customer service levels established by marketing and the senior management of the firm.

Physical distribution contributes to creating demand.

Prompt delivery, product availability, and accurate order filling are important competitive tools in promoting a firm's products.

Also the distribution system is a cost, and its efficiency and effectiveness influences the company's ability to price competitively. All these influence company profits.

Production

Physical supply establishes the flow of material into the production process.

Usually the service level must be very high because the cost of interrupted production schedules caused by raw material shortage is usually enormous.

In some cases the location of factories is determined largely by the sources and transportation links of raw materials.

This is particularly true where the raw materials are bulky and of relatively low value compared to the finished product.

The location of steel mills on the Great Lakes is a good example.

The basic raw material, iron ore, is bulky, heavy, and of low unit value.
Transportation costs must be kept low to make a steel mill profitable.

Iron ore from mines in either northern Quebec or Minnesota is transported to the mills by boat, the least cost mode of transportation.

Unless a firm is delivering finished goods directly to a customer, demand on the factory is created by the warehouse orders and not directly by the final customer.

This can have severe implications on the pattern of demand on the factory.

While the demand from customers may be relatively uniform, the factory reacts to the demand from the warehouses for replenishment stock.

If the warehouses are using an order point system, the demand on the factory will not be uniform and in fact will be dependent rather than independent demand.

The distribution system is the factory's customer, and the way that the distribution system interfaces with the factory will influence the efficiency of factory operations.

**Transportation**

Transportation is an essential ingredient in the economic development of any area.

It brings together raw materials for production of marketable commodities and distributes the products of industry to the marketplace.

It is a major contributor to the economic and social fabric of a society and aids economic development of regional areas.

**Modes of Transportation**

- Rail
- Road including truck, bus, and automobile
- Air
- Water, including ocean going, inland and coastal
- Pipeline
- Multimodal (using 2 or more of the above 5 modes)

**Cost and Service Characteristics**

Each mode has different cost and service characteristics.

These determine the types of goods the mode will best move.

Certain types of traffic are simply more logically moved within one mode than they are in another.
Trucks are best suited to moving small quantities to widely dispersed markets but trains are best suited to moving large quantities of bulky cargo such as grain.

**Costs of Carriage**

Any carrier, regardless of mode, must have certain basic physical elements to be able to provide transportation service.

These elements include ways, terminals, and vehicles.

Each results in a cost to the carrier and, depending on the mode and the carrier, may be either capital (fixed) or operating (variable) costs.

Fixed costs are costs that do not change with the volume of goods carried.

The purchase cost of a truck that is owned by the carrier is a fixed cost. No matter how much it is used, the cost of the vehicle does not change.

Many of the costs of operation, such as fuel, maintenance, and driver's wages, depend on the use made of the truck. These are variable costs.

**Ways**

Paths over which the carrier operates.

Include the right of way (land area being used) plus any roadbed tracks or other physical facilities needed on the right of way.

The nature of the way and how it is paid for vary with the mode.

They may he owned and operated by the government or by the carrier or provided by nature.

**Terminals**

Places where carriers:

- Load and unload goods into and from vehicles and make connections between local pickup and delivery service and line-haul service
- Weight loads
- Make connections with other routes and carriers are made
- Route, dispatch, and maintain vehicles
- Conduct administration and do paper work

The nature, size, and complexity of the terminal varies with the mode and size of the firm and the types of goods carried.

Generally terminals are owned and operated by the carrier, but in some special circumstances they may be publicly owned and operated.
Vehicles

Are used in all modes except pipelines.

Serve as carrying and power units to move the goods over ways.

Usually provided through ownership or leasing by the carrier, although sometimes the shipper owns or leases them.

Miscellaneous

In addition to ways, terminals, and vehicles, a carrier will have other costs such as:

- Maintenance
- Labor
- Fuel
- Administration

These are generally part of operating costs and may be fixed or variable.

Rail

Railways provide their own ways, terminals, and vehicles.

These represent a large capital investment.

This means that a high proportion of the total cost of operating a railway is fixed.

Thus, railways must have a high volume of traffic in order to absorb the fixed costs.

They will not want to install and operate rail lines unless there is a large enough volume of traffic.

Trains move goods by train loads composed of perhaps a hundred cars each with a carrying capacity in the order of 160,000 pounds.

Therefore, railways are best able to move large volumes of bulky goods over relatively long distances.

Their frequency of departure will be less than trucks, which can move as soon as one truck is loaded.

Rail speed is comparatively good over long distances, the service is generally reliable, and they are flexible about the goods they can carry.

Train service is cheaper than road for large quantities of bulky commodities such as coal, grain, potash, and containers moved over long distances.
Road

Trucks do not provide their own ways (roads and highways) but pay a fee to the government in the form of license, gasoline, and other taxes and tolls for the use of roads.

Terminals are usually owned and operated by the carrier but may be privately owned, and, in some cases are owned by the government.

Vehicles are owned, or leased, and operated by the carrier.

If owned, they are a major capital expense.

In comparison to other modes, the cost of a vehicle is small.

This means that for road carriers the majority of their costs are operating (variable) in nature.

Trucks can provide a door-to-door service as long as there is a suitable surface on which to drive.

In the United States and Canada the road network is superb.

The unit of movement is a truckload, which can be up to about 100,000 pounds.

These two factors, the excellent road system and the relatively small unit of movement, mean that trucks can provide fast flexible service almost anywhere in North America.

They are particularly suited to distribution of relatively small volume goods to a dispersed market.

Air

Air transport does not have ways in the sense of fixed physical roadbeds, but it does require an airway system that includes air traffic control and navigation systems.

These systems are usually provided by the Federal Government.

Carriers pay a user charge that is a variable cost to them.

Terminals include all the airport facilities, most of which are provided by the government.

Carriers are usually responsible for providing their own cargo terminals and maintenance facilities, either by owning or renting the space.

The carrier provides the aircraft either through ownership or leasing.

The aircraft are expensive and are the single most important cost element for the airline.

Since operating costs are high, airlines tend to have a high proportion of their costs as variable.

The main advantage of air transport is speed of service, especially over long distances.

Cargo travels mainly in passenger aircraft, and thus many delivery schedules are tied to those of passenger service.

The service is flexible about destination as long as there is a suitable landing strip.
Transportation cost for air cargo is higher than for other modes.

Air transport is most suitable for high-value low-weight cargo or emergency items.

**Water**

Waterways used by water carriers are provided by nature or by nature with the assistance of the government.

The St. Lawrence Seaway system is an example of this.

The carrier thus has no capital cost in providing the ways but may have to pay a fee for using the waterway.

Terminals may be provided by the government but are increasingly privately owned.

In either case the carrier will pay a fee to use them.

Thus terminals are mainly a variable cost.

Vehicles (ships) are provided by the carrier by ownership or leasing.

Thus they represent the major capital or fixed cost to the carrier.

The main advantage of water transport is low cost.

Operating costs are low, and since the ships have a relatively large capacity, the fixed costs can be absorbed over large volumes.

Ships are slow and are door to door only if the shipper and the consignee are on a waterway.

Hence water transportation is most useful for moving low-value bulky cargo over relatively long distances where waterways are available.

**Pipelines**

Pipelines are unique among the modes of transportation in that they move primarily gas, oil, and refined products on any widespread basis.

As such, they are of little interest to most users of transportation.

Capital costs for ways and pipelines are high and are borne by the carrier, but operating costs are very low.

**Transportation**

**Legal Types of Carriage**

Legally carriers are classified as public (for hire) or as private (not for hire).

In the latter case individuals or firms own or lease their vehicles and use them to move their own goods.

Public transport, on the other hand, is in the business of hauling for others for pay.
All modes of transport have public and for-hire carriers.

**For-Hire Carriers**

Include Common Carriers and those which contract to a specified shipper. Both are subject to economic and safety/health regulation by federal, state, or municipal governments.

The US Federal Government has “deregulated” interstate carriers, and they are now permitted to set their own tariffs/rates. The Federal Government provides only health/safety regulation for these carriers.

Depending on the jurisdiction, economic regulation may be more or less severe, and in recent years there has been a strong move on the part of government to reduce regulations.

**Economic regulation has centered on three areas:**

- Regulation of rates
- Control of routes and service levels.
- Control of market entry and exit

**Private Carriers**

Are not subject to economic regulation.

Like public (common) carriers, are regulated in such matters as public safety, license fees, and taxes.

**Common Carriers**

Make a standing offer to serve the public at published rates available to all.

This means that whatever products they offer to carry will be carried for anyone desiring their service.

With some minor exceptions, they can carry only those commodities they are licensed to carry.

For instance, a household mover cannot carry gravel or fresh vegetables.

**Common Carriers Provide:**

- Service available to the public.
- Service to designated points or in designated areas.
- Scheduled service.
- Service of a given class of movement or commodity.

**Contract Carriers**

Haul only for those with whom they have a specific formal contract of service.

They do not hold themselves out to serve the public (although some transportation companies provide both contract carriers and common carriers using different branches of their business).

Contract carriers offer a service according to a contractual agreement signed with a specific shipper.
The contract specifies the character of the service, performance, and charges.

**Private Carriers**

Own or lease their equipment and operate it themselves.

This means investment in equipment, insurance, and maintenance expense.

A company normally only considers operating its own fleet if the volume of transport is high enough to justify the capital expense.

**Service Capability of Legal Types of Carriage**

Service capability depends on the availability of transportation service and this in turn depends on the control that the shipper has over the transportation agency.

The shipper must go to the marketplace to hire a common carrier and is subject to the schedules and regulations of that carrier.

Least control can be exercised over common carriers.

Shippers can exercise most control over their own vehicles and have the highest service capability with private carriage.

**Other Transportation Agencies**

There are a number of transportation agencies that use the various modes or combinations of the modes.

Some of these are the post office, freight forwarders, couriers, and shippers.

They all provide a transportation service, usually as a common carrier.

They may own the vehicles or they may contract with carriers to move their goods.

Usually they consolidate small shipments into large shipments to make economic loads.

**Transportation Cost Elements**

There are four basic cost elements in transportation:

1. Line haul
2. Pickup and delivery
3. Terminal handling
4. Billing and collecting

A knowledge of these costs enables a shipper to get a better price by selecting the right shipping mode.

We will use motor transport as an example, but the principles are the same for all.

Goods either move directly from the shipper to the consignee or move through a terminal.

In the latter case they are picked up in some vehicle suitable for short-haul local travel.
They are then delivered to a terminal where they are sorted according to destination and loaded onto highway vehicles for travel to a destination terminal.

There they are again sorted, loaded on local delivery trucks and taken to the consignee.

**Line-Haul Costs**

When goods are shipped, they are sent in a moving container that has a weight and volume capacity.

The carrier, private or for hire, has basic costs to move this container, and whether the container is full or not these costs exist.

For a truck these include such items as gasoline, the driver's wages, and depreciation due to usage.

These costs vary with the distance traveled and not the weight carried.

The carrier has essentially the same basic costs whether the truck moves full or empty.

If it is half full the basic costs must be spread over only those goods in the truck.

Therefore total line-haul costs vary directly with the distance shipped and not upon the weight shipped.

Suppose for a given commodity the line-haul cost is $3 per mile and the distance is 100 miles, resulting in a total line-haul cost of $300.

If the shipper sends 50,000 pounds, the total line-haul cost is the same as if 10,000 pounds is sent.

However, the line-haul costs (LHC) per hundred weight (cwt) is:

\[
LHC/\text{cwt} = \frac{300}{500} = 0.60 \text{ per cwt (for 50,000 lb -500 cwt)}
\]

\[
LHC/\text{cwt} = \frac{300}{100} = 3 \text{ per cwt (for 10,000 lb-100cwt)}
\]

Thus the total line-haul cost varies with:

The cost per mile.
The distance moved.
However the Line-haul cost per hundred weight varies with:

- The cost per mile.
- The distance moved.
- The weight moved.

The carrier has two limitations or capacity restrictions on how much can be moved on any one trip:

- The weight limitation.
- The cubic volume limitation of the vehicle.

With some commodities their density is such that the volume limitation is reached before the weight limitation.

If the shipper wants to ship more, a method of increasing the density of the goods must be found.

This is one reason some light products are made so they nest (e.g. styrofoam cups) and bicycles and wheelbarrows are shipped in an unassembled state.

It is not done to frustrate us poor mortals who try to assemble them but to increase the density of the product so more weight can be shipped in a given vehicle.

The same principle applies to goods stored in warehouses.

The more compact they are the more can be stored in a given space.

Therefore if shippers want to reduce transportation cost they should:

- Increase the weight shipped.
- Maximize density.

**Pickup and Delivery Costs**

Are similar to line-haul costs except that the cost depends more on the time than on the distance traveled.

The carrier will charge for each pickup and for the weight picked up.

If a shipper is making several shipments it will be less expensive if they are consolidated and picked up on one trip.

**Terminal Handling Costs**

Terminal handling costs depend upon the number of times a shipment must be loaded, handled, and unloaded.

If full truckloads are shipped, the goods do not need to be handled in the terminal but can go directly to the consignee.

If part loads are shipped, they must be taken to the terminal, unloaded, sorted, and loaded onto a highway vehicle.

At the destination the goods must be unloaded, sorted, and loaded onto a local delivery vehicle.
Each individual parcel must be handled.

A shipper who has many customers each ordering small quantities will expect the terminal handling costs to be high because there will be a handling charge for each package.

The basic rule for minimizing terminal handling costs is to minimize handling effort by consolidating shipments into fewer parcels.

**Billing and Collecting Costs**

Every time a shipment is made, paperwork has to be done and an invoice made out.

Billing and collecting costs can be reduced by consolidating shipments and reducing the pickup frequency.

**Total Transportation Costs**

The total cost of transportation consists of line-haul, pickup and delivery, terminal handling, and billing and collecting costs

To minimize shipping costs, the shipper will:

- Decrease line-haul costs by increasing the weight shipped.
- Decrease pickup and delivery cost by reducing number of pickups (by consolidation and increasing the weight per pickup).
- Decrease terminal handling costs by decreasing number of parcels by consolidating shipments.
- Decrease billing and collecting costs by consolidating shipments.

For any given shipment the line-haul costs vary with the distance shipped.

The other costs are fixed

The total cost for any given shipment thus has a fixed cost and a variable cost associated with it.

The carrier will take this relationship into account and either charge a fixed cost plus so much per mile or often a tapered rate.

In the latter case the cost per mile for short distances far exceeds that for longer distances.

The rate charged by a carrier will also vary with the commodity shipped and will depend upon the following:

- Value. A carrier's liability for damage will be greater the more valuable the item.
- Density. The more dense the item, the greater the weight that can be carried in a given vehicle.
- Perishability. Perishable goods often require special equipment and methods of handling.
- Packaging. The method of packaging affects the risk of damage and breakage.
Rate Structures

Carriers have two rate structures:

- One based on full loads called truckload (TL) or car load (CL).
- One based on less than truckload (LTL) and less than car load (LCL).

For any given commodity the LTL rates can be up to 100% higher than the TL rates.

The basic reason for this differential lies in the extra pickup and delivery, terminal handling and billing, and collection costs.

Truckers, airlines, and water carriers accept less than full loads, but usually the railways do not accept LCL shipments.

Transportation Costs and the Total System

Any distribution system should try to provide the highest service level—the number of orders delivered in a specified time—at the lowest possible cost.

The particular shipping pattern will depend largely upon the following:

- Number of customers.
- Geographic distribution of the customers.
- Customer order size.
- Number and location of plants and warehouses.

Suppliers have little or no control over the first three but do have some control over the last.

They can establish local warehouses in their markets.

With respect to transportation it then becomes a question of the cost of serving customers direct from the central warehouse or from the regional warehouse.

Example

If truckload shipments are made the cost is less from the central warehouse but if LTL shipments are made it is usually cheaper to serve the customer from the local warehouse.

Suppose a company has a plant located in Toronto and is serving a market in the northeastern United States with a large number of customers located in Boston.

If they ship direct to customers from the Toronto plant most shipments will be less than truckload.

However if they locate a warehouse in Boston they will be able to ship truckloads (TLs) to Boston and distribute by local cartage (LTL) to customers in that area.

Whether this is economical or not depends on the total cost of shipping direct as against shipping via the warehouse.
Assume the following figures represent the average shipments to the Boston area:

- Plant to customer LTL: $100/cwt
- Plant to warehouse TL: $50/cwt
- Inventory-carrying cost (warehouse): $10/cwt
- Warehouse to customer LTL: $20/cwt

The cost of shipping LTL direct is $100/cwt and the cost of shipping TL to the warehouse and LTL locally is $80/cwt, a saving of $20/cwt.

Now suppose there are customers in Albany. They can be served LTL direct from the Toronto plant or LTL from the warehouse in Boston.

Assume the following figures are representative:

- Plant to CUSTOMER LTL: $90/cwt
- Plant to warehouse TL: $50/cwt
- Inventory carrying cost (warehouse): $10/cwt
- Warehouse to customer LTL: $30/cwt

Either way the cost is the same and a cost equalization point for transportation costs has been reached.

Similarly the location of other markets at the cost equalization point can be calculated.

In this way the areas served by the warehouse and the factory can be defined.

**Effect on Transportation Costs of Adding More Warehouses**

We have seen from the example in the previous section that establishing a warehouse in Boston reduces total transportation costs.

Similarly if a second warehouse is established perhaps in Cleveland we expect total transportation costs to reduce further.

Generally as more warehouses are added to the system we can expect the following:

- The cost of truckload (and car load) shipments to the warehouses to increase.
- The cost of LTL shipments to customers to decrease.
- The total cost of transportation to decrease.

As expected, the major savings is from the addition of the first few warehouses.

Eventually, as more warehouses are added, the savings decrease.

The first warehouse added is located to serve the largest market, the second warehouse the second largest market, etc.

The number of customers served by additional warehouses decreases, and the volume that can be shipped TL to the additional warehouses is less than to the first warehouses.
Warehousing and Distribution Inventory

Warehousing

Warehouses permit high-volume transportation over long distances between factory and markets.

Strategically locating regional warehouses in market areas minimizes the high cost of small-volume shipments from the plant to individual customers.

Warehouses also improve service levels by locating inventory close to the customer for quick delivery. They thus serve both a transportation and marketing purpose.

Types of Warehouses

- Plant warehouses
- Regional warehouses
- Local warehouses

Warehouses may be owned and operated by the supplier or middlemen such as wholesalers or may be public warehouses.

The latter offer a general service to their public that includes providing storage space and warehouse services.

Some warehouses specialize in the kinds of services they offer and the goods they store.

A freezer storage is an example.

The service functions warehouses perform can be classified into two kinds

- The General warehouse
- The Distribution warehouse

General Warehouse

Where goods are stored for relatively long periods and where the prime purpose is to protect goods until they are needed.

There is little handling, little movement, and little relationship to transportation.

Furniture storage or a depository for documents are examples of this type of storage.

It is also used for inventories built in anticipation of seasonal sales.

Distribution Warehouse

Has a dynamic purpose—movement and mixing.

Goods are received in large-volume uniform lots stored briefly, and then broken down into small individual orders of different items required by customer in the marketplace.

The emphasis is on movement and handling rather than on storage.
This type of warehouse is widely used in distribution systems.

The size of the warehouse is not so much its physical size as it is the throughput or volume of traffic handled.

**Characteristics of Warehousing**

As with other elements in a distribution system the objective of a warehouse is to minimize cost and maximize customer service.

The costs of operating a warehouse can be broken down into capital and operating costs.

Capital costs are basically those of space and materials handling equipment.

The space needed depends on the peak quantities that must be stored, the methods of storage, and the need for ancillary space for aisles, docks, offices, and so on.

The major operating cost is labor and the measure of labor productivity is the number of units (e.g. cases) that an operator can move in a day.

This depends on the type of materials handling equipment used, the location and accessibility of stock, warehouse layout, stock location system, and order-picking system used.

**Objectives of Warehousing**

Provide timely customer service.

Keep track of items so they can be found readily and correctly.

Minimize the total physical effort and thus the cost of moving goods into and out of storage.

Provide communication links with customers.

**Warehouse Activities**

To operate a warehouse there are several processing activities that have to take place and the efficient operation of the warehouse depends upon how well these are performed:

*Receive the Goods.* The warehouse accepts goods from outside transportation or an attached factory and accepts responsibility for them. The warehouse must:

Check the goods against an order and the bill of lading
Check the quantities
Check for damage and if necessary fill out damage reports
Perform inspection if required

*Identify the Goods.* The item must be identified with the appropriate stock-keeping unit (SKU) number (part number) and the quantity received recorded.

*Dispatch Goods to Storage.* The goods must be sorted and put away.

*Hold Goods.* The goods are kept in storage and under proper protection until needed.
Pick Goods. Items required from stock must be selected from storage and brought to a marshalling area.

Marshall the Shipment. The goods making up a single order must be brought together and checked for omissions or errors. Order records must be updated.

Dispatch the Shipment. The order must be packaged, shipping documents prepared, and the goods loaded on the right vehicle.

Operate an Information System. For each item in stock a record must be maintained of the quantity in stock, received, and issued and where the SKU is located in the warehouse.

In various ways all of these activities take place in any warehouse.

The complexity depends on the number of SKUs handled, the quantities of each SKU, and the number of orders received and filled.

With any particular mix, to maximize productivity and minimize cost, warehouse management must be concerned with the following:

- Maximum use of space.
- Effective use of labor and equipment.

Maximum Use of Space

Usually the largest capital cost is for space.

This means not only floor space but cubic space as well since goods are stored above the floor as well as on it.

Effective Use of Labor and Equipment

Materials handling equipment represents the second largest capital cost and labor the largest operating cost.

There is a trade-off between the two in that labor costs can be reduced by the use of more materials handling equipment.

Warehouse management will need to ensure the following:

- Selection of the best mix of labor and equipment to maximize the overall productivity of the operation.
- Provision of ready access to all SKUs, insuring that the SKUs should be easy to identify and find. This requires a good stock location system and layout.
- Efficient movement (material handling) of goods.
Factors Influencing Effective use of Warehouses

- Cube utilization and accessibility
- Stock location
- Order picking and assembly
- Packaging

Cube Utilization and Accessibility

Space is required in a warehouse not only for storage but also, for example, for aisles, receiving and shipping docks, offices, and order picking and assembly.

In calculating the space needed for storage, some design figure for maximum inventory is needed.

Suppose that a maximum of 900,000 cartons are to be inventoried and that 30 cartons fit on a pallet. Space is needed for 30,000 pallets and if pallets are stacked three high, then 10,000 pallet positions are required. A pallet is a platform usually measuring 48 x 40 x 4 in.

Example

Assume a warehouse with dockspace 10' X 20', storage space #1, 120' X 4', aisle space 120' X 12' and storage space #2, 120' X 4'

The pallets cannot be placed tight against one another because then they cannot be moved.

A 2-in. clearance must be allowed between them. There is then room for 34 pallet positions along each wall.

Since the pallets are stacked three high there is room for 34 x 3 x 2 = 204 pallets.

As long as all pallets contain the same SKU there is no problem with accessibility.

The SKU can be reached without moving any other product.

However, if a number of SKUs are stored in the area, we want each product to be accessible with a minimum of difficulty.

With different SKUs, stacking of pallets or some other procedure must be used to maximize space utilization.

Stock Location

Stock location or warehouse layout is concerned with where individual items are located in the warehouse.

There is no single universal stock location system suitable for all occasions. But there are a number of basic systems that can be used.

Which system or mix of systems is used depends upon the type of goods being stored, the type of storage facilities required, the throughput, and the size of orders.
Whatever the system, management will want to maintain enough inventory of safety and working stock to provide the required level of customer service, be able to keep track of items so they can be found easily and minimize the total effort required to receive goods, put them away, and retrieve them for shipment.

**Basic Systems of Locating Stock**

*Group Functionally Related Items Together.* Group together those items that are similar in their use (functionally related)—For example put all hardware items in the same area of the warehouse. If Functionally-related items are ordered together this makes the order picking easier. Warehouse personnel will become familiar with where items are located and this will reduce errors.

*Group Fast-Moving Items Together.* If fast-moving items are placed relatively close to the receiving and shipping area, the work of moving them into and out of storage will be minimized. Slower moving items can be placed in more remote areas of the warehouse.

*Group Together Physically Similar Items.* Often physically similar items require their own particular storage facilities and handling equipment. Small packaged items may require shelving while heavy items such as tires or drums require different facilities and handling equipment. Frozen Foods have to be stored together in a freezer.

*Locate Working Stock and Reserve Stock Separately.* Relatively small quantities of working stock—the stock from which withdrawals are made, can be located close to the marshalling and shipping area while reserve stock used to replenish the working stock can be located more remotely.

**Systems for Assigning Specific Locations to Individual Stock Items**

- Fixed location
- Floating location

**Fixed Location**

In this system an SKU is assigned a permanent location or locations and no other items are stored there.

This system makes it possible to store and retrieve items with a minimum of record keeping.

In some small manual systems no records are kept at all.

It is a little like the kitchen cupboards at home where cold cereal boxes are always put away and retrieved from the same shelf.

Everything is nice and simple so one can always find things.

Fixed-location systems usually have poor cube utilization.

If demand is uniform presumably the average inventory is half the order quantity and enough space has to be allocated for a full-order quantity.

Hence, on the average, we could expect about 50% cube utilization.

Fixed-location systems are often used in relatively small warehouses where space is not at a premium, where throughput is small, and where there is a relatively small number of SKUs.
**Floating Location**

In this system goods are stored wherever there is appropriate space for them.

This means that the same SKU may be stored in several locations at the same time and different locations at different times.

The advantage to this system is improved cubic utilization.

However it requires accurate and up-to-date information on item location and the availability of empty storage space so items can be put away and retrieved efficiently.

Modern warehouses using floating-point systems are usually computer-based and a computer assigns free locations to incoming items, remembers what items are on hand and where they are located, and directs the order picker to the right location to find the item.

Thus cube utilization and warehouse efficiency are greatly improved.

**Systems of Order Picking and Assembly**

**Area System**

The order picker circulates throughout the warehouse selecting the items on the order, much as a shopper would in a supermarket.

The items are then taken to the shipping area for shipment.

The order is self-marshalling in that when the order picker is finished, the order is complete.

This system is generally used in relatively small warehouses where goods are stored in a fixed location.

**Modified Area System**

This system operates as the area system except that the working stock and the reserve stock are separated.

A separate work force is used to replenish the working stock from the reserve stock.

**Zone System**

The warehouse is broken down into zones and each order picker (or group of pickers) works only in his or her own area.

An order is divided up by zone and each order picker selects those items in his or her zone and sends them to the marshalling area where the order is assembled for shipment.

Each order is handled separately and leaves the zone before another is handled.

**Sequential Zone System**

The order is broken down into zones and then passed from zone to zone as it is picked.

By the time it exits the last zone, it is assembled for shipment.
**Multiorder System**

This system is the same as the zone system except that rather than handling individual orders, a number of orders are gathered together and all the items divided by zone.

The picker then circulates through his or her area collecting all the items required for that group of orders.

The items are then sent to the marshalling area where they are sorted to individual orders for shipment.

The multiorder system is simple to manage and control, but as the warehouse throughput and size increase it becomes unwieldy.

The zone systems break down the order-filling process into a series of smaller areas that individually can be better managed.

The multiorder system is probably most suited to the situation where there are many items or many small orders with few items.

**Packaging**

The basic role of packaging in any industrial organization is to carry the goods safely through a distribution system to the customer.

In doing so the package must do the following:

1. Identify the product.
2. Contain and protect the product.
3. Contribute to physical distribution efficiency.

For consumer products the package may also be an important part of the marketing program.

Physical distribution must not only move and store products but also identify them.

The package serves as a means of identifying the product in a way that is not possible from its outward appearance.

When shoes are offered in 10 sizes, the package becomes an important identifier.

Packaging must contain and protect the product, often against a wide range of hazards such as shock, compression, vibration, moisture, heat, solar radiation, oxidation, infestation by animals, insects or birds, mold, and bacteria.

Packages are subject to distribution hazards in loading and off-loading, in movement, in transportation, and in warehousing and storage.

The package must be robust enough to protect and contain the product through all phases of distribution.

Packaging is a pure cost that must be offset by the increased physical distribution efficiency that the package can provide.

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There are usually at least three levels of packaging required in a distribution system

1. A primary package that holds the product—the box of cereal.
2. For small packages, a shipping container such as a corrugated box is also needed.
3. A third level of packaging where several primary or secondary packages are assembled into a unit load may also be needed.

**Unitization**

Defined as the consolidation of several units into large units, called unit loads, so there is less handling.

Unit load is a load made up of a number of items, or bulky material, arranged or constrained so the mass can be picked up or moved as a single unit too large for manual handling.

Material handling costs decrease as the size of the unit load increases so it is more economic to move the product by cartons rather than individually and still more economic to move several cartons in one unit load.

This principle is used time and again when we go shopping and put a number of articles into bags and in turn put the bags into the trunk of the car.

In industry, unit loads are used instead of shopping bags.

There are a number of unit-load devices such as sheets, racks, or containers.

One of the most common is the pallet--The pallet is a platform usually measuring 48 x 40 x 4 inches and designed so that it can be lifted and moved by a fork lift industrial truck.

Packages are arranged on it so that several packages may be moved at one time.

Loaded with packages, it forms a cube that is a unit load.

Unitization can be successive.

Shippers place their products into primary packages, the packages into shipping cartons, the cartons onto pallets, and the pallets into warehouses, trucks, or other vehicles.

To use the capacity of pallets, trucks (or other vehicles), and warehouses, there should be some relationship between the dimensions of the product, the primary package, the shipping cartons, the pallet, the truck, and the warehouse space.

The packages should be designed so space on the pallet is fully utilized and so the cartons interlock to form a stable load.

Pallets fit into trucks and railway cars.

The dimensions mentioned earlier, were selected so pallets would fit into nominal 50-foot railway cars and 40-foot truck trailers with a minimum of lost space.

Thus, to get the highest cube utilization, consideration must be given to the dimensions of the product, the carton, the pallet, the vehicle, and the warehouse.
Distribution Inventory

Distribution inventory includes all the finished goods held anywhere in the distribution system.

The purpose of holding inventory in distribution centers is to improve customer service by locating stock near the customer and to reduce transportation costs by allowing the manufacturer to ship full loads rather than part loads over long distances.

Objectives of Distribution Inventory

Provide the required level of customer service.

Minimize the costs of transportation and handling.

Able to interact with the factory to minimize scheduling problems.

Distribution Inventory Systems

Distribution systems vary considerably, but in general they have a central supply facility that is supported by a factory, a number of distribution centers, and finally customers.

Customers may be the final consumer or some intermediary in the distribution chain.

Unless a firm delivers directly from factory to customer, demand on the factory is created by central supply.

In turn, demand on central supply is created by the distribution centers.

This can have severe repercussions on the pattern of demand on central supply and the factory.

While the demand from customers may be relatively uniform, the demand on central supply is not.

It is dependent upon when the distribution centers place replenishment orders.

In turn, the demand on the factory depends on when central supply orders.

The distribution system is the factory's customer, and the way that the distribution system interfaces with the factory has a significant effect on the efficiency of factory operations.

Distribution inventory management systems can be classified into pull, push, and distribution requirements planning systems.

Pull System

Each distribution center first determines what it needs and when and then places orders on central supply--
Each center orders on its own without regard for the needs of other centers, available inventory at central supply, or the production schedule of the factory.

The advantage is that each center can operate on its own and thus reduce communication and coordination expense.

The disadvantage is the lack of coordination and the effect this can have on inventories, customer service, and factory schedules.
Because of these deficiencies, many distribution systems have moved toward more central control.

There are a number of ordering systems that can be used, including the order point and periodic review systems.

Orders are placed on central supply and "pulled" through the system.

**Push System**

In a push system all forecasting and order decisions are made centrally.

Stock is "pushed" out into the system from central supply.

Distribution centers have no say in what they receive.

Different ordering systems can be used, but in general an attempt is made to replace the stock that has been sold and to provide for special situations such as seasonality or sales promotions.

These systems attempt to balance the available inventory with the needs of each distribution center.

The advantage to these systems is the coordination between factory, central supply, and distribution center needs.

The disadvantage is the inability to react to local demand, thus lowering the level of service.

**Distribution Requirements Planning (DRP)**

Distribution Requirements Planning (DRP) is a system of forecasting when the various demands will be made by the system on central supply.

This gives central supply and the factory the opportunity to plan for the goods that will actually be needed and when.

It has the ability to both respond to customer demand and coordinate planning and control.

The system translates the logic of material requirements planning to the distribution system.

Planned order releases from the various distribution centers become the input to the material plan of central supply.

The planned order releases from central supply become the forecast of demand for the factory master production schedule.

**Materials Handling**

Materials handling is the short-distance movement that takes place in or around a building such as a plant or warehouse.

For a warehouse this means the unloading and loading of transport vehicles and the dispatch and recall of goods to and from storage.

In addition, the racking systems used in warehouses are usually considered as part of materials handling.
Objectives of Materials Handling

To increase cube utilization by using the height of the building and by minimizing the need for aisle space as much as possible.

To improve operating efficiency by reducing handling. Increasing the load per move will result in fewer moves.

To improve the service level by increasing the speed of response to customer needs.

Types of Material Handling Equipment

1. Conveyors
2. Industrial Trucks
3. Cranes and Hoists

Conveyors

Devices that move material (or people) horizontally or vertically between two fixed points.

They are expensive, create a relatively fixed route and occupy space continuously.

As a result, they are used only where there is sufficient throughput between fixed points to justify their cost.

Industrial Trucks

Vehicles powered by hand, electricity, or propane.

Diesel and gasoline are not used indoors because they are noxious as well as lethal.

Industrial trucks are more flexible than conveyors in that they can move anywhere there is a suitable surface and no obstructions.

They do not occupy space continuously.

They are the most often used form of materials handling in warehouses and in manufacturing.

Cranes and Hoists

Are able to move materials vertically and horizontally to any point within their area of operation.

They use overhead space and are used to move heavy or large items.

Within their area of operation they are very flexible.

Multiwarehouse Systems

We will look at the result of adding more warehouses to the system.
As might be expected, there is an effect on the cost of warehousing, materials handling, inventories, and packaging as well as transportation.

Our purpose will be to look at how all of these costs and the total system cost behave.

We also want to know what happens to the service level as more warehouses are added to the system.

**Transportation Costs**

In the section on transportation we saw that if shipments to customers are in less than full vehicle lots, by establishing a warehouse in a market area the total transportation cost is reduced.

This is so because more weight can be shipped for greater distances by truck or car load and the less than truckload shipments can be made over relatively short distances.

Generally, then, as more warehouses are added to a system we expect the following:

- The cost of full-load shipments increases.
- The cost of less than full-load shipments decreases.
- The total cost of transportation decreases.
- The major transportation savings are made with the addition of the first warehouses, and eventually, as more warehouses are added, the marginal savings decrease.

**Inventory-Carrying Cost**

The average inventory carried depends upon the order quantity and the safety stock.

The average order quantity inventory in the system should remain the same since it depends upon demand, the cost of ordering, and the cost of carrying inventory.

Safety stock will be affected.

With a constant sales volume, as the number of warehouses increases, the demand on each decreases—this causes an increase in the total safety stock in all warehouses.

**Warehousing Costs**

The fixed costs associated with warehouses are space and materials handling.

The space needed depends upon the amount of inventory carried.

As we have seen, as more warehouses are added to the system, more inventory has to be carried.

This requires more space.

In addition, there will be some duplication of nonstorage space such as washrooms, offices, and so on.

The result is that as the number of warehouses increases, there will be a gradual increase in warehouse space cost.
Operating costs also increase as the number of warehouses increases.

Operating costs depend largely on the number of units handled.

Since there is no increase in sales, the total number of units handled remains the same, as does the cost of handling.

However, the non-direct supervision and clerical costs increase.

**Material Handling Costs**

Material handling costs depend upon the number of units handled.

Since the sales volume remains constant, the number of units handled should also remain constant.

Material handling costs are relatively constant as long as the firm can ship unit loads to the warehouse.

But if the number of warehouses increases to the point that some nonunitized loads are shipped, then it follows that material handling costs increase.

**Packaging Costs**

Per unit packaging costs will remain the same.

But since there will be more inventory, total packaging costs will rise with inventory.

**Total System Cost**

A valid comparison can thus be made.

We have assumed that total system sales remain the same.

Up to a point total costs decrease and then start to increase.

It is the objective of logistics and supply chain management to determine this least cost point.

**System Service Capability**

The other side of the coin is the service capability of the system.

One way of approaching this is by estimating the percentage of the market that is served within a given period.

As expected, the service level increases as the number of warehouses increases.

It increases rapidly from one to two warehouses and much less rapidly as the number is further increased.
Just-in-Time Manufacturing (JIT)

In the past 20 years manufacturing has become much more competitive, not just in North America but globally.

Countries such as Japan and others on the Pacific Rim are able to produce goods of consistently superior quality and deliver them to North American markets at a competitive price and on time.

They have responded to changing market needs and in many cases have detected those needs before the consumer.

The Walkman, developed by Sony, is an example of Japanese market awareness.

Because of such competition, North America has lost the edge in the manufacture of such goods as radios, televisions, cameras, and shipbuilding.

How have the Japanese been able to do this?---It has nothing to do with culture, geography, government assistance, new equipment, or cheap labor.

What it does have to do with is a practice referred to as just-in-time manufacturing.

Just-in-Time Manufacturing (JIT) is a philosophy that relates to the way a manufacturing company organizes and operates its business.

It is not a magic formula or a set of new techniques that suddenly makes a manufacturer more productive.

Rather it is the very skillful application of existing industrial and manufacturing engineering principles.

Japanese have not taught us new tricks but have forced us to look at manufacturing with a different philosophy.

Just-in-Time Philosophy

Just-in-time manufacturing can be defined in many ways, but the most popular is the elimination of waste.

Waste is defined as anything other than the minimum amount of equipment, parts, space, material, and workers' time that is absolutely necessary to add value to the product.

This means there should be no surplus, there should be no safety stocks, and lead times should be a minimum: "If you can't use it now, don't make it now."

