Chapter 12
Just-in-Time/Lean/The Theory of Constraints/Six Sigma

Just-in-Time, Lean, the Theory of Constraints, and Six Sigma are all related methodologies. All four of these methodologies are continuous process improvement programs designed to improve a company’s operations management chain and improve the quality of the outputs of the processes. A strong argument could be made that all four programs are basically the same program with a different name. This would not be unusual in the business world to change the names of programs just to make more money off of books and consulting fees. Although each of these four programs have similarities in their results, the approach of these programs, with the exception of JIT and Lean, are different. The goal of addressing these four programs in the same chapter is to provide the operations management student with alternatives for improving a process or system.

Regardless of the program used to bring about improvements to a process, the first step is to walk the process to identify the non-value-added activities or sub-processes and to identify those processes that are working well and may not necessarily need changing. As mentioned before, it is important to remember two important points about improving operations. The first is that all processes add cost, but not all processes add value to an operation. The programs in this chapter will help the operations management student identify those non-value-adding processes as candidates for improvement or elimination. The second important point is to remember that all improvements are a change, but not all change is an improvement. A promise of “change you can believe in” should really be “improvements you can believe in.”
Just-in-Time (JIT)

This may very well be the most misunderstood and inappropriately implemented program in operations management. JIT has its roots in the rebuilding of the Japanese economy after the defeat of Japan in World War II. Taiichi Ohno gets the credit for developing what became known as the Toyota Production System in the 1950s. This system grew out of the teachings of Dr. W. Edwards Deming, the American statistician that went to Japan after the war to help the Japanese businesses recover.

JIT made its way to the United States and the rest of the world in the 1970s as a result of the growth of the quality of Japanese products in general and the Japanese automobiles in particular. In the 1960s, the words “Made in Japan” on a product almost assured the buyer that the quality was suspect at best. Then the quality revolution in Japan started the flow of high quality products into the marketplace. By the mid 1970s, those same words, “Made in Japan,” symbolized the highest levels of quality worldwide.

As this new wave of quality rolled across the globe, everyone wanted to know how the Japanese firms were achieving lower costs and higher quality products. The answer was JIT. The problem was that the applications of JIT got lost in translation. Instead of Lean as Ohno called it, the JIT program became zero inventories. This spawned a series of the “Zero Inventory Papers” published by what was at the time known as the American Production and Inventory Control Society.¹

¹ The American Production and Inventory Control Society is now known as APICS – The Association for Operations Management.
Just-in-Time is both an inventory methodology as well as a continuous process improvement program. Much has been written about both. As a continuous process improvement program, JIT has a mantra to eliminate all waste. Remember in the discussions on positioning the firm that to be successful if competing on cost, all waste must be eliminated. As an inventory management philosophy, JIT is interpreted to have just enough on the shelf to meet the needs of the customer. Many companies have realized that JIT as a pure inventory methodology may not be the best method available.

For example in the United States in 2001, all forms of transportation came to a halt after the attacks of September 11. Those companies that had moved to JIT inventories had problems meeting deliveries after transportation starting moving again. Hewlett-Packard missed deliveries as a result while Dell was able to meet almost all of their deliveries. The delays in transportation created stockouts and forced companies to reevaluate their JIT policies. Those companies that did not change after 9/11 got another wakeup call in 2002 when the dock workers went on strike on the West Coast. The strike delayed the shipment of items on approximately 300-500 ships depending on which report is most accurate. The 9/11 delays and the dock strike forced many companies to move from JIT to just in case inventories.

As a process improvement program, JIT has great applications to all companies.

