PROCESS
CONTROL
MANAGEMENT
Foreword

MIC has produced this book for us in its Industrial Maintenance Journeyman Programme and it is specifically designed to introduce the basics of maintenance.

This book is intended for use as a reference text to be supplemented by notes and explanations and does not stand alone.

Compilation of this book was completed with standard published material, Tel-A-Train and resource personnel at MIC. No claim is made to the ownership of any material contained herein.

THIS BOOK IS NOT FOR SALE

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Unit Operation

Any activity that alters the physical or chemical characteristics of a material or an object or adds to it in anyway whatsoever.

E.G.
- Grinding Grain
- Drying Hay
- Freezing Meat
- Nailing Box
- Mailing Letter

E.G. of Unit Operations
- Drying
- Size Reduction
- Cleaning
- Sorting (Grading/Separation)

MATERIALS HANDLING

Materials handling is the movement of materials from receiving, through operation, to final shipment. It often represents a significant part of the cost-of-goods-sold, but adds no tangible value to the product. Conventional systems use workers, assisted by trucks, fork lifts, cranes and hoists, conveyors, pipelines and other equipment. Automated systems use robots and computer-guided vehicles. The performance of a processing plant is measurably affected by the efficiency of the movement of material from one unit operation to another.
- The importance of this movement of materials is not essentially a function of its magnitude. Industrial materials handling is a highly specialized enterprise.
- Its procedures and details have developed out of usage and experience in great measure (the rational approach being undeveloped in many cases). Materials handling implies the movement of materials in any direction (E.G. elevation, movement in a horizontal plane)
Handling devices may be classified as follows:
1. Belt conveyors
2. Chain conveyors
3. Screw conveyors
4. Bucket conveyors
5. Pneumatic conveyors
6. Gravity conveyors
7. Cranes
8. Lifts and carrying trucks and carts
Diagram of an elementary control

### INPUT-CONVERSION-OUTPUT CHARACTERISTICS OF TYPICAL PRODUCTIVE SYSTEMS

<table>
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<th>Inputs</th>
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<td>Auto factory</td>
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<td>Oil refinery</td>
<td>Crude oil</td>
<td>Chemical processes</td>
<td>Gasoline, oil, plastics, etc.</td>
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<tr>
<td>Airline</td>
<td>Airplanes, pilots, flight attendants, supplies, customers</td>
<td>Air transportation</td>
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<td>Social Security</td>
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GOODS-PRODUCING FACILITY

SERVICES-PRODUCING FACILITY

GOODS- AND SERVICES-PRODUCING FACILITIES
CARLSEN FIELD RICE MILL
FLOW DIAGRAM WITH MACHINERY
**Nomenclature:** Studies have shown that a process is composed of five types of steps in various combinations. These steps and symbols which have been standardized by the American Society of Mechanical Engineers follow:

1. **Operation** ○: Any activity that alters the physical chemical characteristics of a material or an object, or adds to it in any way whatsoever, such as grinding grain, drying hay, weighing eggs, freezing meat, nailing box, mailing letters.

2. **Transportation** ➔: Any movement of material from one place to another unless such movement is an integral part of an operation, such as milk by pump, refuse by truck, fruit by belt, box by employee, grain by truck.

3. **Inspection** □: An examination by an individual to determine quality or quantity or to verify conditions, such as determining moisture content of grain, determining grade of fruit, checking performance of vegetable washer, noting temperature of pasteurizer.

4. **Storage** ▼: A desirable interruption of activity, such as ingredients being held for future use, fruit being held for optimum market.

5. **Delay** △: An undesirable interruption of activity, such as prunes in tray waiting to be dried, material in truck waiting to be unloaded, employee waiting for machine to operate.

6. **Combined Operation**: Where two or more operations take place simultaneously, the requisite symbols are combined. For example, cheese in a processing room is both a storage and an operation; a mixing process may be both an operation and a transportation.

Process charts may be built around (1) materials, (2) men, or (3) machines. They may show the movement of materials and all operations thereon. They may show the activities of a man or men required to produce a certain end point. Or the activities of a machine or series of machines may be represented.
### A. ORIGINAL CONTROL SYSTEM

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>SUPPLIREE</th>
<th>PRODUCTION SYSTEM</th>
<th>STORES</th>
<th>ORDERING SYSTEM</th>
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<tr>
<td></td>
<td></td>
<td>PIG-IRON STORE</td>
<td></td>
<td>MaxMin Control</td>
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<td></td>
<td></td>
<td>Frequency change.</td>
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<tr>
<td></td>
<td></td>
<td>Receipts: Batch 14 days.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Issue: Daily</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>CASTINGS</td>
<td></td>
<td>Stock Control</td>
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<tr>
<td></td>
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<td>Frequency change.</td>
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<td>Larger batch quantities</td>
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<td></td>
<td></td>
<td>in Foundry.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>FINISHED PARTS</td>
<td></td>
<td>Stock Control</td>
</tr>
<tr>
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<td></td>
<td>Phase change.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Receipts: Multi-phase.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Issues: Single phase</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>FINISHED PRODUCTS</td>
<td></td>
<td>Scheduling to programme in batches</td>
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<tr>
<td></td>
<td></td>
<td>Frequency change.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Made in large batches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Issues: Small</td>
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</table>

### B. MODIFIED CONTROL SYSTEM ELIMINATING ONE STORE

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>SUPPLIREE</th>
<th>PRODUCTION SYSTEM</th>
<th>STORES</th>
<th>ORDERING SYSTEM</th>
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<tr>
<td></td>
<td></td>
<td>FOUNDRY</td>
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<td>Process Batch Production</td>
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<td>Receipts: Batch 14 days.</td>
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<td></td>
<td></td>
<td>Issue: Daily</td>
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<td></td>
<td></td>
<td>Standard batches accumulated in Foundry and Machine shop before passing on to next process. No phases or frequency change.</td>
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<td></td>
<td></td>
<td>SMALL &quot;FITTINGS&quot; STORE</td>
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<td></td>
<td></td>
<td>Phase and frequency change.</td>
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<td></td>
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<td>FINISHED PRODUCTS</td>
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Company making cast Iron stoves and fire grates. Stocks, Storage, and control costs all reduced by changing order systems, to one giving constant frequency and single phase, through following processes of casting, machining and assembly.

**Eliminating stores by change of ordering system**

The illustration shows how a company making cast-iron stoves and grates were able to eliminate one controlled store by changing from a multi-phase to a single phase ordering system. The new system allowed continuous flow between the processes of casting, machining and assembly, and resulted in a reduction in stocks, storage costs and control costs.
(a) Line Layout

(b) Functional Layout

(c) Group Layout

Types of Layout

The rectangles represent machine tools (L=lathe, M=milling m/c, D=drill, G=grinder, etc.). The arrowed lines show the path of material flow between machines. Normally one foreman or chargehand will look after each section of machines. With line and group layout they are responsible for components with functional layout for processes only. Production control is simple and efficient with line layout and group layout. It tends to be much more complicated and less efficient with functional layout.
Establishment of policies regarding quality desired in relation to markets, investment requirements, return on investment potential, competition, etc.

Quality and production engineering design

Design of production system to be compatible with quality, cost and capacity requirements

Quality standards for:
(1) Raw materials
(2) Processes
(3) Product performance

Inspection and control of quality of incoming materials

Physical production of goods

Inspection and control of processes

Inspection and testing for product performance

Distribution, installation, and use of product

Schematic representation of the role of quality control throughout the planning, production, and distribution of a product.
Probability

Introduction

If it were possible to predict the future with complete certainty, the structure of managerial decisions would be radically different from what it is. A wrong decision would be simply the result of failure to consider all the relevant information; there would be no excess production, no clearance sales, no speculation in the stock market, and business failure would be a rarity.

Of course there does not exist complete certainty in the world and the desire to cope with uncertainty in decision making has led to the study and use of probability theory. Often, managers have some knowledge about the possible outcomes in a decision situation; by organizing this information and considering it systematically, they usually reach a sounder decision than they would if they simply guessed.

The concept of probability is a part of our everyday lives in both personal and managerial situations. Whether it is admitted or not probability theory is used when people face uncertainty. Decision makers benefit from their own assessments of the chances that certain things will happen.

