Introduction to Supply Chain and Operations Management

A Real World Perspective

By

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The goal of this textbook is to provide you with both a theoretical framework and a real world perspective of operations management and supply chain management while at the same time providing you with an educational resource to supplement your business education.

This text is provided as an Open Education Resource to help prevent having to make a decision based on cost of whether or not to purchase the textbook for this class over another class' textbook.

This textbook is not meant to replace coming to class. It is designed to supplement the class materials and provide you with a better understanding of the importance of operations management and supply chain management regardless of your major area of study.

Contents

Chapter 1

An Introduction to Operations Management

Why is it important to study operations management and the operations management chain as part of a business education? Regardless of what business activity you may find yourself associated with in the future, there will be an operations management chain supporting it in some fashion. Not only is it important to study operations management as part of your business studies, it is equally important to study current operations management practices to remain current and to identify positive and negative trends in business operations to ensure that your business remains current and competitive in today's changing business environments. For example, the Hawaiian sugar industry continued to do operations the same way for decades and found themselves to be outdated and no longer competitive resulting in the closure of the Maui Sugar Company operations in 2016. The Maui Sugar Company processing facility is shown in figure 1.1.

Another example of not remaining current is Sears. Sears was the largest brick and mortar retailer for over a century and as late as the late 1990s over 75% of American households had at least one Kenmore appliance in the house. Today Sears is almost gone and stores are being closed almost daily as shown in Figure 1.2 of the old Sears in Leavenworth, Kansas.

Figure 1.1: Maui Sugar Company Operations, May 2016, shortly before closing all operations

Figure 1.2 Former Sears Building in Leavenworth, Kansas

What is operations management?

Operations management is the core of almost every business. Operations management includes all of the planning, design, production, sourcing, supply chain operations, customer service, and even the return of products that do not meet the needs of the customers. APICS[1] defines operations management as "1) The planning, scheduling, and control of the activities that transform inputs into finished goods and services. 2) A field of study that focuses on the effective planning, scheduling, use and control of a manufacturing or service organization through the study of concepts from design engineering, industrial engineering, management information systems, quality management, production management, inventory management, accounting and other functions as they affect the operation."[2] It is really the second part of the APICS definition that we will look at in this textbook.

It may be easier to ask, what is not operations management? From a purely academic perspective, almost anything can be classified as part of operations. From a strictly distribution and manufacturing viewpoint, everything could be considered part of operations management. From a services perspective, everything fits under operations management.

Operations management terms, principles, and techniques are consistent across all spectrums of business—regardless of whether the business is a for-profit business, a not-for-profit business, or a service industry. We will look at the principles of operations from the manufacturing and services perspectives. Inherent to the study of operations management are the

[1] APICS is part of the Association for Supply Chain Management (ASCM). ASCM is the largest supply chain management professional organization in the world.

[2] APICS online dictionary app: operations management

basics of supply chain management. Without supply chain management, no operation can be successful as some of the "dot.com" companies discovered in the late 1990s. Some of these companies designed great Web sites but overlooked the need to have a great supply chain to deliver the products advertised on the Web sites. This contributed to the "Dot.com bust."

Why should you care about operations management as a student? Operations management is the foundation of all business operations. Regardless of your major, without the tactics, techniques and procedures associated with operations management a company cannot be successful. The foundation established by this study of operations management will assist you in your study of business and the principles of operations management are transferable to other areas of studies even outside the study of business. Some of the techniques covered in this textbook can be applied to work, study, and your personal life. The goal of this course is for you to understand how operations and supply chain management relate to your particular major.

Why is operations management important in business? All businesses need operations management or at least most of the topics covered in this text to be successful. Organizations exist to meet the needs of societies that people working by themselves could not produce. In order to do this, the companies must master the tactics, techniques, and procedures of operations management discussed in detail in this textbook. The tactics, techniques, and procedures of operations management are not like a menu in a restaurant or an optional list of topics that owners of companies can choose some of and ignore the others. All of the topics discussed in this textbook as part of the operations management chain work together to create the synergy necessary to meet the needs of society and make a profit if the company is a for-profit organization.

Most businesses operate for two reasons 1. The primary reason is to make a profit and 2. The secondary reason for many companies is to put the competitors out of business. Some companies will state in their brochures that they are in business to provide a certain good or service, but the real reason people go into business is to make a profit. Few individuals go into business to lose money unless they are already rich and need a tax shelter to compensate for other income streams. Some professional sports teams appear to fit into that category, the owners are not really concerned with winning or making a profit but just seem to want to show losses to counter other income. Most companies are in business to make money and hopefully put the competition out of business. Any for-profit company that claims to be in business for any other reason is not being honest with the customer or with themselves.

I am sure that Walmart was not started to put other companies out of business but look at what happens to small "Mom and Pop" stores when a Walmart moves into an area. The same is true with The Home Depot and small hardware stores. I am pretty sure the goal of Amazon is to put everyone out of business and be the monopoly that controls everything. Just look at their growth into cloud computing services, ground transportation, every possible product, air transportation and sea transportation.

Companies provide goods and services for a reason—they are in business to make a profit. The only way that a company can make a profit is to focus on the basics of operations management. Some companies are successful without focusing on the basics of operations management but those are the exceptions to the rules.