Reducing waste is important to any company that wants to remain competitive. So, let’s look at

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2 Dell was reportedly a JIT company at the time of the September 11 attacks. However, Dell mandated that its suppliers keep 6-8 weeks of supply in the Dell Supplier Center across the street from their Texas assembly plant. This may be a case of semantics. Technically, the Dell Assembly Facility was using JIT with deliveries every 4 hours and the supplies in the Dell owned Supplier Center were indeed owned by the suppliers – but, if Dell mandates the stockage levels of the Supplier Center, is that really pure JIT?
the goals of JIT. The goal is to eliminate waste. Here are the wastes as identified by the Toyota Production System that has become known as JIT.

- **Overproduction:** JIT seeks to eliminate the waste of producing too much. This includes too much of the right stuff and eliminating the production of items that do not sell at all. This is one area that causes conflicts between accountants and operations management managers. The age old philosophy from the accounting side of the house is that a machine should operate at 100% utilization. However, if 100% utilization of an operation produces more product than the customers want then waste is the result. JIT mandates only producing what is needed and nothing more.

- **Waiting:** The waste of waiting always remind me of the *I Love Lucy* episode where Lucy was working in the candy factory and spent time waiting for the candy to show up and then the candy started coming faster than Lucy could keep up with it. The waste of waiting comes from not balancing the manufacturing line and having machines in the line that produce faster than other machines in the line. If the line is not balanced, there will be waiting at some machines and overproduction at other machines in the line. Balancing the manufacturing line will eliminate the waste of waiting.

  This could also be the waste of watching a machine run. If the machine works well without any human intervention, there is no need to have someone standing there watching the machine just in case it breaks down.

- **Unnecessary handling:** Every time an item is handled there is a chance of damaging, misrouting, or misplacing the item. Eliminating the waste of unnecessary handling
prevents this damage or loss of the product. A good facility layout will eliminate unnecessary handling of the product.

- **Non-value adding processing:** This has been discussed earlier in the text. Every process adds cost, but not every process adds value to an operation. Walking the process, documenting each activity and then preparing a process map will help companies identify non-value-adding processes. Eliminating non-value-adding processes helps companies reduce costs and thereby makes the company more competitive and profitable.

- **Inventory in excess of immediate needs:** This waste is very close in nature to the first waste of overproduction. Careful and accurate forecasting coupled with knowing what the customers need and want will help the company eliminate this waste. This is the waste that led to the misconception of zero inventories. Managing this waste does not mean zero inventories it does mean reducing non-producing inventory.

- **Inessential motion:** Moving for the sake of moving or moving products to multiple intermediate locations is the waste of movement. In some distribution centers there is the process of re-warehousing monthly or quarterly. This results in products moving from one location to another. Like the waste of unnecessary handling, this produces lost, damaged or misplaced items. One of the beauties of RFID tags is the ability to see stuff move around a storage yard for the sake of movement.

One facility that I worked with several years ago had a large quantity of shipping boxes prepped for shipment out of the facility for disposal. Instead of loading the boxes for outbound shipment, when the managers were notified of the boxes, the boxes were moved to another location in the yard that was out of sight. Unbeknownst to the
managers, I had put my initials and date on the boxes while inspecting their yard. A month later the boxes were discovered again during a walk through the yard. This time the manager tried to tell me that this was a new set of boxes being prepped for outbound shipment. However, the manager was a bit embarrassed when I showed him the dates and initials. This was not only a breach of honesty but a classic example of movement for the sake of movement.

- **Rework of defects:** This is a serious waste of assets, time and money. As discussed in Chapter 4, quality initiatives will reduce the amount of rework required to fix defects before shipping to customers or fixing warranty work necessitated by allowing defective products to get in the hands of the customer. The discussion of reverse logistics in Chapter 13 will look at some of the additional costs companies incur from the waste of reworking defects.

- There is another waste that is not a part of the seven wastes of the Toyota Production System. This waste is the waste of meetings. Too many companies have meetings for the sake of meeting with nothing decided in the meeting but to have another meeting. How many times have you sat through a meeting only to wonder what the meeting was about when it was finished and feel like you just wasted a couple of hours of your life?