Basic Probability Concepts

Probability is the chance that something will happen.
Probabilities are expressed as fractions ($\frac{1}{4}, \frac{1}{2}, \frac{3}{4}$) or as decimals (.25, .5, .75) between 0 and 1. As assigned probability of 0 means that something will never happen. As assigned probability of 1 means that something will always happen.

Events and Experiments

In probability theory, an event is one or more of the possible outcomes of doing something.

**e.g.**
If we toss a coin, getting a tail would be an event; getting a head would be still another event.

The activity that produces an event is referred to in probability theory as an experiment.

Mutually Exclusive and Collectively Exhaustive Events

Events are mutually exclusive if one and only one of them can take place at a time.

**e.g.**
In the example of the coin toss two possible outcomes heads and tails can occur.
On any single toss, either head or tails may turn up, but not both.

According, the events heads and tails on a single toss are said to be mutually exclusive.

When a list of the possible events that can result from an experiment together with a list of every possible outcome is developed this termed a collectively exhaustive list.
Three Types of Probability

There are three ways of classifying probability. These represent different conceptual approaches to the study of probability theory; in fact, experts disagree over which approach it is proper to use. The three approaches are as follows:

1. The classical approach
2. The relative frequency approach
3. The subjective approach

Classical Probability

\[
\text{The probability of an event} = \frac{\text{Number of outcomes favorable to the occurrence of the event}}{\text{Total number of possible outcomes}}
\]

- Often called a priori probability (state value in advance)
- => It is possible to make probability statements based on logical reasoning before any experiment takes place.

Relative Frequency of Occurrence

Probability is defined as follows:
1. The proportion of times that an event occurs in the long run when conditions are stable, or
2. The observed relative frequency of an event in a very large number of trials

This method of defining probability uses the relative frequencies of past occurrences as probabilities.

To predict the probability that something will happen in the future, we determine how often it happened in the past.

Subjective Probabilities

Subjective probabilities are based on the personal belief or feelings of the person who makes the probability estimate.

Subjective probability may be defined as the probability assigned to an event on the basis of whatever evidence is available.

This evidence may be data about relative frequency of occurrence or it may be nothing more than a good guess.

The decision makers can use whatever evidence is available and temper with their own personal feelings about the situations.

Note: Probability Rules:

Most managers who use probabilities are concerned with two situations:
1. The case where one event or another will occur, and
2. The case where two or more events will occur.
POISSON DISTRIBUTION

The following diagrams show the probability distribution of \( X \sim \text{Po}(\lambda) \) for various values of \( \lambda \). The horizontal axis gives values of \( x \) and the vertical axis gives values of \( P(X = x) \).

Notice that for small values of \( \lambda \) the distribution is very skew, but it becomes more symmetrical as \( \lambda \) increases.
Poisson probability paper, showing the probability, $P$, that an event will occur $C$ times \textit{at least} (i.e. $C$ times or more) when the expected number of occurrences has the value of $z$
Distribution with same standard deviation or spread, but different mean values
Complete specifications of a sampling plan. An OC curve which goes through points $a$ and $b$ meets the requirements stated by $\alpha$ and $AQL$ and $\beta$ and $LTPD$, thus specifying a sampling plan with a given $n$ and $c$. ($AQL =$ acceptable quality level; $LTPD =$ lot tolerance per cent defectives.)
Relationship of producer’s and consumer’s risk to the OC curve.
Operating characteristic (OC) curve for a sampling plan with \( n = 50 \) and \( c = 1 \).
Average outgoing quality (AOQL) curve for a sampling plan with \( n = 50, c = 1 \), and lot size \( N = 1000 \); OC curve.
Flow of good and bad parts in a typical acceptance sampling plan and basis for calculating average outgoing quality, AOQ.

The average incoming quality is PD, acceptance occurs with probability Pa(from OC curve), then average number of defectives passed,

\[ P_a/100 \times PD/100 \times (N-n) \]

\[ AOQ = \frac{P_a}{100} \times PD/100 \times (N-n)/100N \]

in percent
Double Sampling Inspection

Inspect a first sample of \( n_1 \) pieces

If the number of defectives found in the first sample

Does not exceed \( c_1 \)

Accept the lot

Exceeds \( c_1 \), but does not exceed \( c_2 \)

Inspect a second sample of \( n_2 \) pieces

If the number of defectives found in the first and second samples combined

Does not exceed \( c_2 \)

Exceeds \( c_2 \)

Inspect all the pieces in the remainder of the lot, and correct or replace all defective pieces found
Quality Measure in Goods and Services

Quality control involves “measurement” of the quality characteristic, “feedback” of the data, “comparison” with specified standards, and “correction” when necessary.

Quality control in the production of goods rests heavily upon the measurement of material characteristics. Physical properties, design and product reliability are key elements.

Services often convey intellectual or aesthetic values whose quality is more difficult to measure. Surrogate measures such as service environment or service times are often used to evaluate the quality of services.

Quality Control

Quality control is a system for verification and maintenance of a desired level of quality in a product or process by careful planning, the use of proper equipment, continuing inspection, and corrective action where required.

The establishment, maintenance, and control of quality then deal with the determination of quality standards and the measurement and control necessary to see that the established standards are maintained and practical.

These standards may be specified dimensions, chemical composition of raw materials, hardness, strength, surface finish, or more subjective factors such as dimples in a painted surface, scratches, or other possible defects which may detract from physical appearance.

Quality control is based on the principles of probability and statistics and is a modern decision making tool employed by management to assure a desired quality level of manufactured goods.

The objective of the quality-control department is not to eliminate all variability of the items produced - which would be an impossible task - but to constrain this variability to economically feasible limits.

The basic quality-control plan should provide for the control of the product throughout its development and production cycle.

Quality Control in Manufacturing

There are three important sub-phases which describe quality control in manufacturing, namely:

A. The inspection and control of the quality of incoming raw material.
B. The product inspection and control processes, and
C. The inspection and testing for product performance.

The objectives of quality control in manufacturing are to implement the quality standards by measuring characteristics of the raw material, parts, and products and comparing these measurements with established standards so that we may:

A. Accept or reject and
B. Correct performance through information feedback

The techniques of acceptance inspection and sampling provide control by filtering out items that do not, or probably do not, meet standards.

Process control techniques, on the other hand, are directed toward determining when the process which generates the measurements is probably out of control.

Those techniques provide for corrective reaction to be taken before scrap losses become prohibitive.

Information feedback from the various inspection and production operations provides data for possible revision of quality standards and of product designs.
Variations

In general, variations that occur in an individual process fall in two broad categories:

Chance variations, and

Assignable causes

The chance variations may be due to a complex of minor actual causes, none of which can account for any significant part of the total variation.

These variations occur in a random manner and are a function of the accuracy of the process, should be expected, and largely determine whether a process can deliver the precision stated for output specifications.

Another type of process variation produced by assignable causes are relatively large and traceable to a specific reason.

In general, assignable causes are:

1. Differences among workers.
2. Differences among machines.
3. Differences among materials.
4. Differences due to the interaction between any two or all three of these factors.

The control problem is to distinguish between natural (chance) variations and variations due to assignable causes.

When a process is in a state of statistical control, variations that occur in the number of defects, the size of a dimension, chemical composition, weight etc, are due to chance variation only.

Standards of expected normal variation due to chance causes are set up with the control chart.

A process is said to be “under control” when deviations in output are the result of chance variations.

When variations due to one or more of the assignable causes are superimposed, they “stick out like a sore thumb” and this says that something basic has changed.

When the pattern of output deviations does not follow the distribution expected from chance causes, the process is considered “out of control” and the cause is probably assignable.

Statistical Methods of Controlling Quality

The two major approaches to controlling quality are “acceptance sampling” of incoming or outgoing products and “process control” of the actual transformation activities.

Both methods involve statistical sampling techniques.

Acceptance sampling methods rely upon estimating the levels of defective items before or after a process have been completed.

Process control is more useful during a process to ensure that production is not outside of acceptable limits.

The primary means of process control is via the use of control charts.

The quality characteristic being observed is classified as either an attributes or variables characteristics.

“Attributes characteristics” are either present or not, such as defective or non-defective, or passing a test or failing it.

There is no measure of the degree of conformance.

For attributes data, a discrete distribution, such as the binomial or Poisson, is used to make inferences about the population characteristic being controlled.

“Variables characteristics” are present in varying degrees and are measurable.

Examples are dimensions, weights and times.