A systems approach to operations management looks at the entire system from the beginning to the end. Supply chain management now looks at the supply chain as extending from the supplier's supplier to the customer's customer. Here it is important to introduce a new

concept: an operations management chain. An operations management chain connects the inputs such as raw materials through the transformation processes at various levels all the way through to providing a good or service to a customer and continues through the life cycle of the product or service. This includes the life cycle management of the product, the design of the product or service, the manufacture of the product, the delivery of the service and if necessary, the return or reverse supply chain and the ultimate disposal of the product if necessary. As you can see, the operations management chain is like the supply chain and the two concepts are intertwined and will be addressed in this text. This text looks at operations management from a systems approach to operations management.

Dr. W. Edwards Deming left the US and went to Japan in the 1940s after World War 2 to help the Japanese rebuild their economy and to teach them statistical quality control and the foundations of what we call Just in Time today. Dr. Deming once stated, “If you cannot describe what you are doing as a system, you do not know what you are doing.” The economic meltdown of 2008-2009 showed the world that a lot of companies did not know what they were doing. The pandemic of 2020 has revealed the same thing. Some of the problems that surfaced during those economic crises were the results of decisions made decades earlier. The demise of Sears, the closings of many Macy’s Stores, and the 2020 bankruptcy filing by JC Penney are a good example of an economic crisis revealing flaws in previous decisions. Some of the problems were the result of the focus on the short term bottom line with no regard for the long term and some of the problems were an example of Darrow’s Survival of the Fittest.

Businesses operate in a cycle—failure to plan for survival during the next business cycle may very well result in severe problems when the cycle appears. Operations Management and Supply Chain Management require a total system approach and a long-term focus in order to be

successful. The goal of this study of the operations management chain is to assist the student in being able to describe what they are doing as a system and to see operations management from a systems approach.

A system can be defined as a group of interrelated items, events, or actions. Here are some examples of systems:

- Going to class—watching the videos - reading the assigned materials – staying awake in class - doing the homework problems - studying for exams - passing exams - passing classes – graduating – getting a good job. Figure 1.3 shows these actions as a system.

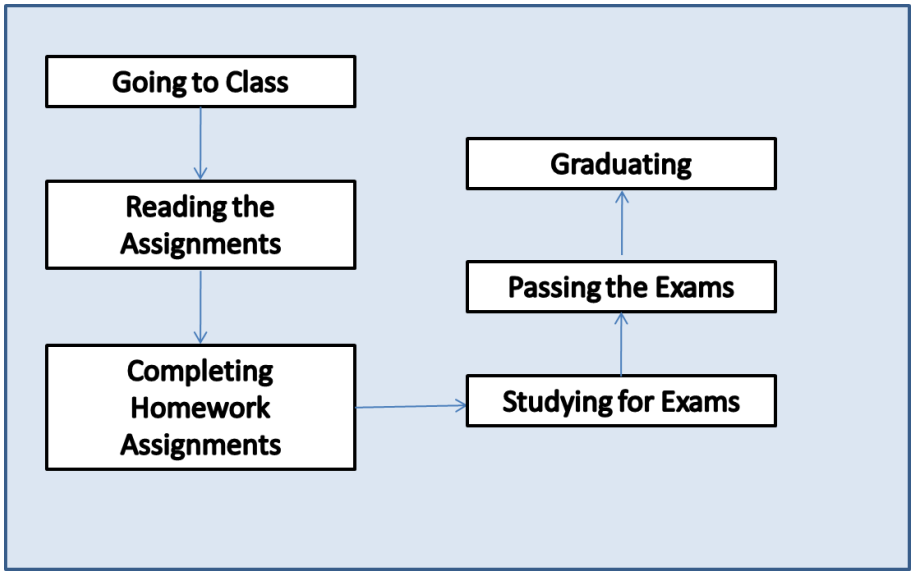

Figure 1.3: Example of a System of Interrelated Events

- Sports: Conditioning – Practice - watching game films - adjusting the game plan - practicing the plan - win games.

Inputs to the Operations Management System Approach

Regardless of the industry that you are working in, operations management is the core process that determines the effectiveness of the business and the profitability of the company. Operations management can be described as a system that includes the inputs, a transformation process and outputs usually in the form of a good or service. Figure 1.4 shows the operations management chain as a system. Critical to this system are the feedback loops between each of the three components of the system.

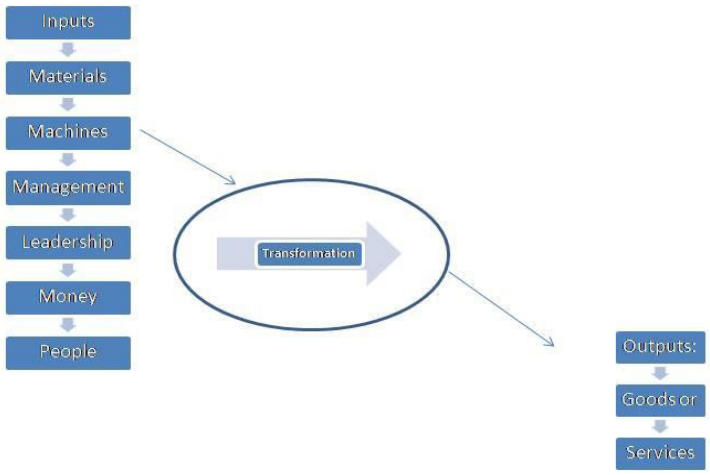

Figure 1.4: The Operations Management System

The inputs to the operations system include:

- **Materials –** the materials inputted into the operations management chain are raw materials, components, assemblies, or other parts. These materials will be transformed into final products, other assemblies, or components that will be transformed in another link of the operations management chain into another completed product or used to provide a service.
- **Machines –** although the machines are the products of another transformation process that converted raw materials, parts and components, machines are inputs into the transformation of other materials, assemblies or components into products. Machines as inputs to the operations management transformation process is an example of the Operations Management Chain. No product or service is produced in a vacuum. The Operations Management Chain may be extended through several links from materials to machines to components to machines to final product and then tied into the Supply Chain to get the product or service in the hands of the final customer.