**JIT Elements**

In addition the wastes of JIT, there are some basic elements associated with JIT. Some of these basic elements of JIT are also just plain common sense.

- Flexible resources. This was the basis for the cellular structure previously discussed. This is also what drives the layouts of fast food restaurants. In a hamburger fast food...
restaurant there is one “cell” where the burger is microwaved, another “cell” where the burger is assembled, still another “cell” taking the order and still another “cell” operating the fry cooker. There are no specialists in this arrangement. Each of the workers is trained to work in all of the “cells.”

- **Pull production system.** As discussed earlier, the pull system only produces a product when there is a demand for it. This concept helps to eliminate the waste of overproduction and excess inventory.

- **Kanban production control.** Kanban literally translates as “card.” A Kanban card alerts the producer to make more of the product. A Kanban could be a signal such as a light to alert the previous operation to make more products or a square on the floor that when emptied alerts the previous operation to make more products. As mentioned in the previous chapter, this concept is derived from the two-bin inventory reorder point concept. Here are some common examples of Kanbans:

  - **Bin Kanban** - when the bin is empty it is the signal to replenish the bin (much like the two-bin system).

  - **Kanban Square** – This is a marked area on the floor or assembly line that is designed to hold a certain quantity of material. When the square is empty it is time to replenish.

  - **Signal Kanban** – This may be as simple as an andon light to signal the previous operation to move more products forward or a triangular sign or a flag that is raised to alert the previous operation to move product forward.
Calculating the number of Kanbans needed – If a company is going to use the Kanban methodology, it is necessary to calculate the number of Kanbans necessary to support the operations. When using the formula shown in Formula 12-1, if a company wants to force more efficiency in the system, the calculation is rounded down and if the company wants to allow a little slack in the system, the company will round the calculation up (see example 12-1).

<table>
<thead>
<tr>
<th># of Kanbans</th>
<th>( \frac{\text{average demand during lead time} + \text{safety stock}}{\text{container size}} )</th>
</tr>
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Formula 12-1: Kanban Calculation

Example 12-1: Kanban Calculation

In Example 12-1, if the company wants to force efficiency in the system, the company will round the number of containers in the system to 4. However, if the company wants a little slack in the system, it can round the number of containers to 5.
Quick setups. Anything that can be done to reduce the setup times falls under this concept. For example, NASCAR teams use guides to make the pit stop tire changing go faster. There is a notch and a mark for the jack man to hit to speed up the setup for the tire changing as shown in Figures 12-1 and 12-2. Figure 12-3 shows another example of quick setups in NASCAR. In order to reduce setup time for the tire changers, each lug nut is glued to the tire and then the tires are arranged in the proper order of use and marked to prevent placing the wrong tires on the car.

Figure 12-1: Tire jack mark for NASCAR pit crews for quicker set up times
The JIT concept of reducing set up times is often referred to as Single Minute Exchange of Dies (SMED). This concept forces a company to take a look at their operations and determine if a quicker set up is possible. In the automobile industry, it used to take weeks to retool a plant to produce a new line or model of an automobile.
This is lost productivity time and lost revenue. If an operation can be analyzed and the steps and set ups reduced to internal and external operations, the process can be streamlined and improved. This concept is the driver for setting up the tires and lug nuts prior to use as shown above in Figure 12-3. This analysis may actually eliminate some set up steps altogether or at least allow for some steps to be accomplished simultaneously external to the operation.

Other examples of quick set ups include the use of:

- Preset buttons or settings such as the quick set buttons on the car stereos. I know it is hard to believe, but there was a time when finding a radio station on the car radio (there were no stereos then) involved the use of the tuning knob for every station.

- Locator pins or guides provide quicker set ups. The Indy Racing League uses a set up pin/guide to assist in getting the tires properly set on the cars prior to fastening the one “lug” nut.

- Using standardized operations helps to reduce setup times and remove wasted time from operations.

