CHAPTER 7

FACILITY LAYOUT

Introduction

Layout refers to the configuration of departments, work centers, and equipment, with particular emphasis on improvement of work (customers or materials) through the system. Layout decisions are important for three basic reasons: (1) they require substantial investments of money and effort. (2) They involve long-term commitments, which make mistakes difficult to overcome and (3) they have a significant impact on the cost and efficiency of short-term operations. This chapter describes the main types of layout designs and the models used to evaluate design alternatives.

The Need for Layout Decisions

The need for layout planning arises both in the process of designing new facilities and in redesigning existing facilities. The most common reasons for redesign of layouts include;

1. Inefficient operations (e.g., high cost, bottlenecks)
2. Accidents or safety hazards
3. Changes in the design of products or services
4. Introduction of new products or services
5. Changes in the volume of output or mix of outputs.
6. Changes in methods or equipment.
7. Changes in environmental or other legal requirements.
8. Morale problem (e.g., lack of face-to-face contact)

7.1. Layout Types

The three basic types of layouts are product, process, and fixed-position. Product layouts are most conducive to repetitive processing, process layouts are used for intermittent processing, and fixed-position layouts are used when projects require layouts. We will study the characteristics, advantages, and disadvantages of each layout type in this section. We'll also take a look at hybrid layouts, which are combinations of these pure types.

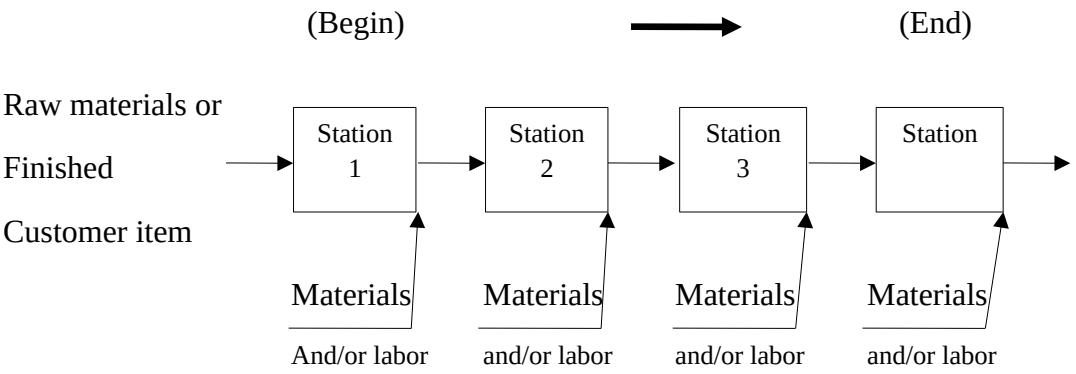
Product Layouts

Product layouts are used to achieve a smooth and rapid flow of large volumes of goods or customers through a system. This is made possible by highly standardized goods or services that require highly standardized (repetitive) processing operations. The work is divided into a series of standardized tasks, permitting specialization of both labor and equipment.

The large volumes handled by these systems usually make it economical to invest substantial sums of money in equipment and job design. Because only one or a few very similar items are involved, it is feasible to arrange an entire layout to correspond to the technological processing requirements of the product or service. For instance, if a portion of a manufacturing operation required the sequence of cutting, sanding, and painting, the appropriate pieces of equipment would be arranged in that same sequence. And because each item follows the same sequence of operations, it is often possible to utilize fixed-path material-handling equipment such as conveyors to transport items between operations. The resulting arrangement forms a line like the one depicted in Figure 7-1.

Figure 7-1

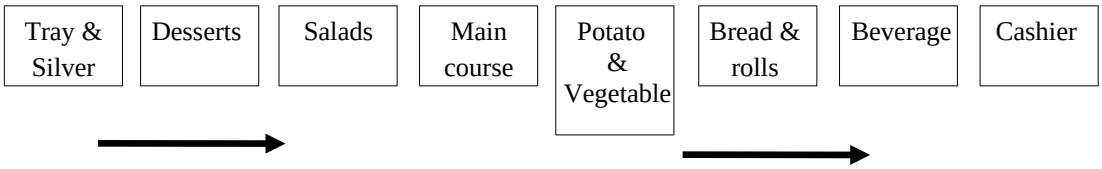
A flow line for production service



In manufacturing environments, the lines are referred to as production lines or assembly lines, depending on the type of activity involved. In service processes, the term lines may or may not be used. It is common to refer to a cafeteria line as such but not a car wash, although from a conceptual standpoint the two are nearly identical. Figure 7-2 illustrates the layout of a typical cafeteria serving line.

