DARDEN BUSINESS PUBLISHING
UNIVERSITY of VIRGINIA

UV3495

BUSINESS PROCESSES & OPERATIONS

This note serves as an introduction to processes in business. It provides a background of terminology and measurements of processes and an example of using these tools to analyze a process. Effective business managers must be able to understand processes and make knowledgeable decisions on how to improve operations.

Importance of Operations Processes

Every business has a set of processes whose goal is to add value for customers. An organization's success is frequently determined by how effectively operations can satisfy customers' expectations. Operations fulfillment is often a critical part of realizing an organization's strategy.

There are countless examples of businesses that depend upon their operational excellence for success. For instance, Wal-Mart's strategy is to be the low-cost retailer of general merchandise. Wal-Mart is the undisputable market leader because its operations processes are the best in supply-chain management, and its efficiency allows significant cost savings through best-practice distribution and inventory. Therefore, discount-store customers choose Wal-Mart because it offers the lowest prices with reasonable service. Alternatively, Ritz-Carlton hotels' strategy focuses on providing the highest personal service at a premium price. Their customers expect extraordinary service in return for the high rates of their hotel. Therefore, the operations at each hotel must ensure that every staff member provides superior service to their guests.

Process Fundamentals

A process is any operation that accepts input and transforms it in some manner that results in value-added output. Traditionally, processes are referenced in regard to product manufacturing. All business, however, whether they be product-based or service-based, involve processes. A clothing manufacturer accepts raw materials as input like material, zippers, buttons, and thread. The process of creating the clothing consists of labor, sewing machines, and energy working together to create a garment. The Darden School also consists of processes. The

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This note was prepared by John Faulk and Robert D. Landel as the basis for class discussion rather than to illustrate effective or ineffective handling of an administrative situation. Rev. 3/04.

First Year Program is a process in which students are the inputs that through instruction and casework are transformed into business managers. Restaurants are an example of organizations having both product- and service-based processes. They not only need to seat patrons and provide superior service but also to prepare delicious meals. When a restaurant has poor service processes, patrons may have to wait to be seated and served. When a restaurant has poor product processes, patrons may be unhappy with the quality of their food. Successful restaurants achieve high levels of both food and service.

Given the critical nature of operational processes in business, managers must have an effective method to analyze and improve them. Process maps (also known as process flow diagrams) provide a means to display complex processes. A process map displays the activities, material flow, and any raw materials (RM), work-in-process (WIP) and finished goods (FG) inventories in the process. Activities are displayed as rectangles, flows as arrows, and inventory as triangles (sometimes inverted). For instance, **Figure 1** displays a simplified process map for a catering operation preparing hamburgers.

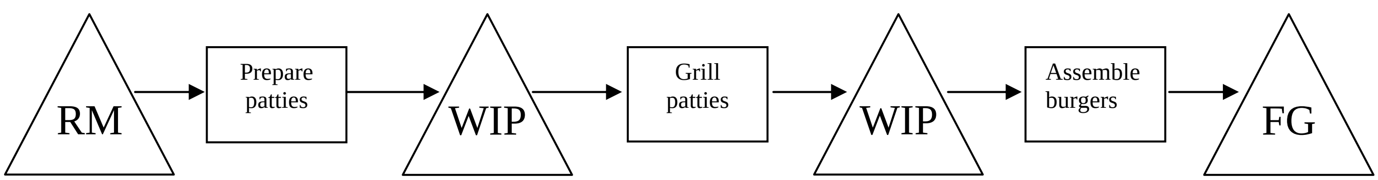


Figure 1: Hamburger Catering Process Map

The raw materials, which consist of ground beef, hamburger buns, lettuce, tomato, etc., enter the process and are stored until needed. The ground beef enters the "Prepare patties" activity where it is shaped into round patties and enters the WIP inventory where the patties wait to enter the grill. Next, the patties are cooked in batches of 20 on the grill, after which they are assembled into hamburgers using other raw materials supplies. An example later in this note will delve further into process analysis.

Process Terminology and Effectiveness

Managers use a number of methods and terms to measure process performance. This is integral so that organizations can understand if they are effectively delivering their product or service. In addition, when processes need improvement, measurements can help determine where such improvement is needed and how successful the modifications are.

An effective process is perfectly aligned with the strategic focus of the business. A company with a low-cost strategy must provide lean, efficient processes. Conversely, a company with a value-added strategy may require activities that necessitate professional-level employees who are paid premium area-wide wages. In other words, more efficient is not necessarily more effective. The Operations Frontier shown in **Figure 2** illustrates the idea of the trade-off between cost efficiency and product/services value added. The frontier curve on the chart reflects the best demonstrated practice. Firms along this curve are achieving superior operational effectiveness. If we return to our initial examples of Wal-Mart and Ritz-Carlton, we would expect Wal-Mart to fall near the x-axis along the frontier curve, signifying best-practice cost efficiency and less valueadded. Ritz-Carlton, on the other hand, would fall near the y-axis along the frontier curve, signifying high value-added with the trade-off of minimal cost efficiency.