- Uniform production levels. This is the goal of every production facility regardless of whether or not JIT is adopted. If a facility can produce at a constant level, there will be less turbulence in the workforce and more predictability.

Uniform production helps to smooth the manufacturing operations while improving the quality of the information being shared by supply chain partners and adds some
level of predictability to the supply chain. One method of achieving uniform production is through the use of mix model assembly operations or being able to make more than one product or model on the same assembly line. At the Harley-Davidson Plant in Kansas City, Missouri, although each of the three main lines are dedicated to a particular line of motor cycles, each line is in fact a mixed model assembly line. On the same line the company makes V-Rods for the US, Japan, Australia, Europe, and California. Each of these “models” requires different braking systems, safety features and emission systems. Having a mixed model assembly line allows the company to balance production while meeting the needs of the customer and keeping the employees working.

- Supplier networks with fewer suppliers. JIT emphasizes fewer suppliers and more long term relationships with suppliers. Long term relationships with suppliers are usually a good as this leads to better cooperation and the sharing of information between customers and suppliers. This is an adaptation of the single sourcing concept discussed earlier. There is an upside to using fewer suppliers. This fosters a better understanding of what customers need. The downside of fewer suppliers is the loss of supply if one of your suppliers has financial problems or goes out of business.

- Quality at the Source. This is important regardless of whether a company uses JIT or not. Some of the Japanese terms and ideas have migrated to other countries as part of this aspect of JIT. One of these concepts is the idea of Jidoka. This is simply empowering the employee to stop the assembly line if the employee discovers a quality issue with the parts or the assembly itself. Another concept that has found its
way into both JIT and Six Sigma is the concept of “poka-yoke.” This is simply idiot proofing the operation so a mistake cannot be made.

**Kaizen**

The 13th Edition of the APICS Dictionary defines Kaizen as: “The Japanese term for improvement; continuing improvement involving everyone—managers and workers. In manufacturing, kaizen relates to finding and eliminating waste in machinery, labor, or production methods.” Kaizen is a continuous process improvement program, however, it sounds so much sexier and important to call it a Kaizen rather than a common continuous process improvement program. Kaizen is literally for the greater good of everyone. A good continuous process improvement program is for the good of everyone in the program. Just because JIT came from Japan and Kaizen sounds so much more impressive, do not get wrapped around doing a Kaizen program and waste time developing a Kaizen when everyone understands continuous process improvement.

**JIT Summary**

As a continuous process improvement program JIT can be used by anyone, as an inventory management program, it may not be applicable to your operations. Eliminating waste is important even if your company is not positioned on competing on cost. Getting rid of non-value-adding operations or processes can make a company more competitive and more profitable. Getting rid of inventory for the sake of JIT may make a company go out of business because of the inability to support customers. If the demand remains constant in the supply chain, someone has to have the product somewhere to meet customer needs.
The Theory of Constraints

“Focusing on everything is synonymous with not focusing on anything. Can we condense all of TOC into one single sentence? I think it is possible to condense it to a single word – focus.”

-Dr. Eli Goldratt

The Theory of Constraints (TOC) grew from the business novel, *The Goal*[^4], by Eli Goldratt, a physicist from Israel. According to the APICS Dictionary, the Theory of Constraints is “A holistic management philosophy developed by Dr. Eliyahu M. Goldratt that is based on the principle that complex systems exhibit inherent simplicity.”[^5] In spite of this inherent simplicity, every system has at least one variable or constraint that limits the throughput of the system. Any increase in the capacity of the system anywhere except the constraint does not increase the capacity of the system. A constraint is a bottleneck that restricts the flow of materials in the system much like the bottleneck of a Coke bottle that limits the amount of Coke that can flow out of the mouth of the bottle. This is exactly why Mickey’s went with the wide mouth bottle – more liquid can pass through the wider mouth and the bottleneck is changed. It is important to remember that just because a process is not the constraint that does not mean that the process is not important.