For variables data, continuous distributions such as the normal are used.
Planning

Objectives

These identify and specify general direction of movement.

Goals (or Targets)

These set the magnitude and nature of the things to be achieved in a specific period of time. A goal is a desired future state that the organization attempts to realize.

Strategies

These are the ways of organizing and allocating available resources to put plans into effect (they recognize the obstacles and problems in achieving goals).

Tactics

These are the detailed methods of setting strategies in motion.

Plan

This is a map or a scheme for making, doing or arranging something.

- The method or mean of giving time to something before it happens in order to have some influence over events when they happen.
- A plan is a blue print for goal achievement and specifies the necessary resource allocations, schedules, tasks and other actions.

Planning

This is the process of putting in place strategies that lead to tactics. All planning is about future events. When we plan we are trying either to product or to arrange what will happen in the future (but we cannot know what will happen in the future).

Goals specify future end (endpoints)

Plans specify today’s means (resources and methods)

The term planning usually incorporates both ideas

It means determining the organization’s goals and defining the means for achieving them.

Aggregate Planning

In a healthy organization, planners are concurrently laying out detailed schedules for the next several days’ activities, planning expected weeks and months into the future, and developing strategies to follow several years hence.

In considering intermediate-range plans for operations a month to a year ahead the physical facilities are assumed to be fixed for the planning period.

Therefore, fluctuations in demand must be met by varying labour and inventory schedules.

Aggregate planning seeks the best combination to minimize costs.
Planning Inputs

Demands for products or services are seldom constant over several months. A prerequisite to aggregate planning is the development of a forecast. The predictions typically concern the overall level of demand, not broken down to a specific mix within a product line. For example, the forecast could estimate the number of gallons of a drink to produce without specifying the size of bottles to put it in, or the number of hospital beds that will be occupied without detailing whether they are in single rooms, double rooms, or wards. Once the forecast is accepted as reasonably accurate, predicted demands are treated as certainties in most planning models. Planners need to know what options are available to meet demand variations and the costs of the options. Options vary among organizations due to different management policies. For instance, a policy might be to never run out of stock. A more lenient policy could be to allow a stock out occasionally while making sure that customers’ orders are assuredly filled within to weeks. The costs involved in the options are not always recorded in accounting records. In the case of later deliveries to a customer, which will the customer’s displeasure eventually cost the supplier in terms of extra expense to handle complaints and possible loss of future orders? Such real but difficult-to-measure costs must be collected, along with readily available data on inventory expenses, overtime charges and similar costs, to develop a reliable expense, production plan.

The purpose of the production plan is to smooth out or eliminate sporadic disruptions in operations caused by fluctuations in demands. This is accomplished by scheduling operations to meet demand patterns over several periods in the future. Suppose the demand for a product declined for six months and then rose for six months. If the production manager had not way to anticipate the demand pattern, he or she would probably decrease output each month by laying off workers or going on a reduced work sheet. Then, as demand rose, the manager would likely hire, institute overtime, or fall behind in meeting orders. These short-term reactions can hurt the morale of the workforce, reduce productivity, and increase personnel costs. An extended planning horizon allows the manager to weigh the effects of different ways to match production rates to sales demands, and to select the plan that minimizes disruptions.

Planning Strategies

Combinations of four controllable inputs to the production process are commonly utilized in aggregate planning.

1. Vary the size of the workforce. Output is controlled by hiring or laying off workers in proportion to changes in demand. There are costs of hiring as well as layoffs.
2. Vary the hours worked. Overtime or shortened work weeks raise or lower production rates
3. Vary inventory levels. Demand fluctuations can be met by stocking items during periods of lower demand and then drawing from the stock-pile for higher demands. There is a cost for holding stocks. If the accumulated stock plus current production cannot meet demand, costs are incurred for back-ordering and customer dissatisfaction.
4. Subcontract. Upward shifts in demand from low-level, constant-production rates can be met by using subcontractors to provide extra capacity. The apparent cost of subcontracting is the difference between the subcontracting company’s price per unit and the marginal cost of manufacturing above the given production rate. Quality and delivery time problems may contribute to higher subcontracting costs.
Traditional Production Planning and Control

At least a dozen separate functions can be identified as constituting the cycle or activities in traditional production, planning and control. Organizationally, some of these functions are performed by departments in the firm other than the production control department. The functions are described in the following sections.

Forecasting

The forecasting function is concerned with projecting or predicting the future sales activity of the firm’s products. Sales forecasts are often classified according to the time horizon over which they attempt to estimate. Long-range forecasts look ahead five years or more and are used to guide decisions about plant construction and equipment acquisition. Intermediate-range forecasts estimate one or two years in advance and would be used to plan for long-lead-time material and components. Short-term forecasts are concerned with the three- to six-month future. Decisions on personnel (e.g., new hiring), purchasing and production scheduling would be based on the short-term forecast.

Production Planning

This is sometimes called aggregate production planning and its objective is to establish general production levels for product groups over the next year or so. It is based on the sales forecast and is used to raise or lower inventories, stabilize production over the planning horizon, and allow for the launching of new products into the company’s product line. Aggregate production planning is a function that precedes the detailed master production schedule.

Process Planning

Process planning involves determining the sequence of manufacturing operations required to produce a certain product and/or its components. Process planning has traditionally been carried out by manufacturing engineers as a very manual and clerical procedure. The resulting document, prepared by hand, is called a route sheet and is a listing of the operations and machine tools through which the part or product must be routed. The term “routing” is sometimes applied to describe the process planning function.

Estimating

For purposes of determining prices, predicting costs, and preparing schedules, the firm will determine estimates of the manufacturing lead times and production costs for its products, the manufacturing lead time is the total time required to process a workpart through the factory. The production costs are the sum of material cost, labour, and applicable overhead costs needed to produce the part. These estimates of lead times and costs are based on data contained in the route sheets, purchasing files, and accounting records.

Master Scheduling

The aggregate production plan must be translated into a master schedule which specifies how many units of each product are to be delivered and when. In turn, this master schedule must be converted into purchase orders for raw materials, orders for components from outside vendors, and production schedules for parts made in the shop. These events must be timed and coordinated to allow delivery of the final product according to the master schedule. Specifically, the master schedule or master production schedule is a listing of the products to be produced, when
they are to be delivered, and in what quantities. The scheduling periods in the master schedule are typically months, weeks, or dates. The master schedule must be consistent with the plant’s production capacity. It should not list more quantities of products than the plant is capable of producing with its given resources of machines and labour.

Requirements planning

Based on the master schedule, the individual components and sub-assemblies that make up each product must be planned. Raw materials must be ordered to make the various components. Purchased parts must be ordered. And all of these items must be planned so that the components and assemblies are available when needed. This whole task is called requirements planning or material requirements planning. The term MRP (for material requirements planning) has come into common usage since the introduction of computerized procedures to perform the massive data processing required to accomplish this function. However, the function itself had to be accomplished manually by clerical workers before computers were used.

Purchasing

The firm will elect to manufacture some components for its products in its own plants. Other components will be purchased. Deciding between these alternatives is the familiar “make-or-buy” decision. For the components made in-house, raw materials have to be acquired. Ordering the raw materials and purchased components is the function of the purchasing department. Materials will be ordered and the receipt of these items will be scheduled according to the timetable defined during the required planning procedures.

Machine loading and scheduling

Also based on the requirements planning activity is production scheduling. This involves the assignment of start dates and due dates for the components to be processed through the factory. Several factors make scheduling complex. First, the number of individual parts and orders to be scheduled may run into the thousands. Second, each part has its own individual process routing to be followed. Some parts may have to be routed through dozens of separate machines. Third, the number of machines in the shop is limited, and the machines are different. They perform different operations and have different features and capacities. The total number of jobs to be processed through the factory will typically exceed the number of machines by a substantial margin. Accordingly, each machine, or work center, will have a queue of jobs waiting to be processed. Allocating the jobs to work centers is referred to as machine loading. Allocating the jobs to the entire shop is called shop loading.

Dispatching

Based on the production schedule, the dispatching function is concerned with issuing the individual orders to the machine operators. This involves giving out orders tickets, route sheets, part drawings, and job instructions. The dispatching function in some shops is performed by the shop foremen, in other shops by a person called a dispatcher.
Expediting

Even with the best plans and schedules, things go wrong. It is the expediter’s job to compare the actual progress of the order against the production schedule. For orders that fall behind schedule, the expediter recommends corrective action. This may involve rearranging the sequence in which orders are to be done on a certain machine, coaxing the foreman to tear down one setup so that another order can be run, or hand-carrying parts from one department to the next just to keep production going.