Value

What is of value to the user?

It is having all the right parts and quantities at the right time and place.

It is having a product or service that does what the customer wants, does it well and consistently, and is available when the customer wants it.

Value satisfies the actual and perceived needs of the customer and does it at a price the customer can afford and feels is reasonable.
Another word for this is quality.

Quality is meeting and exceeding the customers' expectations.

Value starts in the marketplace where marketing must decide what the customer wants.

Design engineering must design the product so it will provide the required value to the customer.

Manufacturing engineering must design a process to make the product, and then manufacturing must build the product according to these specifications.

The loop is complete when the product is delivered to the customer.

Adding value to a product does not mean adding cost.

Users are not concerned with the manufacturer's cost but only with the price they must pay and the value they receive.

There are many activities that increase cost without adding value, such as counting, moving, storing, expediting, searching for, and inspection--As much as possible, these activities should be eliminated.

Adding cost is waste. Anything in the product cycle that does not add value to the product is waste.

**Waste Caused by Poor Product Specification and Design**

The making of waste starts with the policies that management sets to respond to the needs of the marketplace.

Management is responsible for establishing policies for the market segments that they wish to serve and for determining how specialized the product line is to be.

These policies affect the costs of manufacturing.

For example, if the range and variety of product is large, production runs will be short and machines will have to be changed over frequently.

There will be little opportunity to use specialized machinery and fixtures.

On the other hand, a company with a limited product range can likely produce goods on an assembly line basis and take advantage of special-purpose machinery.

In addition, the greater the diversity of products, the more complex the manufacturing process becomes, and the more difficult it is to plan and control.

There is a way that companies can specialize in the products they make and at the same time offer the customer a wide range of options.

This is to standardize the component parts that are used in the different models they make.

They can then supply the customer with a wide variety of models and options made from standard components.

Parts standardization has a number of advantages in manufacturing.
It creates larger quantities of specific components that permit longer production runs.

This in turn makes it more economic to use more specialized machinery, fixtures, and assembly methods.

Standardization reduces the planning and control effort needed, the number of items required, and the inventory that has to be carried.

The "ideal" product is one that meets or exceeds the needs of the customer, makes the best use of material, and can be manufactured with a minimum of waste (at least cost).

As well as satisfying the customer, the product's design determines both the basic manufacturing processes that have to be used and the cost and quality of the product.

The product should be designed so it can be made on the most productive process and so there is a minimum number of operations and motions needed in manufacture and assembly.

There should be as few parts as possible.

The product should not be "overdesigned".

The designer must be careful about features that are important to the customer but should avoid overspecifying features that are not: "Don't gold plate when chrome will do!"

**Waste Caused in Manufacturing**

Manufacturing takes the design and specifications of the product and, using the manufacturing resources, converts them into useful products.

But first manufacturing engineering must design a system capable of making the product.

This is done by selecting the manufacturing steps and the machinery and equipment and by designing the plant layout and work methods.

Manufacturing must then plan and control the operation to produce the goods.

This involves manufacturing planning and control, quality management, maintenance, and labor relations.

There are several sources of waste in this series.

The Toyota company has identified seven important sources of waste. The first four relate to the design of the manufacturing system and the last three to the operation and management of the system:

The Process. The best process is one that has the capability to consistently make the product with an absolute minimum of scrap in the quantities needed and with the least cost added. Waste, or cost, is added to the process if the wrong type or size of machines are used, if the process is not being operated correctly, or if the wrong tools and fixtures are used.

Methods. Waste is added if the methods of performing tasks by the operators cause wasted movement, time, and effort. Activities that do not add value to the product should be eliminated. Searching for tools, walking, or unnecessary motions are all examples of waste.
Movement. Moving and storing components does not add value. For example, goods received may be stored and then issued to production. This requires labor to put away, find, and deliver to production; records must be kept and a storage system maintained; all these add cost without adding value to the product. Poorly planned layouts may make it necessary to move product over long distances; this increases the movement cost and, as well, may add to storage and record-keeping costs.

Product Defects. Defects interrupt the smooth flow of work. If the scrap is not identified, the next work station receiving it will waste time trying to use the detective parts or waiting for good material. Schedules will have to be adjusted. If the next step is the customer, then the cost will be even higher. Sorting out or reworking defects are also waste.

Waiting Time. There are two kinds of waiting time, that of the operator and that of material. If the operator has no productive work to do or there are delays in getting material or instructions, then there will be waste. Ideally, material passes from one work center to the next and is processed without waiting in queue.

Overproduction. Overproduction is producing product over and above that needed for immediate use. When this occurs, raw material and labor are consumed for unneeded work resulting in unnecessary inventories. Considering the costs of carrying inventory, this can be very expensive. Overproduction causes extra handling of material and extra planning and control effort and leads to quality problems. Because of the extra inventory and work in process, overproduction adds confusion, tends to bury problems in inventory, and often leads to producing components that are not needed instead of working on those that are needed. Overproduction is not necessary as long as market demand is met. Machines and operators do not always need to be fully utilized.

Inventory

Inventory costs money to carry and excess inventory adds extra cost to the product.

However, there are other costs in carrying excess inventory.

A better product suggests one that has features and quality superior to others.

The ability to take advantage of product improvement opportunities depends on the speed with which engineering changes and improvements can be implemented.

If there are large quantities of inventory to work through the system, it takes longer and is more costly before the engineering changes reach the marketplace.

Lower inventories improve quality.

Companies can offer better prices if their costs are low.

Lower inventories reduce cost.

Also, if work-in-process inventory is reduced, then less space is needed in manufacturing, resulting in cost savings.

Responsiveness to the marketplace depends on being able to provide shorter lead times and better due date performance.

Manufacturing lead time depends on queue and queue depends on the number and the batch size of the orders in process.
If batch size is reduced, then so will the queue and lead time.

Forecasts are more accurate for nearer periods of time--reducing lead time improves forecast accuracy and provides better order-promising and due date performance.

**Just-in-Time Environment**

There are a number of elements that are characteristic of a JIT environment.

They may not all exist in a particular manufacturing situation.

In general they provide a number of principles to help in the development of a JIT system. These can be grouped as:

- Flow Manufacturing
- Process Flexibility
- Total Quality Control
- Uninterrupted Flow
- Supplier Relations
- Employee Involvement

**Flow Manufacturing**

The just-in-time concept was developed by companies like Toyota and some of the major appliance and consumer electronic manufacturers.

These companies manufacture goods in a repetitive manufacturing environment.

Repetitive manufacturing is the production of discrete units on a line flow basis.

In this type of system the work stations required to make the product, or family of products, are located close together and in the sequence needed to make the product.

Work flows from one work station to the next at a relatively constant rate and often with some material handling system to move the product.

These systems are suitable for a limited range of similar products such as automobiles, televisions, or microwave ovens.

Because work centers are arranged in the sequence needed to make the product, the system is not suitable for making a wide variety of different products.

Demand for the family of products must be large enough to economically justify setting up the line.
Flow systems are cost-effective because:

Work stations are designed to produce a limited range of similar products, machinery and tooling can be specialized.

Material flows from one work station to the next, there is very little buildup of work-in-process inventory.

Manufacturing lead times are short because of the low work-in-process inventory.

In their purest form flow lines are inflexible.

They can only produce a limited family of similar parts, and the quantity must be sufficient to economically justify its use.

Because it is so cost-effective, this system of manufacturing should be used wherever and to whatever extent possible.

**Work Cells**

Many companies do not have a product line that lends itself to flow manufacturing.

The quantities of specific parts are not sufficient to warrant it.

Companies with this kind of product line usually organize their production on a functional basis.

This means that the same or similar operations are grouped together.

Lathes will be placed together as will milling machines, drills, and welding equipment.

Product moves from one work station to the other in lots or batches.

This type of production produces long queues, high work-in-process inventory, and long lead times as well as considerable materials handling.

Very often this kind of layout can be improved. It depends on the ability to detect product flows.

This can be done by grouping products together into product families.

Products will be in the same family if they use common work flow or routing, materials, tooling, setup procedures, and if possible, cycle times.

Work stations can then be set up in miniature flow lines or work cells.

Parts can pass one by one, or in very small lots, from one work station to the next.

This has a number of benefits:

- Queue and lead times going through the cell are reduced drastically.
- Production activity control and scheduling are simplified--The cell is one work center to control as opposed to five in a conventional system.
- The floor space needed is reduced.
- Work cells permit high-variety, low-volume manufacturing to be repetitive.
To be really effective, product design and process design must work together.

Component standardization becomes even more important.

**Process Flexibility**

Process flexibility is desirable so the company can react swiftly to changes in the volume and the mix of the products the company manufactures.

To achieve this, machinery must be flexible and there must be an ability to change over quickly from one product to another.

**Machine Flexibility**

Machinery used should be flexible and inexpensive.

Here it often makes more sense to have two relatively inexpensive general-purpose machines than one large, expensive special-purpose piece of equipment.

Smaller general-purpose machines can be adapted to particular jobs with appropriate tooling.

Having two instead of one makes it easier to dedicate one to a work cell. Ideally the machinery should be low cost and movable.

**Setup**

To have process flexibility, it is essential to be able to change quickly from one product to another. This requires low setup times. In addition, low setup times also have the following advantages:

**Reduced Economic Order Quantity**

Economic lot size depends on the setup cost.

If the setup time can be reduced, then the lot size can be minimized.

For example, if the economic order quantity is 100 units and the setup can be reduced to 25%, then the economic order quantity decreases to 50.

Inventory is cut in half and queue and lead times are reduced.

Reductions in setup of this and greater magnitude are very possible.

The general opinion is that setup can be cut 50% by organizing the work and having the right tools and fixtures available when needed.

For example, in one instance a changeover on a die press was videotaped.

The operator doing the changeover was not in view for more than 50% of the time.
He was away from the machine getting tools, dies, and so forth.

One system for setup reduction, called the "four-step method" claims that reductions of 90% can be achieved without major capital expense.

This is accomplished by organizing the preparation, streamlining the setup, and eliminating adjustments.

**Reduced Queue and Manufacturing Lead Time**

Manufacturing lead time depends mostly on the queue.

In turn, queue depends upon the order quantity and scheduling.

Reducing setup time reduces the order quantity and queue and lead times.

**Reduced Work-in-Process (WIP) Inventory**

Work-in-process inventory depends on the number of orders in process and their size.

If the order quantity is reduced, the WIP is reduced.

This frees up more floor space allowing work centers to be moved closer together.

This reduces handling costs and promotes the creation of work cells.

**Improved Quality**

When order quantities are small, defects have less time to be buried.

Because they are more quickly and easily exposed, there is more likelihood that their cause will be detected and corrected.

**Improved Process and Material Flow**

Inventory acts as a buffer, burying problems in processes and in scheduling.

Reducing inventory reduces this buffer and exposes problems in the production process and in the material control system.

This gives an opportunity to correct the problems and improve the process.

**Total Quality Control**

Quality starts in the marketplace

Quality Is defined as meeting or exceeding the users' expectations.
Quality is important for two reasons:

Quality is what is supplied to the customer, and if the product is defective, the customer will be dissatisfied. If a process produces scrap, it creates disrupted schedules that delay supplying the customer, increases inventory or causes shortages, wastes time and effort on work centers, and increases the cost of the product.

**Who is the User?**

Ultimately it is the company's customer—but the user is also the next operation in the process.

Quality at any one work center should meet or exceed the expectations (needs) of the next step in the process. This is important in being able to maintain the uninterrupted flow of material.

If defects occur at one work center and are not detected until subsequent operations, then time will be wasted and the quantity needed will not be supplied.

For manufacturing, quality does not mean inspection of the product to segregate good from bad parts.

What manufacturing must do is be sure that defects will not be made in the first place.

This means that the process must be capable of producing the required quality consistently and with as close to zero defects as possible.

Manufacturing must do all it can to improve the process to achieve this and then monitor the process to make sure it remains in control.

Daily monitoring can best be done by the operator.

If defects are discovered, the process should be stopped and the cause of the defects corrected.

The benefits of a good-quality program:

- Less scrap
- Less rework
- Less inventory (inventory just in case there is a problem)
- Better on-time production
- Timely deliveries
- More customers who are more satisfied

For a process to continue to produce the required quality, machinery must be maintained in excellent condition, and this can best be achieved through a program of preventive maintenance.

This is important for more reasons than quality.

Low Work-in-Process inventories means there is little buffer available.

If a machine breaks down, it will quickly have an effect on other work centers.

Preventive maintenance starts with daily inspections, lubrication, and cleanup.
Since operators usually understand how their equipment should "feel" better than anyone else, it makes more sense to have them handle this type of regular maintenance.

**Uninterrupted Flow**

Ideally material should flow smoothly from one operation to the next with no delays.

This is most likely to occur in repetitive manufacturing where the product line is limited in variety.

However, the concept should be worked toward in any manufacturing environment.

There are a number of conditions that are needed to achieve uninterrupted flow of materials.

**Uniform Plant Loading**

The work done at each work station should take about the same time.

In repetitive manufacturing this is called balancing the line.

This means that the time taken to perform tasks at each work station on the line is the same or very nearly so.

This way there will be no bottlenecks and no buildup of work-in-process inventory.

**Pull System**

Demand on a work station should come from the next work station.

The pull system starts at the end of the line and pulls product from the preceding operation as needed.

The preceding operation does not produce anything unless a signal is sent from the following operation to do so.

The system for signaling demand depends on the physical layout and conditions in the plant.

The most well known pull system is Kanban.

The details vary about Kanban, but it is basically a two-bin, fixed-order quantity order point system.

A small inventory of parts is held at the user operation, for example, two part bins.

When one bin is used up, it is sent back to the supplier and is the signal for the supplier operation to make a container of parts.

Containers are standard size and contain a fixed number of parts (order quantity). This system also makes the counting and control of WIP inventory much easier.
Valid Schedules

There should be a well-planned valid schedule.

The schedule sets the flow of materials coming into the factory and the flow of work through manufacturing.

To maintain an even flow, the schedule must be level.

In other words, the same amount should be produced each day.

Furthermore, the mix of products should be the same each day.

For example, suppose a company makes a line of dog clippers composed of three models: economy, standard, and deluxe.

The demand for each is 500, 600, and 400 per week, respectively, and the capacity of the assembly line is 1500 per week.

The company can develop a schedule that will satisfy demand and will be level on the basis of capacity.

However, inventory will build up, and if there is no safety stock, a variation in demand will create a shortage.

For example, if there is a surge in demand for the deluxe model in week 1, none will be available for sale in week 2.

An alternative schedule can reduce schedule inventory and the ability to respond to changes in model demand can be increased.

The number of setups increases, but if setup times are reduced, this is not a problem.

The concept can be carried further by making something of each model each day. In this case it would mean producing 100, 120, and 80 of each model each day.

If the line had complete flexibility, these could be produced in the following mixed sequence of 15. This is repeated 20 times during the day for a total output of 300:

E: Economy

S: Standard ESD, ESD, ESD, ESD, SES

D: Deluxe

The company makes something of everything each day in the proportions to meet demand.

Inventories are a minimum.

If demand shifts between models, the assembly line is able to respond daily. This is called mixed-model scheduling.

The schedule is leveled, not only for capacity, but also for material.
Linearity

The emphasis on JIT is on achieving the plan, no more, no less.

This concept is called linearity and is usually achieved by scheduling to less than full capacity.

If an assembly line is capable of producing 100 units per hour, then it can be scheduled for perhaps 700 units for an 8-hour shift.

If there are problems during the shift, there is extra time so the 700-unit schedule can be maintained.

If there is time left over after the 700 units are produced, then it can be spent on jobs such as cleanup, lubricating machinery, getting ready for the next shift, or solving problems.

Supplier Relations

If good schedules are to be maintained and the company is to develop a just-in-time environment, then it is vital to have good reliable suppliers.

They establish the flow of materials into the factory.

The JIT philosophy places a lot of emphasis not only on supplier performance but also on supplier relations.

Suppliers are looked upon as co-producers and not as adversaries.

The relationship between them should be one of mutual trust and cooperation.

The buyer expects that the supplier will:

Be able to supply the quality needed all the time so there will be no need for inbound inspection--This implies that the supplier will have, or develop, an excellent process quality improvement program.
Be able to make frequent deliveries on a Just-in-Time basis--This implies that the supplier will become a just-in-time manufacturer.
Be able to work with the buyer to improve performance, quality, and cost.

For a supplier to start to become a just-in-time supplier a long-term relationship must be established.

 Suppliers need to have that assurance so they can plan their capacity and make the necessary commitment to a single customer.

In return, the supplier has the following benefits:

Has a greater share of the business with long-term security.
Is able to plan more effectively.
Is more competitive as a just-in-time supplier.
Employee Involvement

A successful JIT environment can only be achieved with the cooperation and involvement of everyone in the organization.

The concepts of elimination of waste and continuous improvement that are central to the JIT philosophy can only be achieved through cooperation by people.

Instead of being the receivers of orders, the operators must take responsibility for improving processes, controlling equipment, correcting deviations, and becoming vehicles for continuous improvement.

Their jobs include not only direct labor but also a variety of traditionally indirect jobs such as preventive maintenance, some setup, data recording, and problem solving.

One important aspect of JIT is that employees must become more flexible in the tasks that they can perform.

Just as machinery must be flexible and capable of quick changeover, so must the people who run them.

The role of management must change.

Traditionally management has been responsible for planning, organizing, and supervising operations.

Many of their traditional duties are now performed by line workers.

In a JIT environment there is more emphasis placed on the leadership role.

Managers and supervisors must become coaches and trainers and develop the capability of employees and provide coordination and leadership for improvements.

Traditionally staff has been responsible for such things as quality control, maintenance, and record keeping.

Under JIT line workers perform many of these duties.

Staff responsibilities then become those of training and assisting line workers to perform the staff duties assigned to them.

Manufacturing Planning and Control

No matter what planning and control system is used, the four basic questions have to be answered:

- What are we going to make?
- What do we need to make it?
- What do we have?
- What do we have to get?

The logic of these questions always applies whether we are going to make a Sunday dinner or a modern jet aircraft.
Systems for planning and control vary.

A manufacturing planning and control system (manufacturing resource planning) has proved effective in any manufacturing environment.

The complexity of the manufacturing process, the number of finished items, and parts, the levels in the bill of material, and the lead times have made the planning and control problems either simple or complex.

If anything can be done to simplify these factors, then the planning and control system will be simpler.

In general, the JIT philosophy simplifies these factors, thus making the planning and control problems easier.

The discussion that follows will look at how the various parts of the manufacturing planning and control system relate to a JIT environment.

In general, JIT manufacturing does not make obsolete the manufacturing planning and control system but in some ways does change the focus.

**Forecasting**

The major effect that JIT has on forecasting is shortened lead time.

This does not affect forecasting for business planning or production planning but it does for master production scheduling.

If lead times are short enough that production rates can be matched to sales rates, then forecasting for the master production schedule becomes less important.

**Production Planning**

The JIT system emphasizes relationships with suppliers.

One purpose of production planning is to arrange for long-lead-time purchases.

The JIT process has the potential for reducing those lead times, but more important, it provides an environment in which the supplier and buyer can work together to plan the flow of material.

**Master Production Scheduling**

Some scheduling factors are affected by JIT.

Master scheduling tries to level capacity and JIT tries to level the schedule based on capacity and material flow.

The shorter lead times reduce time fences and make the master production schedule more responsive to customer demand.

The ideal lead time is so short that the company can respond to actual sales and not to forecast.

Where the company builds to a seasonal demand or to satisfy promotion, a forecast is still necessary. Planning horizons can also be reduced.
The JIT system requires a stable schedule to operate.

This principle is supported by the use of time fences.

These are established based on lead times and the commitment of materials and resources.

If lead times can be reduced through JIT practices, then the time fences can be reduced.

Traditionally weekly time buckets are used.

This has given manufacturing an organizational buffer to plan and organize actual work flow.

Because of reduced lead times and schedule stability, it is possible to use daily time buckets in a JIT environment.

**Material Requirements Planning**

Material Requirements Planning (MRP) plans the material flow based on the bill of material, lead times, and available inventory.

Just-in-time practices will modify this approach in a number of ways.

The MRP time buckets are usually 1 week. As lead times are reduced and the flow of material improved, these can be reduced to daily buckets.

The MRP netting logic is based on generating order quantities based on the planned order releases of the parent, the inventory on hand, and any order quantity logic that is used.

In a pure JIT environment there is no inventory on hand and the order quantity logic is to make exactly what is needed.

Therefore, there is no netting required.

If the lead times are short enough, component production occurs in the same time bucket as the gross requirement and no offsetting is required.

Bills of material can frequently be flattened in a JIT environment.

With the use of work cells and the elimination of many inventory transactions, some levels in bills of material become unnecessary.

Both MRP and JIT are based on establishing a material flow.

In a repetitive manufacturing environment this is set by the model mix and the flow rate.

The product to be made is determined by the need of the following work station, which is ultimately the assembly line.

However, many production situations do not lend themselves to level scheduling and the pull system:

Some examples are as follows:

Where the demand pattern is unstable
Where custom engineering is required
Where quality is unpredictable
Where volumes are low and occur infrequently.

**Capacity Management**

Capacity planning's function is to determine the need for labor, equipment, and material in order to meet the priority plans.

Leveling schedules make the job easier.

Capacity control focuses on adjusting capacity on a daily basis to meet demand.

Leveling should make this task easier, but so will the JIT emphasis on cutting out waste and problems causing ineffective capacity use.

Linearity, the practice of scheduling extra capacity, will improve the ability to meet priority schedules.

**Inventory Management**

The JIT system will reduce the inventory in the system, and in some respects this should make inventory management easier.

However, if order quantities are reduced and annual demand remains the same, more work orders and more paperwork must be tracked and more transactions recorded.

The problem then is to reduce the number of transactions that have to be recorded.

One system that is used is called “backflushing,” or post deduct.

Material flows from raw material to work in process to finished goods.

In a post deduct system raw materials are recorded into work in process.

When work is completed and becomes finished goods, the work-in-process inventory is relieved by multiplying the number of units completed by the number of parts in the bill of material.

The system works if the bills of material are accurate and if the manufacturing lead times are short.

**Summary**

The just-in-time philosophy and techniques that seek the elimination of waste and continuous improvement were developed for repetitive manufacturing and are perhaps most applicable there.

However, many of the basic concepts are appropriate to any form of manufacturing organization.

In intermittent manufacturing material is processed at intervals in lots or batches and not continuously.

It is characterized by large variation in product design, process requirements, and order quantities.
In the extreme every job is made to customer specification and there is no commonality in design.

Commonality exists in the processes that are used.

A contract machine shop is an example.

However, many companies make a variety of standard products in small volumes that are manufactured either to stock or to customers order.

Many of these have families of products, and if these can be identified, then work cells can be set up.

No matter what the characteristics of the intermittent shop, there are several JIT principles that can be applied:

Employee involvement

Workplace layout

Total quality control

Total preventive maintenance

Setup time reduction

Supplier relations

Inventory reduction

The JIT manufacturing environment requires a planning and control system.

The manufacturing resource planning system is complementary to JIT manufacturing.

The way that some of the functions are used change to reflect the differences in the manufacturing environment, but overall the functions performed in the MRP2 system are those that have to be performed in a JIT planning and control system.
Handling Obsolete Equipment/Materials, Surplus Equipment/Materials, and Scrap. (Organizing and Controlling the Storage/Disposal of Hazardous/Regulated Materials)

Investment Recovery

The Role of the Materials Management and the Purchasing and Supply Departments

Why is investment recovery and surplus disposal assigned to purchasing? Usually no other department in the firm is as well qualified to perform the task. The professional and managerial skills required for a successful disposal operation are also required to do a good job of buying. No other department of a firm is as concerned with or as informed about materials, their markets, and related operating practices as the purchasing department.

The purchasing department routinely buys a large variety of raw materials, component parts, and equipment. It has knowledge about who makes these materials, what other firms use them, how they are used in its own firm, and how much they cost. This is the precise knowledge needed to sell surpluses of these materials successfully. Also, a relatively large number of buyers in the metal industries regularly buy some form of scrap or other surplus materials for their own manufacturing purposes.

Disposing of Surplus Profitably

When material is declared surplus, the materials management, purchasing, or investment recovery unit, as appropriate, is informed. Following this action, disposal is made by one of seven methods:

1. Use within the firm.
2. Return to the supplier.
3. Direct sale to another firm.
4. Sale to a dealer or broker
5. Sale to employees.
6. Donations to educational institutions.
7. Some combination of the preceding methods.

Buying Surplus Material

Purchasing departments not only sell surplus material; at times they also buy it. Purchasing managers often can find real bargains by shopping among surplus dealers. These dealers can supply almost anything—from transistors to molding machines.

Managing and Disposing of Hazardous Materials (Potential Courses of Action)

The most effective action is to reduce or eliminate the generation of hazardous waste in the first place. Recycling and reusing certain materials often reduces the volume of objectionable materials. Cleaning chemicals to remove hazardous contaminants is another approach used rather widely. Yet another approach to “cleanse” a chemical is to use it in a chemically reactive process that will neutralize it.

Basically, two approaches can be used in disposing of hazardous materials, along with the packaging or containers in which some of the materials were originally shipped.

Purchasing may outsource the entire operation to a specialized contractor or consulting firm in this business. This includes any laboratory testing required to shipment, packaging, transportation, contracting with a hazardous material disposal site, and record keeping and administrative requirements. Purchasing may work directly with a transporter licensed by the Department of Transportation (or federal and state EPAs) to haul the hazardous material --- and handle the other functions itself. Or, of course, it can handle only a part of the other functions and subcontract some along with the transportation activity.
At the disposal sites, most of the materials are incinerated. Other methods include “encapsulation” and use of other methods of destruction, either chemical or physical.

**Purchasing and the Environment**

**Key Environmental Laws**

Lack of knowledge of specific environmental laws does not insulate purchasers and their companies from potential criminal liability for violations. Although federal environmental law specifies that a company must "knowingly" violate a provision, proving your company's innocence can be expensive and time consuming.

**Clean Air Act (CAA)**

A comprehensive and complex law empowering the EPA to set national air quality standards and delegate its enforcement to individual states to abate air pollution. Major provisions of the CAA most likely to affect purchasers include the: (1) acid rain provision requiring U.S. coal-burning power plants to reduce sulfur dioxide emissions by 50 percent by the year 2000, (2) toxic emissions provision requiring a 90 percent reduction in the emission of 189 chemicals, (3) ozone-depleting chemicals (ODC) provision to eventually eliminate the production and use of chlorofluorocarbons, halons, carbon tetrachloride, and other ODCs, and (4) mobile emissions provision requiring a 90 percent reduction of emissions of pollutants from automobiles.

**Toxic Substances Control Act (TSCA)**

This act established a master database, the Toxic Substances Control Act Inventory List (TSCAIL), of every chemical approved for use in the United States. Companies are not allowed to manufacture or use any chemical not on this list. Every company must notify the EPA of any chemical it uses or sells, and refrain from manufacturing or using any new chemical without satisfying the TSCA’s prenotification rules. Purchasers may want to require their suppliers to warrant that any chemical or chemical mixture supplied is listed by the EPA on the TSCAIL.

**Resource Conservation and Recovery Act (RCRA)**

This act, which controls how hazardous chemicals are disposed of, broadly defines hazardous waste to include almost every chemical. RCRA applies to every company that generates more than approximately one-third of a 55-gallon drum of waste per month. Because the law assigns "cradle-to-grave" responsibility to hazardous waste generators, purchasers contracting for waste disposal may want to: (1) deal only with competent and reputable disposal suppliers that have all necessary EPA permits, (2) require a supplier to warrant that all its employees are trained in handling your company’s type of waste, and (3) insist on the right to inspect the waste disposal facility and its EPA permits.

**Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund Act)**

The company or companies that originally generated the waste often are held responsible for all of the clean up costs for toxic waste sites, also called Superfund sites. CERCLA requires the federal government to inventory all toxic waste sites, regardless of when they were created, set priorities for their clean up, and implement site clean up.

**Superfund Amendments and Reauthorization Act (SARA)**

SARA deals with three aspects of toxic waste: clean ups; emergency response to massive spills and other chemical emergencies; and the Emergency Planning and Community Right-to-Know Act (EPCRA). The EPCRA section requires every plant that is using or storing substantial amounts of dangerous chemicals to disclose that fact to the community. Purchasers may be responsible for keeping track of the amount and types of chemicals that enter and leave the plant and the material safety data sheets.
Hazardous Materials Transportation Uniform Safety Act (HMTUSA)  
This act applies to shippers and carriers of hazardous materials, as well as those manufacturers who fabricate and retest containers used for hazardous materials (hazmat). Purchasers’ responsibilities under HMTUSA may include: (1) understanding and complying with the hazmat labeling, packaging, handling, and documentation rules; (2) using only carriers with proper hazmat safety permits; and (3) implementing a hazmat training program that meets Department of Transportation requirements.

Total Cost Revisited: Don't Forget Disposal!  
By considering the disposal variable within a total cost model, the issue becomes highly visible to decisionmakers.

During decision making, embracing every cost issue of all affected operations can enhance competitiveness. To often, when analyzing and optimizing the costs of one function or department, other areas are sacrificed - and frequently to the overall detriment of the firm. To overcome this, purchasers can involve the total cost concept which today includes the environmental variable.

The Environmental Variable and Waste Management  
The 1980s brought to the surface yet another total cost variable formerly left buried in the financial "catch all" of corporate overhead. This environmental variable, created with the enactment of the Resource Conservation and Reclamation Act of 1976 (RCRA), assigned "cradle-to-grave" responsibility. As a result, companies with disposal requirements must calculate the environmental cost of doing business.

The disposal cost question became: "How can we legally dispose of our waste at minimal cost?" Both internal and external reuse and recycling efforts increased, as well as the application of waste treatment technologies to reduce both volume and offensive characteristics. The operative cost variables of waste management follow.

Basic haulage or "tipping" rates. This is the simplest item to measure.  
Development of new alternative relationships. Moving beyond the hauler, sourcing activities include external waste treatment service companies, suppliers of treatment materials and equipment, third-party contractors, and potential users of recycled or reclaimed materials.  
Internal handling. Waste becomes increasingly expensive when alternative disposal strategies call for sorting and collecting activities.  
Process costs. Depending upon the outcome of the make or buy decision, these costs may include acquiring the necessary technology and capital equipment for on-site treatment.  
Materials and supplies. If operating internally, a process will require additional materials such as treatment chemicals, filter media, and MRO items ranging from spare parts to personal safety supplies.  
Direct labor. Process equipment operators, but also additional materials handlers and maintenance personnel.  
Management and supervision.  
Transportation. Shipment of processed materials to a potential outside user, or to and from a treatment facility.

Waste Minimization  
As successful as this total cost approach within waste management may be, the most successful approach, albeit more cumbersome to implement, may be waste minimization. Here, the principal assumption is that waste disposal costs are best addressed through the avoidance of waste creation. Four generic approaches for eliminating waste at its source follow.
Different materials or supplies. Substitution of less hazardous; easier to collect, segregate or treat; or have an alternative use or a ready market for recycling. As an example, more expensive materials may be offset by improved yield factors and/or reduced disposal costs.

Different methods. Altering materials handling techniques, maintenance processes, waste collection, and segregating procedures represent some of the "softer" solutions available. A use or application variable, the segregating process, is frequently offset by substantially higher scrap values. Initial segregation is far more cost effective than subsequently sorting co-mingled waste streams. Improved inventory control can preclude creating obsolete product due to shelf life expiration.

Changes to technology. Modifications may be made to existing process designs, equipment, and the manner in which they interconnect including information collection and reporting on performance. Real-time monitoring and control of operations can potentially avoid the manufacture of off-spec product. Redesign of final products. Recognition of total cost on a product-by-product basis reveals those which may be marginally profitable because of escalating component waste disposal costs. Product redesign and reformulation can potentially reduce these.

All cost elements outlined exist in all firms. Only recently, however, have their recognition and appreciation of their interrelationships begun to emerge. As companies continue to divide their operations into finer and more discreet business units, their ability to grasp the breadth of the total cost concept - which includes the environmental variable - becomes simpler.

A Framework for Action

Starting with the waste generated material, options can be identified by following material flows backward through the supply chain to their origins. This generic framework may be modified to fit particular industry characteristics.

Assess residual outputs: quality and quantity, source or generation point, current disposal method, cost or revenue from current method, hazards and liabilities, and compliance issues.

Assess product outputs: quality and quantity, packaging, inventory practices, shipping modes, and customer characteristics.

Review processes: material and product flows, processes/equipment employed, bills of material, raw materials and work-in-progress inventory practices, production throughput and scheduling, and operating procedures.

Identify inputs: name of items and/or materials, suppliers, quantities, prices, delivery modes, handling, and storage practices.

Develop possible options: substitute materials, other suppliers, potential for supplier returns, improved procedures, salability of waste streams including off-spec products and materials, potential for sales to existing customers.

Review impacts of options: waste stream quantities, product offerings, processes employed, materials and components procured, operating procedures, and benefits. The benefits can include costs avoided, revenues generated, energy recovered, and equivalent market value when used internally.

Disposing of Hazardous Waste

Contracting with a waste-removal service mandates exceptional negotiation skills. The traditional low-quote process must be balanced with other considerations. One of the most overlooked aspects of the purchasing process has always been material disposal. Unwanted, surplus, excess, waste, or scrap equipment and materials suffer from the "out-of-sight, out-of-mind" syndrome. When the materials turn out to be dangerous or hazardous to people or the environment, the task suddenly takes on critical importance. "Out of sight, out of mind" just might put you out of business.

To date, there is no legally sound, court-tested method of transferring risk or responsibility to a third party. Most laws are based on the "cradle-to-the-grave" concept. The initial user is responsible for damage,
loss, injury, or contamination caused by a particular hazardous substance from the time it is originally shipped to the user until the substance is destroyed or degrades to the point where it no longer poses a hazard. Some substances take thousands of years to decay into a harmless substance.

The original manufacturer's responsibility is to use due caution in the manufacture and shipment, to train and protect its own employees, and to provide the user with a material safety data sheet (MSDS) along with the shipment.

Had the initial user not ordered the material, the manufacturer would not have created the material in the first place. How that initial user handles, uses, transports, stores, and eventually disposes of the material is beyond the manufacturer's control. These arguments will usually prevail in court. Purchasing's responsibility is to dispose of these materials legally while protecting the interests and mitigating the risk of the owning entity. There are some substantial penalties for improperly disposing of hazardous wastes. Lawsuits for injury, or damage to public or private property, can be expensive to defend, even if you are innocent.

Strategies

Several strategies have been developed to help deal with these problems. Implementing any one of these strategies can be much less expensive and time consuming than disposal, fines, or litigation.

Redesign the end product to eliminate the use of hazardous materials in the manufacturing process. This strategy is the best course of action to take whenever possible. However, many manufacturing processes cannot occur without the utilization of hazardous materials.

Substitute hazardous materials used in the production process for nonhazardous materials. Newly developed, synthetic, nonhazardous materials may be available for use. "Greening" your production can be much less costly than disposing of hazardous waste. Remember to subtract the cost of disposal from the usually higher procurement costs of synthetics.

Consume the hazardous materials. If you can consume all of your hazardous materials, then you eliminate the disposal problem. Be careful, however, that you don't create a new hazardous substance that must be addressed.

Recycle unconsumed hazardous materials. Many companies have found that leftover or unconsumed hazardous materials are still usable in some form. Some materials are more useful in their recycled state. Utilization of these materials can reduce the amount of hazardous materials being purchased, reduce production costs, and decrease transportation, storage, and disposal costs.

Trade or sell the waste to other consumers. Another company might even be willing to pay you for the right to use unused, surplus, or recycled materials. Be very careful here. You are dealing in leftover, undepleted hazardous materials. While it is legal to sell the material, you will not be relieved from your responsibility. The best you can do is to write indemnification and insert harmless clauses into the sales contract, and hold your breath. You should remove any company identification from any materials leaving your site, and you must supply material safety data sheets to the new owner. Be sure to consult your attorney on title transfer.

Neutralize or detoxify the waste. This is an excellent strategy, if you have the opportunity and capability. If you are fortunate enough to be using a substance that is easily detoxified, you are in luck. Many substances require extensive treatment, autoclave, or high-temperature incineration, to neutralize. Additionally, obtaining permits and certificates from local governments to operate a system can be an insurmountable challenge.
Contracting

Contracting for hazardous-waste disposal calls for a negotiated agreement with a reputable company. Traditional low-bid-process solicitation and competition should not be used. The risks are simply too great. There are several steps that can be taken to ensure an effective selection process.

Check local availability. Several waste-disposal companies are represented in most major metropolitan areas. The Yellow Pages of the closest major city is an excellent source. Other sources include the local chamber of commerce and other organizations that require hazardous waste-removal services. Select two or three disposal companies that you feel might be best suited to dispose of your particular classification of waste. Remember that there are different types of hazardous materials (hospital infectious waste, chemical waste, nuclear waste). Find out which companies specialize in your specific type of waste. Check the disposal company's track record. This is no time to try out the rookie. Of course, this type of action could be viewed as exclusionary. Your management must decide if the merits of inclusion outweigh the risks.

Obtain and check references. Make sure that the clients that the disposal company has served are satisfied with the services. Does the company have adequate insurance? Does the company use a reliable form of transport? Were certificates of disposal properly prepared and delivered? Was the disposal company cooperative in customizing an agreement to fit a specific situation? Avoid signing the disposal company’s standard disposal agreement. It is written in the best interest of the disposal company, not the customer. Renegotiate the standard agreement to minimize your risk.

The "cradle-to-the-grave" philosophy means that the original using organization can never be totally released from responsibility as long as the material or substance is a threat to the public or the environment. Therefore, the only recourse the purchaser has is to involve as many levels of responsibility as possible. A shared responsibility is certainly better than assuming the whole load alone. The objective is to try to get the disposal company to assume a portion of the risk. Of course, the disposal companies will resist, creating a need for increased purchaser negotiating skills. Below are some techniques that have been effective.