TOC, like JIT, is a continuous process improvement program that seeks to produce a process of ongoing process improvement or POOGI. The TOC improvement process has a series of five focusing steps. The first step is to simply indentify the constraint in the system. In TOC


[^4]: The Goal was released in 1984, the term theory of constraints did not appear until 1987.

terminology, an hour lost at a bottleneck or constraint is an hour lost in the entire system. This bottleneck must be modified or eliminated.

Once the constraint is identified, a decision is necessary on how to modify or exploit the constraint. The third step is to subordinate all of the non-constraint operations to the bottleneck. The fourth step is to remove the constraint or modify the operation to increase flow through the constraint. The fifth step is the continuous process improvement step – go back to step one and look for a new constraint and repeat the process while not allowing inertia or short term satisfaction to prevent the process of ongoing process improvement.

TOC works on a system known as Drum-Buffer-Rope to make an operation work. The Drum is the constraint. The constraint provides the drum beat that the rest of the operation should be moving to. Just as the drum beat sets the cadence for a marching unit, the constraint provides the cadence for the operation. The Buffer is the amount of product positioned in front of an operation to prevent work stoppage. The Rope is the flow of material that links the Drum to the rest of the operation or the release of materials to the consumption at the bottleneck.

**Six Sigma**

We looked at Six Sigma during the discussions on quality as a methodology of reducing variability through the use of the Define-Measure-Analyze-Improve-Control (DMAIC) methodology developed by Motorola.

- **Define** – define who the customer is; what the customer wants; and how our company can do it better than the competition.

- **Measure** – in this step the process is walked and documented and a detailed process map with date and time stamps is produced.
- **Analyze** – look at the data from the measure activity and determine how the process can be performed better with less variability and develop this new process.

- **Improve** – put the new process into place.

- **Control** – put controls in place to institutionalize the process and ensure that it works as designed.

Just like JIT and TOC, Six Sigma is a continuous process improvement program. The key to the success of Six Sigma is the continuous aspect. Too many companies complete the DMAIC steps and then find that Six Sigma did not work for them because they did not go back to the Define step and make sure the new process actually worked and worked better than the original process.

Six Sigma originated as a manufacturing process control but has applications to other aspects of the operations management chain. Six Sigma can be applied to warehousing and distribution operations as well as service industry. Granted, in service industries a company may not have one million opportunities but the ability to apply the Six Sigma methodology to reduce variation and improve the quality of the service is available to all companies in the operations management chain.

**Summary**

Just-in-Time, the Theory of Constraints, and Six Sigma provide tools for operations managers to improve their operations. Although each of these approaches are different, the success from them comes from the continuous process improvement aspects of the programs.
Discussion Questions

1. Is Just-in-Time an inventory management technique or a continuous process improvement program? Justify your answer.

2. Does every system have a constraint? If so, describe the methodology to improve the constraint or eliminate the constraint.

3. How do JIT, Six Sigma, and the Theory of Constraints compare and contrast?

4. Are JIT, Six Sigma, and TOC the same?

5. What is the goal of Six Sigma?

6. What are the seven wastes of the Toyota Production System? Give examples of each.

7. If a company increases the capacity of their system at a non-bottleneck process, what is the impact on the system?

8. Does nonConstraint also mean non-important? Explain.

9. What is “Zero Inventory” and how does it relate to JIT?

10. Describe the concept of the Drum-Buffer-Rope.

11. Can Six Sigma be applied to services?

12. What is Kaizen? How does it apply to JIT?

13. The JY Company wants to move to Kanbans to move its supplies forward in the supply chain. If the lead time is 2 days; the demand during the lead time is 400; and the company is using a container that holds 50 items, how many Kanbans will the company need?

14. The JY Company wants to improve the efficiency of the company and its Kanbans, what will that do to the calculation in question 13?

15. How can quick set ups improve operations?