There are many reasons why things go wrong in production: parts-in-process have not yet arrived from the previous department, machine breakdowns, proper tooling not available, quality problems, and so forth.

Quality control

The quality control department is responsible for assuring that the quality of the product and its components meets the standards specified by the designer. This function must be accomplished at various points throughout the manufacturing cycle. Materials and parts purchased from outside suppliers must be inspected when they are received. Parts fabricated inside the company must be inspected, usually several times during processing. Final inspection of the finished product is performed to test its overall functional and appearance quality.

Shipping and inventory control

The final step in the production control cycle involves shipping the product directly to the customer or stoking the item in inventory. The purpose of inventory control is to ensure that enough products of each type are available to satisfy customer demand. Competing with this objective is the desire that the company’s financial investment in inventory be kept at a minimum. Inventory control interfaces with production control since there must be coordination between the various products’ sales, production and inventory level. Inventory control is often included within the production control department. The inventory control function applies not only to the company’s final products. It also applies to raw materials, purchased components, and work-in-process within the factory. In each case, planning and control are required to achieve a balance between the danger of too little inventory (with possible stockouts) and the expense of too much inventory.

PROBLEMS WITH TRADITIONAL PRODUCTION PLANNING AND CONTROL

There are many problems that occur during the cycle of activities in the traditional approach to production planning and control. Many of these problems result directly from the inability of the traditional approach to deal with the complex and ever-changing nature of manufacturing. The types of problems commonly encountered in the planning and control of production are the following:

1. **Plant capacity problems.** Production falls behind schedule due to a lack of labor and equipment. This results in excessive overtime, delays in meeting delivery schedules, customer complaints, backordering, and other similar problems.

2. **Suboptimal production scheduling.** The wrong jobs are scheduled because of a lack of clear order priorities, inefficient scheduling rules, and the ever-changing status of jobs in the shop. As a consequence, production runs are interrupted by jobs whose priorities have suddenly increased, machine setups are increased, and jobs that are on schedule fall behind.
3. **Long manufacturing lead times.** In an attempt to compensate for problems 1 and 2, production planners allow extra time to produce an order. The shop becomes overloaded, or order priorities become confused. And the result is excessively long manufacturing lead times.

4. **Inefficient inventory control.** At the same time that total inventories are too high for raw materials, work-in-progress, and finished products, there are stockouts that occur on individual items needed for production. High total inventories mean high carrying costs, while raw material stockout mean delays in meeting production schedules.

5. **Low work center utilization.** This problem results in part from poor scheduling (excessive product changeovers and job interruptions), and from other factors over which plant management has limited control (e.g. equipment breakdowns, strikes, reduced demand for products).

6. **Process planning not followed.** This is the situation in which the regular planned routine is superseded by an ad hoc process sequence. It occurs, for instance, because of bottle necks at work centers in the planned sequence. The consequences are longer setups, improper tooling, and less efficient processes.

7. **Errors in engineering and manufacturing records.** Bills of materials are not current, route sheets are not up to date with respect to the latest engineering changes, inventory records are inaccurate, and production piece counts are incorrect.

8. **Quality problems.** Quality defects are encountered in manufactured components and assembled products, resulting in rework or scrapped parts, thus causing delays in the shipping schedule.

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### MATERIAL REQUIREMENTS PLANNING

Material requirements planning is a computational technique that converts the master schedule for end products into a detailed schedule for the raw material and components used in the end products.

The detainted schedule identifies the quantities of each raw material and component item.

It also tells when each item must be ordered and delivered so as to meet the master schedule for the final products.
Cycle of activities in a traditional production planning and control system.
Schematic model of a production system
Levels in production planning
1 Programming

Plans production output of finished products

Form of plan

Production programme

<table>
<thead>
<tr>
<th>Product</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
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2 Ordering

Plans material input from suppliers and output of parts from processing departments

'Shop orders' and 'purchase requisitions'

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<thead>
<tr>
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<td>25</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>25</td>
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</table>

3 Dispatching

Plans material output from machines, necessary to complete orders by due-date

'Daily plans' or 'loading schedule'

<table>
<thead>
<tr>
<th>DAILY PLAN</th>
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<tbody>
<tr>
<td>M/C</td>
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<tr>
<td>------</td>
</tr>
<tr>
<td>a</td>
</tr>
<tr>
<td>b</td>
</tr>
<tr>
<td>c</td>
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Levels of production control

---50---
<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
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<th>D</th>
<th>E</th>
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<td>Sales Control</td>
<td>Sales forecast</td>
<td>Sales effort</td>
<td>Sales orders received in given periods</td>
<td>Published sales statistics</td>
<td>To constrain sales to follow the forecast</td>
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<tr>
<td>2</td>
<td>Production Control (progressing)</td>
<td>Production Programme</td>
<td>Batch Frequency Phase and quantity</td>
<td>Parts and products produced in given periods</td>
<td>Progress reports, shortage lists, and orders overdue lists</td>
<td>To constrain production to follow the programme</td>
</tr>
<tr>
<td>3</td>
<td>Purchase Control</td>
<td>Purchase schedules</td>
<td>Source Order quantity Batch quantity</td>
<td>Purchases received in given periods</td>
<td>Goods received notes and purchase records</td>
<td>To obtain purchases when required and at required cost</td>
</tr>
<tr>
<td>4</td>
<td>Quality Control</td>
<td>Acceptance limits</td>
<td>Negligible</td>
<td>Quality achieved</td>
<td>Quality control reports and reject notes</td>
<td>To keep quality within limits</td>
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<tr>
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<td>Cost Control</td>
<td>Standard costs</td>
<td>Negligible</td>
<td>Actual cost</td>
<td>Cost variance reports</td>
<td>To keep costs within required limits</td>
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<td>5b</td>
<td>Budgetary Control</td>
<td>Budgets</td>
<td>Negligible</td>
<td>Expenditure and receipts</td>
<td>Budget variance reports</td>
<td>To keep expenditure and profit within required limits</td>
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<tr>
<td>5c</td>
<td>Cash Control</td>
<td>Cash forecast</td>
<td>Negligible</td>
<td>Liquid capital balance</td>
<td>Variance reports, bank balance, etc.</td>
<td>To maintain required liquidity and limit capital tie-up</td>
</tr>
<tr>
<td>5d</td>
<td>Credit Control</td>
<td>Planned effective credit</td>
<td>Credit terms</td>
<td>Actual effective credit</td>
<td>Credit reports</td>
<td>To maintain that part of the capital arising from credit, within required limits</td>
</tr>
<tr>
<td>5e</td>
<td>Inventory Control</td>
<td>Inventory programme</td>
<td>Negligible</td>
<td>The investment in stock</td>
<td>Inventory reports</td>
<td>To keep the investment within required limits</td>
</tr>
</tbody>
</table>

Some of the conventional controls used in industry
Inventory

Inventory is the physical stock of goods that a business keeps on hand in order to promote the smooth and efficient running of its affairs. It may be held before the production cycle, in the form of raw material inventory; at an intermediate stage in the production cycle, as in-process inventory; or at the end of the production cycle, as finished-goods inventory. A certain amount of inventory is usually necessary, but a business can function with some degree of efficiency over a fairly wide range of inventory levels.

• Control over inventory can be exercised by changing the timing of production runs, by changing the size of the runs, and by changing in promotional effort or sales inducements (marketing activity is either constant or beyond the province of the inventory planner).

Possible advantages associated with increased inventory are the economics of production with large run sizes, faster shipment of orders to customers, stabilized workloads, and profits from speculation in a market where prices are expected to rise. The disadvantage associated with increased inventory is simply that the holding of inventory costs money (e.g. warehouse rent, depreciation and deterioration, interest on invested capital, physical handling and accounting). It is desirable to increase inventory only when the resulting savings (or profits) more than outweigh the cost of the increase.
Inventory Costs

The major costs associated with procuring and holding inventories are as follows:

1. Ordering and set up costs, for placing orders, expediting, inspection, and changing or setting up facilities to produce in house.
2. Carry costs on invested capital, handling, storage, insurance, taxes, obsolescence, spoilage, and data processing.
3. Purchase costs including the price paid, or the labour, material and overhead charges necessary to produce the item.