Techniques

Use indemnification clauses in contracts. Carefully crafted indemnification and hold-harmless clauses can be lifesavers. Most disposal companies will not strenuously object to a fair clause. They will object to assuming the entire risk. Indemnification clauses should be used to cover losses caused by their actions while the materials are in their possession. Be sure to consult your legal counsel in constructing an adequate clause, or amending an existing clause. Ensure adequate insurance. Most disposal companies are required by law to be insured. Be sure to obtain certificates of coverage before releasing materials to the disposal company. Only by reviewing this certificate can you determine the level of protection and the terms of coverage the disposal company has retained. If in doubt, call the insurance company representative listed on the certificate. Finally, make sure that you have adequate insurance to cover any contingency. Of course, insurance for hazardous materials is expensive – but so is litigation. Coverage rates are usually substantially lower if you can show your underwriter that he/she will not be in the first position in the event of a claim. Place the disposal company's insurance carrier in first position. In the event of loss, damage, or injury after pick-up, it is preferable to have the disposal company's or carrier's insurance company in first position. This simply means that you will be in line for liability only after claims against the disposal company and carrier are exhausted. Discuss this strategy with your attorney. The laws vary from state to state, and may affect your position.

Demand and retain certificates of destruction. The certificate of destruction is not a "get out of jail free card" by any means, but is adequate assurance that the disposal occurred in the proper way. Never dispose of a certificate of destruction. Damages caused by hazardous substances that can be traced back to the
original owner will incur liability even if the company is no longer in business. Heirs, successors, and perhaps even new owners may be implicated. This certificate should be retained as long as possible. Properly identify the materials. Proper identification of the materials or substances being disposed of is absolutely essential. Unidentified materials in the shipment may not be handled properly. If you have not identified these materials to the disposal company or carrier, you may have avoided your indemnification. Be sure that you have accurately identified each component that must be destroyed.

While it is absolutely necessary to identify the materials to the disposal company and carrier, identification of the owner is not required. Labels, tags, and markings on packages and substances that identify you as the owner should be removed. Do not remove labels, tags, or markings that identify the product. After the shipment leaves your location, no company identification should remain on the substances whatsoever. Following these few tips can make a big difference in your disposal operations. Consulting an attorney to protect your interests is definitely recommended. Take every precaution to mitigate the risk to you and your company, and you will find that you can dispose of hazardous materials legally, safely, and without self-destructing.

**Risks**

If none of the above strategies for eliminating waste are suitable for your organization's needs, your only option is to dispose of the material by using legal and safe methods. With disposal, your risk increases dramatically. Companies that illegally dispose of materials - in landfills, dumpsters, or sewer systems - if detected, face severe civil and possibly criminal penalties. Even companies that have legally contracted with waste-disposal companies face penalties when the disposal firms act improperly. Any accident, spillage, or contamination prior to destruction will place the original user in jeopardy. The original user may still be liable for the contamination, even if the user was not at fault for the accident. Improperly trained employees of both the using organization and the waste-disposal company may file suit for damages or loss due to injury or contamination. Lack of proof of proper disposal can still place the using organization in a difficult position.

**Hazardous Materials Packaging: To Protect and Comply**

By making an unauthorized change to the packaging purchasers are likely to be subject to all the liability of an unauthorized packaging manufacturer.

All domestic shippers of hazardous materials must comply with HM-181 for new packaging. The standards affect products classified as hazardous by the Department of Transportation (DOT), including flammable liquids and solids, oxidizers, poisons, corrosive materials, and various miscellaneous hazards such as hazardous wastes. The rules may be found in title 49 of the Code of Federal Regulations (CFR), parts 100-180. The primary significance of the new requirements for purchasers is the obligation of the purchaser of hazardous materials packaging to correlate the detailed characteristics of the intended contents with the packaging being purchased.

The regulatory system is based upon recommendations developed by the United Nations (UN) Committee of Experts on the Transport of Dangerous Goods. One fundamental element of the UN recommendations is the division of each type of hazardous material by degree of danger into "packing groups." Packing Group I materials are those with the highest degree of hazard, for example the most highly corrosive materials within the broad regulated class of corrosives. Packing Group II materials pose medium danger, while Packing Group III materials pose the lowest hazard of regulated material. Thus, all hazardous material shippers in the United States must enter the proper packing group of the material being transported as part of their shipping description.
Additional regulations require the shipper to purchase packaging from the manufacturer by identifying the packing group of the intended contents, the specific gravity and vapor pressure of liquids, and the gross mass of the material. With this information, the manufacturer of the box or drum will then determine and perform the minimum required testing. For example, a drum for a Packing Group I liquid must pass a six-foot drop test, whereas Packing Group II packaging needs only to pass a four-foot drop test. Markings are applied to the packaging and a testing report must be prepared and kept by the manufacturer to certify that the packaging meets the purchaser's requirements.

The regulatory system is intended to provide more flexibility, but at first purchasers may find it more cumbersome than the old DOT specification packaging system. In addition, purchasers will have to take steps to assure compliance, such as:
1. Provide detailed information about the product to the packaging supplier.
2. Correlate the hazards of the product with the appropriate packaging, by telling the packaging maker the minimum test levels the packaging must pass.
3. Consider modest changes in packaging to minimize testing, retesting, and additional costs related to testing.
4. Ensure the packaging maker sends a written statement describing the capabilities for the packaging, as confirmed by its testing, and the necessary steps the filler must take to assure closure is completed in the same fashion as the tested design.

By not following these steps during packaging filling and closure, purchasing organizations may void the responsibility of the packaging manufacturer. In addition, by making an unauthorized change to the packaging, purchasers in effect create a new design and, unless that new design has been tested, purchasers are likely to be subject to all the liability of an unauthorized packaging manufacturer.

DOT may make some minor adjustments to the regulations, but no major changes are expected, nor in compliance dates. Therefore, hazardous materials shippers should move forward now not only to assure compliance by the deadline but implement routine training and operational procedures to achieve compliance efficiently.

**GreenSpeak**

"Green" purchasing requires purchasers and suppliers to work together as a team.

Over the months, our hotels have made great strides in substituting products manufactured and packaged from non-environmentally responsible to those more proactive to this concern.

As a supplier and an important element to this critical issue, we ask that you take careful note of our Environmental Purchasing Specifications attached, appreciating that environmental merit of a product will be weighed equally with price, quality, and availability in the purchasing decision. While "perfectly green" products may not be achievable in all aspects, it is our aim that each and every purchase have the least negative impact on the environment.

Preferential treatment may be offered to companies which actively source and offer ecologically sensitive product lines, are responsive to our requests, and practice good environmental stewardship. Conversely, hotels reserve the right to reduce the size of orders given to, or eliminate from the bidding process entirely, any company which fails to address these concerns.

Claims such as "Green," "Biodegradable," "Natural," and "Recycled" need to be substantiated with the initial bid.
Defining Green

What is "green" purchasing? It's part of environmentally conscious management, which can be defined as a system that integrates product and process design issues with the issues of manufacturing production planning and control and supply chain management. Green purchasing identifies, quantifies, assesses, and manages the flow of environmental waste with the goal of reducing and ultimately minimizing its impact on the environment while also trying to manage resource efficiency. A different and new image of "green" purchasing has emerged - one which is cost- and strategy-driven, economically justified, and integrated with corporate and product/process decisions.

Getting the Facts

Even in cases when the supplier has refused to provide information on the grounds that the material composition is proprietary, the purchasing company will refuse to introduce the new material into the plant until its environmental effects are fully known. The supplier will simply not be allowed to do business with the company under these conditions! In this regard, the plant environmental engineer plays a key role as a liaison and information support person to aid purchasing and plant employees who are encountering potentially hazardous environmental situations.

Finding the “Greenest” Suppliers

A key element of evaluation involves understanding and assessing the environmental risk associated with the particular chemical being purchased. Ask the following questions about your suppliers:

- Are their costs out of line, signifying that they have had to pay environmental cleanup fines in the past?
- Is the supplier in danger of being shut down by the government because of environmental violations?
- Are they a healthy company, and what is their employee exposure and safety records?

Supplier selection is also important when raw materials are being purchased for the research function. The specifications for the item often originate from the business strategy -- purchasing's role is to assess available sources of supply and provide a supply strategy. One criterion of this strategy is to evaluate the supplier's capabilities regarding distribution, safety, incidents, health records, and adherence to Responsible Care. Generally, only suppliers who are signatories to Responsible Care will be considered. If not, they are viewed on an exception basis - will the supplier subscribe in the future? Other questions address who moves the product. Dow specifies sources and routings and they rely on the supplier to comply. The supplier will be allowed to move the product if they are considered safe. Otherwise, Dow has their own group of contract carriers to carry out this function. To sum it up, price is not the only factor to consider if purchasing is dealing with a hazardous material. The cost of litigation and cleanup of a spill or accident will far surpass the pennies saved per pound of material.

Purchasers can expect green purchasing to become a fact of life. The only way for many purchasers to make the most of this new development is to understand what is involved in and the reasons for the movement to green purchasing. Green purchasing is a misnomer - the green referred to is not environmental waste reduction but rather increased profits.
Guidelines for Going Green

Managers recognize that purchasing green is not only good for the environment but also very healthy for the bottomline. To purchase green, purchasers and suppliers must actively work as a team - not as adversaries - to draw on each other's skills and knowledge. The following guidelines can help purchasers and suppliers work together toward fulfilling environmental goals:

Have clear, feasible objectives for your organization and for your suppliers that can be measured and captured in quantitative, meaningful terms.
Measure green purchasing and supplier performance using well-understood, quantitative measures.
Communicate all successes internally and also with your suppliers through e-mail, newsletters, and periodic meetings.
Expect that both sides will make mistakes but learn from them.
Be consistent with your suppliers in your pursuit of green purchasing.
Try to link green purchasing with the four strategic dimensions of supplier performance: cost, quality, leadtimes, and flexibility.
Emphasize teamwork and team building structures that bring together suppliers, manufacturing, design engineers, marketing, and purchasing.
Recognize the importance of design in terms of the effective achievement of green purchasing objectives.
Recognize the breadth of opportunities for green purchasing; that is, green purchasing can be achieved by relying on options such as reducing waste, recycling, remanufacturing, prolonging use of the product, reducing the environmental costs created by the use of the product, rebuilding, reverse marketing (creating demand for the waste or pollution), and substitution.
Don't ask your supplier to do anything that you and your organization are not willing to do. Do not, if possible, solely market green purchasing as a "green" activity since this is a kiss of death in many firms; rather, market green purchasing as cost- or quality-driven and measured.

Keep in mind that buy-in from management of both your organization and the supplier's is essential to making the program work.

One Purchaser's Trash is Another's Treasure

Responsible for eliminating your company's waste? Find out if another company sees it as a valuable product. Or maybe you want someone else's trash. Materials exchanges help you sift through the goods.

Materials exchange catalogs, available through any waste exchange agency (see below), offer everything from fish and horse waste, sludge, and worm soil to wood pallets, plastic recording tape cases, scrap rubber, and formaldehyde.

Waste diversion is becoming big business today. And purchasers and materials managers wanting to save money and conserve the environment may find a "buyers' haven" in today's waste exchanges. Nearly 30 waste exchange agencies throughout the United States help business and industry make a profit and save the environment.

Actual costs to participate in materials exchanges vary. The most common fee levied by a materials exchange is a catalog subscription fee, typically $50 per year. The main costs to purchasers and materials managers may be delivery costs for the company acquiring someone else's waste.

A materials exchange program offers businesses a communications medium, usually a periodic catalog in paper and/or electronic format, to advertise materials that would otherwise be destined for traditional disposal facilities such as landfills.

A proposed strategy for getting the most out of the materials exchange concept.
1. Begin to see your business and the materials exchange catalog through new eyes. Turning trash into treasure requires a new perspective. You can't do something new with an old way of thinking. Like the proverbial optimist who sees the good in everyone, you must begin to see potential reuses and recycling opportunities in everything.

2. Study the catalog. This isn't necessary every time, but as a get-acquainted exercise, it's a must. The main tool of the materials exchange agency is the catalog. Investigate how the materials exchange in your area is organized and who is participating. Get a feel for the materials categories, the areas where most things are available, and how items advertised now may meet your needs. (If an exchange agency does not exist in your area, consider starting one.)

3. Look for a match. Check the "materials available" section of the catalog. Are items of interest advertised? If so, call the contacts listed and start shopping. If you have items you're ready to part with, check "materials wanted." If there's a match, make calls to any potential new owners.

4. Write an ad. If you don't see what you want or need (to recycle) in the catalog, there's no better way to learn than leaping in. The only way to know if someone will be interested in what you have is to list it and see what happens. Once you have placed a listing, you are a player.

5. Call the coordinator. If you aren't a big risk taker, even in the reuse and recycling want ads, call the materials exchange coordinator. He or she can tell you stories about matches that have occurred through the catalog or computer network. These anecdotes are always inspirational. Maybe what you have to offer is exactly what the last caller was requesting.

6. Be an avid catalog reader. Always take at least a quick look to be up on what's happening or may have changed in the trend of the materials being exchanged.

7. Talk about the materials exchange concept with others. Materials exchange programs often connect totally unrelated businesses to network them for mutual benefit. What's not to like? Tell your friends, because the more the word goes out the grapevine, the more participants, materials, and great opportunities for trade.

Brag about being a "green" business. As a materials exchange user, you have every right. In your literature, when you state what your company is doing for the environment, list your participation in the exchange right up there with office recycling and purchasing recycled products.

Be creative. If you've done all these things, a whole new world of potential reuse and recycling has been opened up to you.

The sky's the limit. People have developed entire new product lines out of discarded material from another business. What hidden treasure will you find?

A computerized, national network may make finding your treasure among the trash simple. Sponsored by the U.S. Environmental Protection Agency, Pacific Materials Exchange developed the not-for-profit National Materials Exchange Network that electronically links nearly every industrial waste exchange in North America. With a computer and modem, you can call toll free in the United States, 800/858-6625 (Canada 509/325-1724), which connects you to the network listing more than 5,000 materials available and materials needed, including waste by-product, off-spec, overstock, obsolete, and damaged materials; used and virgin, solid and hazardous. Up to now, waste exchanges have relied on print materials to advertise waste streams; and the efforts by individual waste exchanges were generally concentrated in a limited geographic area.
PART II MRP, MRPII, JIT, ERP

MRP

INTRODUCTION

MRP systems have been around for a long time, and we have all heard stories about companies whose MRP implementations were not as successful as those companies had hoped they would be. There are, we think, two underlying causes for this problem. One is that we tend to look at the MRP as a complex computer system that will answer all of our needs (or most of them). The second is that people tend to become slaves of the system, trying to feed it the "right" information in an attempt to analyze the mountains of data that the system generates.

What is happening in the companies that successfully use an MRP system is that the people have learned to use the system as an effective tool. This is done by people just like you and me looking at the underlying process flow in our business organizations. There are two basic actions that we need to examine. We must reduce the lead time that is required to take our product through the process, and we must simplify that process as much as we possibly can. We are going to examine a couple of companies that have done these two things very successfully, with the outcome that both companies improved their schedule adherence. Their processes were simplified to the point that they could produce their products very quickly, making their schedules so dependable that there was marked improvement in customer satisfaction. Of course, one of the chief objectives of any MRP implementation should be enhanced customer satisfaction.

REDUCE LEAD TIMES

There is an old saying that tells us that no matter how short our lead time is today, it should be shorter. Lead time is not a fixed, scientifically-derived quantity. Rather, it is a variable number, and it depends a great deal upon how our people manage it. Lead time is a function of the priority and the queue, or wait time. Both of these can be minimized by keeping the queues short and having the smallest possible amount of product on the shop floor at a given time. To do this with an MRP system, we should have short planned lead times and release our paperwork at the last possible moment. The information listed as "planned order releases" is used to tell us what future actions are needed without actually releasing the orders to work in process.

We must look at ways to increase our throughput rate on each of our shop operations by reducing setups, organizing the workplace, and other techniques such as preventive maintenance to optimize machine usage. Teams of our people should be working on set-up reduction, material movement efficiency, and building quality into the product (as opposed to scheduling inspection time).

One other method of reducing queues and reducing throughput time in the shop is to look at processes from the viewpoint of synchronizing our operations, combining like operations into functional groupings, such as a U-cell or a flow line. We should look at the processes from the point of view of the product as opposed to a functional layout. Rather than becoming more sophisticated with our MRP calculations of capacity loads or the accuracy of our capacity planning logic, we materials professionals must focus on keeping our lead times short and the work-in-process queues small.

One of the best examples of this is a major manufacturer of orthopedic implants --"spare parts" for the human body, such as hips, knees, and bones. Several of these items are single component products that are the best example of the combination of operations into a flow line to reduce lead time. When the company had a functional plant layout, parts of one product family took ninety days of shop lead time. The reason for this was that the work centers were spread out to such an extent that the average product travelled more than nine miles. This situation meant that at any given time, there were more than 20,000 pieces in the various stages of work-in-process. Not only did it take a long time to get the product through, it was
likely that sometime during that time, priorities for a particular order were likely to change. This caused an enormous amount of schedule changing, and the resulting scurrying around that we know as expediting. Attempts to reduce the expediting by creating an increasingly sophisticated MRP system had only marginal results. A quantum leap occurred when the company looked at the manufacturing process and consolidated the work centers into a Just-in-Time flow line. Now, the products only travel about 100 yards down the line, with something less than 2,000 pieces of work-in-process. Concurrent with the consolidation effort they also focused attention on the organization of each work center, and worked to reduce set-ups. The planned lead time, as a result, was cut to fifteen days. Instead of focusing the MRP system on the dynamics of work-in-process, the people now concentrate on getting the signals out to vendors to match the flow rate of production. The people who work with the MRP system are concerned more with the aggregate output demand rate than with the dynamic priority updating inherent in most MRP systems. This all happens because the lead time is short and the queue is small.

SIMPLIFY THE PROCESS

The next step on the journey to improved schedule adherence is to simplify the MRP process to match our simplified shop process. There are several techniques that can be employed to reduce the amount of paperwork generated by the MRP system and the resulting transactions needed to keep it up to date. If we have reduced our process to a flow line, we might want to schedule all of our components as inputs to the flow line, with any intermediate subassemblies taken out of the MRP logic altogether. We can now release only one work order to make a completed assembly. This is known as "flattening the bill". A companion concept is known as backflushing. This consists of setting up an assembly line where the components are stored at the line itself, readily available to the operators for whatever assembly they are making at the time. Rather than process transactions for each component for each order, parts are issued from the stockroom to the assembly area in large quantities. At the end of the line, we process transactions showing the quantity of assemblies produced. By looking up the bill of material in the MRP system, we determine what components must have been used to build these assemblies. We can then subtract that usage from the quantity which was issued and stored at the work-in-process location. Of course, we must focus our attention on the accuracy of our bill of material so that the bill as it resides in the computer matches exactly with the way the shop puts the parts together. only under this condition will backflushing be effective.

The main advantage of this technique is that we have minimized the number of transactions and work orders processed through our MRP system. Many companies create huge numbers of work orders and transactions because the MRP system "requires" it, and the company gets bogged down in paperwork. By flattening the bill and using the computer to calculate the quantity of parts that must have been used, much of this needless detail is eliminated. Therefore, we should focus our efforts on the flow of parts, not on the MRP level-by-level processing.

One of the best examples of this process that we know about is a major manufacturer of material handling equipment. They manufacture belt conveyor systems that utilize rollers to support the belt while the material flows along it. These rollers are made of steel tubes with appropriate bearings, grease seals, and nuts. They are manufactured on an assembly line that stretches the full length of the plant. The components are delivered to work-in-process locations at the various assembly points along the line. Transactions are used to transfer inventory from stores locations to these work-in-process locations. At the end of the day (or the end of the order, whichever comes first), the credit transaction is generated for the assemblies produced, crediting the assemblies into finished goods. The MRP backflushes to issue the components from the work-in-process locations. This is done even for the raw material steel tubing, which arrives at the cutting machines in full bundle quantities. This simplification of the process caused their MRP scheduling system to create only one work order for any particular size of roller. There were no orders for individual pieces, although the engineering bill of material called for individual subcomponents.

This resulted in a drastic reduction in the number of work orders and transactions that needed to be processed through the MRP, allowing the people to focus their efforts on supplying products and

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components to satisfy customers. This is a far better use of time than shuffling paper to appease the MRP system.

A companion process is known as modularizing the bill of material. This is usually employed when a product can be sold with a number of different configurations or options, such as an automobile. Rather than stocking every possible permutation and combination of assembled automobile, it makes more sense to master schedule major components and subassemblies. One of the better examples we know of for this is a major manufacturer of hydraulic motors. They make six different types of motors, but within each type there are virtually an infinite combination of shaft, rotor, housing, and other configurations. As they focussed on the flow of parts within their manufacturing process, they decided to stock just the major components, master scheduling them using the MRP system. When a customer orders a specific configuration, they create one final assembly order, a flat bill of material one level deep that processes the components down the assembly line. Component parts are issued by backflushing the customer order. By using these techniques, this company can effectively manage the total flow of work in the plant using six modular bills of material. This again simplifies the MRP process to allow the people to focus on the flow of parts and not the cumbersome transactions of the computer.

**SCHEDULE ADHERENCE**

There are thousand of things we can do to improve on the MRP system, but we know that the two steps of reducing lead time and simplifying process both yield improvement in schedule adherence. Schedule adherence is one thing that must be achieved in order to satisfy our customers. With MRP systems, we tend to focus on making the due date match the need date as priorities change. This is an important requirement in the maintenance of a valid priority management system. But when we can reduce the lead times and simplify the process to the point where orders are produced very quickly, we can drastically reduce the number of schedule changes required by the dynamics of the marketplace. We find that companies tend to become more reliable in their production when using very short schedules.

This means, simply, that we have the assurance when we start an assembly down one of our assembly lines that we can depend on when that assembly will be completed. Figure 5 emphasizes that we must motivate all our people toward dependable schedule adherence. Once we have this mindset established throughout every level of our company, we can see significant improvement in customer satisfaction -- with both the internal and the external customer.

The conveyer manufacturer is one good example of this mindset that we can identify. Every member of the organization knows that their final assembly schedule for their configured roller-and-frame assemblies will be shipped within four hours of order entry. The production process is set up to support this speed, the planning process is set up to support it, and the familiar name for one of these four-hour orders is a "green" order, indicating that the green light is on for it to flow through the shop unimpeded. They could do this because their process was simplified by flattening the bill of material, minimizing the paperwork, and focussing on quick throughput at the assembly operations.

Our orthopedic manufacturer, on the other hand, communicates very effectively how well we adhere to our schedules for all work orders travelling down the Just-in-Time line. This is done by time-stamping each order on its entry into the work line and logging its completion time. A member of the team then goes to the big whiteboard at the head of the production line and records the lead time it took. The data is plotted on a very prominent graph, communicating to the entire world how well we're doing. (See Figure 6] This graph has become the focal point of the team's ownership of the objective to reduce lead time to meet or beat the plan. Right now, they are discussing the reduction of the planned lead time to under ten days.

**CONCLUSION**

We can see from these examples that the real key to a successful MRP system is that the people look at the process of delivering the product to the customer. We focus on simplifying the process and reducing the
amount of time that it takes for the product to move through our operations. Then we can look at the MRP paperwork system and streamline it to match. Real progress is made when people can use the MRP tool more effectively, and that can be done by looking at our processes and instituting improvements like the ones we have described here. Think about what you can do to apply the techniques that will work in your own business to reduce lead time, shorten the process, and improve your schedule adherence.
Just-In-Time (JIT)

Abstract. Both practitioner-oriented and academic literature suggest that just-in-time (JIT) purchasing as a management innovation can be adopted by organizations as a strategy to gain advantage over their competitors. Seven characteristics of JIT purchasing are identified based on a comprehensive literature review. These elements are supplier cooperation, materials quality, quantities purchased, transportation, top management support, training and employee relations. A review of benefits of JIT purchasing implies that implementation of JIT purchasing can increase firms' performance. The benefits include higher inventory turnover, increased product quality and productivity, which theoretically lead to a reduction in product costs. High product quality and reduced costs will usually result in lower prices. Lower prices will lead to increased market share and profit. Data have been collected by a mail survey from both large and small manufacturing and service organizations. The subjects of the survey are business unit chief officers or high-ranking managers. The firms and subjects are identified through a literature review, and the rosters were provided for this research by the American Society for Quality Control and the National Association of Purchasing Management. The research results are presented and discussed.

Introduction. In the late 1970s and early 1980s, previously unchallenged American industries lost substantial market share in both U.S. and world markets. To regain the competitive edge many companies have impetuously launched into productivity improvement programs (Chase and Aquilano 1992). One of these "so-called improvement programs" is just-in-time purchasing (JITP).

However, implications of JIT on strategic performance has not been explored in the literature. Adam and Swamidass (1989) point out that "manufacturing strategy literature has not formally embraced JIT for its strategic value to manufacturers" (p. 196). A study by A. S. Sohal, Ramsay, and Samson (1993) shows that the link between JIT and competitive strategy is less common than between JIT and operational tactics. The findings of their study reveal that only 17 percent of firms perceive JIT as a strategic tool to increase competitiveness whereas 44 percent think JIT is utilized to improve operations.

Studies by Ansari and Modarress (1987, 1990) show that companies having implemented JITP estimated a 43 percent increase in product quality and a 21 percent improvement in productivity. Given that approximately 50 percent of cost of goods sold consist of costs of materials, firms can utilize JITP to improve their performance. Grounded on both the theory of innovation and the relationship between innovation, strategy, and performance, this study attempts to explain the strategic value of JITP as a management innovation in different types and sizes of organizations. Furthermore, this research examines firm performance based on the theories from business strategy, marketing and operations management. Thus, the purpose of this study is to fill a void in the literature by identifying the effect of JIT purchasing on firms' performance in both large and small manufacturing and service organizations.

Characteristics of JIT Purchasing. Characteristics of JIT purchasing can be broadly categorized into two groups: external and internal. External characteristics require some changes in the way a purchasing department approaches procurement activities. Internal characteristics are those elements that require some organizational commitment.

External Characteristics of JIT Purchasing. External characteristics of JIT purchasing are

1. supplier cooperation,
2. purchased quantities,
3. materials quality and
4. transportation (Schonberger 1982; Schonberger and Gilbert 1983).

As Ansari and Modarress (1990) indicate, although purchasing activities are the same in both JIT and traditional purchasing, they differ in approach. These external characteristics will be briefly discussed as
follows: 1. Supplier cooperation. In JIT purchasing, materials and parts are usually bought from a single source, as opposed to purchasing from multiple sources under traditional purchasing activities. Empirical studies consent that, with the implementation of JITP, organizations have switched to fewer sources (Billesbach, Harrison, and Croom-Morgan 1991; Dion, Blenkhorn, and Banting 1992a; Freeland 1991; O'Neal 1987).

Dealing with fewer suppliers for a particular item or items contributes to establishing a long-term, stable and satisfactory relationship between a supplier and buyer (Ansari and Modarress 1990; Schonberger 1982; Schonberger and Gilbert, 1983). In his study, O'Neal (1989) finds that almost two-thirds of the suppliers have had long-term agreements with their customers.

Supplier evaluation is also different under JIT purchasing from evaluation under traditional purchasing. JIT purchasing emphasizes supplier evaluation based on product quality, delivery performance and price. Supplying defective items is not tolerated. In fact, Billesbach et al. (1991) find that a majority of respondents have evaluated their suppliers based on delivery reliability and quality conformance.

Under JIT purchasing, achieving product quality through a long-term contract at a fair price receives the highest priority. The findings of a study reveal that both U.S. and U.K. companies have placed high priority on quality and delivery in negotiation practices. However, they also rated response flexibility and competitive price reasonably high (Billesbach et al. 1991).

In summary, in terms of suppliers, JIT purchasing differs from traditional purchasing in terms of the number of suppliers, the selection and evaluation of suppliers, and the negotiating and bidding process. Thus, suppliers have a considerable effect on the implementation of successful JIT purchasing (Fawcett and Birou 1993).

2. Purchased quantities. In JIT organizations, products are produced in small lot sizes when needed, and in turn, materials and parts are frequently delivered in small lots (Chapman and Carter 1990). Furthermore, most importantly, lots must be delivered in exact quantities, neither more nor less (Ansari and Modarress 1990; Freeland 1991; Lee and Ansari 1985; Schonberger 1982; Schonberger and Gilbert 1983; Willis and Huston 1990). Several empirical studies find support for the increase in delivery frequency under JIT purchasing.

In his study, O'Neal (1987) finds that, under the JIT system, the average monthly frequency of deliveries increases to 6.9 from 2.8 under traditional purchasing. The study by Dion, Banting, Picard, and Blenkhorn (1992b) produces the following results pertaining to purchased quantities:

- 200 percent increase in number of deliveries
- 50 percent decrease in order lead times
- 50 percent reduction in order size

3. Materials quality. When materials and parts are purchased in small lots and exact quantities, clearly, their quality receives more importance since defective materials and parts cause interruptions in production. Furthermore, the first step of producing quality products is the utilization of the correct quality materials. As a result, supplied materials must have the correct quality attributes (Grieco and Gozzo 1985; Hall 1983; Willis and Huston 1990). Counting and inspection of received materials and parts are reduced or eliminated under JIT purchasing (Ansari and Modarress 1990).

The findings of a study by Freeland (1991) indicate that the selection of both suppliers and materials is based on quality. Also, the findings propose that good quality of materials is necessary in order to implement JIT purchasing. In one study regarding JIT purchasing, 33 percent of buyers reported higher quality in JIT purchased parts (Dion et al. 1992b). The results of the same study show the following changes related to purchased parts quality:
• 40 percent decrease in damaged purchased materials
• 20 percent decrease in buyer complaints about purchased materials

4. Transportation. Under JIT purchasing, agreements define delivery dates or times according to the buyer's schedule, as opposed to shipping dates and times based on the supplier's schedule under traditional purchasing (Ansari and Modarress 1990; Schonberger 1982; Schonberger and Gilbert 1983). Furthermore, JIT purchasing involves both inbound and outbound freight, stressing on-time delivery, whereas traditional purchasing emphasizes outbound freight, stressing low freight cost (Ansari and Modarress 1990). O'Neal (1987) suggests that JIT purchasing requires faster, more responsive modes of transportation than traditional purchasing because of frequent deliveries in small lots. His study indicates that, under JIT, companies switched to motor freight and private carriers from rail transportation and common carriers.

Internal Characteristics of JIT Purchasing
Some internal critical factors are required in the implementation of JIT purchasing, as well as in the implementation of JIT production (Ahmed, Tunc, and Montagno 1991; Ansari 1986; Ansari and Modarress 1986, 1990; Hay 1989, 1990a, 1990b, 1990c; Im and Lee 1989; Lee and Ebrahimpour 1984). These essential elements include the following:

1. **Top management commitment.** Top management should make JIT purchasing a priority for the whole organization and clearly communicate this commitment to the employees. The necessary resources for the implementation of JIT purchasing should be provided by leaders. Moreover, upper management should demonstrate leadership in order to provide positive involvement of other functions (Ahmed et al. 1991; Ansari and Modarress 1986; Hay 1990a; Im and Lee 1989; Lee and Ebrahimpour 1984). In their survey, Fawcett and Birou (1993) find that companies which successfully implement JIT purchasing activities provide support at different levels of management.

2. **Training.** Most importantly, purchasing people must be trained in the JIT philosophy. Also, purchasing people should be trained in the necessary statistical tools, such as statistical process control (SPC), in order to understand the variation in incoming materials. Furthermore, training support in JIT purchasing and quality management should be provided to suppliers (Ahmed et al. 1991; Ansari 1986; Ansari and Modarress 1986; Im and Lee 1989; Lee and Ebrahimpour 1984). Utilizing teamwork from both parties in reducing the common causes of variability in materials and parts can improve quality (Harrison and Voss 1990). In one study, respondents report that the lack of training and education of suppliers has been a major impediment in the implementation of JIT purchasing (Freeland 1991).

3. **Teamwork.** Acquisition teams should be established, which may include purchasing, material control, process/design engineering and production representation. This interaction provides the conditions necessary to solve supplier quality problems and facilitates communication within the entire organization (Giunipero and Keiser 1987; Hall 1983). These teams can be utilized in the selection of new suppliers (Burt 1989).

Strategic Value of JITP as a Management Innovation. Although there is a vast array of literature on innovation, it is hard to find agreement on the definition of innovation. In this study, the definition of innovation is the one adopted by Damanpour and Evan (1984): "the implementation of an internally generated or a borrowed idea -- whether pertaining to a product, device, system, process, policy, program, or service -- that was new to the organization at the time of adoption" (p. 393).

Schroeder, Scudder, and Elm (1989) discuss the effects of innovations assisting in the achievement of significant improvements in organizations' cost, delivery and quality goals. In their study, the researchers present a list of innovation definitions generated by managers. One of these definitions includes changing the relationships with internal and external groups in order to reach goals of the operation in the present and/or the future in a better way, such as supplier relationships with JIT.
The literature on strategy types (e.g., Hofer and Schendel 1978; Miller and Roth 1994; Porter 1980; Richardson, Taylor, and Gordon 1985) reveals that the purpose of adopting specific strategies is to increase market share and performance by either reducing costs or by differentiating products. By adopting a JIT purchasing system as a strategy, firms can both reduce their costs and differentiate their products. As discussed later, benefits of JIT purchasing indicate that firms realize enhanced product quality and reduced costs as a result of the implementation of JIT purchasing techniques (e.g., Ansari and Modarress 1990). O’Neal (1989) suggests that automotive original equipment manufacturers’ (OEM) final assemblers have served as the innovators in developing and implementing JIT systems. With the JIT management system as a major strategy element, the Automotive Industry Action Group played the role of a facilitator in increasing the productivity of the industry.

Pearson and Gritzmann (1990) suggest that the purchasing department can serve as a profit-generating center rather than cost-cutting mechanism. Purchasing costs consist of 50 percent or more of a firm's total revenue in many manufacturing industries. With an increasing concern on product quality in today’s highly competitive environment, a company can gain competitive advantage by utilizing the purchasing department's knowledge of supplier networks. Implementation of the JIT concept brings such an opportunity to purchasing departments in firms.

According to a study by Dion et al. (1992a) although there is not any perceived increase in profit from the products produced with JIT materials, 37 percent of firms reported an increase in their sales as a result of JIT purchasing (Dion et al. 1992a). In their study, Fawcett and Birou (1993) find that improvement in the overall competitive position of the firm was the most positive effect of JIT purchasing.

The benefits of JIT purchasing can be classified into two groups: (1) direct and (2) indirect (Ansari and Modarress 1987; Ansari and Modarress 1990; Gilbert 1990; Hahn, Pinto, and Bragg 1983; Manoochehri 1984; Schonberger 1982; Schonberger and Gilbert 1983). The most important direct benefits include:

1. Increase in purchase material turnover,
2. Increase in ability to meet delivery promises,
3. Reduction in delivery lead time, and
4. Reduction in scrap cost.

The direct benefits of JIT purchasing lead to its indirect benefits. The most important indirect benefits are:

1. Achievement in encouraging suppliers to meet quality requirements,
2. Improved product quality, and
3. Increased productivity.

Based on the literature review up to this point, the relationship between JITP and the performance of firms are summarized in the research model as shown in Figure 1. Based on this model, we suggest that the greater the extent to which companies implement JITP techniques, the higher is the performance. (Figure 1 is not available in this text-only version.)

The theoretical foundation of this study and previous research findings indicate that the effects of JITP strategy on performance may differ across four moderating variables: Industry type, firm size, firm type (the type of organization refers to service and manufacturing organizations) and duration of JIT purchasing practices. The following paragraph provides some examples of the effects of moderating variables.
Fawcett and Birou (1993) identify electronics, machinery, metals and transportation industries as main users of JIT purchasing practices. Some studies document that JIT delivery is considered to be a difficult element of JIT management to implement in small manufacturing firms because these companies may have limited resources (Finch 1986; Finch and Cox 1986). Empirical research in the implementation of JIT delivery in small firms reveals mixed results. Although, in theory, JIT purchasing seems to be advantageous for small businesses and there is some evidence of assistance from large buyers to small companies in its implementation (Sadhwani, Sarhan, and Camp 1987), a survey conducted by Industry Week reveals that some of the small companies complain of swallowing inventories to supply JIT companies (Sheridon 1989). Chase and Aquilano (1992) stress the fact that, although service companies have not concentrated on supplier cooperation for materials because the service costs mostly consist of labor, some service companies such as fast food restaurants can benefit from implementing JIT purchasing. A study by Freeland (1991) classifies organizations based on the benefits realized as 'High-JIT Purchasing Benefits Organizations' and 'Low-JIT Benefits Organizations'. Further analysis reveals that 'High-JIT Purchasing Benefits Organizations' had started to implement JIT in purchasing an average of 33 months before receiving the survey, whereas 'Low-JIT Purchasing Benefits' organizations had begun to institute JIT purchasing, on average, only 24 months before. Freeland (1991) concludes that "the longer JIT purchasing has been in place, the greater the reported overall benefits."

Research Design and Methodology: The research questions of this study lend themselves to cross-sectional mail survey methodology on business units. Because this study examines the relationship between JIT purchasing and firm performance, the target population was U.S. firms which implement JITP techniques. The subjects of the survey are business unit chief officers or managers, with such titles as president and executive vice president, because only these high-ranking respondents would possess the three types of knowledge required for this study. The firms and subjects were identified through a literature review, and the rosters provided to this research by both the American Society for Quality Control (ASQC) and the National Association Purchasing Management (NAPM). An instrument was developed based on an extensive literature review and was pilot tested at a joint meeting of the NAPM and the American Production and Inventory Control Society (APICS).

Target respondents received the questionnaires according to the Total Design Methodology suggested by Dillman. The Total Design Methodology suggests a four-step procedure for mail surveys to achieve a higher response rate. First, the questionnaire is sent to respondents with a cover letter which describes the research project and its purpose, and assures the confidentiality of the replies. The second step requires sending a postcard one week after the initial mailing as a reminder to the nonrespondents. Three weeks after the initial mailing, a follow-up letter with another copy of the questionnaire is sent to subjects who have not responded. Seven weeks after the initial mailing, if a sufficient response rate has not been achieved, a second follow-up letter with the questionnaire is sent to nonrespondents.