  There is a link between the machines and the materials. No matter how good a machine is, the machine cannot produce a quality product without quality materials.
- **People –** unlike materials and machines and other inputs to the Operations Management Chain, labor is not a commodity that can be moved and managed. People must be led not managed (we will discuss this in greater detail in subsequent chapters). People are a major link in the Operations Management Chain. People are necessary to run machines, procure products and materials, maintain machines and systems, move materials, and move final products through the supply chain to the ultimate customer—which is another people link in the Operations Management Chain. The move to automate systems and

remove people from the manufacturing chain at General Motors in the 1980s led to serious problems and placed General Motors on the *Supply Chain Digest* list of the Worst Supply Chain Disasters of All Time.

There is a link in the operations management chain between people and machines. The best machine in the world will have trouble producing a quality product if the operators of the machine do not know how to operate it. And even the best people in an organization need quality managers and leaders to reach new levels of excellence in the production of goods or providing quality services.

- **Management –** someone must manage the system. Without management systems can get out of tolerance easily. With management systems may also get out of tolerance and produce less than quality products. A manager may very well make the difference between a good operation and a mediocre operation. Moving from a line worker to a manager is a big step in a career and does not happen without education and training on how to be a manager. We will look at the Theory of Constraints throughout this study of operations management and the operations management chain. Too often, the constraint on an operations management chain is the training and experience of the manager or management and their policies. One of the goals of this study of operations management is to assist the student in identifying systems and operations management chain constraints and how to improve the systems by removing the constraints—even if the constraint is the management.

  Every transformation link in the operations management chain needs managers to ensure that operations work properly. This is the link between people, machines, and products quality. The next input in the operations management chain is leadership.

- **Leadership –** all too often used interchangeably with management, there is a distinct difference. The simple dichotomy was explained by a Reserve Officer Training Corps (ROTC) instructor at North Carolina State University early in my college days. He explained to us, "You manage things and you lead people." All too often, leaders believe that they lead organizations. In fact, leaders lead the people that make up the organization. Just as a good manager can make a difference in an operation, a good leader will be the difference between a good and a great organization. A mediocre organization will not attract quality people; without quality people to work on the machines there will not be quality products no matter how well the managers try to manage the system. Without quality products, companies will not remain in business too long.

  Just as moving from the line to management is a big step, so is the move from management to leadership. Just because a person is a good worker on the line does not ensure that without additional skills training that person will be a good manager. The same is true for leadership. Not everyone can be a leader, not everyone even wants to be a leader. A good manager does not automatically become a good leader. There are skills necessary for leaders that are not inherent in every manager. These skills can be taught but all too often companies assume that a good manager equals a good leader. Business schools teach business management. Leadership on the other hand must be modeled, not taught. To have a quality company, the company must have a leadership development program to develop leaders that can lead the people and managers of the organization. Leadership is learned by watching other leaders in action and from experience.

- **Money –** without money as an input to the operations management chain, there is no chain. Why, because if no one is buying anything, then no one is selling anything. If no one is buying or selling, there are no materials, components, or parts to make the products or provide the service. If no one is buying or selling, there is no money to hire quality managers, leaders, or workers. With no workers, nothing is produced. And if there is no money, no one is purchasing services from the operations management chain.

Operations Management Chain Transformation Processes

What types of transformation takes place in the operations management chain? Figure 1.5 provides examples of the transformation processes that take place in the operations management chain.