**Total Cost = Ordering Cost + Carrying Cost + Purchase Cost**

**NB**

D - demand in units on an annual basis
C₀ - cost to prepare or set up an order
Cₑ - cost to carry a unit in stock for a given period
P - purchase cost
Q - lot size
Q/2 - average inventory

Ordering cost = \[ \frac{C₀ \times D}{Q \times \text{yr}} \]

Carrying cost = \[ \frac{Cₑ \times Q}{2 \times \text{unit yr}} \]

Purchase cost = \[ \frac{P \times D}{\text{yr}} \]

Stores

A Store is a place where stock is held. In a stream broken into segments by Stores the flow characteristics can differ from one segment to another.

The principal reason for inserting stores to break up the “flow” of material into segments is:

1. To isolate the supply side of the store from unpredictable variations on the demand side, and vice versa.
2. As a convenient centre for “dividing” or “combining” operations.
3. As a frequency change point, receiving at one batch frequency and issuing at another
4. As a phase change point, receiving multi-phase supplies and re-issuing in single-phase lots of product or assembly sets.
5. To reduce the service time on the final inventory.

Most stores in industry carry out all five of these functions. Take, for example, the typical Finished Part Store in this engineering industry. This isolates assembly from variations in supply; acts as a convenient centre at which supplies of common parts can be “divided” into batches for use on different products, acts as a convenient centre at which batches of different parts can be “combined” into “product-sets” ready for assembly; acts as a
quantities at long intervals can be re-issued to assembly in small batches at frequent intervals, acts as a phase change point, where batches of different items provisioned by multi-phase ordering can be re-issued, in single-phase lots, as balanced product sets, and helps to reduce the time between receiving an order and delivery. There are, however, no universal rules that Stores must be used at certain points in the production flow. Each case must be treated on its own merits. There is tendency in industry to look on Stores as necessary features of production which must always be used at certain traditional places in the organization. In fact, straight through flow is always more efficient than spasmodic flow and Stores are very often monuments to our inefficiency in controlling the flow of materials.

STOREKEEPING

The organization of the stores is dependent on the nature of:

a) The product
b) The material used
c) The way in which the flow of production is organized

Stores can be divided into “direct materials” and “indirect materials.”

Direct material stores are:

1. Raw material store
2. Component store
3. Finished parts store
4. Warehouse

Indirect stores are:

1. Tool store
2. Sundry materials store
3. Maintenance store

There may also be special stores such as inflammable store and chemical store. Stores are sometimes built to suit special materials, such as grain, oil, beer or gas, but the term storekeeping is usually applied to stores in manufacturing industries rather than processing plants. The stores collectively hold a very large portion of the production and materials, which may be worth thousands or millions of pounds. Therefore they should be guarded against unauthorized entry and only storemen allowed behind the counter. The usual method is to serve customers through a hatchway. Many of the items, such as light bulbs, paint, cleaning materials and even nuts and bolts, are a great temptation to the “do-it-yourself” enthusiast and, of course, the final product may be just the thing for the kitchen. Most managers and supervisors are required to account for their scrap and losses and an unguarded store may “lose” items needed to cover these losses. Unfortunately, many stores are regarded as non-productive necessary evils and are tucked away in the odd corners nobody wants.
No goods then should leave the stores without “payment” being made. There are three basic methods of payment:

a) Material requisition:
   a. Single items
   b. Bulk requisition
b) Material feed lists, which are standing orders for parts
c) Deposit checks, where items are loaned, such as tools.

**Direct Materials Stores**

1. Raw materials stores

   a) Bulk – These are of special design to suit the individual industry, such as silos for grain, gasometers, oil storage.
   b) Bulk solid – Separate stores are usually maintained for materials such as sheet metal, pig iron, packing material and cartons, and timber.
   c) Engineering production – The smaller items are kept in bins placed in racks. The racks themselves should be in the use of handling trucks. While a neat layout is all important, an efficient system of locating items is absolutely essential. Where code numbers are used for parts and material, the bins may be arranged in code number order, provided that the coding system collects similar items together under the same numerical group. Where the coding is haphazard the bins may be numbered and a cross reference made with the description or code number.
   d) The bins may also carry a “bin card” which indicates the balance remaining in the bin. This must be amended each time issues are made from, or deliveries made to, the control but as an indication to the storeman, the control records should be kept only by production control.

2. Component store

This type of store carries the piece parts which are:

   a) Manufactured in the factory or
   b) Purchased from outside sources, which may include specials castings, switches and plugs, resistors, capacitors and ball races.

Frequently there is no clear distinction between components and raw material. Some firms will class nuts and bolts as components while to others they will be raw materials. Thus the division may be that all purchased material and items will be “**raw material and components**” and items made within the plant “**finished parts.**”

3. Finished part store

Where the concern is not using automation or transfer machines, finished parts need to be stored in readiness for the assembly or sub-assembly stages. Items are “**paid into**” the stores on paper work which may be an internal delivery note (I.D.N.) and then requisitioned out in the usual way. As stated above, it may be that all items made within the plant are kept in this store.

4. Warehouse

   In this store the finished goods are kept prior to dispatch to customers. The general principles of stores control described below apply here also.
Indirect Stores

1. Tool Store

Items issued by the tool store may be classified into two categories.

a) Returnable tools—Taps and drills, cutters for milling machines, lathe tools, spanners and screwdrivers are included under this heading. These tools are issued in exchange for a metal or plastic tool check bearing the operator’s name or number. The check is held against the return of the tool.

b) Consumable tools—Tools which are consumed by the work such as files, glass paper, emery cloth can be obtained on a requisition as they are non-returnable.

2. Indirect materials store

Indirect materials including cleaning materials, rags, lubricating oil, paint and grease are kept apart from the other goods.

3. Maintenance store

All materials are parts required for routine and preventive maintenance are kept in this store.

Receipts and Issues

Goods may be delivered to or withdrawn from the stores on completion of the necessary paperwork. It is not always desirable or possible for the goods to go physically through the stores, but whether they do or not the paperwork must be in order to maintain accuracy in the records.

Issues may be made on a requisition for items of one type or, if a number of different components are required, a bulk requisition may be used. Materials which are required for a batch or flow production line on a reasonably regular basis may be issued on a “feed list.” This is a pre-printed list bearing the description, code number and quantity required of each item to complete, say, a batch of twenty assemblies, or a day’s work, or some other convenient amount. The amount issued is also noted on the list as some items may be in short supply.

Purchasing

Materials, including the raw material from which the products are manufactured, must be continually fed into the organization in order to ensure smooth and efficient production. Suppliers must be found and prices agreed, and in the larger concerns a separate organization exists to vary out these functions: this is the Purchasing or Buying Department. In small forms the responsibility for buying often rests with the owner or manager. It is obviously an important function as economies made during design, planning, manufacturing and other stages can be completely canceled out if the buying is not performed skillfully.

Policy

Probably the most usual method of purchasing is buying in minimum quantities to replace stock, or buying as current prices and conditions indicate. This is sometimes referred to as “current price buying” or “market conditions buying.” The buyer has a free hand, more or less, to decide the right time to place the order, or to obtain alternative quotations to enable comparisons to be made.

A second policy is “contract buying.” In order to avoid the carrying of large stocks by the user, the supplier undertakes to deliver agreed quantities at intervals over the period specified in the contract. This method of buying guarantees a market for the supplier and regular supplies for the customer, subject of course to modification or cancellation of the contract received by reasonable period of notice.
“Bargain buying” is a policy which should be pursued with utmost caution. Purchases made in bulk at “bargain prices” may result in surplus material should the programme for the product be curtailed or terminated; the buyer should therefore be “in the know” as far as the firm’s future policies are concerned. But demand may fall off, or consumers’ tastes may change, either resulting in programme cuts. Thus the risks involved in pursuance of this policy are great. However, the fruits of “bargain buying” when the gamble comes off are greatly reduced material costs with consequently higher profits.