A questionnaire, including a cover letter and a postage-paid return envelope, was sent to 1884 subjects in the beginning of March, 1995. The breakdown of subjects according to membership is as follows: 1180 ASQC members and 704 NAPM members. Due to the sufficient response rate following the second and third steps of the Total Design Methodology, the fourth step was not pursued. Some of the respondents who did not receive the initial questionnaire called to request a copy of the questionnaire upon receiving the postcard. Depending upon their choice, a copy of the questionnaire was mailed or faxed to them. A total of 382 survey replies were received, which equals a 20.3% response rate. Of all respondents, 25.3% are ASQC members and 11.80% NAPM members. Approximately 60% of the responses were received after the initial mailing and postcards. To encourage response (Dillman 1978), it is made known that a copy of the aggregated survey results, with a profile of the individual companies, is to be sent to the respondents at their request at the end of the study.
MRPII For Planning JIT For Execution

The objective of this presentation is to demonstrate how successful companies are able to merge MRPII and JIT. We shall look at several companies and how they plan and control materials and capacities using both MRPII and JIT techniques.

Many people ask if Manufacturing Resource Planning (MRPII) and Just-In-Time can be married together. We say they can by using MRPII for planning and JIT techniques for execution. Many companies try to minimize their inventory investment by implementing an MRPII system. At the same time these companies cultivate a philosophy of continuous improvement on the shop floor. We think companies should extend the philosophy of continuous improvement into the planning process also. We must make improvements to the process of planning what we are going to make, what it takes to make it and what we already have. These are the three main inputs to MRP planning: A master production schedule, bill of material and inventory status.

MRPII FOR PLANNING.

We are familiar with the normal issues surrounding an MRPII implementation. However, when we focus on continuous improvement in the MRPII System we usually see a lot of work on the shop floor execution system. MRP Logic is used to plan the flow of materials, particularity raw materials to support the Master Production Schedule. Many companies establish a Master Schedule and then use the MRP to explode that schedule into the requirements for material. Then we use the requirements as a signal to suppliers for them to establish their Master Schedules. However, the actual release of the materials to move from supplier to user is controlled by Just-In-Time techniques.

FLATTEN BILLS OF MATERIAL.

In order for an MRPII System to work effectively with a JIT Execution System it is imperative that we simplify the Bills of Material. Many companies say to KISS the bills: That is to keep it short and simple. We should attempt to flatten the bill as much as possible, with one being the ideal number of levels. We should reduce any intermediate levels out of our own manufacturing bills. We can and should use techniques such as phantoms and backflushing to remove all sub assemblies that exist inside our own plant. After all, we should question the purpose of any intermediate levels, usually designed for efficiency of supply, and focus on the flow of parts to support the end unit assemblies.

SHORTEN LEAD TIME.

The real enemy of any successful manufacturing company is time. The more time something takes; the more complications are introduced and the more it costs. One company we know of thought efficiency of supply would come from large orders going through functionally grouped departments. One product traveled nine miles, took 90 days and had over 40,000 units of various sizes in work-in-process. Their expectation was that a good scheduling system would eventually keep track of all these orders and give them maximum customer service because "we always have something in process". In reality, the MRPII Planning System becomes much more effective as lead times get shorter. We can shorten lead time by focusing on the flow of product. Our company with nine miles rearranged their work centers to get a product orientated flow that was less than 100 yards. They also worked to reduce setups, which allowed them to lower lot sizes. The combined effect of reduced lot sizes and more direct flow allowed them to reduce work-in-progress queues down to less than 1/10 of what they were previously. All this had the effect of reducing lead time to less than 15 days (from 90). That represents continuous improvement combining the planning system with JIT execution.
MIXED MODEL MASTER SCHEDULING.

The intent of our planning system is to support a Master Production Schedule. Our planning system will be most effective if we continuously improve by removing variation from the plan. We can do that by utilizing the technique of mixed model master scheduling. That is to build some of each item every day. See Figure 3. As you can see, this company plans to build some of each item every day. They were able to accomplish this by simplifying their planning systems. One item had fourteen steps in its routing. Even with bar code data entry they decided that was too many operations to track and reduced it to one. Several layers of their Bill of Material are not processed as an item in their MRPII System. Rather, the raw material is processed into components and flows directly to assemblies out on the shop floor without processing transactions through the planning system.

All of this works together to simplify the Bill of Material, shorten Lead times and reduce the variation in the Master Schedules. We then effectively use the MRPII System to inform suppliers about our planned flow of raw materials.

JIT FOR EXECUTION.

When we can get our Bills of Material flat enough and the production activity controls short enough, then our own execution system becomes so short that it is insignificant compared to purchased parts. One company we know makes components for computer monitors. As they say, "continuous improvement is our production activity control system". Their total shop lead time is less than five days but the monitor glass has a lead time of 10-12 weeks. It is not important to plan and control our production with detailed dispatch plans, rather, first-in-first-out works fine. We use MRPII only as a tool to communicate with our suppliers.

SUPPLIER PARTNERSHIPS.

We have all heard of supplier certification programs tied into quality programs focusing on quality at the source. Many of these certification programs go on to discuss such things as blanket orders with frequent deliveries. I maintain that industry shall continue to use MRPII planning tools to establish the overall requirements with their suppliers. We may even work together enough to reserve capacity with the supplier. Therefore, instead of ordering large blanket orders for specific parts (with their inherent variability), let's reserve capacity based on our aggregate volume using our production plan.

We would then set up a very responsive signal system to let our supplier know exactly what quantity of what items are needed when. We know of some companies that use the telephone to release orders for steel to be delivered from warehouses the next day. More sophisticated systems such as visual signals (kanbans) and Electronic Data Interchange (EDI) can also be used as our partnership seeks win-win solutions that are quicker and quicker.

CUSTOMER PARTNERSHIPS.

A companion idea to supplier partnerships is the same concept applied from the other direction: customer partnerships. We are all customers of suppliers - and conversely a supplier to our customer. Why not work with our customers just like we would like our suppliers to work with us?

Our objective is to work with our customer to remove fluctuations in the rate of demand. We wish to take out variations in the demand for our products. Therefore, let's negotiate with our customer and let them reserve capacity so that we can consistently meet their demands. We can work together to define the beat at which he needs our product.

SYNCHRONIZED FLOW.

When we are armed with knowledge about our customer's requirements we can work together to remove variations from the top level of our schedules. We can then look differently at how the parts flow through
our shop. We know of a company that used to make large batches of common components used in multiple end units. Inventory grew and expediting got out of hand as mismatched lots were being built to optimize efficiency. Their problems reduced significantly when they focused on building all the parts that go into an assembly. They rearranged the shop layout and paperwork system to build matched sets of components to meet assembly requirements.

SHOP FLOOR CONTROL BY SEQUENCE.
When we combine very short lead time with a flow of parts by assembled product, all sorts of opportunities become visible. (Yes, the pun is intended) We know of several companies who have gotten their lead times so short and the production process so predictable that first-in-first-out is good enough production control. One company even releases orders in different colored tote pans according to the day of the week: red on Monday, gray on Tuesday, green on Wednesday etc. Therefore, everyone on the production line knows red tote orders should be worked on before gray etc. This simplified method helps set the sequence of the flow of work.

FLEXIBLE CAPACITY.
When shop lead time gets very short, it is not profitable to focus on measuring workload, backlog, efficiency, utilization and queue. Rather, we focus on what comes in must go out. The company mentioned above with the various color totes can go out on the floor and see when they are falling behind. The team can make decisions about how to get back up to the throughput rate: work over time, add more people, stay late, etc. One company in Mississippi even goes so far as to have college students they can call to come in and form a night shift crew when they need to flex capacity. Federal Express calls in temporary workers each night at the hub in Memphis to make sure that "absolutely, positively" all packages that come in today will go out today.

PERFORMANCE MEASURES.
To change the way we look at our manufacturing output; we need to change the way we measure our performance. Instead of measuring classical efficiency and utilization, maybe we should measure customer service, schedule performance and other measures of continuous improvement.

One very successful method I see being used is to measure how well we respond to delivery of our product to the customer's request date. One company does very well. See Figure 4. "But our customers have unrealistic expectations", you say. Well, yes they do but that's the standard by which we should be judged. So let's start measuring where we are and start the process of continuous improvement.

Another company adds a nice companion measure. Remember how cycle counting looks at the process of inventory control in order to find and fix the causes of errors? Why not use the same concept on orders shipped late? We can look at reasons why orders are late, stratify the reasons and fix the cause for the reasons. See Figure 5.

Another measure I like is schedule adherence as it relates to lead time. Set a planned lead time such as 15 days as the company did in Figure 6. The company posts the goal out on the shop floor and gets everyone on the team to work towards continuous improvement. As you can see through the month of September the team was able to beat the goal. Measure the lead time it takes for the product to get through the shop; focus on it and it will improve.

CONCLUSIONS.
There is an effective compatibility between MRPII For Planning and JIT For Execution. The common thread is to be searching for continuous improvement. As lead time shortens in our own shop, use JIT visual techniques to flex capacity and shorten cycle time. Then we must simplify the planning system. Partnering with our customer to remove variability from the process allows us to use the MRPII Planning System to work with our suppliers to commit their capacity therefore, adding dependability to our supply of raw materials.
ERP

Most purchasing and supply management professionals employ some type of automated system or systems in their respective organizations to process purchasing-related information, such as purchase orders, requisitions, request for quotations, and other documents. However, in many cases, the level of information integration and exchange within your business enterprise may be somewhat limited. The system may help you process the information more quickly, but does it extend beyond that? More specifically, how does your inventory and requisitioning system receive signals or input as to what to buy, how much to buy, when it is needed, and so forth? Is there any type of information linkage between your planning and forecasting system (assuming you have such a system) and your inventory or procurement system? Can you electronically link between scheduled/planned work and bills of material, ultimately converting this to a system-initiated materials requirement? Can you track total costs specific to an asset within your organization? Can you seamlessly integrate your purchasing, receiving, accounts receivable, accounts payable, general ledger, manpower management, equipment maintenance, and asset management records? Can you accurately forecast impending equipment failure (predictive maintenance) and the costs associated with owning an asset? These questions lead to the discussion of enterprise resource planning (ERP) systems, how they affect an organization, and how they can be successfully implemented.

The Purpose of ERP

The primary purpose behind ERP systems or applications is to create a seamless integration of interrelated information across the business enterprise. Recent software providers’ solutions are broadening this theme further by adding new modules associated with workflow, supply chain management, shop floor control, capacity planning, finance, logistics, dispatching, constraint management, and human resources. While this may sound interesting, what does it mean to you in your environment?

On the supply management side, ERP systems offer purchasing functions the potential to:

- Leverage organization-wide purchasing volumes
- Accurately forecast supply demands
- Automate tactical processes, such as purchase orders
- Generate reports independently to identify cost saving opportunities
- Integrate supply capacity information with customer demands
- Leverage data accumulated by other functions in the organization

Enterprise Resource Planning: In a Nutshell

**Enterprise Resource Planning:** This is a system of software programs that ties various business functions together. Typically, the program consists of modules for functions such as finance, manufacturing, purchasing, logistics, sales, and human resources. Because of the integrated nature of these systems, the different functions can relate, analyze, and access information for a competitive advantage.

**Booming Business:** According to AMR Research, a market analysis firm specializing in enterprise applications and enabling technologies, the ERP market will reach $66.6 billion in 2003.
A Typical Scenario

Many large organizations employ different large-scale materials management systems (mainframe hosted). Each of these systems is functional from a standpoint of producing purchasing and stores related documents, allowing dock receivings and accounts payable matching and payment generation. However, that is often the outer extent of the systems. In many cases, the primary customer of the materials organization is the maintenance and operations departments. However, there is no linkage or connectivity between the production planning and maintenance scheduling functions and the inventory, requisitioning, stores, and purchasing functions. Essentially, professionals produce plans and forecasts in separate systems and then manually enter the data in the inventory/stores systems in order to generate a demand on the purchasing function. Ultimately this results in redundant entry of data, time lags, bottlenecks, increased cycle time, increased inventory, and significant manual coordination. Frequently, for MRO based commodities, there is no forecasting mechanism available; you "guesstimate" what your future needs might be based on past activities. This is similar to attempting to drive your car forward while only looking in the rearview mirror.

This typical scenario might lead an organization to search for a better system. Perhaps a group of materials and information technology personnel from the organization participate in a software demonstration provided by an ERP systems supplier. The experience convinces the group that they have been missing a significant opportunity to make a quantum step in how to manage the business. Business systems technology has changed dramatically, but many professionals — because they’re content with current systems — are just not aware of the new technology that has evolved.

How can a simple demonstration lead to successful implementation of today’s latest technology? Why would an organization choose this route? Instead of the above scenario, organizations are looking for a system that would receive orders and automatically send information upstream to production, purchasing, and suppliers. At the same time, inventory, materials, and capacity requirements are made available so that attainable delivery dates can be set. The system communicates to finance and receiving regarding expected invoices and materials. Internally, purchases are fully automated throughout the organization. Throughout the entire process, data is in real time and can be pulled, assessed, and shared with suppliers to optimize their contribution.

The Reach of ERP

The following functions can be encompassed in the enterprise resource planning system:

**General ledger** — integrates with purchasing, inventory, stores, asset management, payroll, accounts payable, accounts receivable, budgeting, fixed asset management, treasury, and cost accounting functions.

**Payroll** — directly integrates labor reporting features and can handle account and preparation of checks.

**Fixed assets** — manages depreciation and other factors associated with buildings, property, and equipment.

**Human resources** — automates personnel management processes, including personnel records, recruitment, and business travel. This function integrates with the payroll, training, and labor management modules. It can also manage safety management and hazmat/environmental exposure.

**Production/manufacturing** — integrates with production scheduling, shop floor planning, order entry, requisitioning, stores, purchasing, and logistics.

**Maintenance** — integrates with asset management; warranty tracking; preventive, predictive, and scheduled maintenance; project management; purchasing; stores; inventory; and general ledger.

**Project management** — monitors costs and work schedules on a project-by-project basis.
Customer service management — administers installation-based service agreements and checks contracts and warranties when customers call for help.

ERP solutions are constantly evolving into larger applications as the supplier either produces additional modules for integration or develops partnerships with third-party suppliers of value-added functionality that can be seamlessly integrated with the base product to expand its capability. Examples of this are:

- Warehouse management systems (WMS)
- Supply chain management (SCM)
- Computerized maintenance management systems (CMMS)
- Enterprise asset management systems (EAM)
- Electronic document management systems (EDMS)
- Forecasting algorithms
- Supplier performance evaluation
- Wireless mobile computing devices for remote access
- Bar code systems
- Graphical warehouse models
- Asset optimization modeling
- Predictive maintenance forecasting/modeling
- Capacity planning
- Transportation management
- Reporting (report writers)
- Data warehousing

Is ERP Right for Your Organization?

When considering whether or not your organization could benefit by moving from an existing legacy system, multiple systems, or no system at all to an ERP environment, consider the following points.

- A change to a new system might be required if your current system(s) no longer supports your needs. For example, to obtain data on total spending for a facility, is information systems (IS) support required? A new system would allow purchasing and supply management to generate such reports independently.

- Current systems are inefficient if they require duplicated efforts in data entry or information processing. For example, as purchases are made, an improved system routes data to receiving, inventory, and finance accordingly.
• Has your organization experienced mergers and acquisitions, resulting in several independent systems, which have difficulty communicating with each other?

• Your motivation to purchase an ERP system should be based on the desire to seamlessly integrate the primary business systems within your organization. This means that there must be a thorough understanding of the business functions prior to selecting and implementing a system. There must also be a willingness to change among all functions within your organization.

• Typically, ERP systems are sold to customers based on an expected return on investment (ROI). If this is the basis on which you are buying the system, and you suspect your executive management will base the project’s success measure on, ensure you have good baseline data that can be measured against post-completion results. The average investment for a new ERP implementation can range anywhere from $2 million to $4 million, depending on the size of the company and the chosen supplier. You will have to determine a business plan that shows the payback for this investment — typically within one to three years.

• Selecting and implementing a system will require a project team committed to the task. In addition to internal resources, many organizations choose a third-party consulting firm to assist in the implementation. Internal resources will be dedicated to this project for the duration (potentially on a full-time basis) so organizations will have to make provisions in the individuals’ work areas accordingly.

• Data will be a critical path. While data conversion, migration, and scrubbing will be time consuming, applying sufficient resources prior to initiating this process to plan and strategize how the data will be used post-implementation is essential in order for your clients to effectively use the product once it has been implemented.

ERP IN MOTION

Here is a typical example that demonstrates how various modules of an ERP system work together. You can see that the system employs a holistic approach to managing data that connects logical business functions and provides needed information at the point of use without having to integrate a variety of freestanding systems. In this example, an internal business unit (operator) has created a work order to repair a piece of capital equipment.
Once an activity has been performed and historical data has been generated, future jobs have a baseline against which they can be scheduled and measured on factors such as cost, expected bill of labor, bill of equipment, or bill of materials. Of significant benefit is that these various bills only need be created one time in the system and then associated with asset work orders when future activities require the same. In these situations, the following can be avoided: manual scheduling of resources, human interaction to ensure availability of materials, physical traveling of paper for approvals and routing, and repeat trips to in-plant stores for parts that were not anticipated. With these activities eliminated, an organization is able to reap the following benefits:

- Increased productivity for maintenance personnel
- More efficient scheduling of crews and assets
- Reduced paperwork
- Reduced overtime requirements
- Reduced inventory requirements
- Reduced stock-outs and work stoppages due to materials shortages
- Improved reporting
- Capability to better understand components of cost and failure analysis
- Improved internal customer service
• Increased availability (uptime) of assets, which may lead to improved asset utilization (or less capital equipment needs)

**Project Manager**

According to the GartnerGroup, Inc., a successful project manager

- is flexible
- is disciplined
- is a quick learner
- is a good decisionmaker
- has ERP experience
- has business experience
- has political clout
- has a formal education
- is well liked
- motivates staff

**RESOURCES**

If you are interested in learning more about ERP applications, there are numerous sources that can provide information that may be of value. The following are independent research organizations that evaluate and report on software and technology.

GartnerGroup. GartnerGroup provides research, analysis, consulting, measurement, decision evaluation, and product and supplier selection tools regarding the information technology industry.

[www.gartner.com](http://www.gartner.com)

Aberdeen Group. Aberdeen Group provides IT consulting and market strategy advice, and publishes research reports and papers on information technology topics.

[www.aberdeen.com](http://www.aberdeen.com)

AMR Research. AMR Research is an industry and market analysis firm specializing in enterprise applications, underlying architectures, and related business and technology trends.

[www.amrresearch.com](http://www.amrresearch.com)

Forrester Research. Forrester is an independent research firm that analyzes the future of technology change and its impact on businesses, consumers, and society.

[www.forrester.com](http://www.forrester.com)

Yankee Group. The Yankee Group specializes in IT research and advisory services, focusing on the areas of strategic planning assistance, technology forecasting, and IT industry analysis.

[www.amrresearch.com](http://www.amrresearch.com)

The following Web sites contain helpful reference and resource information on ERP systems. They include articles about ERP, user discussion forums, supplier evaluations and contact information, industry news reports, and several links to additional ERP resources.
ITtoolbox Portal for ERP  
www.erpassist.com

ERP-People.com  
www.erp-people.com

ERPSupersite  
www.erpsupersite.com

The ERP Fan Club and User Forum  
www.erpfans.com

ERP Hub  
www.erphub.com
PURCHASING

Accounting & Finance for Purchasing

Purpose of accounting and finance.

Financial records based on sales volume in dollars (also referred to as revenue) and expenses or costs of doing business reflect the health and profitability of the business. Such records are required by the taxing authorities and other outside parties as well as managers within the company. Financial reports prepared for outside parties are considered part of Financial Accounting. Financial reports prepared for managers within the company are considered part of Cost or Managerial Accounting.

Why purchasers should know something about accounting and finance.

It is important for purchasers to know if suppliers are financially sound. This is called financial responsibility. Otherwise the supplier may not be able to complete a contract or deliver on time or produce the goods and services to meet specifications. The supplier may be needed in order to obtain information, obtain consumable items or repair components long after goods have been delivered. Knowledge of financial statements helps the buyer predict the staying power of a supplier. Knowledge of the supplier's organizational structure tells the buyer who will be responsible if problems develop.

It is also important for purchasers to work with other company managers in developing, reviewing, and analyzing financial information needed within the company to make management decisions. In this role, the purchaser is often a member of a management team, often headed up by the Financial Manager, the Operations Manager, or the Project Manager.

How business transactions are recorded by accounting.

Transactions are recorded in a journal. Businesses use a double entry system that requires a debit entry and a credit entry for each transaction. Debits are a positive or improvement in assets. Assets are what a company owns. Credits may be thought of as an increase in either liabilities or stockholder’s equity. In accounting terms, “debit” means an entry on the left hand side of the account, while “credit” means an entry on the right hand side of the account. Each journal entry for a debit must have a credit entry made for another account at the same time. For example, if a company receives $20 in cash, the cash account is debited to show cash has been increased by $20. If this item was carried in “accounts receivable” (credit sale), the debit will be offset by charging $20 to accounts receivable, thereby reducing the amount owed to the company. The journal gives a chronological record of all transactions and provides some detail explaining the transaction. Each journal entry is posted to individual ledger accounts. Debits are posted on the left side of the account and credits are posted to the right side of the account. There are separate accounts for cash, accounts receivable, inventory, accounts payable, and everything else showing up on the Balance Sheet.

How accounting reports business activity.

Accounting departments prepare various reports so management can determine how the business is doing and to take corrective action if necessary. Some reports are prepared on a regular basis; such as monthly, quarterly, and annually. Information in these reports is helpful and sometimes required for credit rating services; such as Dun and Bradstreet. They also may be required for stockholders, banks, and other lending institutions.

Types of accounting reports.
Balance Sheet

The Balance Sheet reflects the condition of the business at a particular point in time or rather on a particular date. The report lists the assets (A), the liabilities (L), and the stockholder’s equity (E), all in dollars. The total amount of the assets must equal the combined total of the liabilities and the stockholder’s equity. In other words they must balance. \( A = L + SE \)

Assets are subdivided into Current Assets and Fixed (Long Term) Assets. Current Assets are those such as cash or that can be converted into cash quickly (normally within the current accounting period or one year). Fixed Assets are Capital items (like Property, Plant, and Equipment) or those that may take longer than one year to dispose of or turn into cash. Each asset and each liability shown on the balance sheet has a corresponding ledger account for the category. Typical and usual current asset accounts shown on the balance sheet are Cash, Accounts Receivable, and Inventory. Typical Fixed Assets are Land, Buildings, and Equipment. Most Fixed Assets (other than Land) are depreciated, meaning their value is reduced in the Balance Sheet to reflect the use, over time, of those assets.

Liabilities are subdivided into Current Liabilities and Long-Term Liabilities. Current Liabilities are those that need to be paid within a short period of time (usually one year). Long-Term Liabilities include Long Term Loans from the Bank or Long-Term Bonds issued by the company in order to raise capital.

Profit and Loss Statement (Also called Earnings Statement and Income Statement)

The profit and loss statement shows the revenues (sales) and expenses of the business for a certain period such as a month, or a quarter, or a year. The difference between the revenue (sales) and the expenses indicates the amount of profit or loss for that period.

Cash Flow Statement

A separate report is prepared to show the inflows and outflows of cash during the accounting period. This report normally shows the source of the inflow and the beneficiary of the outflow.

Budgets

A budget is a “monetized plan” showing forecasted or “pro-forma” financial statements reflecting how the company expects to operate during a period of time. All efficient businesses prepare and use budgets. Just like the business plans that they support, budgets are short term (less than 12 months), intermediate term (1 to 5 years) or long term (beyond 5 years).

The budgets may be made for the entire organization or by each department.

Capital Items and Fixed Budgets

Capital budgets show the amounts to be spent for capital items. Capital items are tangible durable products such as furniture, major tooling, and equipment. Budgets for capital items are normally fixed with a specific amount for each item or group of items because the amount to be spent can be closely estimated. The cost of capital items is depreciated or spread over the expected life of the product. For example, if the piece of equipment cost $100,000 and is expected to last ten years, then the product is depreciated by $10,000 per year. In other words, the value on the books is reduced by $10,000 per year by charging the $10,000 to depreciation expense.

Expense Items and Variable Budgets
It is preferable to use variable budgets for consumable items needed to run the business and for products intended for resale. This is because the amount to be spent depends on the sales volume and more must be spent on these types of items as sales go up and less should be spent if sales go down.

Financial Planning Budgets

The controller or chief financial officer probably makes a budget that reflects anticipated income and expenses. This major plan is used by management to approve or disallow items on the other types of budgets. It is used to determine the need for borrowing or raising additional capital.

Manpower or Headcount Budgets

These are often made for the number of people required to operate the business. Each department may estimate how many people are needed for the entire year or for each month of the year. Often salaries and pay increases by job or by individual are also budgeted.

What budgets are used in purchasing

Capital budgets are established by other departments, but purchasing may need to develop information for use both those other departments and also establish and obtain approval for a capital budget for items needed within the purchasing department. Such items may include new furniture, personal computers, or a copier machine for use within the purchasing operation. An expense budget may be needed for travel to suppliers or to a seminar. A headcount budget may be needed to maintain the same number of buyers or hire more help. On the other hand, purchasing usually has no control over items needed for manufacturing or for inventory for resale. Those items are usually budgeted by other departments or determined by sales volume.

Financial Analysis

It is important to evaluate the financial strength of a supplier before giving a major order to that supplier. A strong financial position indicates that the supplier will be able to fulfill the order. It means the supplier will have the funds or be able to obtain the funds necessary to buy any material required. A strong financial position means the supplier will likely remain in business to make good on any warranty and provide any needed repair parts or service for the purchased item. Here are some of the ways financial condition may be checked.

Obtain Bank References

Contact the bank to verify the supplier has an account and how long it has been established. Ask how much the average balance is. Ask if the supplier has a line of credit with the bank. Compare the average balance to the accounts payable amount to determine if the supplier has sufficient funds to cover current bills.

Contact a Credit Reporting Service

Ask Dun & Bradstreet or another credit reporting service for a credit report. Although there are fees for these reports, it is a small price to pay for some assurance that the supplier is capable. Often the buyer's accounting department already has paid an annual fee for a volume of such reports and they may get the report for purchasing. The buyer must not accept all information in the reports without question as the credit service often simply obtains the information directly from someone at the supplier who may or may not be totally truthful.

Obtain the Supplier's Financial Statements
The buyer may obtain financial statements for analysis directly from the supplier or through the “Edgar Website” maintained by the Securities and Exchange Commission or sometimes even through a stock broker. The information is available to the public for public (Stock Exchange) listed companies. Although private suppliers may not want to cooperate because they feel the information is confidential, it can be pointed out that the information will not be disclosed elsewhere and it will be used strictly to evaluate the ability of the supplier to fulfill the requirements of the order and the ability to become a continuing source of supply. The buyer should request the current annual statements plus annual statements for two previous years.

Observe if revenue and profit are going steadily up, down, or fluctuating. Increasing or steady amounts are favorable, decreasing amounts unfavorable. Fluctuating revenue is cause for caution and further analysis. Calculate liquidity ratios. The Current Ratio should be computed. The Current Ratio is current assets divided by current liabilities and indicates how prepared a company is to pay its current debt. A rule of thumb is that a Current Ratio of 2 or higher is satisfactory although the average for healthy or not so healthy organizations may differ by business type. The Quick Ratio should also be computed. The Quick Ratio is also referred to as the Acid Test Ratio, and is a good indicator of business strength. The Quick Ratio is calculated by dividing Cash, Marketable Securities, and Receivables (or all Current Assets except for Inventory) by Current Liabilities. This is a somewhat better indicator than the Current Ratio because it eliminates the Inventory amount from the calculation since inventory may not be as easily converted into cash when needed. The Debt to Equity Ratio should also be computed. This is determined by taking total liabilities (debt) and dividing by total stockholder’s equity. This ratio provides a quick look at how the supplier is financing his operation using debt and equity and helps financial institutions like banks determine whether or not the supplier is “loan worthy”. Too much debt compared to equity is not looked on with favor by financial institutions.

Checking Invoices for Accuracy

Invoices should agree with purchase orders and the quantities and specifications of the goods received should match both the purchase order and the invoice. This checking operation is not considered a responsibility of purchasing operations and good accounting practice usually frowns on assigning this function to buyers or other purchasing personnel. It is considered poor accounting control. Of course, it may be necessary in a very small company that has very few employees. Otherwise the comparisons are usually made by accounts payable personnel. Many organizations now use the computer to make the comparisons. When discrepancies are found, the invoices may be returned to the seller for correction or the goods may be returned to the seller. Buyers often must resolve disputes through negotiation with the supplier when the responsibility for errors is not clearly established.
Administration of Purchasing

How work can be divided in a multi-buyer environment.

Work volume in purchasing may be delegated to buyers by product category, part number, or by supplier name. It is considered best to have a single buyer responsible for the same item and the same category of items and is best to also have a single buyer or purchasing manager responsible for the selection and evaluation of a supplier's performance.

The types of organizational structure for purchasing and the advantages and disadvantages of each.

The organization of purchasing is often a function of the company's organizational structure.

Decentralized

A highly decentralized purchasing organization in one where every employee buys whatever he or she needs to accomplish his or her business duties. Some new businesses or small organizations use this method until the excessive cost of this method is discovered. Other organizations have one purchasing agent or even an entire purchasing department at every branch or plant location. The argument for this structure is that communications between the user and the buyer are better and the use of local suppliers promotes good will in the community. This seems less true today with the availability of FAX machines, e-mail, and modern transportation.

Modified

A modified system is where certain items or categories of items are purchased at a central location such as the home office and other items are purchased locally. This is a compromise and is well suited to situations where a local operation may be purchasing goods that are not purchased elsewhere.

Centralized

A highly centralized purchasing operation is one where all purchases are made from one location. Centralized purchasing provides the following advantages.
1. Buyer Specialization
   Fewer buyers can be used and each buyer can spend more time learning the intricacies of the products under his responsibility unlike the decentralized system where a purchasing agent must know about every product that might be purchased.
2. Economies of Scale
   A buyer buying for many locations has larger volumes that normally reduce the cost. Negotiations and documentation are done once during a given period instead of many times. Duplication of effort is avoided.
3. Supervision is Easier
   A highly qualified purchasing manager can be hired to supervise buyers whereas it is unlikely that a local branch can afford to hire expensive purchasing talent or is unlikely to have experienced purchasing professionals available.
4. Product Standardization Reduces Costs
   Product Standardization generally means that all employees and departments use the same brand, make and model of any particular product. This can reduce costs in a few ways. Since volumes are higher, economies of scale (as stated above) becomes a factor. Also, since parts for products are standardized, volume discounts can be obtained. Cost of servicing products can also be reduced because fewer service providers are required.

Staff (Specialized) Purchasers
A purchasing staff is often used by larger organizations. Staff positions usually have little direct authority. Those in staff positions act as consultants or perform duties other than those that carry out the everyday function of the business. Staff purchasing people write policies and procedures, conduct audits of purchasing operations, plan and recommend actions, gather statistics, conduct price and cost analysis, and report activities. Sometimes these staffs will conduct outsourcing and/or offshoring from non-domestic sources. In larger organizations, staff purchasing people award and administer “corporate blanket order contracts” that are used everywhere within the organization. Some organizations also have negotiators on their staff, particularly for larger, more complex contracts. Purchasing staffs often report to the highest level within the organization. They may report to a Vice President of Purchasing or the President of the company. Those with the title of V.P. of Purchasing or Director of Purchasing may hold staff positions.

Line

Those in line positions carry out the everyday needs of the organization. Their responsibilities relate to the core operation of the organization. In manufacturing companies, purchasing will usually report to the Manufacturing or Operations Manager. Manufacturing/operations is most definitely a line function. In non-manufacturing organizations, purchasing will often report to the Chief Financial Officer, who heads the accounting and finance functions. These are most definitely staff functions. Purchasing Managers usually perform a Staff Role for their Manufacturing or CFO supervisors and a Line Role with respect to the buyers reporting to them.

Forms

The essential forms used in purchasing and how they are used. Numerous types of forms are used in business and what is used varies by industry and individual company; however, the following forms are used throughout the business world and are considered essential for good purchasing practices.

Requisitions

Forms used by the person or department needing material or services to notify purchasing what to buy. Normally the form is a hard copy, but some companies are now notifying purchasing through computer screens.

Bills of Material

These are used primarily by manufacturing companies. The items listed on a bill of material are the components used in the manufacturing process to make a finished product. However, bills of material are sometimes also used for a long list of finished goods needed for inventory.

Request for Quotation

This form is a “solicitation” and is often referred to as an RFQ. It is used to ask suppliers to submit information about products for sale. The information may be about specifications or about prices and terms of sale only. The latter is particularly true when the request is for an item made to the buyer's specifications. The form usually has spaces for the names and addresses of more than one supplier, although the copies sent to suppliers only show the name of the supplier that it was sent to. The other names and addresses are blanked out. A space is provided for the buyer to indicate the deadline when the form should be returned. The form is often used as an offer to buy as well as to simply obtain information. Bids may be accepted as final offers to sell or as subject to negotiation. For larger purchases, the “solicitation” may take the form of an “Invitation for Bid”, “Invitation to Bid”, “Request for Bids”, “Request for Proposals”, or “Request to Negotiate”.

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Bid Analysis

A spread sheet form used by buyers to enter all the data received from each supplier so the offers can be compared for delivered cost. The form often contains spaces to be filled in for F.O.B. point, payment terms, price, and other information. The columnar design is ideally suited for computer spread sheet programs such as Lotus and Excel.

Purchase Orders

This is the most important form used in purchasing for business. The form is used to notify the selected supplier of an offer to buy a product or service or to confirm a contract already made. The form contains spaces for the most frequently used terms and conditions. They include the date of the order, the date delivery is required, the F.O.B. point, the method of transportation requested, the payment terms, the quantity ordered, a description of the product, the piece price, the extended price for the quantity ordered, and the total price of the order. It is usually a multipart form.

In legal terms, the purchase order is considered an offer by the buying organization to buy the goods or services identified therein. The supplier accepts the purchase order by either signing the document (a bilateral contract) or by performing (a unilateral contract).

The original and possibly a copy are sent to the supplier. The copy is called an acknowledgment and is to be signed and returned to the buyer. Another copy is usually sent to accounts payable notifying accounting that it is an authorized purchase for the terms and conditions shown on the filled in form. A copy with supporting documents is kept on file in purchasing. Standard terms and conditions are preprinted on the front and on the back of the form. The terms and conditions are sometimes referred to as "boilerplate." Purchase Orders or "PO's" are prenumbered for control purposes. No one other than an authorized buyer should give a purchase order or a purchase order number to a supplier.

Purchase Order Revisions

This form is used to make revisions to the purchase order without the necessity of rewriting all terms and conditions of the original. The form usually indicates that all other terms and conditions remain the same except for the changes specified.

Purchase History

A purchase history showing prices paid, the date of purchase, the quantity purchased, and the name of the supplier is essential to determine the amount purchased with a supplier and to evaluate prices from new suppliers or negotiate with existing suppliers. In the past all such information was recorded on handwritten records. Today, most companies obtain this information from data stored in the computer.

Inspection Reports

Inspection report forms are not normally designed or initiated by purchasing but are important for purchasing operations. Usually a quality control or quality assurance function issues inspection reports. They are essential for rejected material received from outside suppliers that does not meet specifications. The reason for the rejection must be clearly stated and sufficient information must be included so the buyer can make a claim or negotiate a settlement with the responsible supplier.

Receiving Reports
Receiving report forms are issued by the receiving function. The form shows when the material was received, the name of the supplier, the items and quantities that were received and any damage or discrepancies in the shipment. The name of the carrier should also be given.

How to find sources of supply.

Supplier names, addresses, and telephone numbers along with other information about suppliers can be obtained from various directories. A buyer can learn about new suppliers by attending trade shows, reading trade magazines, and questioning salespeople from other suppliers. Names of companies in foreign countries can usually be obtained from the Consul located at the foreign embassy's office in Washington, D.C., New York, and sometimes other major cities in the U.S. The Internet can be used to access information about products and companies. Commonly used hard copies of directories include the following.

Yellow Pages

The Yellow Pages of telephone books are an excellent choice for quick information. They are free for your own location. They may be ordered for other major cities at a small cost. The weakness is that no individual names are given and product descriptions are often insufficient. There is little or no information about a company's capabilities.

Thomas Register

This is the most common and perhaps most widely used directory for industrial buyers. It can be purchased, or much of the information can be obtained from its Web site. Very little financial information is included and no individual contact names are provided.

Special Product Directories

Nearly every industry has its own directory that can either be obtained from a trade magazine or from an industry association. Most include little or no financial information and no individual contact names.

Standard & Poor's Register of Corporation, Directors, and Executives

A valuable book that can be rented for $510 a year or checked at nearly every business library. Not much product information, but names of officers and titles are given. Annual sales volume is included as well as the date the business was started.

Internet

The Internet has now become a popular source to find suppliers. Search engines make locating companies with needed products easy. Suppliers and customers can find each other no matter what the physical distance in a short amount of time. The Internet can save a buyer much time; however, negotiating a better price may not be as easy.

How computerization makes purchasing easier. Computers have replaced many of the tedious manual operations that made purchasing one of the most difficult functions to administer. Enormous amounts of typing, filing, and paper distribution were necessary and still are in companies that have not taken advantage of the power of the computer. Not only has purchasing reduced the labor required to process transactions, it has provided a vast amount of information quickly and economically to help buyers negotiate better purchases.

Here are some of the ways the computer is now being used in purchasing.
Requisitioning
With a LAN (Local Area Network) individuals or departments can send their requests for material via e-mail or by using forms contained in a purchasing program. The user types the requirements and they appear on the buyer's monitor or may be printed out in the purchasing office. Requirements entered in this fashion are recorded for reference later if needed.