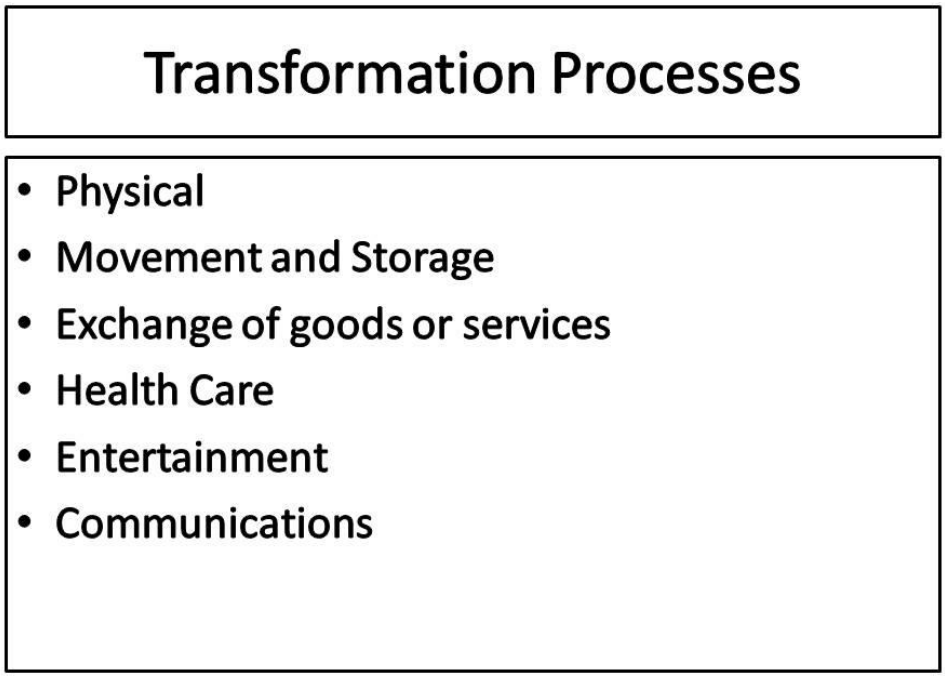

Figure 1.5: Transformation Processes

- **Physical –** A physical transformation is seen in manufacturing where the raw material input is transformed into a finished product. This form of transformation is the most discussed transformation process in Operations Management. Another example of a physical transformation can be seen in building a house as the materials are transformed from a collection of inputs into a finished house. Dell conducts a physical transformation from subassemblies into a finished computer.
- **Movement/Storage –** Moving the product from one point to another in the supply chain is distribution. If the goods are moved, (it could be a move of 1 inch) the transformation process is the movement of the goods; if the goods are moved and then stored, the transformation process is the storage of the goods until another move transformation takes place.
- **An actual exchange of goods –** In retail operations there is a transformation that includes the input of a customer with cash or credit and the input of a retailer with a good or service. The transformation is the exchange of the good or service for the cash or credit. The output of the process is the customer with the new product or service and a retailer with the capability to procure more goods to sell to another customer. This in turn stimulates the physical processes of the manufacturing transformations. This same exchange process may take place between a wholesaler and a retailer or the distributor and the retailer.
- **Physiological –** A physiological transformation has the input of a sick patient; a transformation process that includes the appointment with a health care provider and perhaps the use of a medication and advice from the doctor. The output of this system hopefully is a well patient.

- **Entertainment as a transformation –** Assuming that entertainment may be a transformation in an operations management, the inputs would be customers needing some form of entertainment and the payment for that entertainment; the transformation is the entertainment (good or bad); and the outputs of this transformation would be customers that are either happy with the process or unhappy with the transformation. The output is dependent on the quality of the transformation process.
- **Communications Transformation –** Effective communications require a very good transformation process to be effective. The inputs are the messages or words from one source; the transformation is the understanding of the message; and the output may very well be the actions taken as a result of the transformation and understanding.
- There may be more than one transformation process in the Operations Management Chain as shown in Figure 1.6.

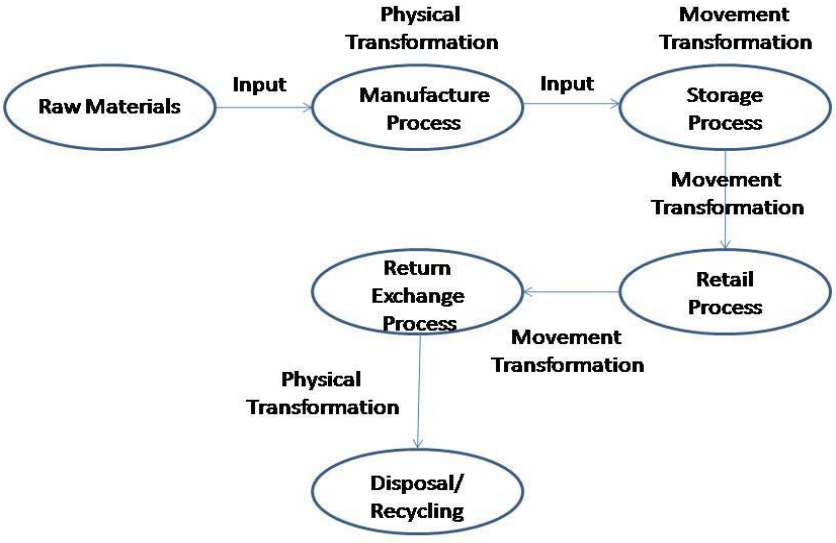

Figure 1.6: Example of Multiple Transformations in the Operations Management Chain

Topics in Operations Management

Decision Making. Operations management involves decision making which will be discussed in greater detail in another chapter. Decision making provides a competitive advantage.

Customer Service. Is customer service important to the operations management chain? Should customer service be a part of the study of operations management? Is customer service a product/ an output/ an input/a transformation process? An argument could be made for each—we will take a detailed look at each from an operations management chain perspective.

During our look at operations management, we will look at the differences between products and services as we look at the product/service design processes. This discussion will look at forecasting and why forecasting for services is a little more difficult than forecasting for products.

The quality of a product is determined by the customer. The quality of a service is very similar. Strength, durability, and performance are examples of attributes of services—this includes the length of repair time, the quality of repairs, and the ease of repairs. These attributes are just some of the factors that separate services operations management from manufacturing operations.

The study of operations management will look at the design of a product or service and the need to design quality into the product or service vice trying to inspect it in later. Management and leadership of the company not only should be part of the design process but must be involved if the launch of the product or service is going to be successful. A company's strategy should drive the product development, the service development, and the competitiveness of the company or country. We will look at strategy and competitiveness in the next chapter.

All operations add cost to a product or service but not all operations add value to a product or service. Operations Managers are responsible for determining which processes or operations add value and which ones are non-value-adding. If a process does not add value to the bottom-line profits, the experience of the customer or the quality of the product then there is no value added. Our look at process and product design will discuss the methods for identifying value added and non-value-added processes and how to improve the operations management chain by eliminating non-value-added processes.

Impacts on Operations Management:

To fully understand the basics of operations management, it is necessary to look at the impacts on operations management from history.