Procedure

The usual procedure is for the purchasing department to handle all purchasing from outside sources. This usually covers requirements of individuals who may wish to obtain special items for their inspection, research, production or other activities. The only member of the firm who have contact with suppliers are the buyers, and other members of staff order through the central purchasing department usually carries a comprehensive library of catalogues, the where the necessary information is not available the buyer may request the services of supplier’s representative. The forms used and procedures followed are covered later.
Record of an inventory item.
<table>
<thead>
<tr>
<th></th>
<th>Stock control</th>
<th>Component batch scheduling</th>
<th>Period batch control</th>
<th>Standard batch control</th>
<th>Maxmin control</th>
<th>Base stock control</th>
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<tr>
<td>2 Batch quantity</td>
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<td>3 Order interval</td>
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<tr>
<td>5 Order point</td>
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<tr>
<td>6 Period cover</td>
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<td>7 Stock limits</td>
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Ref: Chapter: 21 22 23 24 25 26

Types of ordering system
The plan (different for each part)

The method

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<td>Part</td>
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<tr>
<td>1/4</td>
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</tbody>
</table>

1. All finished items held in controlled store
2. All transactions recorded on receipt or issue notes
3. Notes used to maintain balance of stock record
4. When stock drops to order point issue new order

The stock control ordering system
Levels of Production Control

In production control three main levels of progressive planning have become established and have acquired names. They are known as “programming,” “ordering,” and “dispatching.” Programming plans the production output of products from the factory as a whole, ordering plans the output of components from the suppliers and departments, which is necessary to meet the programme, and dispatching, finally, considers each department in turn, and plans the output from the machine tools and other work centres, necessary to carry out the orders.

The plan made at these three levels is known respectfully as the production programme, the orders or order schedules and the daily plan, or daily order or work. The production programme shows the quantities of products to be produced and the time at which they are to be completed. In the long run the total output shown in the production programme ought to be the same as that shown in the sales programme produced by the marketing function, but in the short run these two programmes can differ widely due to seasonal variations.

The orders show the quantities of components to be produced by suppliers, and by the different production departments in the enterprise, and again show the times at which they are to be delivered. Orders are merely an extension in greater detail of the plans already made in programming, and they must therefore be related in terms of quantity and time to the plans already made and shown in the programme.

The “daily plan” for each production department shows the quantities of components to be produced by each work centre each day. “Daily plans” again are an extension or elaboration of the plans made in ordering, and they must therefore be related in terms of quantity and time to the plans previously made and shown in the orders.
Classes of Process and Related Problems

Inventory Process

This is a process which involves on or both of the following decisions:

a) How many (or much) to order (i.e. produce or purchase)
b) When to order

These decisions involve balancing inventory carrying costs against one or more of the following:

- Order or run setup costs,
- Shortage or delay costs, and
- Costs associated with changing the level of production or purchasing

Some of the tools applicable to these problems are:

- Economic – order- quantity equations, and
- Linear, dynamic and quadratic programming

Allocation Process

This is a process which arises when

a) There are a number of activities to be performed and there are alternative ways of doing them, and
b) Resources or facilities are not available for performing each activity in the most effective way.

The problem, then is to combine activities and resources in such a way as to maximize over-all effectiveness.
The resources and/or the activities may be specified.
If only one is specified the problem is to determine what mixture of the other will yield maximum effectiveness.
The tools which have come to be most closely associated with allocation problems are linear and other types of
mathematical programming.

Waiting-Time Process

This is a process which involves the arrival of units which require service at one or more service units.
Except in very rare cases, waiting is required of either the units requiring service and/or the service units.
Costs are associated with both types of waiting time

- The problem is to control arrivals or to determine the amount or organization of service facilities which
  minimizes the sum of these two types of costs.
  1) Queuing theory is applicable to problems involving determination of the number of service facilities
     required and/or the timing (i.e. scheduling) of arrivals.
  2) Sequencing theory is applicable to problems which involve determining the order in which units avail-
     able for receiving service should be serviced.
  3) Line-balancing theory is applicable to the problems which involve the grouping of work elements of the
     service activity into a sequence of servicing stations.
Replacement Process

This process falls into two classes depending on the life-pattern of the equipment involved:

1) Whether the equipment deteriorates or becomes obsolete (i.e., becomes less efficient) with use or new developments (e.g., machine tools) or
2) Does not deteriorate but is subject to failure or “death” (e.g., light bulbs).

For deteriorating items, the problem consists of timing the replacement so as to minimize the sum of the cost of new equipment, the cost of maintaining efficiency on the old, and/or the cost of loss of efficiency. For items that fail, the problem is one of determining which items to replace (e.g., all but those installed in the last week) and how frequently to replace them in such a way as to minimize the sum of the cost of the equipment involved, the cost of replacing the units, and the cost associated with failure of the unit.

Maintenance problems can be considered a special class of replacement problems since maintenance usually involves the replacement of a component of a facility or resource rather than the whole. Consequently, the same type of approach is applicable to both maintenance and replacement problems.

Competitive Process

A competitive process is one in which the efficiency of a decision by one party is capable of being decreased by the decision of another party (e.g., a “game”). A game is specified by a number of players, rules for play such that all possible permissible actions can be specified, a set of end states (e.g., win, lose, and draw), and the payoffs associated with these end states. The basic set of techniques applicable to this class of problem is known as the theory of games. Another type of competitive situation is one in which bidding takes place. It differs from a game in the following way:

a) The number of competitors is not usually known;
b) The possible “plays” are generally unlimited in number;
c) The payoffs are not known with certainty but can only be estimated; and
d) The outcome of a play (win or lose) can usually only be estimated.

Combined Processes

Real systems seldom involve only one of the processes. For example, a production control problem usually includes some combination of inventory, allocation, and waiting-line processes. Or, a problem of replacement of items that fail usually involves an inventory problem, and a bidding problem may require the allocation of resources among several possible items on which bids can be placed. The usual procedure for handling combined processes consists of “solving” them in sequence.
Perception

A person’s perception of a thing, a fact, or an act may be quite different from the actual and also may be quite different from the perception anyone else has of that thing, fact, or act.

There is a differentiation between perception and actuality. Perceptions are of extreme importance to understanding organizational behavior, for people act on the basis of which they think they see or understand. Perception is, in part, a process which entails being sensitized to and developing certain interpretations of stimuli or facts. Some factors enter our consciousness very quickly and easily, and others, because of their high thresholds, enter only with difficulty, if at all.

One of the basic factors in perception is the ability of people to take a limited number of facts and pieces of information and fit them into a whole picture.

This process of closure plays a central role on perception. The “picture” formed has a considerable degree of internal consistency in that its parts seem to fit together in a way that makes sense.

Cues

In learning about things we not only learn what they are but we also learn what these things mean. Upon receiving a signal we perform an interpretative step by which a meaning is attached to it. Many of these “meanings” are so common and fundamental in our understanding of the world that we fail to note them except under unusual circumstances.

Many of the “meanings” which things have for us come from our culture. These common interpretations of things help enormously in communicating, but they sometimes make it difficult to set factors in perspective so that we can really understand the reasons for behavior.
Thresholds and the Idea of Selectivity

We all have certain things (stimuli) to which we are “sensitized” and when these appear we are instantly alert and eager to examine them. There are other stimuli of relative unimportance to us to which we do not pay as much attention and may, in effect, actually block out. We have thresholds, or barriers which regulate what information from the outside world reaches our consciousness. On some matter the barriers are high and we remain oblivious to them, but on others which are quite important to us we are sensitized and, in effect we lower the barrier, permitting all the information possible concerning these matters to reach our consciousness.

Resonance

Through experience and what we see ourselves to be, the understanding of a particular item of information may be very similar to that of others (people). e.g. if all the employees in a welding department were involved in welding and the work of one were changed, making it difficult for him to do his job, we would probably expect him to be annoyed and upset by this. We might be surprised, however, to find most of the other welders in the department almost as disturbed about the change as the man directly involved. What we would be witnessing is ‘resonance’. Since all the people in the department look upon themselves as welders, they know what the change to the individual welder means in annoyance and inconvenience. They can easily pout themselves into his shoes and, once having done so, probably feel almost as disturbed as he.

Closure: Filling in the Picture

Most of us at one time have seen pictures in which a set of dots or lines are sufficient to see the picture of the shape we take the dots and lines to represent. On the paper the dots and lines are not connected, and yet in our mind’s eye we have no difficulty in linking them to see them represent or portray something. This process of filling in the picture is called “closure”. We do this not only with pictures but also with other types of information which come to us about the world around us. e.g. as someone describes a third party, and gives information about his height, weight, general build, colour, education, personality, and occupation, he is only supplying bits and pieces of information which our minds fit together into a complete picture. Forming this mental image or picture from fragmentary information is not only common but a necessary phenomenon. If we had to wait for all the details before the picture were really clear, life’s activities would be slowed almost to a standstill. At the same time we must recognize that however useful and necessary the process of closure may be, we are still forming an impression or mental image based on limited facts which may differ from the real thing. The more the difference, the less accurate perception becomes and, therefore, the less suitable our behavior may be.