Purchase Order Generation
Buyers enter all necessary information to generate Purchase Orders that are delivered via the Internet or are printed out and mailed in the customary method. Some systems include a variety of standard terms and conditions that are stored in the computer and can be selected by the buyer to suit the transaction. P.O.’s generated this way eliminate the need to type similar information for a particular supplier every time that supplier receives an order. Default addresses, payment terms, and F.O.B. points are automatically inserted unless revised by the buyer. Errors are minimized because they can be corrected on screen before the orders are printed or sent.

Purchase History
Traditionally records of purchasing activity are kept on cards that show the name of the supplier, the quantity ordered, the date of the order, a description of the item ordered, and the purchase order date. Some also record the date the shipment was received along with any discrepancies or quality problems. This information is valuable to check previous prices paid. It helps determine how much business was given to each supplier and how the suppliers performed over time. However, it is difficult to accumulate totals for all the various items purchased from each supplier and how much was spent with each supplier. The computer keeps most all of the required information automatically or it can be obtained easily from the database obtained from computer stored purchase order records.

Purchase Reports
Perhaps the most valuable benefit derived from computerization of purchasing records is the information obtained from various reports. A listing of all suppliers and how much was spent with each helps the buyer concentrate cost reduction efforts on those with the largest volume of business. A listing of how much was spent on each item and on categories of items offers a similar benefit. A listing of the number of items processed, the number of orders issued, and the amount spent by each buyer helps in evaluating workload and in planning the staffing level.

Sourcing As stated in the preceding section many buyers now source using the Internet. This is a timesaving tool and can be very helpful; however, remember that many times prices are fixed when using this method.

Methods of Procurement
Procurement methods are those procedures by which the purchasing organization translates requirements into contracts. Procurement methods establish the methods of both offer evaluation and supplier selection. The method of procurement and the type of contract are arguably the two most important decisions made during the advance purchasing planning process.

Low Dollar Value Procurement Methods
Most organizations employ a combination of the following procurement methods for low dollar value purchases from commercial sources:

1. Oral (Telephone) Ordering
2. Blanket Purchase Agreement
3. Written Purchase Order
4. Imprest (Petty Cash) Fund
5. Credit Cards
6. Other methods, including electronic ordering, use of consignments, and purchase order drafts

Simplified, Small, or Informal Purchases

In most public sector purchasing organizations these are called "Simplified, Small, or Informal Purchase Procedures". Generally, these procedures should not be used for the following:

1. Purchases of other products or services in which there are complex questions to be considered or specific contract provisions to be included (inspection and testing, insurance, patents, price adjustments, and so forth). This is generally true in the Federal Government part of the public sector of purchases in excess of $100,000.

2. Purchases of research and development, complex studies and services, or other requirements which demand judgmental technical evaluation or involved negotiations, and where award cannot be made confidently on the basis of low price. In such purchases, formal methods should be used.

3. Requirements for Consultant Services. Extreme caution should be used in acquiring these services by use of small purchase methods because of the possibility of entering into improper personal service contracts. Internal guidance on purchasing expert and consultant services should be reviewed prior to each purchase.

If the needed goods or services cannot be provided by an established source and the expected cost is more than the low dollar value threshold, the requisition and all supporting information should be reviewed for completeness and forwarded to the purchasing professional with the appropriate authority for handling the purchase. Purchasing professionals with relatively low levels of purchasing authority can play a valuable role in the initiation of these larger dollar volume purchases by assisting technical personnel in preparing requisitions and related supporting material.

Oral Ordering

A good business practice which reduces the paperwork associated with small purchases is to permit the oral placement of orders, primarily for supplies, by purchasing professionals. This method reduces paperwork by permitting less formal documentation of the Order, as well as encouraging faster delivery by the supplier. It is useful in situations where other simplified methods, such as calls against blanket purchase agreements are not practical. The oral ordering method should be considered for use when all of the following conditions can be met:
The item description is simple and can easily be communicated verbally with a minimum change of misunderstanding. Oral ordering is generally applicable to the purchase of standard items and is not intended for special orders or nonstandard designs;

The purchase does not exceed the low dollar value threshold (or the purchasing professional's delegated procurement authority, if less);

Effective competition can be obtained for purchases over a certain dollar amount, and quotations are obtained and documented.

A written or electronic PR exists;

The supplier does not require a written order in advance of shipment or performance.

Conditions Inappropriate for Oral Ordering

Oral ordering should generally not be used if detailed specifications or elaborate terms and conditions are required. If the supplier selected for award will accept an oral order, the purchasing professional should give the supplier the oral purchase order number and the date of order; (the oral order number is assigned in the same manner as for a written order. The supplier should be told to include the oral order number and date on the invoice. However, if the transaction will be covered under a blanket purchase agreement, a call or release number will be needed in lieu of a purchase order number. If the transaction will be paid for by use of the imprest fund, no order number is needed, but the supplier must be notified that payment will be made in cash); the item description, unit, quantity, and price; the required delivery date and location; quoted terms and conditions (e.g., discount, if any); method of shipment, when applicable; F.O.B. point; method of payment (C.O.D., imprest fund, written invoice, etc.); and the address to which the invoice will be submitted after the delivery is made, if applicable.

Documentation of Oral Orders

The oral order must be documented promptly after it is placed, normally within two (2) days. Documentation may be accomplished by using a purchase order, a blanket purchase agreement call, or if payment will be made by imprest fund. If all items on a requisition cannot be obtained from one supplier, or if price or other considerations necessitate purchase from more than one supplier, each order placed must be documented separately.

When a supplier accepts an oral order, but requires a written confirmation, the oral order may be placed and followed promptly by a confirming written purchase order which obligates the funds and documents the item description, the price, and the terms. A confirming written order is normally used when the supplier requires a written purchase order document, and the need is so urgent that the order must be entered immediately and work started before a written order can reach the supplier and/or when the purchase is of such a nature that costs cannot be accurately determined at the outset, and it is customary in the trade to charge for an estimate. For example, some equipment repairs involving disassembly and inspection to determine the repairs needed meet this qualification. In such cases, the purchasing professional should provide oral authorization for the disassembly and inspection, and then issue a confirming purchase order for this work plus the repair work, based on the estimate furnished by the supplier. If the cost cannot be determined exactly but can be reasonably estimated, the purchasing professional should issue a written purchase order in advance, showing an estimated amount, instead of sending a confirming order later.

Written Purchase Orders
The most frequently used method for effecting small dollar value purchases is issuance of a written purchase order. When sent to a supplier, this document acts as the purchasing professional's offer to buy at the prices and under the terms and conditions stated. When received and accepted by the supplier, the purchase order becomes an agreement having the same force and effect as a formal contract. In addition, there are other, more simplified methods which may be used instead of a written purchase order, under specified conditions, to expedite processing and reduce the administrative burden.

Definition

A purchase order is a transaction requesting the delivery of supplies or equipment or the performance of services. It is normally a written document, signed by a purchasing professional and addressed to a supplier, however, it may be oral. It contains all of the terms and conditions that will govern the delivery or performance, but it does not obligate the supplier to perform.

Unilateral Orders

When sent to a supplier without requesting the supplier to sign and return a copy, the Order is a unilateral (one party) document. It is the purchasing professional's offer to contract, i.e., to buy at the prices and under the terms and conditions stated. Issuing the purchase order by itself gives no assurance that the supplier will render the requested delivery or performance, nor does it obligate the supplier to perform.

Only when the supplier accepts the purchase order by performance does the unilateral order become a formal contract. Contract formation by supplier performance is the normal purchase order method. Using this method, the supplier accepts simply by proceeding to furnish the supplies or services ordered or by proceeding to carry out the order to the point where substantial performance has occurred. In this way, the supplier indicates consent to the purchase order's terms and conditions.

Bilateral Orders

A bilateral (two party) purchase order becomes a formal contract when both parties have signed the document. Using this method, the purchasing professional sends the purchase order to the supplier requesting that the supplier sign and return a copy of the purchase order or provide any other form of written notification indicating receipt and acceptance.
Written Purchase Order Advantages

Although the administrative cost involved with using a written purchase order is greater than for other simplified transactions, the document affords many advantages. It can be used when detailed specifications are involved, when a large number of line items are being purchased, and when the dollar amount exceeds the limit for use of the imprest fund or a blanket purchase agreement. The purchase order document contains terms and conditions necessary to specify the rights and obligations of the parties. These may be either printed on the back of the form or attached to it. They may be supplemented by other terms and conditions needed for a specific transaction. Delivery orders are also documented on the same form.

Use as Delivery Orders and Receiving Documents

Purchase order forms are also used as delivery orders for purchase under indefinite delivery contracts or Cooperative, Corporate, or Lead Division contracts. Preparation of such forms as delivery orders is essentially the same as for preparation of a purchase order.

Most purchase orders forms are multipurpose forms which can be used not only to order materials, but may also to receive them. The front of many purchase order forms is a format for insertion of the particulars of the purchase, as well as a receiving report format.

A continuation sheet, provides additional space for continuing the item descriptions placed on the purchase order form, or for continuing information in any other block when the purchase order form does not provide enough room (for example, multiple addresses and delivery dates, additional terms or conditions, etc.).

Written Acceptance

For some purchases, it is desirable to know immediately whether the supplier has accepted the purchase order. In those situations, a notice indicating the requirement for an imprest fund acceptance notice should be included in the written purchase order.

Written acceptance is often desirable when the time of delivery or performance is critical; when the purchasing professional has experienced problems with the supplier in the past; when the contract is for services; when the contract requires performance over an extended period of time; when the item needed is complex (not off-the-shelf); when the purchase is of a relatively high dollar value; or when the presence of special terms and conditions make the contract administration more complex.

Once signed and returned by the supplier, the Purchase Order becomes a binding bilateral contract.

Purchase Terms and Conditions

The terms and conditions are normally stated on the purchase order document. Suppliers should be notified that the purchasing professional's terms and conditions shall govern. Nevertheless, a supplier may acknowledge a purchase order with a standard acknowledgement form that contains other terms and conditions, such as "prices subject to change prior to delivery" or "prepayment required." Such an acknowledgement is a counteroffer, and the purchasing professional must deal with it promptly. The order may be cancelled outright, or the purchasing professional may return the counteroffer as unacceptable and attempt to negotiate acceptance of the purchasing professional's terms. If the terms of the counteroffer are acceptable, and do not conflict with the standard terms and conditions, they may be accepted. If there is any question as to the acceptance of the supplier's terms and conditions, contact the Procurement Manager for advice. If prompt action is not taken, the purchasing professional may be held to have accepted the supplier's terms.
Unpriced Orders

The use of unpriced orders is discouraged because it is not a good business practice. There are times, however, when it is not possible to establish a firm fixed price for supplies or services until the work is performed. In this case, the purchasing professional may use unit prices with ceilings or a ceiling for the total order.

Purchase Order Distribution

Purchasing professionals should distribute copies of the purchase order from at the time of preparation, following procedures used by their respective activities.

Distribution must be limited to the minimum necessary for essential administration and transmission of contractual information. Distribution should not be delayed until the goods are received. The normal distribution is:

Original - Supplier
1 copy - Accounts Payable
1 copy - Warehouse Receiving (Supplies)
1 copy - Purchasing professional's PO File
1 copy - Requisitioner

Blanket Purchase Agreements

Establishing a blanket purchase agreement or blanket order with a supplier is the equivalent of opening a charge account. It is not a contract, but rather an agreement which is convenient for both the purchasing professional and the supplier. The agreement permits specifically named individuals who are not purchasing professionals to place over-the-counter request instead of by written purchase order. The purchasing professional designates such individuals, and may revoke such designation as needed. The purchasing professional is responsible for ensuring that designated individuals understand the operation of the agreement, and their responsibilities and limitations when placing calls. The blanket purchase agreement utilizes consolidated invoicing (usually monthly) for all purchases made during the previous billing period. Persons not specifically named on blanket purchase agreements may not place calls against the blanket agreement, even though they are delegated purchasing authority as a warranted purchasing professional. (Of course, the purchasing professional who established the blanket may obviously place orders, modify and terminate the blanket.) Thus, establishment of a blanket purchase agreement with a supplier from whom frequent, repetitive purchases are made can significantly reduce paperwork and administrative cost per order.

No Obligation to Place Orders

Under a blanket purchase agreement the purchasing professional is not obligated to place any orders, and the supplier is not obligated to accept any orders. In other words, a blanket purchase agreement is not enforceable against either party. An enforceable contract does not come into being until a call against the blanket purchase agreement is given by the purchasing professional and accepted by the supplier. In this regard, a blanket purchase agreement can be contrasted with a definite delivery type of contract that would be created in a janitorial services situation.

Conditions Appropriate for Use

Blanket purchase agreements are useful and authorized when a variety of items in a broad class of goods, such as hardware, is purchased from local suppliers, but the exact items, quantities, and delivery
requirements are not known in advance and may vary considerably from order to order; when there is a need to obtain commercial sources of supply for an organization that does not have or otherwise need authority to purchase; and when the writing of numerous purchase orders and the processing of many invoices can be avoided.

**Multiple Agreements Recommended**

It is preferable to have blanket purchase agreements established with several suppliers for the same classes of items or services. Orders can then be placed conveniently with the firm that offers the best value, price and other factors considered, for a particular purchase, and therefore provide for competition.

Purchasing professionals should review their past order files for recurring requirements for related items, the files should be reviewed to see if certain suppliers tend to receive many orders. If so, the purchasing professional should investigate the possibility of establishing a blanket purchase agreement. As a rule of thumb, unless an average of four calls per month over a 6 month period are placed against a Blanket agreement, another procurement method may be more economical.

**Appropriate for Repetitive Ordering**

The potential savings to be gained through the establishment of a blanket purchase agreement are directly related to the number of repetitive purchases made. Occasional needs of small dollar amounts are more appropriately handled by another purchase method, such as oral orders or written purchase orders. Also, when the specifics of a recurring requirement are known, another type of purchase order may afford a more appropriate vehicle.

**Imprest (Petty Cash) Fund**

An imprest or petty cash fund is a cash fund charged against the purchasing organization's account and advanced by the Finance/Accounting Department to a properly authorized cashier. Imprest funds cashiers are designated by the Finance/Accounting Officer upon the recommendation of a higher level manager. The fund is used to make immediate cash payment of relatively small amounts for authorized purchase of supplies and nonpersonal services. It generally is of a revolving type, replenished to a fixed amount as the cash is spent or used. Although the imprest fund is more properly a disbursing device than a procurement method, it is included in this discussion of procurement methods because funds in an imprest fund can be used to pay for purchases which are made through the oral ordering method discussed earlier. The imprest fund should be used when such use will eliminate costly, time-consuming paperwork and when making direct cash payment wills be advantageous to the purchasing organization.

**Credit Cards**

Although different organizations have different policies and procedures, the following policies and procedures from one specific organization using a corporate type credit card were found to provide an adequate degree of controls and safeguards. These policies and procedures could of course be modified to meet specific organizational objectives.

**Functional Responsibilities**

The cardholder is the individual to whom a card is issued. The card bears this cardholder's name and may only be used by this individual to pay for authorized purchases. All purchases that will be paid for using the card must comply with the purchasing organization's existing policies and procedures. Each
cardholder is to reconcile his/her monthly statement and forward the reconciled statement to his/her approving official.

An approving official will review the cardholder's monthly statement and serve as liaison with the contacts identified in paragraphs below. The approving official will certify the cardholder's monthly statements and ensure that payments are for purchases which are authorized and made in accordance with existing policies and procedures. The approving official will also assist the cardholder in resolving disputed payments. The approving official has authority to direct the purchasing professional to instruct the bank issuer of the credit card to cancel a card at any time. The approving official should be a high level official within the purchasing organization. A cardholder cannot be his/her own approving official. A cardholder should not be an approving official for his/her own supervisor.

The purchasing manager issues a delegation of authority to cardholders and approving officials. The delegations normally specify the authority being delegated and any limitations on the authority.

The bank issuing the card issues a Statement of Account on a monthly basis to all card holders. This Statement lists all payments authorized for purchases and credits made by the cardholder and billed by merchants.

A purchasing professional administrative manager generally serves as the focal point for coordination of the applications, issuance and destruction of cards, establishment of reports, and administrative training.

The purchasing organization's Finance Office makes payment for the approving officials' certified monthly statements.

A legally trained individual within the purchasing organization is generally assigned to coordinate, process and monitor all disputed purchases, credits or billing errors.

Someone within the purchasing department (sometimes the cognizant purchasing professional responsible for setting up the agreement with the bank) acts as liaison between the purchasing organization and the issuing bank. This person oversees the credit card program and establishes guidelines. Changes to dollar limitations or authorized merchant codes are generally approved by this individual.
Policies Appropriate for Use of Credit Cards

The credit card should be used to pay for low dollar value purchases made in accordance with Standard Purchasing Practices. It should primarily be used to pay for supplies or services acquired using oral solicitation procedures. It may also be used to pay for supplies or services that are acquired through a purchase order or written contract. Without exception, the credit card may only be used to pay for authorized purchases. Generally the credit card should not be used for cash advances.

The Purchasing Manager should delegate authority to make purchases up to a given amount per transaction to be paid for using the credit card to individuals that have a need for the authority. Individuals that have not taken formal purchasing training courses should receive orientation/training on low dollar value purchasing. These individuals should also receive procurement ethics training.

When the account information is submitted to the purchasing professional administrative manager contact, a signature card should be completed that states the approving official may certify credit card invoices for payment. The signature card should be forwarded to the Finance Office after completion. An alternate approving official should be designated to avoid statement processing delays and late payment penalties.

Electronic Ordering

This method requires the purchasing professional to place an order electronically with a supplier (using some form of Electronic Data Interchange (EDI)). Many larger suppliers have the capability of accommodating this form of purchasing. Fax transmissions are increasingly being used both in the solicitation and ordering processes.

Use of Consignments

This method requires the purchasing professional to place an order to cover materials and supplies physically located on the purchasing professional's premises. Under this method, the purchasing organization draws from the supplier-maintained and owned inventory. The supplier verifies withdrawals and bills the purchasing professional on some regular schedule. This is an increasingly popular procurement method.

Purchase Order Drafts

This method requires the purchasing professional to use a combination purchase order and blank check. The supplier completes the blank check, which is limited to relatively low dollar amounts and sends it to the designated bank for processing and payment. Drafts (sometimes called warrants) are very popular in public school districts for payment of employees.
Procurement Methods Generally Employed for Higher Dollar Value (and More Complex) Purchases

Most organizations employ a combination of the following procurement methods for higher dollar value purchases from commercial sources:

(1) Competitive Bidding

(2) Negotiation

Although these are the two basic procurement methods, there are modifications or adaptations of these two. These modifications either relate to use of "hybrid" methods or relate to the instrument or ordering mechanism which results from the competitive bidding or negotiation processes. "Hybrid" methods would include:

(1) Two-step Bidding

(2) Sealed Bidding/Formal Advertising

Methods which relate to the instrument used or the ordering mechanism would include:

(1) Systems Contracting

(2) Contracts for "Just-in-Time"

(3) Use of "Standing Orders"

Competitive Bidding

Competitive Bidding is the most widely used method of procurement for larger value purchases in commercial and industrial settings. In the Federal Sector and in some states, the method is referred to as "Competitive Proposals". The method contemplates the seeking of competition (either on a full and open basis) or among firms that are considered "preferred", "partnered", "certified", or "prequalified" suppliers. Restriction of competition to the latter four categories is very common among commercial and industrial organizations. For most private entities, competitive bidding (almost always without a public opening), is the preferred procurement method. Firm-fixed-price purchasing with the lowest responsive and responsible bidder is attempted and often achieved. Some firms and industries know no other way of purchasing. This is particularly true of the construction business, where a firm-fixed-price contract with the lowest responsive, responsible bidder after competitive bidding is the normal procurement method.

Competitive bidding is generally appropriate whenever there is expected to be adequate competition on the procurement; when there is sufficient time for the solicitation, evaluation, and award processes; when the description of requirements is sufficiently definite to allow offerors to bid without a great deal of pricing contingency; and when the decision to award a fixed price contract can be readily arrived at based upon prices submitted and price-related factors.
Negotiation

Some purchasing situations, however, provide more opportunity and present significant challenges, making it appropriate and/or necessary to deviate from the strict firm-fixed-price competitive bidding mode of selection and to engage in some degree of negotiation, either on technical qualifications, cost of performance, or both. When the organization desires to award a contract to the supplier with the highest affordable technical quality, but that desired quality cannot be defined in the statement of requirements, use of a "Best Value" evaluation approach must be employed. This permits the organization to request technical (and other) proposals, from which the level of quality can be inferred.

In many procurements, it is highly appropriate to use a logical mix of technical/management and price/cost/business evaluation criteria in selecting a firm. Typically, the more technical the work, the more weight that is given to the technical criteria. Procurements of research and development services, for example, often warrant consideration of price/cost only if offerors are otherwise equally technically qualified (as a "tie-breaker"). Consultants are almost always selected on technical qualifications (as long as the rate of compensation doesn't exceed pre-established policy parameters).

Two Step (Bidding)

Two-step bidding is considered a "hybrid" method of procurement because it contemplates technical negotiations followed by a price competitive selection similar to the process used in competitive bidding. In the first step, the purchasing professional solicits technical proposals (only) from potential suppliers. A purchasing professional team evaluates the technical proposals, conducts technical negotiations as necessary, and then places the proposals in three categories:

(1) Acceptable
(2) Subject to Being Made Acceptable
(3) Unacceptable

The second step is to solicit priced offers (no cost proposals required) from the firms which have submitted technical proposals in either of the first two categories. The award decision is then similar to the decision made in competitive bidding (i.e., the lowest, responsive, responsible firm normally gets the award.

Sealed Bidding/Formal Advertising

This is a "hybrid" method of procurement because it is an adaptation of competitive bidding. In addition to following the normal rules for competitive bidding, a public bid opening is held and firm, strict rules are followed on acceptance and evaluation of bids. Because it is so rigid and inflexible (no negotiations or discussions are permitted), this method is used almost exclusively in the public (government) sector.
Systems Contracting

This method relates to the ordering mechanism employed during the life of the contract. It is often used in manufacturing environments for ordering or MRO materials. It contemplates a high degree of cooperation between the purchasing professional and supplier facilitating a reduction in inventory for both the purchasing professional and supplier. Ordering is accomplished by designated purchasing organization personnel using an order release form so designed as to permit the supplier to use the form for stock picking and order assembly. The form normally contains instructions for routing and delivery. The method contemplates sharing purchasing organization usage estimates and schedules to the supplier so that, in an ideal condition, the method acts similar to "stockless purchasing". This type of contract is similar to a "requirements" or other indefinite delivery type contract (see the discussion on types of contracts).

Contracts for “Just-in-Time”

Another method which relates to the ordering mechanism employed would contemplate a contract providing for "Just-in-Time" ordering. This is similar to systems contracting with one major difference. The primary focus here is on manufacturing materials and components as opposed to MRO items. Because there has been so much written about just-in-time, we shall not explore the concept in depth. Use of this method provides reduced inventory investment, reduced warehouse space, better inventory turnover, purchase savings in lower prices, and paperwork simplification.

Use of “Standing Orders”

An additional instrument used to facilitate ordering is a "standing order". Such an instrument normally is negotiated and contains fixed prices during the ordering period. It is sometimes called "open-ended ordering" and, like the systems contract, is similar to a "requirements" or other indefinite delivery or blanket order type contract.
Types of Contracts

Types of contracts that are available are explained below. Some general rules on types of contract are indicated below.

GENERAL RULES ON TYPES OF CONTRACTS

• Although cost reimbursement and incentive contracts are available for use on many contracts, the most common types of contracts used are firm-fixed-price, indefinite-delivery type, and time-and-materials/labor hour (or a combination of these)
• The cost-plus percentage-of-cost type of contract should not be used.
• The firm-fixed-price type of contract shall be used whenever practical, and the purchasing professional should state the reason(s) include in his/her negotiation memorandum for selecting a contract type other than firm-fixed-price.

Fixed-Price Family of Contracts

Firm-Fixed-Price

A firm-fixed-price contract provides for a price that is not subject to any adjustment on the basis of the supplier's cost experience in performing the contract. This contract type places upon the supplier full risk and full responsibility for all costs and resulting profit or loss. It provides maximum incentive for the supplier to control costs and perform effectively and imposes a minimum administrative burden upon the purchasing professional.

A firm-fixed-price contract is suitable for acquiring commercial products or commercial-type products or for acquiring other supplies or services on the basis of reasonably definitive functional or detailed specifications when fair and reasonable prices can be established at the outset.

Fixed-Price With Economic Price Adjustment/Escalation

A fixed-price contract with economic price adjustment provides for upward and downward revision of the stated contract price upon the occurrence of specified contingencies. Economic price adjustments are of three general types:

1. Adjustments based on established prices. These price adjustments are based on increases or decreases from an agreed-upon level in published or otherwise established prices of specific items or the contract end items.
2. Adjustments based on actual costs of labor or material. These price adjustments are based on increases or decreases in specified costs of labor or material that the supplier actually experiences during contract performance.
3. Adjustments based on cost indexes of labor or material. These price adjustments are based on increases or decreases in labor or material cost standards or indexes that are specifically identified in the contract.

A fixed-price contract with economic price adjustment may be used when:

1. There is serious doubt concerning the stability of market or labor conditions that will exist during an extended period of contract performance; and
2. Contingencies that would otherwise be included in the contract price can be identified and covered separately in the contract. Price adjustments based on established prices should normally be
restricted to industry wide contingencies. Price adjustments based on labor and material costs should be limited to contingencies beyond the supplier's control.

A fixed-price contract with economic price adjustment should not be used unless it is necessary either to protect the supplier and the purchasing professional against significant fluctuations in labor or material costs or to provide for contract price adjustment in the event of changes in the supplier's established prices.

Fixed-Price Incentive

A fixed-price incentive contract is a fixed-price instrument that provides for adjusting profit and establishing the final contract price by application of a formula based on cost as accrued and normally performance factors. The negotiated contract parameters include a target cost, target fee (profit), share formula, and ceiling price.

A fixed-price incentive contract is appropriate when:

1. A firm-fixed-price contract is not suitable;
2. The nature of the supplies or services being acquired and other circumstances of the procurement are such that the supplier's assumption of a degree of cost responsibility will provide a positive profit incentive for effective cost control and performance; and
3. If the contract also includes incentives on technical performance and/or delivery, the performance requirements provide a reasonable opportunity for the incentives to have a meaningful impact on the supplier's management of the work.

A fixed-price incentive contract should be used only when:

1. This contract type is likely to be less costly than any other type;
2. It is impractical to obtain supplies or services of the kind or quality required without the use of this contract type;
3. The supplier's accounting system is adequate for providing data to support negotiation of final cost and incentive price revision; and
4. Adequate cost information for establishing reasonable firm targets is available at the time of initial contract negotiation.

Indefinite-Delivery (Blanket Order) Type

Indefinite-delivery type contracts are often called "open end" or "term" contracts. They are quite frequently employed in service and supply contracts, either in pure form or in combination with other types such as firm-fixed-price and time-and-materials or labor-hour. There are three basic forms of indefinite-delivery type contracts, including requirements contracts, indefinite-quantity indefinite delivery, and definite-quantity indefinite delivery. Since the first two are more commonly used, let's explore these two in some detail.

Indefinite Quantity-Indefinite Delivery (IQID) Contracts

The IQID establishes firm fixed unit prices for the units of work sought by the purchasing professional. It states a guaranteed minimum quantity (base amount) and an estimated maximum quantity (ceiling or cap). This contract type is utilized when the purchasing professional is seeking supplies or services that requires high mobilization or start-up costs which would not be recoverable if only a small percentage of the total estimated services were actually ordered. The base amount should be more than just a nominal quantity, but should not exceed the total amount the purchasing professional feels certain will be needed. This base provides the supplier with a minimum upon which to offer, thus providing a means to recover costs of mobilization or start-up.
IQID contracts provide the purchasing professional with certain benefits. Should the supplier's performance be poor, the supplier may be paid for the guaranteed minimum and the contract closed. A new solicitation and subsequent contract for the supplies or services can then be issued. The purchasing professional should be aware, however, that in a new solicitation, there is no guarantee that the same supplier will not be the lowest offeror.

When an IQID contract is awarded, the purchasing professional is generally authorized to order any number of units to the maximum amount estimated for each work item in the schedule. The supplier is then responsible for supplying the minimum quantities and additional quantities up to that maximum. If the purchasing professional fails to order the base amount, the supplier must still be paid the minimum amount guaranteed by the contract.

Funds for this type of contract are obligated only for the amount guaranteed at the time of award. The balance of the funds for the units of work in excess of the base are obligated through delivery orders as the items or services are procured by the purchasing professional.

Requirements

The requirements contract establishes firm fixed unit prices for the units of work sought by the purchasing professional. This type contract provides that quantities stated in the schedule are estimated and are not determined by the contract award. This type contract further provides that the stated quantities are used only for the purpose of evaluating offers and determining the low offeror. Offerors are put on notice that all or none of the work may be ordered. This type contract also provides that the contract is guaranteed that if any contract work listed in the schedule is needed during the term of the contract, such will be procured from this supplier. This procurement guarantee excludes performance of such work by the purchasing professional in-house forces unless the contract contains a provision that under specified circumstances the purchasing professional reserves the right to use in-house employees. Such reservations must be very explicit.

The solicitation package for a requirements contract must clearly state that estimated quantities shown are solely for offering and offer evaluation purposes. The solicitation documents include a reasonable maximum ceiling or cap that may be ordered overall and limits any delivery order amount and number of delivery orders at any one time under the contract. This cap or ceiling protects the supplier from being inundated by an unanticipated workload and allows the purchasing professional to solicit for large jobs separately.

The requirements contract does not obligate funds at the time of contract award. Obligation of funds occurs upon issuance of a delivery order. When the need for the item or service is required, a delivery order is written pursuant to the terms of the contract.

The requirements type contract does not provide the supplier with any insight of how to gear up for the work; it only provides an estimate on which to base minimum levels of personnel, supplies and equipment. As a result of the unknowns associated with this type of contract, its use may attract few offerors.
Blanket Agreement

A blanket agreement is a written instrument of understanding that contains:

1. Terms and conditions applying to future orders (calls) between the parties during its term;
2. A description, as specific as practicable, of supplies or services to be provided; and
3. Methods of pricing, issuing, and delivering future orders (calls) under the blanket order.

A blanket agreement is not a contract. Blanket agreements may be used if there is a wide variety of items in a broad class of services or goods that are generally purchased but the exact items, quantities, and delivery requirements are not known in advance and may vary considerably, or in any other case in which the writing of numerous procurement orders can be avoided through the use of this procedure. A ceiling must be established for the total instrument as well as for each order (call).

Cost Reimbursement/Reimbursable Family of Contracts

General Guidance on Use

These types of contracts are suitable for use only when uncertainties involved in contract performance do not permit costs to be estimated with sufficient accuracy to use any type of fixed-price contract. They are particularly appropriate for research or preliminary exploration or study where the level of effort required is unknown and for development and testing.

A cost reimbursement contract provides for payment of allowable incurred costs, to the extent prescribed in the contract. These contracts establish an estimate of total cost for the purpose of obligating funds determining the fixed fee, and establishing a ceiling that the supplier may not exceed (except at its own risk) without a modification to the contract.

Cost reimbursement contracts should be used only when the supplier's accounting system is adequate for determining costs applicable to the contract; when appropriate surveillance during performance will provide reasonable assurance that efficient methods and effective cost controls are used; and when this particular type of contract is likely to be less costly than any other type or it is impractical to obtain supplies or services of the kind or quality required without the use of this contract type.

Cost With No Fee and Cost Sharing With No Fee

These are cost-reimbursement contracts in which the supplier receives no fee. They may be appropriate for research and development services, particularly with non-profit educational institutions or other non-profit organizations, and for facilities contracts. In cost contracts, the purchasing organization reimburses the supplier all reasonable, allocable, and allowable costs. In cost sharing contracts, the purchasing organization splits the total costs in some way (50-50, direct-indirect, or by phase).

Cost-Plus-Fixed Fee

A cost-plus-fixed fee contract is a cost-reimbursement contract that provides for payment to the supplier of a negotiated fee that is fixed (in dollar amount) at the inception of the contract. The fixed fee does not vary with actual cost, but may be adjusted as a result of the changes in the work to be performed under the contract under the changes article or other mechanism specifically set forth in the contract.
Cost-Plus-Incentive-Fee

A cost-plus-incentive-fee contract provides for a target cost, a target fee, a minimum and maximum fee, and a fee adjustment formula.

Under this type of contract, the purchasing professional reimburses the supplier for all actual allowable costs. Then, the purchasing professional applies the fee adjustment formula. Under the formula, if the actual allowable costs exceed the target costs, the supplier's fee is less than the target fee and vice versa. In other words, the lower the supplier's costs, the higher the supplier's fee. Regardless of cost incurrence, the contract will not earn more than the maximum fee or less than the minimum fee. Performance incentives may be applied to the contract arrangement to supplement the cost incentive, if appropriate.

The cost-plus-incentive-fee contract is suitable for use in development and test programs when cost (and performance) incentives are likely to motivate the supplier.

Cost-Plus-Award Fee

The cost-plus-award-fee contract is a cost-reimbursement contract that provides for a fee consisting of:

1. A base amount fixed at inception of the contract; and
2. An award amount that the supplier may earn in whole or in part during performance and that is sufficient to provide motivation for excellence in such areas as quality, timeliness, technical ingenuity, and cost-effective management.

The amount of the award fee to be paid is determined by the supplier's performance in terms of the criteria stated in the contract. Criteria are generally of a subjective nature.

The cost-plus-award-fee contract is suitable for use when:

1. The work to be performed is such that it is neither feasible nor effective to devise predetermined objective incentive targets applicable to cost, technical performance, or schedule;
2. The likelihood of meeting a purchasing objective will be enhanced by using a contract that effectively motivates the supplier toward exceptional performance and provides the purchasing professional with the flexibility to evaluate both actual performance and the conditions under which it was
3. Any additional administrative effort and cost required to monitor and evaluate performance are justified by the expected benefits.

“Hybrid” Contracts

Time-and-Materials

This type of contract is commonly used in purchasing.

A time-and-materials contract provides for acquiring supplies or services on the basis of:

1. Direct labor hours at specified fixed hourly rates that include wages, overhead, general and administrative expenses, and profit; and
2. Materials at cost, including, if appropriate, material handling costs as part of material costs.

A time-and-materials contract should be used when it is not possible at the time of placing the contract to estimate accurately the extent or duration of the work or to anticipate costs with any reasonable degree of confidence.
A time-and-materials contract should be used:

1. Only when no other contract type is suitable; and
2. Only if the contract includes the establishment of a separate ceiling amount for labor, beyond which the fixed hourly rates specified in the contract will be reduced by deleting the profit included therein (in order to avoid a cost-plus-a-percentage-of-cost situation).

Labor-Hour

Labor-hour contracts are a variation of the time-and-materials contract, differing only in that materials are not supplied by the supplier or, if they are supplied, their cost is included in the loaded hourly rate.

Combination Contracts

The purchasing professional will be confronted with many situations which call for a flexible approach to structuring contracts. Many functions require consideration of combination or composite contract-type thinking. It is not uncommon to be confronted with a situation which requires consideration of a combination firm-fixed-price/requirements/time-and-materials contract, particularly where a contract must, of necessity, incorporate both service and construction work.

Combination/composite contract thinking has logically spread into the supply and service contract business in general. Many purchasing situations call for work "as needed", which essentially means the contract needs an indefinite-delivery type and/or time-and-materials/labor-hour type schedule of "on call" requirements (often in conjunction with firm-fixed-price work).

The combining of contract types in a single contract document for associated services is practical because it reduces the number of formal solicitation packages that have to be prepared, the solicitation effort, and the resulting contract documents. For instance, one contract can contain a combination of a firm-fixed price and time-and-materials work.

Letter Contract

A letter contract is a written preliminary contractual instrument that authorizes the supplier to begin immediately performing work. Their use should be strictly discouraged.
Evaluation and Analysis-Low Dollar Value (Small) Purchases

The evaluation and analysis process is considerably less complex for low dollar value purchases than it is for larger complex contracts. Because of that, we shall devote our first discussion to the process of evaluating those lower dollar value purchases.

Purchases using “low dollar value procedures” may use factors other than price as the deciding factor in award. These purchases do not require the use of explicitly stated technical evaluation factors to determine which firm is in line for award. However, where awarding to other than the low quoter, the purchasing professional should document the file as to the reason for not awarding to the low quoter. This is particularly appropriate for situations where the low quoter is determined to be a nonresponsible firm by virtue of demonstrated poor past performance or inability to satisfy other contractor responsibility standards.

Factors to Consider

The purchasing professional should evaluate the quotations received in order to determine which quotation represents the most favorable buy. The critical determining factor often is price. Nevertheless, other factors do come into play.

In many purchases, the purchasing professional must analyze the operation of such quantitative factors as discounts, all-or-none qualifications, and transportation charges in determining the lowest evaluated price to the purchasing organization. Various adjustments to prices may need to be made, singly or in combination.

Generally, quotations may be evaluated using a number of criteria in addition to price. These criteria are shown below

Evaluation Factors in Addition to Price for Low Value Purchases

1. Relative quality and adaptability of supplies or services;
2. Supplier's financial responsibility;
3. Supplier's skill;
4. Supplier's experience;
5. Supplier's record of integrity in dealing;
6. Supplier's ability to furnish repairs and maintenance;
7. Time of debriefing or performance offered;
8. Compliance with specifications.
This flexibility permits the purchasing professional to award to other than the lowest supplier. However, when doing so, the reason why award does not go to the low supplier must be documented on an abstract of bids.

Awards may only be made to responsible suppliers. Responsibility factors to be considered include any or all of the criteria above.

For many purchases, it is necessary to negotiate before issuing the purchase order to make sure that the purchasing professional obtains the best deal available. Guidelines for conducting negotiations are presented later in this text.