- In middle school and high school most of us studied the **Industrial Revolution**. In Middle School we looked at the impact of the Industrial Revolution on the manufacturing of goods and the start of the transformation from an agrarian society to a manufacturing society. The impact on manufacturing impacted the thoughts on operations management even though the concept of operations management was not conceived. The impacts on operations management from this period of time included:
    - James Watt and the invention of the Steam engine in 1769. As every school kid learns in grade school, this had an extreme impact on the building of products and how products were produced.
    - In 1776, while the Colonies that later became the United States were discussing a break from England and were drafting the Declaration of Independence, Adam Smith was studying the concept of the **division of labor** in manufacturing. His research and theories are still taught in business schools today.

- History is taught differently in different countries and even in different parts of the country. School children in the Southern United States, especially, learn about the impact to the growing, processing, and sorting of cotton seeds from the cotton from the invention of the Cotton Gin by Eli Whitney. The cotton gin allowed plantation owners to process more cotton as this invention quickly separated the cotton ball from the cotton seed. What is not taught is the fact that Eli Whitney is also the father of interchangeable parts in manufacturing. In the 1790s, Eli Whitney received a US Government contract to manufacture muskets for the Army. As is typical with many government contracts even today, he got behind schedule on his contract. He was later called in to see the President to explain why he was behind in delivering the weapons to the Army. Whitney took a weapon to the meeting with the President. Whitney explained to the President that he was developing a system where the parts of the muskets could be interchanged between weapons. Prior to this, if a musket part broke, the weapon was useless and worthless. With the advent of the **interchangeable parts** as designed by Whitney, the muskets he was making could be repaired without losing the weapon completely. In a modern day analogy, without interchangeable parts if the light bulb in your lap blew out you would have to get a new lamp rather than replacing the bulb. Figure 1.7 is a replica of the muskets that Eli Whitney was working on.

Figure 1.7 Replica of Eli Whitney Musket

- **Scientific Management** focused on the way items were made and the people that made the products. The impacts on Operations Management from Scientific Management include:
    - Frederick W. Taylor came up with the principles of Scientific Management and the analysis of workflows in the later part of the nineteenth century and became popular in the early twentieth century. These same principles are still in use today. In fact, the works of Taylor focused on gaining efficiency and reducing waste—not unlike the lean and Six Sigma movements of the late twentieth century.
    - In 1912, Henry Gantt invented the activity scheduling chart that bears his name and is still in use in program and project management today as will be discussed in more detail in the discussion on program and project management. Gantt charts, simple to use bar charts for program management, were used in projects such as building the Hoover Dam.
    - In 1913, Henry Ford designed the moving assembly line at his Rouge River Plant. The basics of the assembly line can be seen in today's automobile and motorcycle assembly plants. Henry Ford gets credit for designing the assembly that is not indifferent from the lines used by automobile manufacturers today. In addition to the assembly line, Ford is also the father of the modern day Reduce, Reuse, Recycle concepts. He was "green" long before political leaders started pushing the "green" movement and long before being green was politically correct. Ford had his suppliers deliver parts to the plant in wooden boxes that were specially designed with holes in the boxes in specific places. The suppliers could not figure

out why the holes were in specific places. Seems Ford was using the sides of the wooden boxes as the floorboards of the cars.

  - In addition, Ford was known for saying "you can have it in any color you want as long as it is black." It wasn't that he was that fond of black paint; it was because through research he knew that the black paint cured faster than other colors thus prompting his demands that the Model A stay black even when other colors were available.

- **Human Relations** or the lack thereof. Human relations/human resources should be the office and activities that allow companies to find the right personnel—however, somewhere along the line the human part of the human relations equation got changed. Instead of trying to fill the right person in the right slot somewhere along the line, in a lot of companies, the concept became "let's fill the slot with the right resume" regardless of the real qualifications. If an applicant does not have the right "buzz words" in the resume, the applicant does not even become a candidate regardless of how qualified that person may be. The advent of the computer age coupled with the advent of the Internet has allowed companies to de-personalize the human aspect of human relations/human resources. The human resources concept has encouraged human resources managers to use management theories and practices to manage people like any other commodity.
  - The US Army moved away from local personnel offices at every installation to regional hiring offices in the name of efficiency and cost savings. The result was a decline in the human aspect of human resources and a loss of local advisors for hiring officials. This led to a lack of confidence in the human resources process.

- Another example of the loss of the human factor in operations management came a couple of years ago when a company advertised for a supply chain manager and then after a plethora of resumes were received, the company called and asked what skills they should look for in a supply chain manager. This was a question that probably should have been asked prior to the advertisement of the job.
- Another example came when I was talking to a Human Resources conference. I was informed by the Vice President of Human Resources of a major company that they "did not have time to focus on the people as they were focused on profits." This was in response to a comment that a focus on hiring, training, and retaining the right people is critical to a successful operation and a measure of the leadership of the company. Later in the discussion, it came out that this particular company was having trouble retaining people because the company was in bankruptcy. My suggestion was that perhaps since the company was focusing on profits rather than people and was in bankruptcy; perhaps the time was now to start focusing on people as the current focus was not working.
- Part of the Human Resources focus on Operations Management includes looking at how employees are treated and compensated. This includes answering or at least looking at the question: does employee ownership impact operations? Southwest is a good example of employee ownership. In the Kansas City area Hy-Vee is an employee-owned grocery store that prides itself in the pride of ownership and the service provided by the employees. The Publix grocery store chain has survived and thrived for the same reason – the employees are also the owners and care about customer satisfaction.