Many things influence closure and the accuracy of perception.
Weighted Effect

Another fact concerning the process of forming the bits of information into an image is that some items of information are more important than others. Sometimes it seems that the things learned first have a controlling influence over the interpretation of information acquired later. This is not the only way in which one element of information can order perception. There are some words, or other cues, having such strong effect that regardless of which, they occur in the sequence of information they mold or order the resultant image. The tendency for one item to influence the total perception is frequently called the “halo effect”.

Persistence of Perception Organization

Once we have formed an impression of a person or a situation the impression is likely to have a surprisingly long life.

Reasons:

1) The threshold or sensitizing tends to help maintain some organization in our perceptions. We readily admit those things we want to see, or that fit our images, and exclude, or play down, those things that do not seem consistent or supportive.
2) The internal consistency tends to help interpret new information in a way meaningful to the impression already formed.

Although a particular organization for perception may have considerable tenacity, this is not to suggest that it is completely unchangeable. Some impressions which people form do seem to exist unchanged for a long period of time; others change fairly rapidly and easily. The ease with which impressions change depends on many factors, some rooted in the personality of the individual, others in the importance of the particular image to him, and still others in the forces at work to bring about the change.

Social Reality

Behind these processes there is the human being’s desire or need to know and understand the world in which he lives, to know the meaning of the information he receives. People are continuously attempting to know what information is important and which it means. Some of this learning comes through experience but a great deal of this learning comes from being told by others what signals mean. Man needs to “understand” the meaning of the signals he receives for a number of reasons.
1) Understanding the real world: we need to know what the real world is like so that we can behave appropriately.
2) Congruency of perceptions and compatible behavior: most of our life and behavior exists in association with other people, which requires behavior to be compatible, that is, integrated or complementary. Since behavior is determined in part by perceptions, this compatible behavior will be influenced by the degree of congruency of perceptions people hold.
3) Interpersonal behavior: often we are more concerned with what a particular signal means in regard to interpersonal behaviour than in regard to what it means about the “real” world. In these situations people are
seeking meaning of signals, not to understand the real world in any absolute sense, but as an element to permit them to live more satisfactorily in a social world.

Consensus

Consensus about the meaning of a signal or piece of information is an important aspect of perception in interpersonal behavior. Developing group consensus is a basic process which permits the individual to achieve closure. Checking to maintain consensus is a group mechanism to sustain perception organization. Both group events have their roots in the basic human need for the individual to understand this world.

Figure-Ground Reversal
To Become a Better Listener

1) Listen attentively
   • It is impossible to listen and talk at the same time
   • Be aware of physical barriers to listening
   • Relax, do not give the impression of wanting to jump right in the talk
   • Create a relaxed, accepting environment
   • Establish good, gentle intermittent eye contact and use appropriate cues to assure the other person; however, do not violate personal space
   • Fight off distraction

2) Listen for the other person’s main ideas
   • Speed of thought over words
   • What is the speaker getting at
   • Do not think too far ahead

3) Be sensitive to your emotional deaf spots (words that make your mind go off on a tangent) – otherwise, you set up your own listen barriers.

4) Take brief notes if necessary
   • Words and phrases rather than complete thoughts

5) Empathize with the other person
   • Your objective is to see the other’s point of view

6) Don’t make hasty judgements
   • The context of words, etc., are important to the evaluation of meaning

7) React to the information, not the person

8) Include the emotion of the other person
   • Vocal and non-verbal cues
   • Use this to interpret the literal meaning to get better understanding

9) Use feedback
   • Check your understanding with what you have heard
   • Summarise what you understand

10) You must be able to select the critical aspects of a message

11) While listening, try not to be/appear critical (either mentally or verbally) of the other’s point of view
    • Put aside emotions (particularly anger)

12) Ask questions to clarify, to permit further expression of the other’s thoughts.

13) Be motivated to listen and display an appropriate attitude.
Safe working conditions contribute to effective motivation by freeing workers from physical danger. Yet safety is an enigma. Employees do not want accidents, but they often form habits or put themselves in situations where accidents are inevitable. Employers know that accidents are expensive, but few recognize the true total cost. We talk about a completely safe design, but there is no such thing. We cannot even agree on the worth of an arm, or a leg, or a life. Individually we would put an infinite value on the lives of our intimates, but how many lives must be endangered before we finally undertake expensive or inconvenient correctional measures? That we cannot afford to assign a lifeguard to each swimmer in a public pool, or erect an automatic warning device at every intersection, crosswalk, and railroad crossing is not a sign of inhumanity; it is a realistic compromise forced on us by a lack of resources.

Concern for safety has never been greater than it is today. Now the problem is to convert this concern into acts that meet our philosophical and ethical objectives within the constraints of practical economics.

The first safety problem is to admit that safety is a problem. Workers must not believe that accidents always happen to someone else. Management must believe that accident prevention is worth the cost. Furthermore,
both workers and managers must remain impressed with their safety responsibilities for successful long term programs. A particularly macabre incident such as a person being crushed, burned, or sliced to death can spur immediate dramatic safety measures, but continuous attention to more mundane accidents builds enduring safety patterns.

When it is accepted that safety effort is emotionally satisfying and economically logical, the next step is to determine why accidents occur. There are two basic causes: unsafe acts by workers and unsafe working conditions. Every accident has overtones of both causes. The reason behind identifying the cause is to categorize the effort that will prevent the accident.

**Unsafe Acts**

Faulty work habits and careless worker behavior are classified as unsafe acts. Automobile drivers engage in unsafe acts when they exceed speed limits, disregard traffic rules, misjudge clearance, or fail to signal their intentions. Such behavioral patterns are learned over a period of time. As accident causes, unsafe acts are harder to detect and more difficult to control than mechanical causes. They also probably account for the most accidents and injuries.

**REASONS WHY ATTENTION TO SAFETY IS IMPORTANT**

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<tr>
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Fault tree analysis of eye injuries caused by particles thrown off during grinding and polishing operations.
**Man – Power Supervision**

**Introduction**

Man is employed in a production system for the work he does. This work is physical, mental or both. It takes effort. There must be reasons for man to expend the effort. His behavior in any situation, work or play, is the result of a complex pattern of cause-and-effect relations. It is a temptation to grab the first apparent cause, usually wages, and proclaim that its effect is work. The extension of this cause-effect formula is that the more you pay the more work you get. Though there is some merit in the “dollars equal doing” equation, it is incomplete. The problem is to find what other elements should be included in the motivation formula.

During the World War I era, the prevailing philosophy was that people worked solely to feed and shelter themselves. The way to get more out of them was to threaten most of the 1950s, the feeling switched to opinions that people worked out of “loyalty” to an organization; therefore the way to increase productivity was to organize company ball teams, pump in soft music, and pile on the fringe benefits. Today we are still searching. Money retains its influence as a motivating factor up to a certain level. Beyond that point, money and fringe benefits do not automatically lead to more productivity. Even the power to fire is a diminishing threat and motivating forces owing to increased worker mobility and skill shortages, perhaps the motivators that in the long run make better workers are psychological – feelings of responsibility and accomplishment.

**Want Strength**

“Man does not live by bread alone” is a threadbare statement because it states so clearly man’s motivational needs. Employees who are paid a reasonable wage, a want no one will deny they have, usually show up for work. How much they do on the job depends a lot on how the job provides for the whole pattern of their wants. Their productivity is influenced by their personal wants such as the approval of those they respect or their vision of success. It takes more than money to motivate them.

A want pattern starts with the basic physiological need for food, water, shelter, exercise, stimulation and other factors of well-being. Less tangible wants, often referred to as psychological needs, are superimposed on the basic pattern. A man may want prestige and not actually need it in a physiological sense; but if he wants it. Man does not always want what will benefit him. His wants may seem completely irrational to an impartial observer, but what he wants is what he believes he needs. And for these wants he will work.