Figure 7-2

Cafeteria line



Examples of this type of layout are less plentiful in service environments because processing requirements usually exhibit too much variability to make standardization feasible. Without high standardization, many of the benefits of repetitive processing are lost. When lines are used, certain compromises may be made. For instance, an automatic car wash provides equal treatment to all cars-the same amount of soap, water, and scrubbing-even though cars may differ considerable in cleaning needs. As a result, very dirty cars may not come out completely clean, and relatively clean cars go though the same system with considerable waste of soap, and energy.

Product layouts achieve a high degree of labor and equipment utilization which tends to offset their equipment costs. Because items move quickly from operation to operation, the amount of work-in-process is often minimal. Consequently, operations are so closely tied to each other that the entire system is highly vulnerable to being shut down because of mechanical failure or high absenteeism. Maintenance procedures are greater to this. Preventive maintenance-periodic inspection and replacement of worn parts or those with high failure rate-reduces the probability of breakdowns during the operations. Of course, no amount of preventive activity can completely eliminate failures, so management must take measures to provide quick repair. These include maintaining an inventory of spare part and having personnel available to quickly restore equipment to normal operation. These procedures are fairly expensive; because of the specialized nature of equipment, problems become more difficult to diagnose and resolve, and spare-part inventories cab be extensive.

The main advantages of product layouts are:

1. A high rate of output
2. Low unit cost due to high volume; the high cost specialized equipment is spread over many units.

3. Labor specialization reduces training costs and time, and results in a wide span of supervision.
4. Low material-handling cost per unit; material handling is simplified because units follow the same sequence of operations.
5. A high utilization labor and equipment.
6. Routing and scheduling are established in the initial design of the system; they do not require much attention once the system is operating.
7. Accounting, purchasing, and inventory control rate fairly routine.

The primary disadvantages of products include;

1. The intensive division of labor usually creates dull, repetitive jobs that provide little opportunity of advancement and may lead to morale problems, and to repetitive stress injuries.
2. Poorly skilled workers may exhibit little interest in maintaining equipment or in the quality of output.
3. The system is fairly inflexible in response to changes in the volume of output or changes in product or process design.
4. The system is highly susceptible to shutdowns caused by equipment breakdowns or excessive absenteeism.
5. Preventive maintenance, the capacity for quick repairs, and spare parts inventories are necessary expenses.
6. Incentive plans tied to individual output are impractical since they would cause variations among outputs of individual workers, which would adversely affect the smooth flow of work through the system.

U-Shaped Layouts: Although a straight production line may have intuitive appeal, a U-shaped line has a number of advantages that make it worthy of consideration. One of disadvantages of a long, straight line is that it interferes with cross travel of workers and vehicles. A U-shaped line is more compact; it often requires approximately half the length of a straight production line. In addition, a U-shaped line permits increased communication among workers on the line because workers are clustered, thus facilitating teamwork. Flexibility in work assignments is increased because workers can handle not only adjacent stations but also stations on opposite sides of the

line. Moreover, if materials enter the plant at the same point that finished products leave it, a U-shaped line minimizes material handling.

Of course, not all situations lend themselves to U-shaped layouts; on highly automated lines there is less need for teamwork and communication. And entry and exit points may be on opposite sides of the building. Also, operations may need to be separated because of noise or contamination factors.

Process Layouts

Process layouts are designed to process items or provide services that involve a variety of processing requirements. The layouts feature departments or other functional groupings in which similar kinds of activities are performed. A manufacturing example of a process layout is the machine shop, which has separate departments for milling, grinding, drilling, and so on. Items that require those operations are frequently moved in lots to the departments in a sequence dictated by technical considerations. Different products may present quite different processing requirements and sequences of operations. Consequently, variable-path material-handling equipment (forklift trucks, jeeps, and tote boxes) is needed to handle the flexible necessary to handle a wide range of processing requirements. Workers who operate the equipment are usually skilled or semiskilled.

Process layout are quite common in service environments. Examples include hospitals, colleges and universities, banks, auto repair shops, airlines, and public libraries. For instance, hospitals have departments or other units the specifically handle surgery, maternity, pediatrics, psychiatric, emergency, and geriatric care. And universities have separate schools or departments that concentrate on one area of study as business, engineering, science, or math.

Because equipment in a process layout is arranged by type rather than by processing sequence, the system is much less vulnerable to shutdown caused by mechanical failure of absenteeism. In manufacturing systems especially, idle equipment is usually available to replace machines that are temporarily out of service. Moreover, because items are often processed in lots, there is considerably less interdependence between successive operations than with a product layout. Maintenance costs tend to be lower because the equipment is less specialized than that of product layouts, and the grouping of machinery permits repair personnel to become skilled in handling

that type of equipment. Machine similarity reduces the necessary investment in space parts. On the negative side, routing and scheduling must be done on a continual basis to accommodate the variety of processing demands typically imposed on these systems. Material handling is inefficient, and unit handling costs are generally much higher than in product layouts. In process inventories can be substantial due to batch processing. Furthermore, it is uncommon for such systems to have equipment utilization rates under 50 percent because of routing and scheduling complexities related to the variety of processing demand being handled.