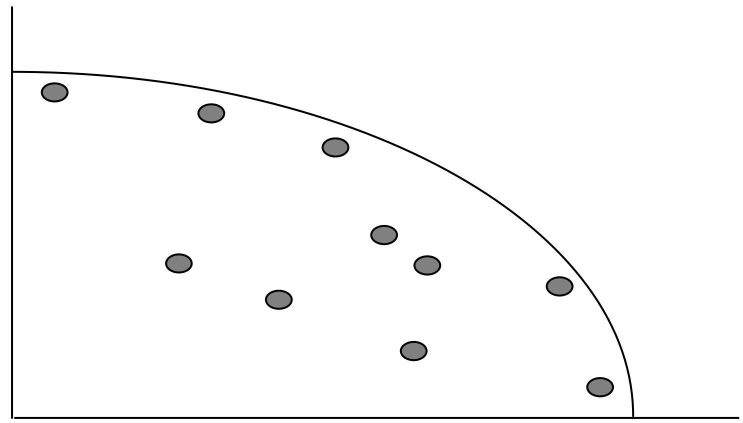


Figure 2: Operations Frontier Curve

Throughput rate

Throughput rate measures the rate of output for a given process. It can also be a measure applied to an individual activity in a process. It is expressed in terms of units of output per time period, such as pounds per week, units per hour, or customers per day. For instance, in our hamburger-catering process, the throughput rate would be measured in number of hamburgers per hour. The maximum throughput rate for an entire process is determined by the smallest throughput rate activity in the process.

Cycle time

Cycle time refers to the average time between the completions of consecutive units. The reason cycle time refers to an average time is that processes often work in batches. For our hamburger example, let's suppose that the caterer prepares the hamburgers at a capacity of 120 hamburgers per hour. This would imply that, *on average*, the cycle time of the catering hamburger operation is 1/120th of an hour or 30 seconds. Of course, it is clear that the caterer does not complete a hamburger every 30 seconds but instead may complete 40 hamburgers every 20 minutes. You will notice that the *minimum* cycle time refers to the inverse of the *maximum* throughput rate. In reality, processes seldom operate at maximum throughput rate (sometimes called "full capacity"). Therefore, the cycle time may vary according to a scheduled production plan.

Throughput time

Throughput time (also known as lead-time or manufacturing lead-time) corresponds to the amount of time needed to flow throughout the entire process. When there is a WIP inventory in a process, the throughput time will be affected.. Long throughput times can be costly in industries where product can become obsolete or out of style, as in the technology or fashion industries.

Batch size

The batch size refers to the number of units that flow through the process together during production. This size is determined by an operations planner; it is sometimes constrained by the size of the equipment in the activity. For example, in our hamburger-catering process, the number of burgers we can prepare at once will be limited by our grill size. If we can only fit 20 burgers on our grill, we will work in batches of no more than 20.

Set-up time versus run time

Set-up time refers to the fixed time necessary to prepare an activity for receiving and starting the work content of the activity. This typically comes into play when a machine is used to produce several different products. For instance, in an auto-painting process, it may be necessary to change the color of paint being used in the painting machines. The time needed to do this would be set-up time. Another example would be the time needed to preheat an oven before baking cookies. Alternatively, run time refers to the amount of time necessary to process a unit or a batch of units through the activity. Run time would correspond to the time needed to paint the automobile or bake a tray of cookies.

Bottleneck

As the term implies, the bottleneck in a process is the activity in the process that limits flow through the process. The reason for a bottleneck could be constraints on labor, machinery, raw materials, or market demand. Because the bottleneck is the limiting factor in a process, management must clearly identify and understand it in order to improve throughput rate performance.

Utilization

Utilization refers to the ratio of how much of a resource is used versus how much is available. Therefore, utilization is often measured with respect to labor, capacity, machinery, materials, etc. Low utilization can result from inefficiencies, such as machinery breakdowns or understaffed processes.

Little's Law

Little's Law demonstrates the relationship in a process between inventory, throughput rate, and throughput time. The relationship holds that for average values:

Inventory = Throughput Rate x Throughput Time

Little's Law is important because it shows the impact that average throughput rate and throughput time have on the average inventory of a process. For instance, it is clear that decreasing the average throughput time for a unit flowing through a process will decrease the average inventory within the process. Alternatively, decreasing throughput rate will also decrease the inventory in a process; however decreasing throughput rate is a poor choice when demand exceeds supply.