For all but the most straightforward purchases, preparation of an abstract or matrix of the quotations facilitates the evaluation process.

Pricing for Low Value Purchases

If low dollar value purchasing procedures and approaches to pricing are to be effective, all persons involved must demonstrate ability to use pricing judgment and discretion in exercising their authority. Because of the simplified procedures for small purchases, authority and responsibility are delegated to a greater number of people. These personnel may make the ultimate decision to buy, sometimes while talking to the supplier on the phone. Their actions must be based on sound judgment so that the best buys, price and other factors considered, can be made.

All purchasing professionals have an obligation to procure at fair and reasonable prices. The terms “fair” and “reasonable” signify that a price is acceptable to both the purchaser and the seller. Whether the price paid is in fact fair and reasonable will depend on the effectiveness of the purchasing professional in evaluating quotations and reaching a conclusion. To be effective, the purchasing professional must develop a working knowledge of the products being bought and the industries being dealt with. This knowledge will facilitate decisions as to the fairness and reasonableness of the prices to be paid.

Different Conditions Require Different Analytical Methods

The conclusion that a price is fair and reasonable must be based on some form of price and/or cost analysis. How detailed this analysis will be depends on the dollar value and the nature of the product or service being purchased.

Price Analysis

Both Dobler and Burt (1996) and Graw (1994) assert that "Some form of price analysis is required for every purchase." Although this is true, price analysis takes on special importance when it is employed by itself (without the use of cost analysis). Price analysis is generally used without cost analysis for low dollar purchases; for most competitive purchases, even though of a large dollar value; for purchases based upon existing catalog or market prices; and for purchases of items or services for which regulated prices exist (regulated utility services).

Basic for Comparison

To perform price analysis, the purchasing professional must have a base or reference to which the quoted price can be compared. That basis for comparison must itself be known to be reasonable. Then the purchasing professional must ensure that the quotation and the base are truly comparable and that the comparison is not being made between apples and oranges. That is why the comparison of competitive quotations is such an effective method of price analysis. If the purchasing professional can be reasonably
assured that the items are comparable and, presuming that the firms involved are really competing with one another, then the lowest price submitted will be reasonable.

In performing price analysis, comparability is the key. One must consider:

• quality of the items for which prices are being compared;
• quantities involved in the sale;
• delivery conditions (f.o.b. origin versus f.o.b. destination);
• market conditions (for some items, tomorrow's price may be different from yesterday's, often by a wide margin).

If the purchasing professional can arrive at a reasonable base for comparison, even though it includes adjustments for differences in relation to some of the items listed above, the use of price analysis techniques will determine whether a price is fair and reasonable.

Methods of Price Analysis

Many methods of price analysis are available. Selection of the method to use depends on the specific features of the acquisition situation. In many instances, a combination of methods is best. The following methods are among the most commonly used:

Comparison With Competing Offers on the Instant Procurement

This is generally considered a primary method of price analysis. It is nothing more than the act of seeing what price quoted is the lowest among those received. Unless there is some doubt about the adequacy of competition, this method is generally considered a conclusive judge of price reasonableness. The purchasing professional must be sure, however, that the prices compared are submitted on the same basis and that factors such as transportation charges to be paid by the purchasing professional (when delivery is to be f.o.b. origin) have been considered. See the discussion below with respect to placing offers on the same basis.

Comparison With Established Catalog Prices

In the absence of price competition this method of price analysis should be considered a primary method of comparison. The method is supported by the fact many suppliers publish prices for items which are regularly offered for sale. Quotations can be compared to those published prices, but caution is required. First, the purchasing professional must make sure that the catalogs represent actual prices which are now or were recently being charged. (Catalog prices are frequently discounted for Government agencies and large corporations, which are generally considered "most favored customers" because of the large volume of business they engage in). Second, the purchasing professional must be sure that the price listed applies to an item which is sufficiently similar to the required item to provide a sound basis for comparison. Third, the purchasing professional must be sure that the catalog or price list applies to the same class of trade. If one item at a time is being purchased, comparison to the Sears or Montgomery Ward catalog price is indicated. But if the purchase is for wholesale quantities, the Sears or Wards prices are not indicative since they do not reflect normal trade or quantity discounts.

Comparison With Established Market Prices
Like the comparison with established catalog prices, this method of price analysis should be considered a primary method in the absence of price competition. Many items are regularly traded at prices which tend to fluctuate over short intervals. Catalogs of prices for these items are not published because changes occur too rapidly. But if the purchasing professional can establish the price range in which sales are being made to the general public (through trade journals or other sources), that range can be used as a basis for comparison.

Comparison With Prices Set By Law or Regulation

This is another primary method of price analysis which is appropriate when dealing with regulated utility services. Regulated utilities (electric companies and the like) are required to seek the approval of their regulatory commission before they can adjust their rates. These public regulatory commissions are zealous of the consumer interest and grant increases in rates rather sparingly. If the purchasing professional is buying regulated services, the regulatory commission approved rates will be published and available to the purchasing professional. The purchasing professional, however, must be assured of the fact that the classification being used by the utility is correct. Many electricity tariffs (rate schedules) will have different rates for heavy and light users; for commercial, industrial, and governmental users; and for non-profit users. The purchasing professional must assure the lowest rate available to the purchasing professional's specific situation is the one applied. In addition, the purchasing professional must recognize that his organization may have an opportunity to impact the rates through the process of "intervention" at the public utility hearings. He should recognize further his organization may be able to establish a rate category specific to his organization's circumstances. These opportunities should be explored if appropriate.

Comparison With Current Prices Paid for the Same or Similar Items, Past Prices Paid for the Same or Similar Requirement, and Past Offers

This method of price analysis should be considered only after one or more of the primary methods discussed above has been attempted. If the price quoted is the same or less than that which was recently paid for the same or similar items, the current quotation is likely to be reasonable. Purchasing professionals should be careful, however, to ascertain that the historical prices to which a comparison is made were themselves adequately analyzed for reasonableness. Further, they should take into account price trends (up or down) caused by market or economic conditions, rapidly fluctuating commodity prices, or other factors. Often the purchasing professional will have a basis for comparison in the form of prices for an item that is similar but not identical to the one being bought. If the purchasing professional can, through some method of price analysis, determine what the difference in price should be between the item being purchased and the one for which prices are available, that difference can be used as an adjustment in order to arrive at a valid comparison. Price history information can be obtained from the records of the Contracting or Purchasing Department, the requisitioning activity, or if necessary, from other contacting organizations. The purchasing professional must be sure the price history applies to the same item under similar conditions.
Comparison With Producer Price and Other Market Indexes

This technique, although it is generally considered a secondary method of price analysis, is very powerful and should be considered for use even when other more obvious comparative methods are available. This method is often used in conjunction with the method discussed immediately above in order to make prices from different points in time comparable with respect to a specific point in time. There are numerous indexes available to the purchasing professional for use in the following analytical procedures:

- Adjusting previous prices for the effects of inflation from the purchase date to the present.
- Adjusting current prices for the effects of inflation from the present to the previous purchase date.
- Extrapolating current prices into the future based upon the assumption future price increases will mirror the past. This is generally done through forecasting of index numbers.
- Comparing prices paid in two successive contracts with increases in market prices during the same period.
- Comparing price increases in one commodity against price increases in another commodity during the same time period.
- Comparing general growth in prices (Consumer Price Index) with growth of specific items or commodities (Producer Price Index).

Sources of Indexes

Although the Consumer Price Index and the Producer Price Index (both monthly publications available from the U.S. Department of Labor Bureau of Labor Statistics (BLS)) are the two most commonly used indexes in price and cost analysis, there are several other publications which may be of interest to buyers. The BLS also publishes wage and benefit changes resulting from collective bargaining settlements and unilateral management decisions, statistical summaries, and special reports on wage trends in its monthly publication entitled "Current Wage Developments" in addition to articles on labor force, wages, prices, productivity, economic growth, and occupational injuries and illness in its monthly publication entitled "Monthly Labor Review". Still other helpful BLS publications include the "Area Wage Surveys" published in 70 different parts throughout the year. These surveys include office clerical, professional, technical, maintenance, custodial, and material movement occupations. The U.S. Departments of Commerce, Interior, and Energy also publish specialized information which may be helpful in analyzing labor and material price trends. Many commercial and industrial publications have helpful pricing information which can also be used to analyze labor and material trends. Many of these are industry specific.

Comparison With Cost Estimating Relationships, to Include Rough Yardsticks and Parametric Relationships

This comparison technique is considered by many to be a powerful secondary method of price analysis. Cost estimating relationships are defined as relationships between cost and an item or service characteristic. Typical cost estimating relationships include those included on the next page.
COST ESTIMATING RELATIONSHIPS

• The cost of construction based upon floor space, roof surface area and/or wall surface;

• The cost of gears based upon gear net weight, percent of scrap produced by the gear, inches of teeth cut into the gear, the hardness of the gear, and/or the envelope of the gear;

• The cost of trucks based upon truck empty weight, truck gross weight, horsepower, number of driving axles, and/or loaded cruising speed;

• The cost of passenger cars based upon curb weight, width of wheel base, square feet of passenger space, and/or horsepower;

• The cost of turbine engines based upon dry weight, maximum thrust, cruise thrust, specific fuel consumption, bypass ratio and/or inlet temperature;

• The cost of reciprocating engines based upon dry weight, piston displacement, compression ratio, and/or horsepower;

• The cost of sheet metal based upon net weight, percent of scrap, number of holes drilled, number of rivets placed, inches of welding, and/or volume of envelope;

• The cost of aircraft based upon empty weight, speed, useful load, wing area, power, and/or landing speed;

• The cost of diesel locomotives based upon horsepower, weight, cruising speed, and/or maximum load on standard grade at standard speed.

Developing the Cost Estimating Relationship

The "and/or" in the explanations above suggest that cost estimating relationships can be based upon more than one independent variable (the "based upon" factors). Although the simplest cost estimating relationships are linear (indicating a straight line on a graph of the independent and dependent variables), some relationships are curvilinear (other than a straight line). Such relationships are best dealt with by using computers. Actually modern computer programs are helpful in developing all types of cost estimating relationships and are even more important when forecasting dependent variables (the "costs" indicated above which are "based upon" the independent variables suggested.)

When developing a cost estimating relationship, it is necessary first to designate and define the dependent variable (the factor that is influenced or caused by the independent variable). The dependent variable is generally cost or manhours.
After designation of the dependent variable, one must select item characteristics to be tested for estimating the independent variable. The independent variable is the factor that influences or "drives" the dependent variable. Finding that independent variable is not always easy. The purchasing professional will need to draw upon his/her personal experience, the experience of others, and published information. In selecting the independent variable, the purchasing professional should consider only factors which are (1) readily available in a statistically usable form; (2) quantitatively measurable; (3) related to performance characteristics of the item or system being explained by the cost estimating relationship.

After selection of the dependent and independent variables, the purchasing professional will need to collect data concerning the relationship between the two. Data for at least five points (often years) should be collected. The data should be checked to assure that it is relevant, comparable, and free of unusual elements.

After collection of the data, the purchasing professional will need to examine the relationship between the independent and dependent variables. This examination can be something as simple as graphing the data to something as complex as running the data through a computer regression analysis program. The purpose is to test the degree of relationship between the variables. A high correlation coefficient between the variables usually indicates that the independent variable will be a good predictive tool.

After examination of the relationship, the purchasing professional will need to determine the relationship that best predicts the dependent variable. This generally requires testing more than one independent variable against the dependent variable.

Once the best relationship is identified, the model or formula resulting from the effort is saved for use as a forecasting tool.

Comparison With In-House Estimates

If the requisitioner has developed a competent cost estimate for the item or service to be acquired, the quoted price can be compared with that estimate. Care should be exercised to ensure that the estimate is a sound base for comparison which takes into account all factors which will affect the price. The estimate should have been prepared when the PR was submitted, without knowledge of the quotes received. The estimate is not to be based on the amount of program funds available, but in consideration of the current market prices for the goods and services being requisitioned. Detailed, "bottom-up" estimates are particularly important in purchasing of services, particularly construction services. A detailed in-house estimate will be very helpful to the construction purchasing professional for comparison with the low bidder's working papers whenever there is some question about whether the low bidder has missed some work in his bid. By doing a "side-by-side" comparison of the low bidder's working papers and the in-house estimate, serious estimating errors can be discovered. The prudent course of action for the purchasing professional in such an eventuality is to permit the low bidder to withdraw his bid and proceed on to the next bidder (who would generally be subjected to a similar type of comparison.) If, of course, the low bidder had bid in line with the in-house estimate, there would be no need for a "side-by-side" comparison.
In-house estimates are also essential in performing cost analysis, particular in limited competition situations. When a potential supplier submits a cost proposal in response to the solicitation, the purchasing professional generally relies upon his own engineer's estimate of required manhours, material quantities, and equipment quantities in analyzing the supplier's cost proposal. In many cases, the labor rates, material prices, and equipment rates included in the in-house estimate are good guides to follow also. Generally, however, these rates (and the accompanying indirect rates) are subject to additional verification by purchasing professional and/or auditor review of supplier books and records and/or market rate analysis.

Comparison With Prices Determined by Value and Visual Analysis

These techniques are generally considered tertiary or "auxiliary" price analysis techniques. Value analysis is the task of determining why seemingly similar products should be price differently. The technique helps the purchasing professional understand the reason for price differences between past buys and present offers. Buyer value analysis generally concentrates on utility and aesthetic qualities of similar items in order to derive opinions of respective value. The analysis normally takes place in two stages. In the first stage the purchasing professional lists the functions required and compares the required functions to those of alternative products. In doing this, the purchasing professional assumes that an item with a lower use value should have a lower price (an assumption which may not be supported in fact). In the second stage, the purchasing professional identifies and compares the aesthetic functions to those of alternative products. Upon completing the second stage, the purchasing professional often finds that the price differentials, if any, are supported by the aesthetic differences rather than the use differences. Commercial and industrial entities are generally more interested in use than aesthetic value.

Visual analysis is a simpler technique in that it involves visual inspection of the item (or alternatively, the representations of the item in drawings), in order to develop a rough estimate of the value. Because it concentrates on obvious, external features of an item, it should be used only to get you "into the ballpark". However, it can prevent mistakes and oversights and lead to questions about offered prices. The purchasing professional who bought the now infamous "$600 Hammer" would probably have benefited from this analytical technique.

Evaluation Factors for Award of Multiple Contracts

When quotations are obtained on related items such as various supplies, small hardware items, equipment parts, or office supplies, the purchasing professional may stipulate in the Request for Quotations that the purchasing professional reserves the right to award on an all-or-none basis; that is, the purchasing professional may purchase from the offeror who submits the lowest total price for all items, rather than issue a purchase order to each supplier on the basis of the lowest quotation on each item. Purchasing on the basis of lowest total cost may afford savings since the cost of writing and administering multiple purchase orders and making multiple payments may be rather expensive. At many organizations, the cost of issuing an order and paying the invoice for a low value purchase is estimated at $100. (The Federal Government uses $500--other organizations use factors falling between these two values).

This amount will be used as an evaluation factor when considering award of multiple orders from a single RFQ.
EXAMPLE 1

In the following example, award in the aggregate should be made to Supplier B because that will result in a total savings, even though B was not low on each item.

SUPPLIERS

<table>
<thead>
<tr>
<th>Item No.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Low Quotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$125</td>
<td>$130</td>
<td>$133</td>
<td>$125 (A)</td>
</tr>
<tr>
<td>2</td>
<td>$150</td>
<td>$144</td>
<td>$147</td>
<td>$144 (B)</td>
</tr>
<tr>
<td>3</td>
<td>$148</td>
<td>$143</td>
<td>$140</td>
<td>$140 (C)</td>
</tr>
<tr>
<td>Totals</td>
<td>$423</td>
<td>$417</td>
<td>$420</td>
<td>$409</td>
</tr>
</tbody>
</table>

Cost to Issue Purchase Order(s) $100 $300

Total Cost $517 $709

To determine whether purchases should be made based on lowest total cost, it is necessary to ascertain the administrative cost of the method of purchase.

It may not always be advantageous to award "all or none" therefore, suppliers should be advised that the purchasing professional reserves the right to award (or not award) on that basis after evaluation of supplier quotations.

Prompt Payment Discounts

A prompt payment discount is a reduction in price on the condition that the purchasing professional pays the bill within a certain number of days after receipt of an invoice. Prompt payment discounts can be a significant source of savings.

It is often to the supplier's advantage to take a smaller payment quickly rather than wait for a few extra dollars. Suppliers have to worry about their cash flow; they have to be sure to have money on hand to pay their employees and to meet their obligations. Their accounts receivable, that is, money owed to them, cannot be used to pay those bills; they have to have cash on hand or deposits in the bank. If they do not have enough, they must often borrow and pay interest. Also, if they do not receive payments, they may have to go through the process of issuing a second invoice to ensure that the first one was received, which process of course costs money. For these reasons, even large companies may offer a discount to customers who pay quickly.

Prompt payment discounts are generally stated as a percentage off the stated price if payment is made within a certain number of days. The notice "2 percent, 20 days", means that if the invoice is paid within 20 days of the date it is received, the customer may deduct 2 percent from the total. On a $5,000 purchase, for example, a 2 percent discount means a savings of $100. Discounts may be offered on a sliding scale: "2 percent, 20 days; 1 percent, 30 days."

When written solicitations are used, the purchasing professional should always check to see if the supplier has offered a prompt payment discount. When oral quotations are received, the purchasing professional should inquire about such discounts. The purchasing professional should, under certain circumstances, solicit prompt payments discount but will not consider the discount in the price evaluation.
Because the time needed to process payments exceeds 10 days, discounts of less than 20 days should not be negotiated.

(Domestic) Transportation Terms

F.O.B. (Free On Board) point refers to the location at which the seller delivers the supplies or materials to the purchasing professional. The seller owns the goods until they reach that point, and has responsibility for shipment and damage to that point. At that point, the purchasing professional takes ownership of the supplies or material, and is responsible for damage and costs incurred after that point. The owner of the goods is responsible for determining and exercising control over the shipment of the goods. There are three major types of f.o.b. points in common use:

"F.O.B. Origin" means free of expense to the purchasing professional delivered on board the indicated type of conveyance of the carrier (or of the purchasing professional, if specified) at a designated point in the city, county, and state from which the shipment will be made and from which line-haul transportation service (as distinguished from switching, local drayage, or other terminal service) will begin.

When quotations have been requested on an F.O.B. Origin basis, the purchasing professional will take possession of the item at the contractor's location, arrange for transportation, be responsible for loss or damage in transit, and pay any freight charges involved in getting it to the point of actual use. In such a case, the purchasing professional must determine the lowest applicable freight charge between the supplier's location and the point of use.

When specifying F.O.B. shipping point, be sure to understand where that shipping point is. The sales office could be in Seattle, but the plant and shipping point in Miami. Shipping costs could then be much more expensive than anticipated. Freight rates can be obtained from the traffic unit. This amount must then be added to the quoted price to arrive at a price for evaluation. Obviously, the same procedure must be used for all supplier prices.

A variation is sometimes used which provides that the supplier transfers title to the purchasing professional upon delivery of the goods to the carrier, but prepays the shipping costs and charges the costs to the purchasing professional. The purchasing professional owns the goods during shipment, and is responsible for loss or damage en route.

"F.O.B. Origin, Freight Allowed" means free of expense to the purchasing professional delivered on board the indicated type or conveyance of the carrier (or of the purchasing professional, if specified) at a designated point in the city, county, and state from which the shipment will be made and from which line-haul transportation service (as distinguished from switching, local drayage, or other terminal service) will begin; and an allowance for freight, based on applicable published tariff rates (or Government rate tenders) between the points specified in the contract, is deducted from the contract price. In this instance, title is transferred to the purchasing professional when the seller delivers the goods to the carrier. The seller reimburses the purchasing professional for the transportation costs. Responsibility for loss or damage during transit is assigned to the purchasing professional.

F.O.B. Destination" means free of expense to the purchasing professional delivered on board the carrier's conveyance, at a specified delivery point where the consignee's facility (plant, warehouse, store, lot, or other location to which shipment can be made) is located; and supplies shall be delivered to the destination consignee's wharf (if destination is a port city and supplies are for export), warehouse unloading platform, or receiving dock, at the expense of the contractor. The purchasing professional shall not be liable for any delivery, storage, demurrage, accessorial or other charges involved before the actual delivery (or "constructive placement" as defined in carrier tariffs) of the supplies to the destination, unless such charges are caused by an act or order of the purchasing professional acting in its contractual capacity. If rail carrier is used, supplies shall be delivered to the specified unloading platform of the consignee.
If motor carrier (including "Piggyback" is used, supplies shall be delivered to truck tailgate at the unloading platform of the consignee. If the contractor uses rail carrier or freight forwarder for less than carload shipments, the contractor shall ensure that the carrier will furnish tailgate delivery if transfer to truck is required to complete delivery to consignee.

In this instance, ownership of the goods transfers to the purchasing professional when they are delivered to the specified destination. The seller pays the transportation costs and is responsible for loss or damage to the destination. This is the preferred method because the seller must handle problems that occur before the goods are received by the purchasing professional.

When the F.O.B. point is at destination, an article which requests the supplier to "prepay and add" freight costs is inappropriate and shall not be used.

Written Solicitations for Larger Value Purchases

Within the public sector, suppliers are generally selected on a sealed bid or formal advertising basis. For most private entities, competitive proposals (almost always without a public opening), is the preferred procurement method. In both the public and private sectors, firm-fixed-price purchasing with the lowest responsive and responsible bidder is attempted and often achieved. In the public arena, some industries and firms know no other way. This is particularly true of the construction business, where a firm-fixed-price contract with the lowest responsive, responsible bidder after sealed bidding/formal advertising is the preponderant procurement method. Some purchasing situations, however, often provide more opportunity and present significant challenges, making it appropriate and/or necessary to deviate from the strict firm-fixed-price after advertising mode of selection. When the organization desires to award a contract to the supplier with the highest affordable technical quality, but that desired quality cannot be defined in the statement of requirements, use of a "Best Value" evaluation approach must be employed. This permits the organization to request technical (and other) proposals, from which the level of quality can be inferred.

Importance of Price/Cost as an Evaluation Factor

Although price/cost should always be a factor in selection of suppliers, the degree of importance of price/cost as a factor should be open to rational and flexible treatment. Typically, in procurement of architect-engineering (design) services, price/cost is considered only after selection based on technical qualifications has been made. This is an industry-wide practice, but can be deviated from if justified. Some firms have adopted a policy of considering price as well as technical factors even in selection of architect-engineering contractors. In many other procurements, it is highly appropriate to use a logical mix of technical/management and price/cost/business evaluation criteria in selecting a firm. Typically, the more technical the work, the more weight that is given to the technical criteria. Procurements of research and development services, for example, often warrant consideration of price/cost only if offerors are otherwise equally technically qualified (as a "tie-breaker"). Consultants are almost always selected on technical qualifications (as long as the rate of compensation doesn't exceed pre-established policy parameters).

Every procurement, irrespective of the procurement method used, must use price analysis as a tool to determine whether or not the price is reasonable. Generally the purchasing professional (without outside assistance) conducts the price analysis. In addition, the purchasing professional should anticipate the potential need for cost data in those instances where price analysis alone cannot assure fairness and reasonableness of price. When cost data is required on a specific purchase, the purchasing professional must coordinate the cost analysis of the cost proposal or cost data submitted by the supplier. In addition, the purchasing professional must, where appropriate, use the results of the price and/or cost analysis in negotiating the price with the supplier.
Cost Analysis

Inasmuch as we previously discussed price analysis, we shall direct our attentions to the second analytical method of Cost Analysis.

Cost analysis is the review and evaluation of the separate cost elements and proposed profit/fee of (a) an offeror's cost or pricing data, and (b) the judgmental factors applied in projecting from that data to the estimated costs, in order to form an opinion on the degree to which the proposed costs represent what the contract should cost, assuming reasonable economy and efficiency. It includes the verification of cost data, and evaluation of cost elements, including all the elements below.

ELEMENTS OF COST ANALYSIS

1. Determination of the necessity for and reasonableness of proposed costs.
2. Projection of the offeror's cost trends, on the basis of current and historical cost or pricing data.
3. A technical appraisal of the estimated labor, material, tooling and facilities requirements and of the reasonableness of scrap and spoilage factors.
4. The application of audited or negotiated indirect cost rates, labor rates, or other factors.

Among the evaluations that should be made, where the necessary data are available, are comparisons of an offeror's current estimated costs with:

(1) Actual costs previously incurred by the same contractor or offeror;
(2) Previous cost estimates from the offeror or from other offerors for the same or similar items.
(3) Other cost estimates received in response to the solicitation.
(4) Independent cost estimates by technical personnel.
(5) Forecasts of planned expenditures.

Cost Analysis NOT NEEDED When:

Cost analysis should not be employed when reasonableness of price can be established by:

(1) Adequate price competition;
(2) Established catalog or market prices of commercial items sold to the general public in substantial quantities; or
(3) Prices set by law or regulation.
BEST VALUE/BUY EVALUATION PROCESS

When factors other than price/cost are included in the evaluation criteria for award, the organization generally follows a 14 step process as shown below.

BEST VALUE/BUY EVALUATION PROCESS

1. An advance purchasing plan is developed.
2. A source selection plan is developed (see explanation below).
3. Offers are solicited using a written solicitation.
4. Technical/management and price/cost/business proposals are submitted.
5. Proposals are evaluated and scored (see discussion below).
6. A competitive range for negotiation is determined. If two or more proposals are fully acceptable and price competition is present, award is made. If negotiations are required for technical and/or cost reasons, the process continues.
7. If discussions are to be held, all offerors outside the competitive range are notified.
8. Offerors still within the competitive range are invited to discussions and advised of their deficiencies.
9. Remaining offerors are invited to submit best and final offers (BAFOs).
10. A final evaluation is made and final scores determined.
11. The source selection official (normally the purchasing professional) is provided with the results of the final evaluation.
12. The source selection official makes an award decision.
13. The purchasing professional awards a contract and notifies unsuccessfuls.
14. Unsuccessful offerors are briefed upon request.

SOURCE SELECTION PLAN

In conducting a "Best Value" source selection process, the purchasing professional team should develop (on a team basis) a source selection plan that contains the items below.

CONTENTS OF THE SOURCE SELECTION PLAN

- The technical/management criteria/evaluation factors for award in their relative order of importance. (These factors should be tailored to the procurement, and include only those factors that will have an impact on the source selection decision);
- Proposal submittal requirements for the offerors to respond to the criteria;
- Procedures to be used to select a technical/management review team;
- Procedures for the technical/management review team to use in evaluating technical/management proposals;
- Procedures for the purchasing professional to use in evaluating price/cost/business proposals;
- Plans for contract negotiation, if appropriate; and
- The designation of the source selection official (if other than the purchasing professional)

Evaluation Factors Included in the Solicitation

Purchasing professionals should assure (through use of a team approach) the solicitation language contains the evaluation factors for award and proposal submittal requirements that are spelled out in the source selection plan. In accomplishing this, the team should assure that all the items identified below are accomplished.

SOLICITATION EVALUATION FACTOR AND PROPOSAL PREPARATION INSTRUCTIONS
• The sections of the solicitation containing the factors for award and proposal submittal requirements should be kept separate but are highly correlated and not inconsistent with each other. (Each criteria must have a corresponding proposal submittal requirement addressing that criteria);
• The evaluation criteria should be either listed in a descending order of importance or are weighted, (with the total adding up to 100%);
• The proposal submittal instructions should contain proposal page limitations;
• The proposal submittal instructions should clearly specify the number of proposal copies to be submitted;
• The proposal submittal instructions should clearly specify that price/cost/business proposal level of detail should be limited to the highest practicable level of the work breakdown structure; and
• The proposal submittal instructions should require the technical, management, and price/cost/business proposal volumes to be separate, distinct documents.

Evaluation of Offers

Assuming the potential suppliers all respond timely and in conformance with the terms of the solicitation, the purchasing team must then begin the evaluation process. The evaluation process works best when predetermined forms and procedures govern the process. These predetermined procedures generally call for the purchasing professional to log in all proposals and then distribute the various sections to the evaluation team. The purchasing professional normally retains all price/cost/business proposals. The purchasing professional generally retains one "master copy" of all other proposals and then releases the remaining copies of the technical/management proposals to the head of the technical/management evaluation team. After the head of this team distributes the proposals, the members of the team conduct their evaluation. Normally the team follows the following procedures:

1. All members of the team review all proposals.
2. Members of the team use pre-prepared evaluation forms. Rating schemes commonly used include application of points to supplier responses to evaluation factors; use of color coding (blue (exceptional), green (acceptable), yellow (marginal), and red (unacceptable) are the most commonly used) to reflect categorization of quality of response to evaluation criteria; or use of adjectival ratings, structured around a three, four, six, or ten descriptor scoring system.

A workable ten descriptor scoring system is shown below.

<table>
<thead>
<tr>
<th>ADJECTIVAL RATING</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outstanding</td>
<td>10</td>
</tr>
<tr>
<td>Superior</td>
<td>9</td>
</tr>
<tr>
<td>Excellent</td>
<td>8</td>
</tr>
<tr>
<td>Very Good</td>
<td>7</td>
</tr>
<tr>
<td>Good</td>
<td>6</td>
</tr>
<tr>
<td>Adequate</td>
<td>5</td>
</tr>
<tr>
<td>Weak</td>
<td>4</td>
</tr>
<tr>
<td>Poor</td>
<td>3</td>
</tr>
<tr>
<td>Very Poor</td>
<td>2</td>
</tr>
<tr>
<td>Inadequate</td>
<td>1</td>
</tr>
<tr>
<td>Nonresponsive</td>
<td>0</td>
</tr>
</tbody>
</table>

After aggregation of individual team member scores/ratings, the technical/management evaluation team chief must identify each proposal as being within one of the following categories:
(1) Proposal is acceptable as received.
(2) Proposal might be brought to an acceptable status with a reasonable effort on the part of the purchasing organization and the supplier.
(3) Proposal is not acceptable--no further consideration warranted. Proposals in this category are so technically inadequate as to remove them from further consideration. Examples of such deficiencies are the offer of an approach previously found unworkable or the offer of an effort which is inconsistent with the stated objectives of the solicitation.

Documentation of Technical Evaluation

The team chief must document his/her findings in a memorandum to the purchasing professional. If the purchasing professional plans to hold negotiations with the offerors, these negotiations cannot commence until this report is received. In addition to communicating which of the three above categories the proposals are in (and the results of the point evaluation, if conducted), the technical/management team chief should include a narrative evaluation specifying the strengths and weaknesses of each proposal and any reservations or qualifications that might bear upon the selection of potential suppliers for inclusion within the competitive range. Specific technical reasons supporting an unacceptable determination of any proposal should also be included.

Evaluation of Price/Cost/Business Proposal

Although the purchasing professional is primarily responsible for the price/cost/business proposal evaluation and the pointing of these proposals, (if pointing is required by the evaluation plan in the source selection plan), the purchasing professional who has requested and received detailed cost proposals in the conduct of a best value source selection will have some additional effort on his/her hands. In such circumstances (not the normal rule, since most procurements will not require cost proposal submission because of the presence of price competition) the purchasing professional will generally find it necessary to obtain technical evaluation input concerning the cost proposals. The technical/management review team can assist in determining whether the cost proposals reflect an adequate understanding of the work. Evaluation of the direct cost elements can reveal whether the proposer has adequately provided for the required services, materials, equipment, travel, and other expenses.

The cost proposal must provide a "mirror image" of the technical approach included in the technical proposal. Failure of the offeror to address areas of work in the cost proposal should cause the purchasing professional to question whether the offeror really understands the work. This evaluation should address the items shown below.

FOCUS OF THE TECHNICAL EVALUATION

- The completeness of the supplier's proposed costs. This assumes the supplier presented a work plan to accomplish the proposed efforts in its technical proposal. The degree to which the supplier
correlates and allocates the labor, material, and other resources to the work plan in the technical proposal will directly influence the efficiency, productivity, and schedule compliance.

- The relationship of the proposed costs to the required work. In this assessment, the technical/management team will determine whether all costs proposed are necessary for the satisfactory completion of the work. Proposed costs for work determined to be unnecessary should be excluded.
- The degree to which the proposed effort is duplicated. A given cost proposal may contain costs which have been proposed elsewhere in the same proposal or in prior proposals for work that was completed prior to the instant contract.
- The validity of the estimating techniques employed in the proposal. If historical data is used in projecting future cost, the team should determine if the current contract schedule, workload, and other conditions have been adequately considered as a basis for projecting the historical costs to the future.
- The impact of schedule and workload. This evaluation looks at the time period for the contract scope of work and attempts to determine whether the total quantity of effort proposed is correlated with that scope. The team will review the cost proposal to assure themselves there is a proper balance of manpower working on a task versus the time span over which the task is performed.

Technical (Quantitative) Analysis of the Supplier’s Cost Proposal

In addition, if cost and price negotiations are required, the purchasing professional will need the technical/management review team to provide a quantitative analysis of the offeror's quantities of labor, materials, and equipment so that purchasing professional (or auditor) developed rates can be applied against them in deriving a total cost position for negotiation. This analysis of the supplier's cost proposal should address all the items identified below.

FOCUS OF THE TECHNICAL ANALYSIS OF THE SUPPLIER’S COST PROPOSAL

- The appropriateness of the proposed skill level and mix. This analysis is important because labor is generally the largest element of cost in many contracts. Part of understanding and evaluating estimated labor is to recognize the patterns in the incidence of different types of labor. Each phase of a work effort will have its own unique combination of required labor types. The skill, grade, and salary levels proposed must make sense when the phases are compared not only with the job as a whole, but with each other.
- The reasonableness of proposed direct labor hours. This analysis attempts to determine whether or not the supplier has based the hours on proper planning and that it contemplates the sound use of labor and reasonable economy and efficiency of operation. The tests for labor hour reasonableness will include consideration of the necessity of the proposed effort, the adequacy of the work plan, whether any work has been duplicated, the applicability of historical data, the conditions under which the work will be performed, the estimating methods employed, and the supplier's knowledge of the task. (If the supplier has performed similar work for the purchasing professional's organization or similar organizations, the supplier's personnel may manifest a classical "learning curve", meaning their productivity will be greater than average on your contract because they learned how to do the job on earlier contracts. Learning is a universal phenomenon which applies to service contracts as well as supply contracts.)
- The reasonableness of the proposed material types and quantities. Material can be quite significant as a cost element. Ideally, the supplier will have developed consolidated lists or bills of materials based upon some sort of takeoff from existing plans and drawings. In that eventuality, the engineer/technical member can readily compare the quantity of proposed material with the quantity of material estimated on the detailed in-house estimate. In the absence of such plans, the supplier may have to rely on historical experience. The supplier's estimate of material quantities should be analyzed by not only comparing against prior contract usage but also by projecting reasonable learning in the usage of materials. The learning curve applies in general to use of materials as well as labor.
The reasonableness of the proposed other direct costs (quantities). Other direct costs are those costs which are specifically identified with a project but which do not fall within the classification of direct labor or direct material. Examples include equipment, subcontracts, travel, automatic data processing, consultants, and meetings and conferences. These direct costs are reviewed to determine whether the costs are properly classified in accordance with the supplier's accounting system, and the backup data in support of the costs are valid, current, and applicable to the work required.

The reasonableness of the proposed profit or fee. Although the technical team should not be asked to develop a recommended profit or fee, it can render an opinion on the inherent technical, management, and cost risk they perceive in the work as well as an opinion on the degree to which the supplier is willing to assume that risk. Generally, higher cost estimates (padding of cost, either in quantity or rates) evidence an unwillingness by the supplier to assume risk.

Accounting/Rate Analysis

As we indicated earlier, the purchasing professional will need to develop rates (labor, material, equipment, overhead, G&A, and profit) that can be applied against the quantitative positions taken by the technical/management evaluation team in deriving a total cost position for negotiation. This analysis of the supplier's cost proposal is called "Accounting or Rate Analysis". In many organizations, the purchasing professional is assisted in this analysis by a "cost/price analyst", an "estimator", or even a "contract auditor". Accounting Analysis should determine the reasonableness of all the rates identified below.

RATES TO BE ANALYZED

- Proposed labor rates. On contracts with incumbent firms, it is a fairly simple proposition to review historical payrolls and track specific employees to the proposal. Historical rates will, of course, be extrapolated to reflect salary increases in effect during the period of performance. These increases must, of course, be reviewed in the light of past history and economic reasonableness before they are accepted. On contracts which require the supplier to acquire new employees, the offer letters may be reviewed to determine rates. Lacking this evidence, wage and salary survey information available from the American Management Association, the U.S. Department of Labor, and others can be consulted for reasonable, market-based rates in the area of contract performance.

- Proposed material prices. On contracts with incumbent firms, it is relatively easy to review books and records to track prices paid for proposed materials. These prices paid, if used as a basis for the estimate, would need to be extrapolated to the period of contract performance using an appropriate whole price index escalator. On contracts with no previous incumbent experience, proposed material prices should be pegged to whatever published, catalog, or market prices are available in the literature. In conducting the material price analysis, the purchasing professional or auditor/analyst/estimator acting in his/her stead must assure that costs are consistently treated in accordance with the normal cost-keeping system of the supplier, that costs are traceable to and can be supported by such documentation as bills of material, supplier quotes, and subcontracts, and that costs are reasonable in view of actual prices, adjusted for trade discounts, refunds, rebates, allowances, prompt payment, etc.

- Proposed other direct cost prices/rates. Other direct costs generally include a combination of different types of costs, including specialized labor, equipment, and support-type costs. The rates for these types of costs should be analyzed by pegging them wherever possible to the market as well as past history and experience by the supplier and/or purchasing organization.