- Human resources management includes not only what employees are hired, how the employees are trained but also how the employees are treated while employed by the company. This goes a long way in keeping quality employees at a company and not only builds employee pride but also prevents having to use time and money to train new employees constantly. In the late 1990s there was a distribution center in West Memphis, Arkansas that experienced a 95% employee turnover rate – they were constantly hiring and training new employees.
- From 1927 - 1932, Elton Mayo conducted his famous Hawthorne studies at the Western Electric Hawthorne Works. During this series of motivational studies, lights at the Hawthorne plant were turned up and production went up—assumed to be linked to the increase in lighting; then the lights were turned down and productivity went up. As it turns out the improvements in productivity and motivation were tied to the employees feeling like someone was concerned about them and had nothing to do with the brightness of the lights.
- Abraham Maslow established hierarchy of needs in the 1940s and published his findings in a paper titled "A Theory of Human Motivation" in 1943. Maslow's hierarchy of needs is still taught in business schools over seventy years later and is considered in hiring actions in major companies. One company that I interviewed with was so focused on meeting basic needs that they overlooked the need for self-esteem and self-actualization.
- Frederick Herzberg and Douglas McGregor developed their motivational theories through studies and research in the 1950/1960s. Herzberg looked at the factors that caused satisfaction and dissatisfaction at work. McGregor published his book,

The Human Side of Enterprise, in 1960. His Theory X and Theory Y views of motivation were detailed in this publication. McGregor's theories assumed that workers are inherently lazy and need to be motivated or were inherently motivated and did not need a lot of external motivation to get them to work. Dr. William Ouchi later came along with his Theory Z approach stating that workers do not neatly fit into one category or the other but actually may fit into both categories. This meant that there was no one size fits all HR approach.

  - Perhaps the goal of human resources management should be akin to the thoughts of Jim Collins in his book *Good to Great.* HR needs to focus on getting the right people in the right seats on the bus. In other words, getting the right employees in the right jobs in order to be successful in operations.

- **Management Science** or the study of management as a science has enabled companies to focus their efforts on improving management of resources and operations. Some of the impacts on the management of operations from Management Science include:
  - Linear programming was developed in 1947 by George Dantzig. Linear programming can be accomplished through specialty programs or on Excel today. Because of its applications to manufacturing and scheduling of resources it is still in use to maximize production of products and product mixes and to maximize customer satisfaction and/or profitability.
  - The development of the first digital computer by Remington Rand in 1951 led to a whole new way of managing and later a new way of communicating and sourcing. What an impact this had on the management of the operations. Try to imagine daily life without the use of smartphones or computers.

- Operations research/systems analysis was evident in our earlier example of Henry Ford and the curing process for black paint. With the use of simulations to determine the impacts of systems and decision before implementation, cost avoidance and systems miscues can be minimized. DuPont and the US Navy developed the techniques of the **Critical Path Method** (CPM) and the **Program Evaluation and Review Technique** (PERT) that will be discussed in greater detail in the discussion on Project Management.
- Joseph Orlicky working for Oliver Wight developed a simple technique for material planning and time phased ordering known as **Material Requirements Planning** in the 1960s. When originally designed the MRP system was simple because most companies were manufacturing only a few products. As companies implemented automation and increased their product lines the MRP programs became more complicated and now MRP is seen as the precursor to modern day Enterprise Resource Planning programs widely used today. We will look at this in more detail later in the course.

- **Quality**. The **Quality Emphasis** movement has had great impacts on the management of the operations management chain. This will be discussed in greater detail in a separate chapter. The focus on quality adds a whole new perspective to the management of operations. The focus and emphasis on quality has forced companies to change their focus from producing products to producing quality products. Some of the impacts on the quality emphasis movement that will be discussed in greater detail include:
  - **Lean/Just-In-Time**. The JIT movement was originally thought to be another great Japanese import in the 1970s. Shigeo Shingo and Taiichi Ohno developed

the Toyota Production System based on lessons learned from Dr. W. Edwards Deming. This concept is often misunderstood. We will address both Lean and Just-in-Time in a later chapter.

  - **Reengineering** emerged in the 1990s as a result of the books by Hammer and Champy. Their series of books prompted companies to look at reengineering the company and management. Unfortunately, for most of the companies that undertook reengineering (approximately 70% of all reengineering projects) failed. Most of these programs failed due to a lack of leader involvement. In 2009, they released an update on Reengineering that revealed that they had ignored a small part of the corporation. That small part was the people aspect. This ties back to our discussion of human resources.

- **Information Age/Internet Revolution** – Al Gore claimed during the 2000 Presidential Election that he "invented the Internet." And we all know that a politician would never lie to us. This invention was an expansion of previous research and with the availability of the internet to everyone, great strides have been made in operations management. Today it is hard to imagine a world without the internet. But it was not until the mid-1980s that this was available to the general public and it was the mid-1990s that most people finally got access and their own e-mail addresses. The availability of information and the ability to pass this information to almost anybody has impacted the management of operations while at the same time it has created a new set of problems for information security. Globalization and the Internet Age coupled with the Information Revolution provided a number of impacts to operations management, the biggest impact was the advent of electronic commerce or e-commerce.