An Example of Process Analysis

We can illustrate each of these process analysis ideas best through an example. The process shown below in **Figure 3** shows the previous example of the catered hamburger operation but with process times for each given activity in the process.

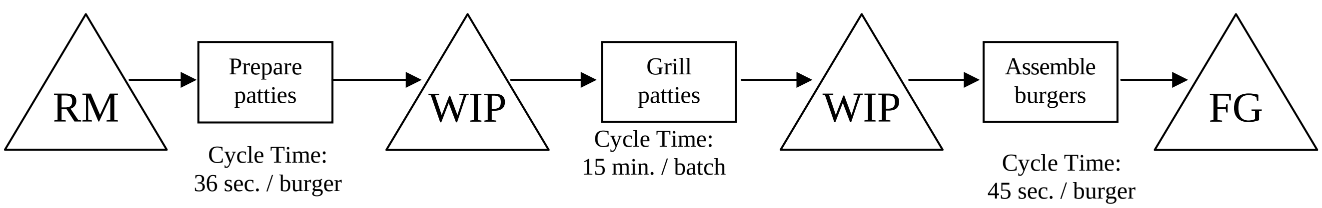


Figure 3: Catered Hamburger Operation

For this process, make the following assumptions:

- Patty preparation and burger assembly are performed on an individual basis (i.e., not in batches).
- The grill has a set-up time of 5 minutes for cleaning between batches and a run time of 15 minutes for a batch of 20 patties. Hamburgers are grilled in batches of 20 patties at a time, because that is the maximum that the grill can accommodate at once, and the caterer wants to fully utilize the grill.

We want to determine the following:

- What is the maximum throughput rate (capacity) of each activity in isolation?
- What is the bottleneck of the process?

- What is the average throughput rate (capacity) of the total process?
- What is the cycle time of the total process?
- What is the average throughput time of the process?
- What could be done to improve capacity in this process?

As previously mentioned, the cycle time is the inverse of an activity's throughput rate. Therefore, we can find the throughput rate capacity of each activity by inverting the given cycle times, as shown in **Table 1**.

Task	*Cycle Time*	*Throughput Rate*
Prepare patties	36 sec. / burger	100 burgers / hour
Grill 20 patties in batch	5 min. set up + 15 min. grill = 20 min.	60 burgers / hour (3 batches/hr)
Assemble burgers	45 sec. / burger	80 burgers / hour

Table 1: Capacity of each activity in isolation

In addition, we know that the bottleneck in a given process is driven by the activity within a process with the smallest capacity. In this instance, it is clear that grilling the patties is the bottleneck in this process.

The capacity or maximum throughput rate of the entire process, as we know, is driven by the capacity of the bottleneck activity. Once the bottleneck is identified, the process capacity is known. The capacity of the bottleneck in this process is 60 burgers per hour. Therefore, this is the capacity of our process and the rate at which all of our processes will effectively operate. It makes no sense to prepare patties constantly at a rate of 100 burgers per hour when they can only be grilled at a rate of 60 burgers per hour! Doing so would result in an unnecessary buildup of WIP.

The cycle-time of the process can be found once we know the capacity. The cycle-time is the average amount of time between the completions of successive units. Given that the capacity is 60 hamburgers per hour, the cycle-time is expressed as one minute. Again, this does not imply that a hamburger is necessarily completed every minute, but that, on average, a hamburger is completed every minute.

The throughput time of our process can also be determined. Remember, throughput time is the amount of time it takes for a given input to flow through the entire process. Knowing the capacity and batch sizes for each task, we can determine the respective throughput times.

Table 2: Throughput times for each activity

Task	*Capacity*	*Batch Size*	*Throughput Time*
Prepare patties	100 burgers / hour	1 burger	36 seconds
Grill patties	60 burgers / hour	20 burgers	20 minutes
Assemble burgers	80 burgers / hour	1 burger	45 seconds

Table 2 shows the throughput times for each activity. Transforming these into the throughput time for the entire process can be deceiving. Throughput time is not necessarily the result of the sum these times. The WIP must be taken into account. **Figure 4** shows the times spent on each activity task per burger. The important factor to recognize is that the WIP is dependent upon the capacity of the upstream tasks. **Figure 4** shows the throughput times for each activity and the average of WIP data that have been observed over time.