In sum, process layouts have both advantages and disadvantages. The advantages of process layouts include:

1. Systems can handle a variety of processing requirements
2. Systems are not particularly vulnerable to equipment failures.
3. General-purpose equipment is often less costly than the specialized equipment used in product layouts and is easier and less costly to maintain
4. It is possible to used individual incentive systems.

The disadvantage of process layouts include:

1. In-process inventory costs can be high if batch processing is used in manufacturing systems.
2. Routing and scheduling pose continual challenges.
3. Equipment utilization rates are low
4. Material handling is slow and inefficient, and more costly per unit than in product layouts.
5. Job complexities often reduce the span of supervision and result in higher supervisory costs than with product layouts.
6. Special attention necessary for each product or customer (e,g., routing, scheduling, machine setups) and low volumes result in higher unit costs than with product layouts.
7. Accounting, inventory control, and purchasing are much more involved than with product layouts.

Fixed-position Layouts

In fixed-position layouts, the item being worked on remains stationary, and workers, materials, and equipment are moved about as needed. This is in marked contrast to product and process layouts. Almost always, the nature of the product dictates this kind of arrangement: weight, size, bulk, or some other factor makes it undesirable or extremely difficult to move the product. Fixed-position layouts are used in large construction projects (buildings, power plants, and dams), shipbuilding, and production of large aircraft and space mission rockets. In those instances, attention is focused on timing of material and equipment deliveries so as not to clog up the work site and to avoid having to relocate material and equipment around the work site. Lack of storage space can present significant problems. For example, at construction sites in crowded urban locations. Because of the many diverse activities carried out on large projects and because of the wide range of skills required, special efforts are needed to coordinate the activities, and the span of control can be quite narrow. For reasons, the administrative burden is often much higher than it would be under either of the other layout types. Material handling may or not be a factor; in many cases, there is no tangible product involved (e,g, designing a computerized inventory system). When goods and material are involved, material handling often resembles process-type, variable-path, general purpose equipment. Projects might require use of earth-moving equipment and trucks to haul materials to, from, and around the work site, for example.

Fixed-position layouts are widely used for farming, firefighting, road building, home building, remodeling and repair, and drilling dot oil. In each case, compelling reasons bring workers, materials, and equipment to the “product’s” location instead of the other way around.

Combination Layouts

The three basic layout types are ideal models, which may be altered to satisfy the needs of a particular situation. It is not hard to find layouts that represent some combination of these pure types. For instance, supermarket layouts are essentially process layouts, and yet we find most use fixed-path material-handling devices such as roller-type conveyors both in the stockroom, and belt-type conveyors at the cash registers. Hospitals also use the basic process arrangement, although frequently patient care involves more of a fixed-position approach, in which nurses, doctors, medicines, and special equipment are brought to the patient. By the same token, faulty

parts made in a product layout may require off-line reworking, which involves customized processing. Moreover, conveyors are frequently observed in both farming and construction activities.

Process layouts and product layouts represent two ends of a continuum from small batches to continuous production. Process layouts are conducive to the production of a wider range of products or services than products are often in demand. However, process layouts tend to be less efficient and have higher unit production costs than product layouts. Some manufacturers are moving away from process layouts in an effort to capture some of the benefits of product layouts. Ideally, a system is flexible and yet efficient, with low unit production costs. Cellular manufacturing, group technology, and flexible manufacturing systems represent efforts to move toward this ideal.667.

Table 7.1

Product and process layouts compared

	Product Layout	**Process Layout**
Description	A sequence arrangement of personnel &/or equipment designed to provide standardized processing.	A functional arrangement of personnel &/or equipment designed to handle a variety of processing requirements.
Focus of layout	Balance operation to avoid bottlenecks, and attain a smooth flow of work.	Arrange equipment or departments to minimize transportation costs and/or congestion.
Processing examples of; goods services	Repetitive or continuous, automobiles, video tapes, car wash, cafeteria line.	Job shop or batch, furniture, baked goods, auto repair, health care.
Product or service variety	Low	Moderate to high
Typical processing worker skill levels	Low, semiskilled	Semiskilled to highly skilled.
Flexibility	Very low	Moderate to High

Volume	High	Low to moderate
Work-in-process inventory levels	Low	High
Material handling	Fixed path(e.g., conveyors)	Variable path(e.g., forklifts)
Primary approach to equipment maintenance	Preventive	As needed
Benefits	Low cost per unit, high productivity	Can handle a variety of processing requirements

7.2. Cellular layouts

Cellular manufacturing

Cellular manufacturing is a type of layout in which machines are grouped into what is referred to as a cell. Groupings are determined by the operations needed to perform work for a set of similar items or part families that require similar processing. The cells become, in effect, miniature version of product layouts. The cells may have no conveyor zed movement of between machines, or may have a flow line connected by a conveyor (automatic transfer).