- **E-commerce** provided operations management with new forms of businesses. These include business to business (B2B); Business to Consumer (B2C) such as consumers buying directly from a company from their website thus eliminating the need for a bricks and mortar operation or in conjunction with the bricks and mortar operation; Consumer to Business (C2B) as in a reverse auction site; and Consumer to Consumer (C2C). E-bay was originally designed to be a C2C business but has morphed over time to be both a C2C and a B2C as more companies are using E-bay to sell overstock and refurbished items.
- **Globalization of Supply Chains.** Just as the advent of the Internet impacted operations management, it also impacted the management of supply chains. With the Internet, companies can source from Asia, build in the States and sell to customers in Europe without ever speaking face to face with the supplier or the customer. Just as the Information Age added the problem of information security, the globalization of supply chains has added a whole new problem in the area of supply chain security. The problems associated with supply chain security will be discussed in a separate chapter.
- **E-commerce explosion**. With the growth of Amazon, the explosion of e-commerce continues to impact operations. The pandemic of 2020 has helped to continue the fueling of e-commerce as people continue to turn to safer ways to shop.
- **Internet of Things**. The internet of things comprises all of the devices connected to the internet from my coffee pot to my phone to my watch. Think of all the devices that you use every day that are connected to the internet.

- **Blockchain**. The latest development to impact supply chain management is blockchain. Developed originally to track the flow of bitcoin, blockchain offers the supply chain a digital ledger or chain of custody for products to pinpoint who did what, when it was done and identify issues in the supply chain.

Operations Management as a discipline

The operations management includes the product design process which will be discussed in detail in another chapter. A good design process includes not only the product design but also the process design or how the product will be made. Whereas the process design describes how a product will be made; the product design includes:

- Designing a product or service for a specific purpose—although sometimes the design for a specific purpose does not always end up with the product and purpose originally intended. Viagra was originally designed to be a product for high blood pressure but has obviously been more successful for other purposes.

  The post-it note was a by-product of an attempt to develop a new glue and a way for one of the designers to mark pages in his hymnal. Obviously, that mistake was a very profitable one for 3M. The product minoxidil was not originally designed to help grow hair, but a world class powerlifter and amateur chemist named Tony Fitton noticed the side effect of the drug and used the product to help balding males to grow hair.
- The design process sometimes includes the planned obsolescence of the product. Not a popular technique but it is used by computer designers and many other electronics product designers. The design process within operations management must include answering the question— “What should the product look like?”

- The design process has to also answer the question— "What should this product do?" The answer to this question should come from the needs of the customer and should come from the first step of Six Sigma according to Motorola. In an introductory course on Six Sigma at Motorola University, students are taught that the first step of Six Sigma has to focus on the customer and should answer three basic questions:
    - Define who the customer is.
    - Define what the customer wants.
    - Define how we do it better than the competition.
- What additional options and optional features should the product have? This is another question that the design process should answer. While deciding what new products to design and produce, companies also have to decide what products need to be improved and what products need to be phased out of production based on the product life cycle.

  Sometimes some companies discover that some products are better off not being altered. Companies such as Waffle House[3] (as shown in figure 1.8) and In-N-Out Burger[4] have

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[3] The simplicity of Waffle House can be seen in their visible food preparation operations that are on display for all customers to see while waiting for their food.

[4] The In-N-Out Burger chain was formed in 1948 in California. In-N-Out was the first drive in hamburger store and the first restaurant to use two way communications to order food at the drive in. The menu of In-N-Out has not changed since its inception and the process of fresh ground beef, fresh cut potatoes and fresh bread and vegetables has not changed since the first restaurant was opened by the Snyder family in 1948. Because of the link with the growth of the freeway system and the fresh products has contributed to contributing to the In-N-Out chain becoming almost a cult like following and customer loyalty. In-N-Out will only expand into areas that can be supported from their corporate owned and operated meat processing plants.

opted to keep the simple products simple. In-N-Out prides themselves on their simple menu. Keeping operations and options simple is not always a bad decision as the success of these companies show.

Figure 1.8: Simplistic Restaurant Food Preparation Area of Waffle House

Operations Management and Free Trade

Do free trade agreements really help promote more trade? This was the promise of the North American Free Trade Agreement (NAFTA). This promise was not as successful as promised as evident by the lack of "free" movement across the US–Mexico border for Mexican-based truckers. As a result, the United States-Mexico-Canada Agreement (USMCA) was signed in November 2018 (go to: https://ustr.gov/trade-agreements/free-trade-agreements/united-states-mexico-canada-agreement for more information of this agreement).

The Free Trade Agreement created by the formation of the European Union has been much more successful. Although the viability of that agreement will be tested when the exit from

the EU by Great Britain (Brexit) is completed. The Free Trade Zones within the United States have provided a form of improvement in the operations management chain by allowing products to come into the US FTZs, assembled into products and then shipped out without paying tariffs. The Free Trade Zone Colon in Panama is a classic example of the operations of a FTZ. The Colon Free Trade Zone (Zona Libre, Colon) is organized into two basic areas. The storage or distribution center area supports the "retail" area that allows companies from all over the globe to have store fronts for arranging shipments of products from Colon to the respective company's facilities without having to pay customs or duties on the products. Figure 1.9 shows the retail area of the Free Trade Zone Colon. Figure 1.10 shows another FTZ in Panama based out of the old Howard Air Force Base, now known as Panama Pacifico.

Figure 1.9 Inside the Retail Area of FTZ Colon

Figure 1.10 Diorama of the Panama Pacifico FTZ

Globalization and Competitive Companies

"With the storehouse of skills and knowledge contained in it millions of unemployed, and with the even more appalling underuse, misuse, and abuse of skills and knowledge in the army of employed people in all ranks of industries, the United States may be today the most underdeveloped nation in the world."

- W. Edwards Deming, *Out of the Crisis,* 1982

The globalization of corporations has impacted operations management while lengthening the operations management chain. Corporations have expanded globally in order to compete with other corporations globally.