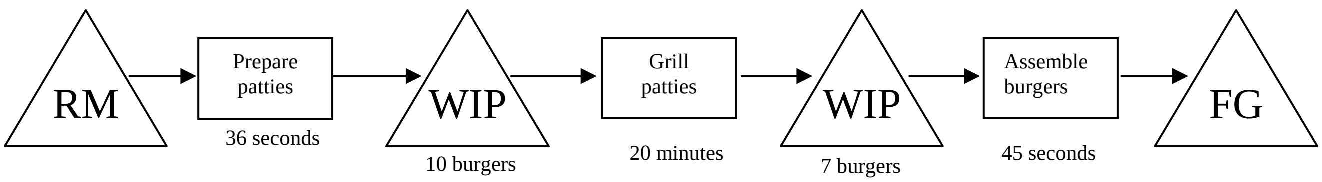


Figure 4: Throughput Times in the Process

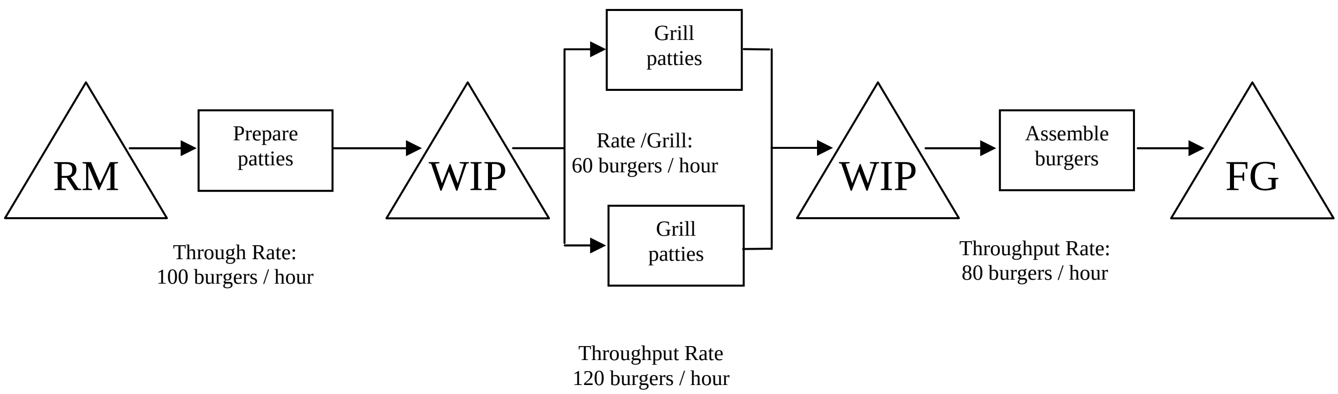
Little's Law states that the inventory within a process is equal to the throughput time multiplied by the throughput rate. We know our total inventory in the system, on average, is 39 burgers (1 in prepare patties, 20 in grill patties, 1 in assemble burgers, and 17 in WIP). Therefore, we can find our throughput time for a burger to leave raw materials to arrive at finished goods through the following calculation:

$$ThroughputTime = \frac{Inventory}{ThroughputRate} = \frac{39\,burgers}{60\,burgers/hour} = 0.65\,hours$$

Therefore, on average, the throughput time for this process is 0.65 hours or 29 minutes.

Finally, how can we improve this process capacity? Given that the bottleneck of a process determines overall maximum capacity, it is clear that improving a bottleneck activity capacity will improve overall process capacity. The bottleneck in our example is the grilling activity, which limits production to 60 burgers per hour. Since the burgers have to be cooked for a given amount of time, one way to increase capacity is to add another grill to the system. One could do this by replacing the current grill with a larger one or adding another grill in parallel, as shown in **Figure 5**. By adding another grill with a capacity of 60 burgers per hour in parallel to the current grill, this task has an effective capacity of 120 burgers per hour. When this is done, the bottleneck shifts from the grilling activity, which now has a capacity of 120 burgers per hour, to the assemble-burgers activity, which has a capacity of 80 burgers per hour. It is important to recognize that adding capacity to a bottleneck constraint only improves process capacity to a point at which the activity is no longer the bottleneck.

Figure 5: Hamburger-Catering Process with Added Grill



This example gives you an overview of how to measures processes. All processes are different, and this is just one example of analysis. The important thing to remember when analyzing processes is the need to:

- Draw a process map to fully understand the flow of materials.
- Analyze each task in isolation to determine the process bottleneck.
- Determine overall process capability measurements by consolidating individual task performance and bottleneck flow rates.

Summary

In closing, operations are an instrumental part of achieving an organization's given strategy. Effective organizations will consistently demonstrate best practices to achieve a competitive advantage. Managers can improve upon operations by matching capacity to demand while decreasing the inventory and throughput time in a process. The measurements and terms introduced in this note provide a framework on which to build operational effectiveness.