- Proposed overhead and General and Administrative (G&A) rates. If the supplier is doing business with a governmental entity, the chances are that he will have been subjected to some sort of overhead rate audit by that government entity. Audit results are formalized into a rate agreement that tells the firm what rates will be used for prospective bidding purposes as well as for retrospective (close-out) purposes. The purchasing professional should ask the supplier for a copy of his latest governmental rate agreement.
Failing that, the purchasing professional should request the supplier divulge his detailed estimate of the costs included in the overhead and G&A pool projections for the contract period in question, divulge his estimated bases used in calculating his rates for that period, and explain how the rates were derived. Failing that, the purchasing professional should request certified financial information from the company which can be used to derive rate approximations.

Proposed Profit or Fee Rate

In addition to analyzing elements of cost the purchasing professional should assess the technical, management, and cost risk of the work as well as determine the degree to which the supplier is willing to assume that risk. Generally, higher cost estimates (padding of cost, either in quantity or rates) evidence an unwillingness by the supplier to assume risk. In addition to considering risk and the relative difficulty of the job, the purchasing professional should consider the size of the job, the period of performance, the amount of investment being made by the supplier in performing the work, the amount of assistance (purchasing professional-provided property and financing) being provided by the purchasing organization, and the amount of subcontracting involved.

Source Selection Decision

The source selection decision may be made without negotiation or further discussion, particularly in those situations where two or more proposals have been rated as "acceptable" and price competition is evident. In most procurements the purchasing professional will make the source selection decision, giving full and due consideration to the technical/management team recommendations. In more complex procurements, the source selection official may be a high level manager in the organization, or even the general manager. If technical and/or price negotiations are considered necessary, a systematic approach must be taken to the process of negotiation.

Determination of Supplier Responsibility

Before an order can be placed with a supplier, the purchasing professional must make a determination that the otherwise successful offeror is "responsible". This means, generally speaking, that the purchasing professional must be sure that the supplier has the capability (called competence, capacity and credit) and the willingness (called tenacity and perseverance) to do the job correctly. General standards of responsibility (FAR, 1996), include the items included below.

RESPONSIBILITY FACTORS

* Adequate financial resources to do the job, or the ability to obtain them;
* Ability to comply with the required or proposed delivery date or schedule, taking into account all existing business commitments;
Satisfactory record of performance (a supplier may generally be determined nonresponsible based on recent unsatisfactory performance in the same or a related area of work);

Satisfactory record of integrity and business ethics;

The organization, experience, accounting and operational controls, and technical skills, or the ability to obtain them (including, as appropriate, such elements as production control procedure, property control systems, and quality assurance measures applicable to the materials to be produced or services to be performed by the prospective contractor and subcontractors);

The production, construction, and technical equipment and facilities, or have the ability to obtain them; and

Must be otherwise qualified and eligible to receive an award under applicable laws and regulations.

In many cases, the purchasing professional, accompanied by appropriate technical team members, will be required to visit the supplier's facility in order to gather the facts and information needed to make an affirmative decision relating to supplier responsibility. If a team is assembled, different individuals will be requested to address the supplier's ability to perform; the supplier's financial status or condition; the supplier's quality control, quality assurance, and related systems; the supplier's organization and management; and the supplier's labor status.

The purchasing professional's signature on the purchase order or contract is an affirmative determination that the supplier is responsible.

Analyzing Supplier Performance Using Rating Systems

Most organizations will have individual supplier historical performance records and data on file to assist them in their responsibility determinations. These ratings will generally address the supplier's performance in terms of price, delivery performance, quality, and service. Some organizations go beyond a simple rating system in more sophisticated systems, commonly known as the "Categorical Method", the "Weighted-point Method", and the "Cost-Ratio Method". These methods are explained below.
Categorical Method

This uses a strictly qualitative approach. In addition to keeping and maintaining a record of all suppliers and their products or services, the purchasing department establishes a list of factors for evaluation purposes. He assigns a grade to a particular purchase transaction which measures supplier performance in each of the established areas. A grade of plus, minus, and neutral is commonly used. Based upon some form of composite rating, the supplier is given an overall rating and generally notified of the rating.

Weighted-Point Method

This method goes beyond the Categorical Method and assigns an appropriate weight to each performance factor. The weight assigned is a reflection of the purchasing professional's judgment about the relative importance of the specific performance factor. The purchasing professional develops an overall rating for each supplier by multiplying each factor weight by the performance number which corresponds to that factor and then adds the resulting mathematical products. (This is similar to the "weighted guidelines" system used in Federal procurement). The total of the resulting mathematical products determines the supplier's final rating for the period. Some organizations use this method in conjunction with the categorical method.

Cost-Ratio Method

This method relates acquisition and handling/inventory costs to the value of each shipment received from individual suppliers. The lower the ratio of costs to shipments, the higher the rating for the supplier, and vice versa. Generally, the method is applied by first determining the costs for quality, delivery, and service for each supplier; converting each of these three costs to a cost ratio by dividing each cost by a given total order cost for a transaction; totaling the resulting cost ratios to derive the supplier's overall cost ratio; and then applying the overall cost ratio to the supplier's order price to develop an "adjusted price" which is equal to the actual price times 1 plus the supplier's overall cost ratio. The organization would then use the adjusted price as the basis for evaluating supplier performance.
Economics

A knowledge of the fundamentals of economics is essential for good purchasing. A particularly important area is price theory.

Decisions to buy are rational with sufficient time, information, and resources. When knowledge is used to apply energy to materials so that materials become more valuable it is called production. Productive resources are land, labor, capital, and entrepreneurship. Adam Smith, an eighteenth century philosopher sometimes called the father of modern economics, said that people act rationally and with purpose to maximize their satisfaction, given their limited time, information, resources, and budgets.

A purchase eliminates funds for investment in an alternative product. Opportunity cost is the value of the best alternative given up when a choice is made.

There are two types of economics.

1. Normative economics is based on value judgements and is concerned with what should be.

2. Positive economics is based on what is and describes tendencies in economic behavior that can be observed and tested.

The law of diminishing returns.

Less and less extra output is obtained when additional input is added when all other inputs are fixed. This can be restated by saying that the marginal product from each unit of input will decline as the amount of that input increases, holding all other inputs constant. For example, suppose three requests for bids are sent out at a total administrative cost of $150 or $50 per request and the difference in the lowest price from one supplier and the highest price from another is $600. The saving from this action results in a net saving of $450. Therefore to improve savings, six requests for bids are sent out for an administrative cost of $300, still $50 per request. The difference in prices between the lowest and the highest bidder now becomes $600. However, the net saving is only $300.

How supply and demand affect price.

In general as supply increases price declines, as supply decreases price rises. Conversely, as price is increased demand usually declines and as price is reduced, demand usually rises.

Types of Competition in the Market

<table>
<thead>
<tr>
<th>Type</th>
<th>Buyers</th>
<th>Sellers</th>
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<tbody>
<tr>
<td>Market (Full and Open)</td>
<td>Many</td>
<td>Many</td>
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<tr>
<td>Monopoly</td>
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There are both legal and illegal monopolies. Holders of patents have a legal monopoly. In practice there are few complete monopolies. A buyer usually has a choice of substitute products.

Types and use of price indexes.

Price indexes are numbers developed to measure changes in price levels of product categories. The numbers are created from a weighted average of the prices of a number of items. Changes are published
and compared with previous periods. Data for the indexes are gathered by the government and used to calculate various indexes. The most widely known index is the Consumer Price Index or CPI. It measures the prices of products and services purchased by the public. Buyers and sellers usually find the Producer Price Indexes or PPI more meaningful. The PPI indexes measure the prices of various categories of goods purchased by business. Typical indexes are for finished goods, capital equipment, containers, and materials and components for construction.

The meaning of price elasticity.

The price elasticity of demand measures how much the quantity demanded of a product changes when its price changes. When demand is price-inelastic, a price decrease reduces total revenue. When price is price-elastic, a price decrease increases total revenue. When there is unit-elastic demand a price decrease leads to no change in total revenue. The price elasticity of supply measures the percentage change in quantity supplied divided by the percentage change in price.

The meaning of inflation and deflation and how buyers respond.

Price inflation is when there is a general increase in the level of prices. Deflation is when there is a general decrease in the level of prices. Inflation is helpful to borrowers because they pay back cheaper money than they borrowed. However, the lending rate usually anticipates the rate of inflation and compensates for the reduction in the value of repaid debt. Inflation is harmful to people on fixed incomes because the fixed amount of money they have becomes less valuable and earns less real dollars. Business buyers find it more difficult to make long term contracts at fixed prices during periods of high inflation. This problem is circumvented by allowing what is called "escalation." Inserting an escalation clause into the agreement allows the seller to increase prices by an amount equivalent to the rate of inflation. Alternatively, buyers permit sellers to increase prices to cover actual cost increases incurred by the supplier. Buyers often require the seller to document these actual cost increases caused by changes in material and labor prices. Agreements with suppliers should also include a provision requiring price reductions in the event that deflation occurs.
International Trade

There are many similarities as well as many differences in making purchases internationally. Today, every professional buyer should consider foreign suppliers if the amount of the purchase justifies the additional administrative cost and risk involved. Also, there are many products that can only be obtained by importing them.

The differences between international and domestic trade.

The major differences between domestic and international trade are language, culture, transportation time or cost, and the duties imposed. In addition, there are added risks associated with political instability. Language is not the barrier it once was because English is the accepted language of business in most countries throughout the world. However, knowing the local language does improve the ability to negotiate successfully. Perhaps more important than language is knowledge of cultural differences and the customs of the country. For example, it is the practice for the buyer to take gifts when visiting a supplier in Japan.

Finding international sources of supply.

The U.S. Government provides data that reveals what products are currently being imported from each country so the buyer can look in those countries that supply needed products. Supplier directories are published for foreign countries that give the names and addresses of companies and what they sell. Buyers often receive help from foreign consulates in the U.S. who provide lists of companies wishing to export to the U.S. Trading companies located in the foreign country and with offices sometimes in the U.S. are a source of supply. They find manufacturers in the foreign country and handle all the paperwork involved with the transaction as well as all of the communications with the manufacturer. The disadvantage is that the trading company is a middleman that involves an additional cost. Many buyers feel the cost is more than worth it. In addition those manufacturers dealing with the trading company are often very small, difficult to locate, and may not be able to or want to deal directly with the U.S. supplier.

Foreign exchange.

One complication involved in international trade is the differences in money used in the foreign country and in the U.S. The amount of foreign currency equivalent to the U.S. currency constantly changes and therefore it is necessary and important to establish pricing based on one currency or the other and to establish the rate of exchange or how it will be set. Exchange rates are published in the Wall Street Journal and available from major commercial banks.

Duties and other cost considerations.

The amount and responsibility for costs are subject to negotiations with the supplier, but the following costs are incurred by someone.

Freight forwarders and customhouse brokerage fees
Processing shipping bills and tracking shipments may be handled by firms specializing in those functions.

Custom duties

Import tariffs are imposed on products by the government. The amount of these duties varies depending on the product or product category. Sometimes the duties are so high that importation is unprofitable.

Freight to the dock in the foreign country
The cost of transportation to the port of departure is often paid for by the supplier depending on negotiations, but the cost is eventually passed on to the buyer.

Ocean freight or air transportation cost

Ocean shipping is the usual method of transportation outside of North America for most products that are bulky, heavy, or in large quantities. Expensive air transportation is normally used for small quantities of critically needed items and for small and light weight products.

Freight from the port of entry to the final delivery point

Inland freight is a cost for either a domestic or an international shipment. It should not be forgotten when comparing the total costs from a domestic supplier with an international supplier.

Insurance

Many companies have insurance that covers domestic shipments but does not include goods in transit outside of the U.S. Buyers usually ignore the need for insurance for domestic shipments either because the shipments are F.O.B. delivered, or because the value and risk of loss is small. However, foreign shipments carry more risk and it is more difficult and takes longer to get paid for any losses from foreign suppliers. It is wise to purchase insurance for international shipments.

Bank charges

There is a cost to exchange currency and pay for letters of credit. These charges vary from bank to bank and may be small, especially for good customers, but whatever the amount, it should be added to the total cost of the purchase.

Inspection charges

Independent inspection companies can be hired to check goods before shipment. This is an economical approach if specifications can be verified from drawings or other documentation. The inspector takes measurements or counts as required and reports the results. Goods can then be approved for shipment or rejected before the cost of transportation is incurred. Companies that do a high volume of international business or have many shipments may use an employee who lives in or near the foreign country. Occasionally quality assurance personnel or buyers may travel to make inspection of specific or random shipments.

Related travel expenses

It is not always necessary for a buyer to travel to a foreign supplier to conduct business. Many foreign suppliers have offices or representatives, or even warehouses within the U.S. Nevertheless, any anticipated travel expense deemed necessary by buyers or inspectors should be added to the cost of the purchase.

Method of payment and letters of credit

The usual method of payment for foreign purchases is by a letter of credit. An application for a letter of credit is made by the buyer or the buyer's accounting department and issued by a domestic bank and sent to a correspondent bank in the foreign country. The letter of credit describes the goods and specifies what paper-work such as bills of lading and inspection reports be prepared and accepted prior to shipment. An irrevocable letter of credit insures that payment will be made by the foreign bank to the supplier upon shipment to the port or other destination if the goods are prepared as specified and the paperwork is in order.

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Law

Some believe that the single most important subject that buyers should know is the law. Without such knowledge a buyer can cost the organization thousands, if not millions of dollars and even run the risk of being put in prison. The law practices in the United States are based on English common law in every state except Louisiana where it is based on the French tradition. Purchasers who purchase globally (offshore) must be familiar with the CISG (Convention on International Sale of Goods), which has been adopted by most developed countries of the world.

Types of law

Common law is based on established cases decided in court and ruled on by a judge. Future decisions are based on previous rulings. Those previous rulings carry more weight when they have been made closer to the jurisdiction considering the new case. For example, a New Jersey court would pay more attention to a previous ruling made in New Jersey than it would to one made in another state or country. Likewise, the court is likely to pay more attention to recent rulings rather than older decisions. Most law is established from decisions made in previous cases.

Statute law is established from written documents approved by federal, state, county, or city legislatures.

Laws that affect purchasing operations.

The law of agency establishes the rights and responsibilities of agents such as purchasing agents and sales agents. Contract law establishes the requirements for a contract. The antitrust-trust laws prohibit monopolistic practices and unfair dealings by buyers and sellers. Laws regarding employment practices and environmental issues also affect purchasing operations. The Uniform Commercial Code is the most important law for day to day purchasing operations. It is also important for buyers to know the implications of patent and trademark law. International laws vary from country to country and may affect how purchasing transacts business in those countries.

Defining a purchasing agent and other agents.

An agent is given authority by the principal. In the case of a buyer, the organization is the principal represented by the person who hires the buyer or the person who the buyer reports to. In the case of a salesperson, it is the organization that hires that salesperson. Authority may be limited or complete. Purchasing agents usually have the authority to buy many different types of products. They normally have the authority to select the supplier, negotiate, and make an agreement (contract). Only authorized agents have the authority to make purchase agreements and only authorized salespeople have the authority to make sales agreements. However, that authority may be conveyed to individuals if they make those agreements on their own and are allowed to continue to do so.

The responsibility of the agent is to be loyal to his or her employer and to protect the interests of the employer. At the same time the responsibility of the employer (principal) is to pay the agent and to honor the agreements made by the agent.

What makes a contract?

A contract is an agreement between individuals or organizations. There must be an offer, acceptance, and mutuality of intent. There must be consideration (under the Uniform Commercial Code, or UCC), the agreement must be concerned with legal subject matter, and the parties contracting must be “competent”.

The contract need not be in writing unless it falls under the Uniform Commercial Code that requires any transaction between merchants for an amount of $5,000 or more for goods (new UCC) to be in writing in
order to be enforceable. Buyers for business are considered merchants. Goods are any tangible products, like production materials, components, and equipment.

Capable parties are those who are not insane, intoxicated, or under the influence of drugs. Consideration is something of value such as money, goods, or services that are provided. There is no requirement for consideration under the CISG.

There is a contract whenever a buyer makes a purchase.

What makes an offer and acceptance?

An offer may be made in the form of a bid or by actual shipments of goods, or by a written document such as a letter or purchase order. An acceptance may be made by unprotested receipt of goods or services, by use of goods, by a written document such as a letter or purchase order.

When you can and cannot cancel an order without penalty.

Generally, you can cancel an order without penalty if the products are stock items that can be sold elsewhere and the supplier has not incurred any costs. You may be able to cancel if the supplier fails to live up to the terms of the contract, particularly if you have given the supplier a chance to correct errors and he has failed to do so within a reasonable time.

Remedy and right to recover damage and "cover."

If the seller fails to deliver goods according to the agreement, the buyer has the right to recover damages. The buyer has the right to cancel the order and purchase the goods elsewhere and recover any difference in cost from the failing supplier.

The importance of the UCC.

The Uniform Commercial Code or UCC is a law passed by all states except Louisiana that covers transactions between merchants (buyer for business and seller) for goods (tangible products). The law was passed to provide uniformity of interpretation of business agreements between firms located in different states. It provides the terms and conditions of sale. It is the ruling document for most agreements made by professional purchasing people unless such agreements specifically make terms and conditions other than specified by the UCC. The law was recently updated and is yet to be codified by most State Legislatures.

Types of warranties.

There are express warranties and implied warranties. Express warranties are established in various ways. Samples that represent the product that will be purchased establish an express warranty. Express warranties are given when a seller states what a product will do or gives a specific description of a product such as its dimensions, chemical components, or type of material making up the product. General statements in a sales brochure or by a salesperson such as "it is the best product of its type" or that "it is better than the competition" are not express warranties. They are called "puffery" and salespeople are expected to exaggerate the worth of their own products for sale.

Under the UCC there is an Implied warranty of fitness for its intended purpose and Implied warranty of merchantability when a product is sold by an organization that normally deals in that type of product. If the buyer purchases using a buying organization specification, suppliers will usually disavow these implied warranties.

Consequential damages.
Most warranties by suppliers cover the value of the product and not other costs that may result from the product failure. A supplier's standard agreement form usually excludes the supplier from liability for consequential damages. For example, if someone is injured as a result of product failure, the costs of medical expenses or settling a law suit can be hundreds or thousands of times more than the cost of the product. These are consequential damages.

Antitrust laws.

The penalties for breaking the antitrust laws can be imposed on either buyer or seller or both and may be fines or imprisonment. The laws make it illegal to fix prices among suppliers, to monopolize, and to conspire in restraint of trade. Reciprocity is a violation of antitrust wherein a buyer agrees to buy from a company if that company also buys from the buying company. It is a violation for competitors to agree to split territories. It is a violation to use tie in agreements wherein a buyer must buy certain products in order to get other products.

Patents and trademarks.

Patents are basically monopolies to prevent others from making, using, or selling a product that is authorized by the government. Trademarks are restrictions by the government for use of product names, logos, and artwork by anyone other than the authorized trademark holder. Use by other than the authorized holder of a patent or trademark can result in confiscation of products made or purchased as well as payment to the authorized holder for any lost profit. Buyers should be aware that imported goods that violate patents may be confiscated by customs even though the buyer has already paid for them by a letter of credit or other means. The seller in the foreign country may incur no loss since the U.S. law does not apply to them. However, companies may also obtain foreign country patents.

Work for hire.

The design of products fully designed or in part designed by a supplier may be owned by the supplier. If the buyer wishes to order the same item from another supplier, he may not be able to do so unless the design is changed. To avoid this problem, the contract for the products or services should include a term that the order is "work for hire." This means that any creative effort is being done for the buyer and becomes the buyer's property to use in any way desired without further cost.

Terms and Conditions.

The buyer may specify many different terms and conditions and negotiate with the supplier to add or delete various terms. As a minimum, nearly all purchase orders should include the F.O.B. point, the payment term, the place for delivery, the date for delivery, the quantity, and a price term.

Payment Terms

There are dozens of possible payment terms. Here are the most common.

Net
The same as cash. Payment is due upon receipt of the goods.

Net 30 or Net 60 or Net 90, etc.
Payment is due within 30 days (or 60, or 90, or whatever number of days specified). Many buyers further define all net terms to indicate that payment is due the specified number of days after either the due date, the date of actual receipt of the goods, or the date of the invoice, whichever is later.
A discount of 1% (or 2% or whatever other percentage specified) may be taken off of the invoice if paid within 10 days (or any other number of days specified), but the full amount is due within 30 days (or any other number of days specified). This is a “prompt payment discount”. A typical discount is 2%, 10, net 30. In order to determine the “interest rate foregone” or “annualized cost of foregoing a prompt payment discount”, you need to use the following formula:

\[
\frac{a}{1-a} \times \frac{360}{c-b}
\]

For the above discount, the result is \(0.01/\frac{98}{360}/20\) or 36.7%.

F.O.B. term and other terms indicating where title passes.

F.O.B. is one of the most important and misunderstood terms. It literally means “free on board” and is where title (ownership) of the goods passes from the seller to the buyer. The following are the most common uses.

F.O.B. Destination

Title to the goods passes from seller to buyer after it is delivered to the specified destination. The supplier owns the goods up to that point and is therefore responsible for all costs unless otherwise agreed and responsible for the goods.

F.O.B. Shipping Point or Origin

Title to the goods passes to the buyer immediately upon shipment at the shipping location wherever that may be. The buyer becomes owner of the goods at the shipping point and is therefore responsible for all costs including transportation unless otherwise agreed and is also responsible for payment of the goods.

F.O.B. Detroit (or any other city or location)

The same reasoning applies as in the above two examples.

In addition to the above Domestic Shipping Terms, the following “Incoterms” (International Chamber of Commerce Terms) are common. There are 13 “Incoterms” contained in a pamphlet available from the International Chamber of Commerce.

C.I.F. (plus a named location)

A term used for goods shipped by ocean and meaning Cost, Insurance, and Freight. The seller pays all cost, insurance, and shipping charges to the named location where the buyer takes title to the goods.

F.A.S. (plus a named port)

A term used for goods being sent by ocean and meaning Free Alongside Ship. The seller pays all charges up to that point where title passes to the buyer.

International Law
With burgeoning global commerce, a new lexicon, if not alphabet, must become familiar to the purchasing professional. This is the United Nations Sales Convention, or Convention on International Sale of Goods (CISG), officially presented in Vienna in 1980 and since embraced by countries from all parts of the world. The CISG has now become the uniform international purchasing code of countries that account for over two-thirds of all world trade.

One stark example shows the importance of the CISG: A typical contract boilerplate may say that "the law of New York State applies" to a transaction. The parties to an international sale of goods may be shocked to find that this now can mean that the CISG governs their transaction -- for the simple reason that treaties signed by the United States take precedence over state laws where they apply.

**Similar but Different**

While the CISG is similar to the UCC in many respects, there are important differences that every purchasing professional should know.

Like Article 2 of the UCC, the CISG applies to sales of goods, and governs the formation of the contract and the rights and obligations of the seller and purchaser. It leaves to domestic law most questions of validity as well as questions of the contract's effect on the property interest in the goods sold. It does not apply to contracts to supply services, or to consumer sales or sale of securities, ships, vessels, hovercraft, aircraft, or electricity, or to contracts for goods in which the purchaser undertakes to provide a substantial part of the materials necessary to manufacture or produce the goods. What remains, however, is a vast array of transactions in every imaginable line of business. Sales of airplane engines and wine, candy and copper and nickel, textiles and clothing, computers and test tubes and trucks are among the many situations that have appeared in courts around the world and been held subject to the CISG.

The CISG applies automatically to contracts of sale of goods between parties whose places of business are in different countries where those countries have adopted the CISG by signing the Convention (so-called Contracting states). It may also apply to such contracts when one party, or even neither party, is from a Contracting state. The parties can agree in their contract that the CISG applies. Many reported cases involve contracting parties from countries that have not yet signed the CISG -- evidence of its impact on businesses, whether or not their governments have embraced its provisions.

The CISG works like the Book-of-the-Month Club. When subscribing, a member automatically receives a book each month unless he takes the initiative and indicates otherwise. The CISG is such a "club." When a country subscribes to the CISC it can automatically receive this "book" of laws as the governing law of their applicable contracts, unless the parties indicate otherwise. This is why, if your purchase order states: "This transaction shall be governed by the law of the state of New York" and it's an international purchase covered by the CISG, the CISG "and not the UCC -- is what you are apt to get, even though you may have expected to get the UCC."
Freedom of Contract
The most fundamental provision of the CISG is freedom of contract. This means you can contract out of the CISG if you want to. In order to do so, however, the contract should clearly and explicitly state that you do not wish the CISG to apply. Within limits, you can also vary any of its terms. By tradition, the typical U.S. purchase order is today tailored to the provisions of the UCC. When the CISG applies, the boilerplate provisions of your purchase orders ought to be tailored to it.

In its substantive provisions, the CISG has many similarities to the UCC; in that respect, much of it requires minimal adjustment for U.S. parties. But, it also has features similar to civil law. They follow.

Can an Oral Deal Be Binding?
Forget about Sam Goldwyn's maxim, "An oral contract is not worth the paper it is written on." As a general rule, under the CISG there is no way you can prevent assertions that contracts have been concluded solely on the basis of oral statements, for example, during the course of a telephone conversation. Recommended steps to help avoid honest misunderstanding include documenting your conversations -- a routine that is generally desirable in any negotiation. Also, conclude your conversation with, "You, of course, recognize that we do not have a contract until..." This approach can help avoid honest misunderstandings. Finish by sending a follow-up letter that sets forth the precise status of the negotiations.

Offers May Be More Binding Than You Thought
Suppose you say, "If I do not receive your acceptance by April 22 this offer expires." Under the UCC, you may generally withdraw this offer prior to April 22 if the other party has not yet accepted it. Under the CISG, this may not be the case -- unless you say so.

It May Not Be as Easy to Cancel a Contract
It's generally easier to cancel a contract under the UCC than under the CISG. On the other hand, if you want to improve your ability to cancel a contract that is governed by the CISG, you can easily do so by putting the right words and phrases in your standard terms and conditions.

Notification of Defects
As a purchaser, pay special attention to notification of defects. Under the CISG, you lose all remedies unless you send a timely notice of defects. The UCC also has such a rule. But there are circumstances in which the CISG's notice requirements can be tighter. How do you respond to this? Put in your terms and conditions the notice rules you think are most appropriate to the product you are purchasing.

Other variations between the CISG and the UCC exist. Some of the other differences are of a more technical nature. For purchasers that source internationally, understanding the differences between the CISG and UCC can help in negotiations and final contract development.

If you contract with an international supplier and don't want to use the CISG, memorize article 6 of the CISG, "The parties may exclude the application of the Convention..." and include the phrase in your contract. Then specify the use of the UCC in your contract.

International Negotiations and Oral Agreements
Sometimes, international parties in a negotiation may be motivated to take your discussions as offers. Under the CISG, there is no provision for preventing assertions that contracts have been concluded solely on the basis of oral statements. To avoid committing yourself follow the advice below.

- Document your conversations.
- Conclude the conversation with, "You, of course, recognize that we do not have a contract until..."
• Send a follow-up letter that sets forth the precise status of the negotiations.

Find out about the CISG on the Internet at WWW.CISG.LAW.PACE.EDU.

Countries that account for two-thirds of all world trade have adopted the CISG as their governing uniform international sales law. Even if you've set terms and conditions that exclude the CISG, in a battle-of-the-forms transactions, it may govern your purchase if your supplier's acceptance doesn't exclude the CISG. So, the CISG continues to require the careful attention of today's international purchasers.

**Anti-Boycotts Legislation**

These pieces of legislation pertain to organizations doing business which might "cooperate" in the boycott of one nation against another. It is erroneously presumed to apply only to transactions occurring in the Middle East (the Arab-Israeli boycott). However, it also applies to "boycotts" in such other areas as India versus Pakistan and the Peoples’ Republic of China (mainland) versus Republic of China (Taiwan). The issues are often subtle, and frequently occur in such innocuous-looking documents as letters of credit. There is a requirement to "report" requests to participate in a boycott, which is very frequently overlooked, and results in the majority of violations by and prosecutions of purchasers and sellers.

**Foreign Corrupt Practices Act**

While this impacts the seller more frequently than the purchaser, it should not be overlooked. Essentially, it prohibits an organization or individual from making a payment that might benefit a foreign official. Purchasers should review it with legal counsel, so that they can recognize the issues which trigger its provisions.

**Customs Laws**

This is the body of law which governs the importation of goods into the United States. These laws will impact virtually all imported goods (and some services). They are quite complex, and will generally require the assistance of a customs broker or other import specialist.

**Export Administration Act**

Purchasers frequently overlook these laws, as they do not perceive themselves as "exporting." In reality, whenever a specification, drawing, or prototype is provided to a foreign person or entity, an "export" of technology occurs. While a majority of such exports are not restricted, some may be, and such controlled exports are not always obvious. As is the case with importation, the key here is to obtain advice and/or assistance from an "expert." This may often be someone other than the expert who is used for importation.

**Antitrust and Unfair Trade Practices**

There are four principal federal laws which deal with antitrust and competitive practices:

1. Sherman Antitrust Act (1898)
2. Federal Trade Commission Act (1914)
3. Clayton Antitrust Act (1914)
4. Robinson-Patman Act (1936)

Each of these was intended to promote competition and to ensure that a fair and open marketplace exists in the U.S. economy. Many states have similar legislation, but such laws would generally apply only to transactions within that state. Most of the federal and state legislation is aimed at trade practices of sellers, although some provisions apply either directly or indirectly to purchasers. Volumes are written about each of these laws, however, the following discussion emphasizes and highlights the provisions which are relevant to the purchasing professional.
**Sherman Antitrust Act**
This legislation prohibits any action or conspiracy "in restraint of trade," and prohibits any "monopoly or attempt to monopolize." Most prosecutions under this act are for price fixing, bid rigging, or other forms of collusion among sellers. However, it also prohibits reciprocal dealings whereby a purchase of one product by a purchaser is conditioned upon the reciprocal purchase by the seller of a product from the purchaser’s organization. The purchasing professional should be aware that such actions are prohibited by law, and should avoid any conduct which might be perceived as encouraging or condoning such activities.

**Federal Trade Commission Act (FTCA)**
The FTCA created the Federal Trade Commission (FTC), and provided the power for the FTC to interpret trade legislation such as the Sherman Act’s "restraint of trade" provisions. It also prohibited "unfair competition" and "unfair or deceptive" trade practices. These prohibitions are clearly aimed at the seller’s practices, and have very limited application to purchasers.

**Clayton Antitrust Act**
This legislation declared "price discrimination" to be illegal, and prohibited sellers from exclusive-dealing types of arrangements with purchasers and/or product distributors. Some of its provisions also govern corporate mergers or acquisitions that might create a monopoly. The Robinson-Patman Act significantly amended many of the substantive provisions of the Clayton Act, and is now the primary legislation to deal with these subjects.

**Robinson-Patman Act**
This legislation is the most familiar to purchasing professionals and is often used as an excuse by sellers to not provide lower prices to purchasers during aggressive negotiations. This Act specifically prohibits sellers from "price discrimination," where the effect of such discrimination may substantially limit competition or create a monopoly. While this is obviously aimed at sellers, there is also a provision which prohibits purchasers from "knowingly inducing" a discriminatory price. It should be emphasized that the purchaser can be liable under these provisions only if the seller was guilty of price discrimination that had the stated adverse effect on competition in the marketplace. There are several defenses to liability contained in the Act, which make prosecution difficult. It is for this reason that there have been no Robinson-Patman Act cases filed by the FTC in the 1990s. Where does this leave the purchasing professional? According to James Johnstone, in "The Robinson-Patman Act: No Barrier to Effective Purchasing," in Purchasing Today®, September 1996, The Robinson-Patman Act does not present a real barrier to effective, aggressive purchasing. The purchaser should not "knowingly induce" a discriminatory price; however, most price concessions are not "discriminatory." A few older cases of purchaser liability were based on a purchaser purposely misleading a seller to lower its prices based on a false assertion that the seller’s competition had provided a lower price. While a seller may legally lower its price to "meet competition," the purchaser should not mislead a seller in negotiations.

These laws are complex, and this summary is intended to provide only general guidance on this subject. The purchasing and supply professional should consult with legal counsel whenever circumstances create a suspicion of prohibited conduct by the seller, or when purchasers’ actions could conceivably violate such laws.
Foreign Laws to Consider

The above mentioned are only a few of the U.S. laws which may apply to international transactions. However, U.S. laws should not be a purchaser’s only concern: these transactions will also be affected by the laws and regulations of the other country or countries from which goods or services are purchased. This is an area about which volumes are written, and is too complex to cover in this publication. This is particularly significant considering that each country will have its own unique laws and regulations which will apply only in certain circumstances. This is, therefore, an area that will require consultation with an attorney who is familiar with the local country’s legal system. Relatively few U.S. attorneys possess such expertise, so be cautious who you engage for such advice. This may require engaging a foreign attorney, but this is not always the case. Some areas of foreign law which should be considered are:

Contract law. In some countries, certain contracts require approval of the local government. It would be important to know if this is a requirement.

Export control. Just as the United States Government controls exportation of certain commodities or services, foreign governments may prohibit or control export of the item(s) being procured.

Currency control. Not all countries allow transactions to be conducted in U.S. dollars or other non-local currencies. This may be a critical element to address in the terms and conditions.

Criminal law? Yes, your transaction could be "illegal" if structured in a certain manner. Criminal liability in some countries is a considerably different concept than in the United States with all of our due process protection of the individual. This is not something you want to find out the hard way.

Terms and Conditions for International Purchases

As with establishing any contract, the purchasing and supply professional must: (1) understand the environment in which he or she is operating, (2) recognize the risks associated with the transaction in this environment, and (3) properly allocate these risks by clearly defining the rights and obligations in the contractual terms and conditions.

There should be no doubt that the environment for international purchases is considerably more complex. It follows that the terms and conditions for such transactions will be equally complex. The complexity will naturally be influenced by the following factors:

- the country with which you are contracting
- the size of the transaction
- the type and technical complexity of the goods or services being purchased
- any previous relationship between the parties
- consideration of the issues unique to the international transaction which are outlined above

Because of the multitude of transactionally unique issues to be addressed, there is no "standard" set of terms and conditions which are appropriate for all international transactions. Most organizations’ "boilerplate" approach to purchase order terms and conditions will be especially inappropriate for international transactions. This is an area that will require "customization" for each transaction. The best approach to the task of drafting such terms and conditions is to utilize a checklist to ensure that this multitude of issues is considered and addressed. Such checklists are available to the purchasing professional from many sources, such as Business Laws, Inc. in their Legal Aspects of International Sourcing. A list of "minimums" should also be developed to replace or supplement the purchaser’s
domestic purchase order or contract. There are many clauses which may be appropriate only for specific circumstances or transactions. Consequently, even the seasoned professional should use a checklist to ensure that all issues are considered and adequately addressed in the terms and conditions. In international sourcing, Incoterms are normally invoked.

**Incoterms 2000**

**ICC International Chamber of Commerce**
WWW. WWW.iccbooks iccbooks.com com

These are the international commercial terms. They are a set of rules for the interpretation of trade terms, in a contract of sale. They are published and regularly updated by the International Chamber of Commerce to help parties to avoid misunderstandings, with all the waste of time and money that this entails.

Purpose of the Incoterms
1. To determine the seller’s and buyer’s respective obligations concerning responsibilities and charges for the transportation of goods from the seller’s premises to the buyer’s place.
2. To avoid any misunderstanding in the following questions: “Who is responsible for what? Who is going to pay for what?”

An incoterm is a 3 letter word followed by a name of place. They apply only to the contract of sale in some very distinct respects. They deal with a number of identified obligations imposed on the parties.

There are 13 Incoterms and each one fits a specific situation and specific means of transport

The structure of Incoterms
4 groups of terms
Group E departure
EXW Ex Works (…named place)
Group F Main carriage unpaid
FCA Free Carrier (…named place)
FAS Free Alongside Ship (…named place)
FOB Free On Board (…named port of shipment)
Group C Main Carriage Paid
CFR Cost and Freight (…named port of destination)
CIF Cost Insurance and Freight (…named port of destination)
CPT Carriage Paid To (…named place of destination)
CIP Carriage Insurance Paid To (…named place of destination)
Group D Arrival
DAF Delivered at Frontier (…named place)
DES Delivered Ex Ship (…named port of destination)
DEQ Delivered Ex Quay (…named port of destination)
DDU Delivered Duty Unpaid (…named place of destination)
DDP Delivered Duty Paid (…named place of destination)

Each Incoterm has a unique allocation of risks from the seller to the buyer. The purchaser needs to use the correct Incoterm for his offshore transaction.
The terms, one by one. Where are the risks transferred?

EXW: Ex Works (…named place)
Risks are transferred from the seller to the buyer, when the goods have been placed at the disposal of the buyer at the seller’s premises or another named place not cleared for export and not loaded on any collecting vehicle.
The buyer bears all risks and costs involved in taking the goods from the seller's premises and thereafter.

FAS : Free Alongside Ship (…named port)
For maritime and inland waterway only
Risks are transferred to the buyer when the goods have been placed alongside vessel nominated by the buyer at the named port of shipment.
The seller also clears the goods for export.

FCA : Free Carrier (… named place )
For any mode of carrier.
Seller delivers goods, cleared for export, to the carrier named by the buyer at the specified place.
If delivery occurs at the seller's premises, the seller is responsible for loading.
If delivery occurs elsewhere, the seller must load the conveyance but is not responsible for unloading.

Only for Sea Freight.

FOB : Free On Board (…named port of shipment )
Risks are transferred as the goods pass the ship’s rail at port of shipment.
The seller clears the goods for export.

CFR : Cost and Freight (…named port of shipment)
Same transfer of risks.
Seller delivers when the goods pass the ship's rail at the port of export.
The seller pays cost and freight for bringing the goods to the foreign port and clears the goods for export.

CIF : Cost, Insurance and Freight (named…)
Same transfer of risks as for FOB and CFR.
Seller delivers when the goods pass the ship's rail at the port of export.
The seller pays cost and freight for bringing the goods to the foreign port, obtains insurance against the buyer's risk of loss or damage, and clears the goods for export.

All Means of Transport...

CPT : Carriage paid to (…named place of destination)
Risks transferred as indicated in FCA.
Seller delivers goods to carrier it nominates and pays costs of bringing goods to the named destination.
The seller also clears the goods for export.