**Resistance to Effort**

In nature a state of rest is the equilibrium position. To change the state takes effort. In a state of rest, man has few of his wants satisfied. To satisfy a want takes effort. The want and the resistance to effort are opposing forces. For work to result, man’s wants must be stronger than his resistance.

Resistance to effort varies with the individual and the situation. If a man is sick, weak, or fatigued, his resistance is increased even when his wants remain strong. Noisy or unsanitary conditions, personality clash, and autocratic supervision contribute to the resistance. Some people are more mindful of particular discouragements than others. One person can ignore distractions while another surrenders to them. Nevertheless, attention to well-established design considerations for human comfort will obviously reduce resistance for the majority.

Further attention to human relations by supervisory personnel can cater to special problems of individuals and minority groups.

**Effective Motivation**

The difference between want strength and the resistance to effort is effective motivation, the driving forces to the exertion of effort on a particular task. If the task is to difficult, individuals will not attempt to satisfy the
want. Thus, more difficult tasks require special incentives, or the tasks must be resigned to allow their accomplishment with less effective motivation. Bonus compensations are an example of the former and machine-assisted operations are an example of the latter.

Most work-for-pay situations are at a disadvantage from the start. In industrial plants the workers exert effort to earn rewards that must be converted later to want satisfaction. Thus, if someone wants a new boat, he seldom builds one; he works at a job that pays enough to buy the boat. A worker on a job that results directly in his own want satisfaction, such as building a boat, will select the most effective methods he can find and will work enthusiastically.

Profit-sharing plans are attempts at creating in employees the feeling of working for oneself. The incentive-pay and bonus schemes are designed for the same purpose. Many managers have concluded that money in routine amounts (such as an annual raise to reflect increased productivity) is largely taken for granted, anticipated before it arrives, and viewed as a justly deserved reward for past services — not as a stimulus to new effort.

Another factor affecting the reward system is the degree of immediacy. It is easier to increase effective motivation if wants are satisfied within a short time. Credit buying is a classic example of attempts to shorten the waiting period for want satisfaction. Some say it is not the employer’s business how workers spend their money; but if workers waste their money and do not get their wants satisfied, job performance will suffer. Employees who have to use their wages to pay off old debts soon lose their motivation to work. Company credit unions and worker counseling help combat this type of problem.

No one has been able to pin down the all-purpose, magic motivator, if indeed it exists, but new approaches are continually being promoted. Current attention is largely devoted to behavioral approaches that attempt to make work more satisfying to the worker. A well-known example is job enrichment, described by its chief sponsor, Professor Herzberg, as an approach that “...seeks to improve both, efficiency and human satisfaction by means of building into people’s jobs, quite specifically, greater scope for personal and more opportunity for individual advancement and growth.” He further states,” The term ‘job enrichment’ is firmly lodged in the vocabulary of managers, behavioral scientists, and journalists...The result has been that job enrichment now represents many approaches intended to increase human satisfaction and performance at work, and the differences between all the approaches are no longer clear.”

N.B.

A few of the management strategies for improving worker motivation are briefly described below:

Job enrichment stresses opportunities for individual growth on the job by giving greater depth (responsibility) to work assignments.

Job enlargement concentrates on giving greater breadth (diversity) to tasks performed by a worker through administrative directives.

Participative management solicits support of employed by seeking their advice for job-related decisions.

Industrial democracy places worker representatives on all decision-making bodies in the organization.

Organizational development attempts to change attitudes and values to improve communication and reduce conflicts.

The above strategies have a behavioral flavor instead of the efficiency or engineering emphasis. An ideal situation satisfies both the mental and physical conditions required for a motivated workforce.

The choice of the motivation strategy and the tactics to employ depends on the particular factors present in the production setting. Job expectations differ according to the nature of the work and the workforce, but safer and more pleasant working conditions are always appreciated. The opportunity to perform a variety of operations may make the work more interesting to some people, and being able to participate in managerial decisions may be valued by others. The success of any approach depends heavily on the capabilities and convictions of managers and supervisors. No approach is a guaranteed trigger for a burst of motivation, and higher motivation does not necessarily translate into production profits. That is what makes human factors intriguing.
A team is a group of individuals who must work interdependently in order to attain their individual and organizational objectives. Organization accomplish their work through a number of different kinds of teams e.g. task forces.

A team differs from other types of groups in certain basic elements.
- Team must have a charter or reason for working together.
- Members must be interdependent – they need each other’s experience, ability and commitment in order to arrive at mutual goal.
- Team must be accountable as a functioning unit within a larger organizational context.

Much management training is concerned only with the dissemination of management concepts and individual skill development. This training does nothing about resolving the real problems of work teams or helping managers who interact on the job to communicate and relate better to one another.

Team building is an organized effort to improve the effectiveness of the team. By experimental learning there is an increase in skills for effective team work. Team building deals with the work performed and an appraisal of the group itself as it functions to do the work. Without a clear agreement of what and how each will contribute written down on paper, commitment to the team project is of little value because no one knows just what any team member has actually agreed to do.

**Team Effectiveness**

This is achieved through
1. Leadership – participative.
   - More important that the particular leadership style is the team leader’s ability to combine individual efforts into group output, provide the necessary liaison between the team and the total organization and accomplish this in a manner consistent with the values of team leader and other members.

2. Group Dynamics
   - The very nature of teamwork depends on the effectiveness of the interaction among team members. Concepts of contact, role, values and inter-dependence are elements of effective team interaction.
     a) Contact – relationships relaxed but not necessarily warm. “You are free to be who you are, and I am free not to like you as long as this does not detract from team effectiveness:
     b) Role – specific task of each member and interaction necessary to get the task completed. Each member’s unique contribution to achievement of clear objectives agreed on, is recognized.
     c) Values – All decisions are based on values
       - High value placed on task effectiveness
       - Focus on objectives rather than ongoing activities
       - Emphasis on doing the right things.
       - Dealing in the present i.e. effective teams focus on “right her right now”. Teams can make more appropriate decisions when it is concentrating on what is happening than why it is happening.
     d) Interdependence – individuals must combine their separate efforts in order to produce an organization result.

Focus effort is on combining rather than coordinating resources. Enable the approach to objectives from a position of strength and creativity.
Team Concepts

- Performance must be continually critiqued.
- Team cannot rest on past accomplishments
- Team must constantly strive for greater teamness
- Must be willing to engage in introspection and feedback
- Leader must be democratic, sharing leadership and decision making
- Sharing, caring, risk-taking and experimentation are paramount
- Openness, spontaneity, mutuality are important
- Team members must be committed
- Team building is not a one-shot affair, but a long term investment needing follow-up
- Team focuses on work improvement rather than improvement in interpersonal competence
- Team cannot overcome problem that relate to the larger system e.g. poor top leadership
- There is need for a facilitator who acts as catalyst, standard setter, challenger, issue raiser, processor, etc.
  Facilitator’s effectiveness comes when the group no longer needs facilitator.

Styles of Supervision and Leadership

There are different leadership styles: supervisors approach their work and the people who work for them in different ways.

a) **Authoritarian** supervisors, who tell their staff what to do and expect them to get on with it, no questions asked;
b) **Democratic** supervisors, who are more willing to discuss work plans and problems with their staff, and give their staff the feeling that they are joining in the decision-making process;
c) **Laissez-faire** supervisors, who simply leave their staff to get on with their work.

Another way of analyzing styles of supervision and leadership is into the following four categories:

a) **The ‘tells’ kind**: decisions are made by the manager or supervisor and then announced to subordinates, to be carried out without question;
b) **The ‘sells’ kind**: the manager persuades subordinates to accept decisions by explaining how they were made;
c) **The ‘consult’ kind**: managerial decisions are deferred until the problem has been presented to the group and their suggestions have been received;
d) **The ‘joins’ kind**: the manager delegates to the group the right to make decisions. He defines the problem and the limits within which action can take place, but the actual decision will normally reflect the majority opinion of the group

The findings of employee attitude surveys suggest the ‘consultative’ style is preferred to the others by subordinates, but the most effective style of leadership in a particular situation will depend on the circumstances of the situation.
Basic Control Cycle

- Goal Setter
- Decision Maker
- Discriminator
- Sensor
- Corrective Action
- Activity

1. Set Standards
2. Standard
3. Gather data on performance
4. Compare performance data with standards
5. Corrective Action
6. Work
Progression of goals or standards and control loops.
Simplified schematic of control loops within loops.