In the cellular layout, machines are arranged to handle all of the operations necessary for a group (family) of similar parts. Thus, all parts follow the same route although minor variations (e.g., skipping an operation) are possible. In contrast, the functional layout involves multiple paths for parts.

There are numerous benefits of cellular manufacturing. These relate to the grouping of equipment and include faster processing time, less material handling, less work-in processing inventory, and reduced setup time.

Group Technology

Effective cellular manufacturing must have groups of identified items with similar processing characteristics. The grouping process is known as group technology and involves identifying items with similarities in either design characteristics, and grouping them into part families. Design characteristics include size, shape, and function; manufacturing or processing

characteristics involve the type and sequence of operation required. In many cases, design and processing characteristics are correlated, although this is not always the case.

Conversion to cellular manufacturing can involve costly realignment of equipment. Consequently, a manager must weigh the benefits of a switch from a process layout to a cellular one against the cost of moving equipment as well as the cost and time needed for grouping parts.

7.3. Other service layouts

In addition to the layout already described, there are other layouts found in service environment, such as warehouse, retail and office layouts.

Warehouse and storage layouts

The design of storage facilities presents a different set of factors than the design of factory layouts. Frequency of order is an important consideration; items that are ordered frequency should be placed near the entrance of the facility. Any correlations between items are also significant (i.e. item A is usually ordered with item B), suggesting that placing those two items close together would reduce the cost and time of picking (retrieving) those items. Other considerations include the number and widths of aisles, the height of storage racks, rail and/or truck loading and unloading, and the need to periodically make a physical count of stored items.

Retail layouts

The objectives that guide design of manufacturing layouts often pertain to cost minimization and product flow. However, with retail layouts such as department stores, supermarkets and specialty store, designers must take into account the presence of customer, and the opportunity to influence sales volume and customer attitudes through carefully designed layouts traffic pattern and traffic flow are important factors to consider.

Office layouts

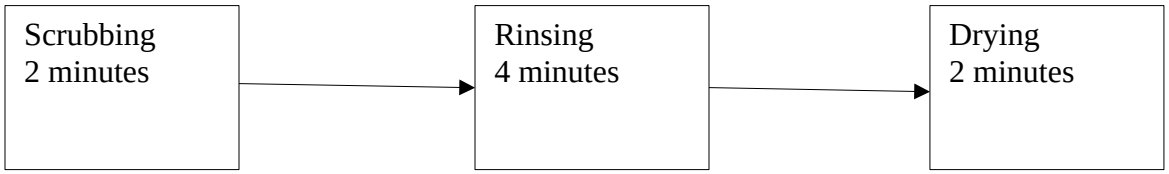
Office layouts are undergoing transformation as the flow of paperwork is replaced with the increasing use of electronic communication. That means there is less need to place office

workers in layout that optimize the transfer or information or paper work. Another trend is to project an image of openness, and office walls are giving way to low-rise partitions and glass walls.

7.4. Designing product layouts: Line Balancing

The processing of deciding how to assign tasks to workstation is referred to as line balancing. The goal of line balancing is to obtain task grouping that represent approximately equal time requirements. This minimizes the idle time along the line and results in a high utilization of labor and equipment. Idle time occurs if task times are not equal among workstations; some stations are capable of producing at higher rates than others. These “fast” stations will experience periodic waits for the outputs from slower stations or else be forced into idleness to avoid buildups of work between stations. Unbalanced line are undesirable in terms of inefficient utilization of labor and equipment and because they may create morale problems at the slower stations for workers who must work continuously.

Lines that are perfectly balanced will have a smooth flow of work as activities along the line are synchronized to achieve maximize utilization of labor and equipment. The major obstacle to attaining a perfectly balanced line is the difficulty of forming tasks bundles that have the same duration. One cause of this that it may not be feasible to combine certain activities into the same bundles, either because of differences in equipment equipments or because the activities are not compatible (e.g. risk of contamination of paint from sanding). Another cause of difficulty is that differences among elemental task lengths cannot always be overcome by grouping tasks. A third cause of an inability to perfectly balance a line is that a required technological sequence may prohibit otherwise desirable tasks combinations. Consider a series of three operations that have duration of two minutes, four minutes, and two minutes, as shown in the following diagram. Ideally, the first and third operations could be combined at one workstation and have a total time equal to that of the second operation. However, it may not be possible to combine the first and third operations. In the case of an automatic car wash, scrubbing and drying operations could not realistically be combined at the same workstation due to the need to risen cars between the two operations.



Line balancing involves assigning tasks to work stations. Usually, each workstation has one worker who handles all of the tasks at that station, although an option is to have several workers at a single workstation.