CIP : Carriage, Insurance paid to (…named place of destination)
Risks transferred as indicated in FCA.
Seller delivers the goods to a carrier it nominates but also pays the cost of bringing the goods to the named destination.
The seller also obtains insurance against the buyer's risk of loss or damage during carriage and clears the goods for export.

For trucking or railways…
DAF : Delivered At Frontier (…named place)
Both parties must specify which frontier.
Risks are transferred once the goods have been placed at the disposal of the buyer on the “arriving means of transport”
Goods are not unloaded at the frontier.
Seller clears goods for export but not for import at the customs border of the destination country.

When the seller is responsible all the way…

DES : Delivered Ex Ship (…named port of destination)
Risks are transferred upon arrival, on board of the vessel when the goods have been placed at buyer’s disposal at the unloading point.
Seller delivers when goods are at the buyer's disposal on board the ship
Goods are not yet cleared for import.
The buyer pays discharging costs.

DEQ : Delivered Ex Quay (…named port)
Transfer of risks on the quay (dock) at the port of destination.
Seller delivers when the goods are placed at the buyer's disposal, not cleared for import, on the dock (quay) at the named port of destination.
The seller pays discharging costs, but the buyer pays for import clearance.

DDU : Delivered Duty Unpaid (…named place of destination)
Risks are transferred when goods have been placed at the buyer’s disposal on any arriving means of transport non unloaded at the named place of destination.
Seller delivers the goods to the buyer not cleared for import and not unloaded from the arriving means of transport at the named destination.
The buyer is responsible for all import clearance formalities and costs.

DDP : Delivered Duty Paid (…named place..)
Same as DDU but cleared out of customs.
Seller delivers goods to the buyer, cleared for import (including import license, duties, and taxes) but not unloaded from the means of transport.

Cultural differences.

A purchaser must consider cultural differences as well as legal-system differences. There are a many cultural differences between countries, but there are three major differences that affect purchase contracting.

The first difference is a different emphasis on "uncertainty avoidance," a term developed and explained by Geert Hofstede in his pioneering book Culture's Consequences. Simply put, it reflects differences in how sure people in a culture want to be of the future before they will proceed with something. France and Japan have high uncertainty avoidance scores. The U.S. has a fairly low score. This cultural characteristic affects lead time and flexibility more than it affects anything else.

In addition to different emphases on uncertainty avoidance, there are different mechanisms for coping with uncertainty. In the U.S., a legal contract is a major uncertainty avoidance mechanism. A normal American reaction to any potential difficulty is "put it in the contract." We even usually have a "complete agreement" clause, which states that the total understanding between the companies is in the contract. A contract reduces uncertainty by allowing a powerful third party, the courts, into a dispute.
In most Asian countries, even those with high uncertainty avoidance, contracts are much shorter and much vaguer. In those societies, the major uncertainty avoidance mechanism is to get to know potential business partners very well before entering into a business relationship.

This leads to the second major cultural difference, the importance of a personal relationship in business. The US treats business rather impersonally compared to other countries. Fons Trompenaars, a Dutch researcher, illustrates this well. He runs multinational workshops in Europe where he asks for reactions to hypothetical situations. One question involves a car accident where your close friend is driving. The friend is speeding and injures a pedestrian. The friend's attorney comes to you and encourages you to lie in court to protect your friend. Trompenaars asks two questions: What right does the friend have to ask you to lie in court? Would you or would you not lie? Approximately 95% of Germans, Canadians and Americans answer either that the friend had no right to ask this or the friend had some right but they still wouldn't lie. Approximately 65% of Spanish and 25% of Koreans give these answers. While Trompenaars' book seems to treat this data as an 'honesty graph', it's much more enlightening to consider it as a graph of the different importance and sense of obligation given to friendships in different countries.

Trompenaars specifically suggests not loading contracts with penalty clauses or strict requirements when dealing with cultures that get low scores on this exercise. These clauses will be seen as an accusation that the other party would cheat if the contract didn't forbid it, and a person whose integrity is challenged may react by acting with less integrity.

The third major cultural difference is the attitude toward contracts. Western cultures, and particularly the United States, tend to believe "a deal is a deal," and once a contract is signed everyone is expected to follow it without requesting changes. As a result, contracts are expected to cover everything that could happen and become very long. In most Asian countries there is a more flexible attitude. A contract is seen as more of a guideline, and life with its frequent changes is seen as too complex to capture all the possibilities in a written document. As a result, if something unexpected happens, either party is able to reopen negotiations. Both parties are assumed to be well intended and to take reasonable care of each other's interests.

Both of these attitudes toward contracts can be carried to counterproductive extremes. The best solution is somewhere in the middle.

U.S. legal practices. There are a few legal practices that are especially disturbing to sellers in other countries. We already mentioned one, which is that contracts become lengthy because too many items go into them. A second one is that they are wordy and written in a special type of English, legal English (More on correcting that later). A third common problem is that they are written one-sidedly and give the buyer a variety of rights and the seller as few rights as possible. Domestically, we recognize that the draft language is usually negotiable and the buyer often doesn't seriously intend to insist on it. Buyers routinely, and sometimes carelessly, send these draft documents to foreign sellers with an assumption that they will ask to have items changed if they find them distasteful. Some special caution is needed here. There have been academic studies that show that one of the biggest obstacles to a negotiated agreement that could have been win-win is the opening offer being seen as completely unreasonable to the other party. A seller faced with an unreasonable contract may draw back from the deal.

Purpose of contracts. I see two major purposes for written, signed agreements between the buyer and seller. The first purpose is to get people to write down and agree (in some degree of detail) to the major responsibilities of the parties. I believe this is especially important when dealing with foreign suppliers. This exercise will bring most disagreements and misunderstandings into the open before business starts. It also creates a document that will survive personnel changes.

The second major purpose is to use a signed, legally enforceable agreement to get a party to do something they would not do otherwise. A strong third party, normally a court, enforces compliance. Achieving this goal is much more difficult when dealing internationally. The international legal system is slow and
expensive. A legal cycle may be several times longer than a product life cycle. Many major companies do not try very hard to make an agreement that will be useful in court.

Preparing a contract draft. Here are six key steps to take in preparing a contract proposal for foreign suppliers. This is by no means an exhaustive list, but one designed to reduce problems due to legal and cultural differences.

1. **Remove all clauses from your standard contract that are applicable in the US only.** Some of these are veterans' rights, EEO, and OSHA clauses. Even if a clause says "when applicable" take it out if it isn't applicable. One very common clause states in essence "Seller will follow all U.S. federal, state and local laws." A foreign supplier will have a difficult time even deciding which laws are applicable, if any. If there is a particular U.S. law or group of laws that you want the seller to follow, state it.

2. **Rewrite or eliminate all clauses that are too harsh or one-sided.** Carefully consider whether they are necessary, and if not, take them out. A clause stating that the supplier will not sell to anyone else at a lower price, for example, is a poor way to start a new relationship. If there is a clause that you would normally agree to make two-way during negotiation, make it two-way before the supplier sees it.

3. **Simplify the English.** Legal writing is often indefensibly hard to read. If one of the major purposes of an agreement is to document expectations, then the contract should function as a communication tool. If you are working with an attorney, this is not a trivial problem. Many complex contract clauses have been passed on from attorney to attorney over the years with a comment that "this has worked in the past." To rewrite them into simple English will take time and thought. You might face resistance.

   Fortunately, you have support. The Securities and Exchange Commission has drafted rules that require prospectuses to be written in plain English. Vice President Gore's Reinventing Government program is requiring all government communications to be written in plain English. Both organizations have published guidelines. Some key recommendations are:

   - use active verbs
   - use short sentences
   - avoid legalese and jargon
   - use bulleted lists and tables, rather than long lists of words separated by commas

   A good test, and an enlightening exercise, is to use your word processor's grammar checker on your contract proposal. Often, the grammar checker will reject entire paragraphs. (Think of the effect of this style of writing on someone for whom English is a second language.) Pay attention to typography, white space and overall appearance of the document.

4. **Decide if you want to have the United Nations Convention on the International Sale of Goods (CISG) applicable to your contract or not.** The CISG is a UN treaty that the US and several other countries have signed. Often, the buyer's and seller's countries have both signed it, it will be applicable to your contract unless you specifically exclude it. There are some aspects of the CISG that are unfavorable to buyers and some that are unfavorable to sellers, and it is not completely understood. Most companies exclude it. You will need to put specific exclusionary language in

5. Consider arbitration rather than courts to solve problems. Arbitration will be faster and less costly in most cases. It also will tend to reach a compromise, rather than have one party prevail completely. It is a good solution for solving what both parties see as a temporary impasse in their relationship.

6. Establish the courts and legal system under which disputes will be settled. You need to pick a country and city. If the supplier has all of its assets in its home country, often the best choice is the supplier's home country. This works best if the buying company has a legal presence in the supplier's country and there is a stable, functioning legal system.
Mathematics

The ability to do arithmetic is essential for any buyer or purchasing manager. A purchasing professional should be skilled in taking percentages, converting decimals and fractions, and in converting units of measure. Knowing the true time value of money helps determine actual purchase cost.

Using decimals and fractions.

The fractions 1/2, 3/4, and 7/8 convert to and are equivalent to the decimals 0.5, 0.75, and 0.875. These conversions are obtained by dividing the top number known as the numerator by the bottom number known as the denominator. The decimals 0.125, 0.375, and 0.1875 convert to and are equivalent to the fractions 1/8, 3/8, and 3/16.

Calculating percentages.

Fractions are converted to percentages by first converting them to decimals and then multiplying by 100. For example 1/4 converts to 0.25 which becomes 25%. Multiplying by 100 only requires moving the decimal point two places to the right. It is important to establish the proper base when calculating the percentage change. For example, suppose a supplier was charging $10 for an item and raises the price to $12. The base was 10. Dividing 2 by 10 converts to a 20% increase. However, if the price was $12 and the buyer negotiates a reduction to $10, the savings is only 16.66%. It is a saving of $2, but 2 divided by the base of 12 converts to 0.1666 or 16.66%.

Converting units of measure.

It is important to use the correct unit of measure to multiply the quantity by the same unit of measure as the price. For example, if the price is given per foot, then the quantity should be in feet in order to compare total cost. If the price is given in pounds, then the quantity should be in pounds in order to compare total cost.

Likewise, it may be necessary to convert units of measure for quantities given in the English system to units of measure for quantities given in the Metric system. For example, suppose the buyer was asked to order 15 yards of a material, but the prices were given as $47 per meter. The buyer needs to convert yards to meters to know how much the charge will be. Since 1 yard equals 0.9144 meters then 15 yards equals 13.716 meters and the charge will be 13.716 x $47 or $644.65 assuming the charge will only be for the exact length requested. The following are common conversions that are helpful to know.

Common Conversions

1 quart = 0.9463 liter 1 gallon = 3.7853 liters 1 inch = 2.54 centimeters 1 yard = 0.9144 meters
Using simple and compound interest.

Buyers should understand the principles of simple and compound interest.

Calculating the value of payment discounts.

There are various types of discounts offered by suppliers. Some are based on the quantity purchased for a single item or for the amount purchased over an extended period of time. Others are based on the buyer's type of business. For example, schools and colleges may receive a special discount.

Most discounts simply specify a percentage that may be deducted from the price. For example, a supplier may indicate that the buyer may receive a 15% discount. If the published or stated list price is $50, then...
the actual price paid will be $42.50. This is calculated by multiplying 0.85 times $50 (remember to convert decimals to percentages you multiply by 100, therefore to convert percentages to decimals you divide by 100). The answer can be obtained by multiplying the list price by 0.15 and subtracting the result from $50 or by first subtracting 0.15 from 1.0 and multiplying the result by $50.

Another type of discount is that for paying early and is negotiated as the payment terms. For example, 1% 10, net 30 means that a discount of 1% may be taken on the total value of the order if paid within ten days. It is calculated the same as above except it is taken on the total order rather than on one item. Another type of discount is called a chain discount and is given as a series of discounts such as 10, 5, and 5.

Determining the present value.

If the price is the same, it is more costly to pay now rather than later. That is because money has a time value. Interest is paid for the use of money or interest is lost if money must be spent now rather than later. Here is the formula for calculating the present value.

\[ P = \frac{S}{(1 + r)^n} \]

where \( P \) = present value
\( S \) = future value
\( r \) = interest rate
\( n \) = periods

Most buyers use “Present Value Tables” and Financial Calculators to perform present value computations.

Converting foreign currencies.

Nations use different currency that must be converted to another nation's currency when business transactions are made between two countries. The conversion factors are different from country to country and at different times. Buyers must take this into consideration when making an international purchase and decide on which currency will be used for pricing and payment. There is a risk in paying more or an opportunity to pay less in one currency rather than the other if the rate of change is different when delivery is made and payment is due. The risk can be offset by hedging practices such as purchasing the currency needed for the order at the time the order is placed.

Measuring domestic and international cost increases.

If the purchase agreement is made in U.S. dollars and the dollar becomes less valuable in relation to another currency, then more dollars are required to pay for material than would have been required when the order was placed. Thus the buyer experiences a cost increase, but the foreign supplier does not receive any more funds or any additional profit.
Negotiating

Who negotiates and types of negotiations.

Everybody negotiates. The baby cries for food or attention, teenagers offer to cut the grass for a bigger allowance, husband and wife bargain for where to go on vacation. Successful business people must be good at negotiating to succeed. Full time buyers spend most of their time negotiating.

What is negotiable.

Everything is negotiable regardless of what is claimed. However, it takes skill to learn what the other party wants and is willing to give up to obtain their objective.

Types of negotiations.

Buyers conduct quick everyday negotiations by simply asking for a better price or quicker delivery. More formal negotiations are conducted for major purchases and long-term agreements.

Steps in the formal negotiation process.

Preparation for negotiations improve the chances for obtaining a better deal. The best results can be obtained by using the following steps.

1. Gather complete information. Learn who the competition is. Learn what the competition has to offer. Learn what the economic and financial situations are for the industry and for the supplier. Learn as much as possible about all the individuals taking part in the negotiation. Learn as much as possible about the product to be purchased. Determine the supplier's most important needs.
2. Plan the negotiations. Set objectives. Know what you want to accomplish and the ideal agreement. Decide on what is most important. Decide on the minimum acceptable agreement. Prepare various offers and counteroffers. Plan the time and site for the negotiation. Plan who will attend the negotiating session. Plan the strategy and tactics.
3. Evaluate the merits of the supplier's offer. Calculate the costs. Decide on what elements are acceptable and those that are undesirable or completely unacceptable.
4. Communicate your offer.
5. Answer objections properly.
6. Evaluate counteroffers and offer alternatives repeatedly until agreement is reached or until further negotiations are deemed impossible.

When you should negotiate.

Negotiations are a continual process. Formal negotiations should be planned at convenient times for the buyer as well as the seller. Many purchasing profession-als limit major negotiations for a single item or single supplier to one or two times per year.
Why negotiations fail.

These are the usual reasons why negotiations fail.

<table>
<thead>
<tr>
<th>Inadequate planning</th>
<th>Ignoring the give/get principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intimidating behavior</td>
<td>Impatience</td>
</tr>
<tr>
<td>Loss of temper</td>
<td>Not listening</td>
</tr>
<tr>
<td>Arguing</td>
<td>Ignoring conflict</td>
</tr>
</tbody>
</table>

Not communicating

Using the learning curve.

The learning curve plots average labor cost for the number of units produced and slopes downward. This is explained by the increases in efficiency gained from experience. The use of the curve helps buyers negotiate with suppliers and to offset arguments for increased prices resulting from increased costs. As more is produced of new products the labor costs go down.
Purchasing Management

Purchasing has been and probably continues to be an underrated business function. Its importance can be grasped by realizing that savings from any reductions in costs go directly to the bottom line. Compare this with the profit produced by increased sales that only increases profits after deducting the cost of goods sold and the sales expense.

Policies and procedures.

Written policy and procedures help a purchasing department function better. They provide guidelines to establish uniformity and consistency to the purchasing operation and are easy to refer to when needed. Written policies and procedures help clarify thinking and lead to a more efficient operation. They make training of new employees easier. They document rules and regulations to make enforcement easier. Written manuals provide a way of comparing the stated policies and procedures with actual practices. Operations should be required to follow the written manuals or the manuals should be revised to correspond to better methods. Purchasing policy and procedure manuals are required for company certification.

Advantages and disadvantages of single sourcing.

Sometimes a buyer is forced to use only one supplier for an item. This is the case where an item is patented or where it would be cost prohibitive to pay for more than one set of tooling. When there is a choice, there are at least seven advantages of using one supplier for the same item.

Advantages of using a single supplier.

Duplication of effort is eliminated.
Economies of scale are provided.
Negotiating power is improved because of a larger quantity.
Duplicate inventories are eliminated (in process, in transit, or in storage).
The opportunity for consistent quality is improved.

Some of the disadvantages of using a single source are as follows.

Supply protection may be affected by a labor strike or a fire at the supplier's facilities.
The supplier may file for bankruptcy.
Short term negotiating power is reduced because of no competition.

Advantages of using more than one supplier for the same item.

The risk of total supplier failure is reduced.
Competition is enhanced.
There is protection from a strike at one supplier.
Negotiations are easier because of competition and comparative information.
Risk of stock-outs is reduced.

Value analysis - what it is and how to use it.
As practiced in U.S. firms for many years, value analysis techniques were most widely used in programs designed to engineer unnecessary costs out of existing products. Finally, the more progressive firms began to follow the Navy's lead by establishing what they too called "value engineering" programs—programs that applied the value analysis concept during the early stages of the new product design process. And, clearly, this is the first point at which, should be applied. This is where the greatest benefits are produced for both the firm and its customers.

What is the mix of value analysis and value engineering applications in American industry today? No one really knows. But the number of both programs has grown markedly in the last decade, with value engineering programs setting the pace.

The VE concept finds its most unique use in two kinds of companies—those that produce a limited number of units of a very expensive product and those that mass-produce products requiring expensive tooling. In these types of companies, value analysis of all items already in production is often impractical because it is then too late to incorporate changes in the product economically. In manufacturing certain electronic instruments used in defense systems, for example, the production run is often so short that it precludes the effective use of value analysis after production has been initiated. In fact, the Federal Acquisition Regulations now stipulate that most major defense procurement contracts must be subjected to value engineering studies prior to initial production.

A somewhat different situation that produces similar operating results is found in firms mass-producing automobiles. For example, in manufacturing the body panel for a car, once the design is fixed and the dies are purchased, it is normally too costly to change them, even though value analysis studies might subsequently disclose design inefficiencies.

Value engineering utilizes all the techniques of value analysis. In practice, it involves very close liaison work between the purchasing and supply, production, and design engineering departments. This liaison is most frequently accomplished through the use of product design teams or various procurement and production coordinators, who spend considerable time in the engineering department studying and analyzing engineering drawings as they are initially produced. Once coordinators locate problem areas, value analysis techniques are employed to alleviate them.
VA/VE Tools

Although different companies stress different variations of the fundamental idea, two general conceptual tools are basic to the operation of a VA/VE program:
1 Design analysis of the required product, part, or material
2 Cost analysis of the required product, part, or material

Design Analysis
Design analysis entails a methodical step-by-step study of all phases of the design of a given item in relation to the function it performs. The philosophy underlying this approach is not concerned with appraisal of any given part per se. Rather, the appraisal focuses on the function which the part, or the larger assembly containing the part, performs. This approach is designed to lead the analyst away from a traditional perspective which views a part as having certain accepted characteristics and configurations. Instead, it encourages the analyst to adopt a broader point of view and to consider whether the part performs the required function both as effectively and as efficiently as possible. Both quality and cost are objects of the analysis.

One technique many firms use in analyzing component parts of a subassembly is to dismantle, or "explode," the unit and then mount each part adjacent to its mating part on a pegboard or a table. The idea is to demonstrate visually the functional relationships of the various parts. Each component can thus be studied as it relates to the performance of the complete unit, rather than as an isolated element. Analysis of each component in this fashion attempts to answer four specific questions:
1 Can any part be eliminated without impairing the operation of the complete unit?
2 Can the design of the part be simplified to reduce its basic cost?
3 Can the design of the part be changed to permit the use of simplified or less costly production methods?
4 Can less expensive but equally satisfactory materials be used in the part?

When viewed in this manner--from the standpoint of composite operation and cost--possibilities for making component design simplifications frequently are more apparent than is possible under the original design conditions. This in no way reflects unfavorably on the work done initially by the design engineer. The discovery of such potential improvements is simply the product of an analysis with a substantially broader orientation than that possessed by the original designer. An organized VA/VE study usually utilizes a number of individuals with different types of backgrounds, experience, and skill impossible to combine in the person of a single designer. Resulting design changes often permit the substitution of standardized production operations for more expensive operations requiring special setup work. In some cases, considering the volume of parts to be produced, an entirely different material or production process turns out to be more efficient than the one originally specified.

The specific manner in which a value analyst approaches the problem of design analysis is a highly creative matter which differs from one analysis another. Each possesses unique analytical abilities and develops unique terms of thought. Some companies, however require analysts to follow one or more general approaches which are designed to stimulate and organize their efforts. The commonly used are (1) the value analysis checklist, (2) the functional cost approach, (3) the use of brainstorming, and (4) the use of Suppliers.

The Value Analysis Checklist

Most companies develop some type checklist to systematize a value analyst's activity. Literally hundreds of questions and key ideas appear on these lists. Some of them are highly specialized for particular types of products. Illustrative of the more general questions the following checklist.

First, determine the function of the item, then determine:
1. Can the item be eliminated?
2. If the item is not standard, can a standard item be used?
3. If it is a standard item, does it completely fit the application, or is it a misfit?
4. Does the item have greater capacity than required?
5. Can the weight be reduced?
6. Is there a similar item in inventory, that could be substituted?
7. Are closer tolerances specified than are necessary?
8. Is unnecessary machining performed on the item?
9. Are unnecessarily fine finishes specified?
10. Is "commercial quality" specified? (Commercial quality is usually most economical.)
11. Can you make the item less expensively in your plant? If you are making it now can you buy it for less?
12. Is the item properly classified for shipping purposes to obtain lowest transportation rates?
13. Can cost of packaging be reduced?
14. Are suppliers being asked for suggestions to reduce cost?

In using this or similar checklists, an analyst evaluates the component under investigation with respect to each item on the checklist. When a question is found to which the answer is not entirely satisfactory, this becomes a starting point for more detailed investigation. The checklist focuses the analyst's attention on those factors which past experience has proved to be potentially fruitful cost reduction areas.
Quality

Total quality involves every aspect of the business. It differs from traditional quality requirements that only were concerned about the delivered product. Shipments delivered too early or past the scheduled date indicate unacceptable quality. Slow response to phone calls or errors on invoices are other signs of less than satisfactory quality. Professional buyers address the quality issue at the start of discussions with a new supplier.

The buyer's definition of quality.

The proper quality level is that specified in the agreement or with the order. If the specifications are vague or incomplete, the supplier is not likely to produce a desired product. Yet, the supplier cannot be justifiably blamed.

How quality is measured.

Quality checks by inspectors from the buying organization may be made during the manufacturing process at the supplier's facilities or upon receipt of the material. In either case inspections should compare the product with the specifications given in the agreement. Wherever possible, goals should include objective measurements rather than subjective opinion.

Total Quality Management

As defined by ISO:

"TQM is a management approach of an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society."

In Japanese, TQM comprises four process steps, namely:

2. Atarimae Hinshitsu – Focuses on intangible effects on processes and ways to optimize and reduce their effects.
3. Kansei – Examining the way the user applies the product leads to improvement in the product itself.
4. Miryokuteki Hinshitsu – Broadens management concern beyond the immediate product.

TQM requires that the company maintain this quality standard in all aspects of its business. This requires ensuring that things are done right the first time and that defects and waste are eliminated from operations.

Origins

Although W. Edwards Deming is largely credited with igniting the quality revolution in Japan starting in 1946 and trying to bring it to the United States in the 1980s, Armand V. Feigenbaum was developing a similar set of principles at General Electric in the United States at around the same time. "Total Quality Control" was the key concept of Feigenbaum's 1951 book, Quality Control: Principles, Practice, and Administration, a book that was subsequently released in 1961 under the title, Total Quality Control (ISBN 0-07-020353-9). Joseph Juran, Philip B. Crosby, and Kaoru Ishikawa also contributed to the body of knowledge now known as TQM.

The American Society for Quality says that the term Total Quality Management was first used by the U.S. Naval Air Systems Command "to describe its Japanese-style management approach to quality
improvement.\[1\] This is consistent with the story that the United States Department of the Navy Personnel Research and Development Center began researching the use of statistical process control (SPC); the work of Juran, Crosby, and Ishikawa; and the philosophy of Deming to make performance improvements in 1984. This approach was first tested at the North Island Naval Aviation Depot.

In his paper, "The Making of TQM: History and Margins of the Hi(gh)-Story" from 1994, Xu claims that "Total Quality Control" is translated incorrectly from Japanese since there is no difference between the words "control" and "management" in Japanese. William Golimski refers to Koji Kobayashi, former CEO of NEC, being the first to use TQM, which he did during a speech when he got the Deming prize in 1974.

TQM in manufacturing

Quality assurance through statistical methods is a key component in a manufacturing organization, where TQM generally starts by sampling a random selection of the product. The sample can then be tested for things that matter most to the end users. The causes of any failures are isolated, secondary measures of the production process are designed, and then the causes of the failure are corrected. The statistical distributions of important measurements are tracked. When parts' measures drift into a defined "error band", the process is fixed. The error band is usually a tighter distribution than the "failure band", so that the production process is fixed before failing parts can be produced.

It is important to record not just the measurement ranges, but what failures caused them to be chosen. In that way, cheaper fixes can be substituted later (say, when the product is redesigned) with no loss of quality. After TQM has been in use, it's very common for parts to be redesigned so that critical measurements either cease to exist, or become much wider.

It took people a while to develop tests to find emergent problems. One popular test is a "life test" in which the sample product is operated until a part fails. Another popular test is called "shake and bake", in which the product is mounted on a vibrator in an environmental oven, and operated at progressively more extreme vibration and temperatures until something fails. The failure is then isolated and engineers design an improvement.

A commonly-discovered failure is for the product to disintegrate. If fasteners fail, the improvements might be to use measured-tension nutdrivers to ensure that screws don't come off, or improved adhesives to ensure that parts remain glued.

If a gearbox wears out first, a typical engineering design improvement might be to substitute a brushless stepper motor for a DC motor with a gearbox. The improvement is that a stepper motor has no brushes or gears to wear out, so it lasts ten or more times as long. The stepper motor is more expensive than a DC motor, but cheaper than a DC motor combined with a gearbox. The electronics are radically different, but equally expensive. One disadvantage might be that a stepper motor can hum or whine, and usually needs noise-isolating mounts.

Often, a "TQMed" product is cheaper to produce because of efficiency/performance improvements and because there's no need to repair dead-on-arrival products, which represents an immensely more desirable product.

TQM, just another management fad?

Abrahamson (1996) argued that fashionable management discourse such as Quality Circles tends to follow a lifecycle in the form of a bell curve. Ponzi and Koenig (2002) showed that the same can be said about TQM, which peaked between 1992 and 1996, while rapidly losing popularity in terms of citations after these years. Dubois (2002) argued that the use of the term TQM in management discourse created a positive utility regardless of what managers meant by it (which showed a large variation), while in the late 1990s the usage of the term TQM in implementation of reforms lost the positive utility attached to the...
mere fact of using the term and sometimes associations with TQM became even negative. Nevertheless, management concepts such as TQM leave their traces, as their core ideas can be very valuable. For example, Dubois (2002) showed that the core ideas behind the two management fads Reengineering and TQM, without explicit usage of their names, can even work in a synergistic way.
Part IV. Practice CISC M Exam

Below are “sample questions” from the Body of Knowledge. They in no way represent all the Body of Knowledge and the questions themselves will not be found on the CISC M Examination. The content of the questions may, however, be tested.

1. In which type of production environment do managers face the challenges of capital decisions, technological advances, scheduling service delivery and managing demand to avoid peaks and to promote off-peaks?
   a. low labor intensity
   b. high labor intensity
   c. low interaction/customization
   d. high interaction/customization

2. Under which environmental standard must companies pledge their belief that corporations have a responsibility for the environment and conduct their business as responsible stewards of the environment by operating in a manner that protects the Earth?
   a. ISO 9000
   b. ISO 14000
   c. CERES Principles
   d. self-certification

3. Which of the following activities should not be a candidate for outsourcing?
   a. Activities that have a high degree of variance.
   b. Activities that take place infrequently.
   c. Activities that require customer specific knowledge.
   d. Activities that are low in strategic importance.

4. A car repair shop has four main processes: customer check-in, diagnosis/inspection, repair and checkout. The check-in process takes 20 minutes; diagnosis and inspection takes 40 minutes; repair takes 1 hour and checkout takes 10 minutes. Where is the bottleneck in the car repair shop?
   a. check-in
   b. diagnosis/inspection
   c. repair
   d. check-out

5. Which of the following statements is incorrect?
   a. In a TQM system, the primary rule is to recognize your core competencies.
   b. In a TQM system, drivers are typically defined internally.
   c. In an ROQ system, customers set the parameters for evaluation.
   d. In an ROQ system, marketing selects the quality improvements that lead to the greatest return on investment.

6. Which of the following is not a challenge of using regression for site selection?
   a. Users may not trust the "black box" approach.
   b. Regression-based scores do not have intrinsic meaning.
   c. Regression scores do not have the accuracy of budget numbers.
   d. Firms must have historical data in order to run regression.
7. Contract types:
   a. have little relationship to the use of price and/or cost analysis in a specific purchase.
   b. **reflect the degree of risk the Purchasing Organization desires to assume for performance.**
   c. are limited to firm-fixed-price and fixed-price-incentive in contracts arrived at through sealed or competitive bidding.
   d. Are determined by the supplier as part of the bid/proposal submittal process.

8. Fixed-price contracts have in common an agreement by the supplier to deliver a product or perform a service in accordance with the terms and conditions of the contract. Under this family of contracts:
   a. there is an agreement by the Purchasing Organization to pay a price equal to the firm price specified in the contract or, if the contract includes a tentative price subject to later adjustment, at no more than a specified ceiling.
   b. the parties agree to an estimate of total costs and the Purchasing Organization is not obligated to reimburse the supplier for costs incurred in excess of that estimated amount.
   c. the supplier agrees to use its best efforts to complete contract requirements within the estimate, to notify the Purchasing Organization should there be reason to think that this will not happen, and at that time to give the Purchasing Organization a revised estimate of the cost for performing the contract.
   d. the supplier is not obligated to continue performance or otherwise incur reimbursable expenses in excess of the established estimate unless and until notified by the Purchasing Organization that the contract funding and the estimate have been increased.

9. The following contract type typically imposes the greatest cost risk and administrative and audit burdens on the Purchasing Organization:
   a. Fixed-price-incentive-fee (FPIF)
   b. Firm-fixed-price (FFP)
   c. **Cost-plus-fixed-fee (CPFF)**
   d. Fixed-price-with economic price adjustment (FP/EPA)

10. The analytical method that is appropriate for all types of procurement situations and contract types is called:
   a. Cost Analysis
   b. Value Analysis
   c. Parametric Analysis
   d. **Price Analysis**

11. The two components of cost analysis are:
   a. Price analysis and profit analysis
   b. **Accounting (rate) analysis and engineering (quantitative) analysis**
   c. Direct and Indirect analysis
   d. Estimating and cost/price analysis review

Questions 12 and 13 are based upon the information shown below. Listed below are several methods of price analysis.
(1) Comparison with other prices quoted/bid/proposed
(2) Comparison with prices established by the market (market prices)
(3) Comparison with catalog prices
(4) Comparison with previous prices paid or quotations received
(5) Comparison with in-house estimates
(6) Comparison with prices determined by parametric analysis or rough yardsticks
(7) Comparison with Producer Price Indices (or other published indices)
(8) Comparison with prices determined by value or visual analysis

12. Which of the above methods would be considered necessary whenever the purchases needs to adjust previous prices paid for inflation/deflation?
   a. (5) Comparison with in-house estimates
   b. (6) Comparison with prices determined by parametric analysis or rough yardsticks
   c. (7) Comparison with Producer Price Indices (or other published indices)
   d. (8) Comparison with prices determined by value or visual analysis

13. Which of the above methods would be considered the strongest method of price analysis:
   a. (1) Comparison with other prices quoted/bid/proposed
   b. (2) Comparison with prices established by the market (market prices)
   c. (3) Comparison with catalog prices
   d. (4) Comparison with previous prices paid or quotations received

Problems 14 thru 15 are based upon the below information. There are several methods of procurement available to the professional purchaser. These methods include the following:
   (1) Competitive bidding
   (2) Negotiation
   (3) Two Step Bidding
   (4) Systems Contracting

14. Which of the above methods would be appropriate whenever the purchaser wishes to award a contract to the bidder providing the lowest bid (assuming the bid is responsive and the bidder is responsible)?
   a. (1) Competitive Bidding
   b. (2) Negotiation
   c. (3) Two Step Bidding
   d. (4) Systems Contracting

15. Which of the above methods would be appropriate whenever the purchaser wishes to take technical proposals, evaluate them, and then solicit bids from those submitting acceptable technical proposals?
   a. (1) Competitive Bidding
   b. (2) Negotiation
   c. (3) Two Step Bidding
   d. (4) Systems Contracting
Part V. CISCM Body of Knowledge (BOK) and Reference List

BODY OF KNOWLEDGE

Capacity Management

John H. Blackstone Jr., CFPIM

273 pp., 1989, Stock #03601

This text covers the traditional areas of production planning, master scheduling, long-term capacity planning, capacity requirements planning, input/output control, operations scheduling, and dispatching. Topics such as capacity planning for adjunct resources, synchronized production, stochastic line balancing, and performance measurements also are discussed.

Crafting and Executing Strategy

Arthur A. Thompson Jr., A.J. Strickland III, and John E. Gamble

592 pp., 2001, Stock #03473

The hallmark of the 14th edition is thorough coverage of the strategy-related changes in the business landscape being driven by globalization, the Internet, and dot-com companies. A defining highlight of this edition is the addition of two new chapters—one detailing strategy-making in globalizing market environments and one describing business models and strategies for e-commerce environments. Crafting and Executing Strategy delivers content to satisfy the market's legitimate yearning for a comprehensive teaching and learning package that targets crafting, implementing, and executing business strategies.

Distribution: Planning and Control

David Frederick Ross, CFPIM

840 pp., 2004, Stock #03442

This second edition provides manufacturers, distributors, and retailers with an updated approach for implementing effective distribution and planning control systems in the 21st century. Following the central core of the first edition, the book uses a business model that views the various functions of the enterprise, from top management planning to detailed inventory management, warehousing, and customer management, as a single, integrated, customer-satisfying entity. Based on this model, the author demonstrates how the tremendous opportunities posed by the advent of new factors such as the Internet, collaborative channel synchronization, and the concept and practice of supply chain management have dramatically altered and broadened the science of distribution and logistics.

Introduction to Materials Management

J.R. Tony Arnold, CFPIM, CIRM, and Stephen N. Chapman, CFPIM

480 pp., 2004, Stock #03813
This book is an introductory text that describes the basics of supply chain management, manufacturing planning and control systems, purchasing, and physical distribution. New features of this edition include enhanced coverage of performance metrics, ERP, supply chain approaches and implications, lean production fundamentals, and basic scheduling rules.

**Just-in-Time: Making It Happen**

William A. Sandras Jr., CFPIM

366 pp., 1989, Stock #03114

This hands-on guide to implementing JIT and total quality control in your manufacturing operations will show you how to work through a JIT implementation and overcome all possible obstacles in your path. In addition, you'll get practical advice on how to organize the implementation team, develop a working kanban system, restructure the shop floor, reduce and avoid setups, create more efficient links to suppliers and customers, overhaul accounting practices, develop empowered work teams, and measure performance. Also available as part of a discounted series.

**Manufacturing Planning and Control Systems for Supply Chain Management**

Thomas E. Vollmann, CFPIM, William L. Berry, D. Clay Whybark, and F. Robert Jacobs

598 pp., 2004, Stock #03406

Vollmann, Berry, Whybark, and Jacobs' Manufacturing Planning and Control Systems provides comprehensive real-world coverage of the concepts, tools, and methods used to manage and control manufacturing systems. This revised edition explores ERP system coverage and the impact of these systems in the field. Each chapter provides a managerial issues overview, a detailed technical presentation, examples of company implementations, and concluding principles. This book is intended primarily for classroom use. Answers to the questions posed in the text are available only through an instructor.

**Principles of Operations Management**

Jay Heizer and Barry Render

638 pp., 2004, Stock #03104

This text provides a state-of-the-art overview of operations management. The authors present an exclusive behind-the-scenes look at Hard Rock Cafe, one of the most widely recognized company names in the world, for an inside look at operations in a service environment. Discover how operations management is put into practice at Hard Rock Cafe in examples, photos, seven video cases, and a global profile. The book includes a CD-ROM of exercises that correspond with examples in the textbook.
**Production and Inventory Management**

Donald W. Fogarty, CFPIM, Ph.D, John H. Blackstone Jr., CFPIM, Ph.D, and Thomas R. Hoffmann, CFPIM, CIRM, Ph.D

870 pp., 1991, Stock #03501

This comprehensive introduction to P&IM principles, techniques, and systems covers the basics of the key industry topics, including planning, inventory management, implementation and control, operations research techniques, and models. This second edition includes many greatly enhanced sections on manufacturing issues, including JIT, simulations, the P&IM environment, capacity management, and MRP II. Intended primarily for classroom use, answers to the questions posed in the text are available only through a qualified instructor.

**Purchasing**


©International Purchasing and Supply Chain Management Institute, 2006
Forecasting Handbook (2004). Published by American Certification Institute, Lewes, Delaware.

Glossary of Purchasing, Logistics, and Supply Chain Management Terms (2004). Published by American Certification Institute, Lewes, Delaware.


CISG References