Some corporations chose to expand globally in order to cut costs. At least the stated objective of offshoring operations and expanding globally was to cut costs and control more of the operations management chain and the supply chain from sourcing to manufacturing and to manufacture in a lower cost country. This has not always been the result. In some cases, the expansion has actually cost the companies more in transportation and supply chain inventory costs so that the expansion goals of cost cutting were not met. As we recover from the COVID-

19 Pandemic it will be interesting to see if companies reduce their reliance on foreign manufacturing and return to domestic operations.

Some companies have expanded globally in order to enter new markets. As we will see in the next chapter this has to be part of the overall corporate strategy and has to be researched carefully. Wal-Mart (see www.walmart.com) used this technique to expand into Germany. Germany had a discount chain that somewhat resembled a Wal-Mart SuperCenter known as Wertkauf. Wertkauf carried almost all of the things you would find at a Wal-Mart SuperCenter to include clothes, food, household goods, and recreational equipment. During my tour in Germany, this was one of my favorite local stores for shopping. Wal-Mart wanted to expand into Germany and saw Wertkauf as a logical expansion opportunity. The Wal-Mart culture and the German mindset did not mix leaving Wal-Mart with a failed expansion attempt and leaving Germany without Wertkauf.

To compete with local companies, it may be necessary to expand globally as Wal-Mart attempted to do in Germany and as Wal-Mart has done rather successfully in Mexico and China. In other cases, the only way to get into a market is to establish a "local" operation. In other cases, it may become necessary to compete globally to expand out of a corporation's home country. The Home Depot announced in 2012 the closing of their stores in China as a result of not fully understanding the market and the culture.

In the updated version of the 2007 Best Seller, *The World is Flat;* Milton Friedman looked at the globalization of companies and their supply and operations management chains that have become flattened by the globalization of operations. Friedman also discussed the outsourcing and offshoring of operations to other countries to take advantage of the resources of

the countries. Friedman's book is a detailed discussion of the globalization of companies, their operations, and their supply chains.

The Operations Management/Supply Chain Management Star

Several years ago, I developed what I call the Operations Management/Supply Chain Management Star to show the interrelations between these topics and the other business disciplines. The purpose of the star is to link all of the business disciplines together to enable you to see that operations and supply chain management cannot be accomplished without the other business disciplines and if you moved one of those into the center you could make the same argument for that discipline as well. The star is shown in Figure 1.11.

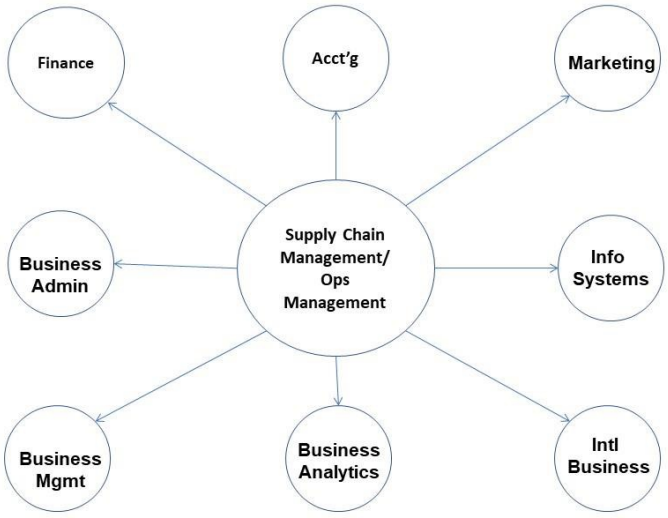

Figure 1.11 The Operations and Supply Chain Management Star

Summary

Operations Management is a complex subject that has impacts on every aspect of a business. A systemic approach to operations management looks at the inputs, the transformation

processes, and the outputs of an operation management chain. Operations management does not operate in a blind or a vacuum. Operations Management is a system of interrelated processes that include sourcing, manufacturing, distributing, and consuming products and services. This textbook and course will look at the processes and links that make up operations management and supply chain management.

Thinking and Discussion Questions for Chapter 1

1. How does the Department of Labor define services and products? http://www.dol.gov
2. What are the differences between goods and services?
3. What are the inputs to the operations management chain?
4. Discuss the operations management as a system?
5. How did the industrial revolution impact operations management?
6. Is there a difference between a purely academic approach to operations management and a practitioner's approach?
7. How does operations management relate to your major?

33

Chapter 2

Supply Chain Management

Supply Chain Management is a matter of vital importance to the company – the road to survival or ruin for the company. It is mandatory that it be thoroughly studied.[5]

As a result of the panic buying of 2020, everyone now thinks they know what a supply chain is, and the issues associated with supply chains – primarily based on the biased reporting of many "news" reports.

Prior to the COVID-19 crisis/pandemic of 2020 few people talked about supply chain management outside of the supply chain profession. After the panic buying and then the resultant shortages coupled with the excesses of agricultural products due to industry shutdowns, primarily the schools, entertainment, food service, travel and amusement park industries, all of a sudden everyone was talking about supply chain management and pointing at the supply chain as the reason for the shortages. It is always easy to blame someone or something for issues. The goal of this chapter is to provide insights into what a supply chain is and how it impacts daily life.

[5] A editorial change to the words of Sun Tzu in the opening verses of *The Art of War*

The issues associated with the supply chain and the COVID-19 panic buying clearly demonstrate the line I used to use with my Soldiers when I was in the Army: "Supply chains are invisible as long as everything works right. No one cares about the supply chain until something goes wrong."

The APICS Operations Body of Knowledge states, "In the simplest terms, supply chain management is balancing or synchronizing supply with demand."[6] The Supply Chain Council (a part of the Association for Supply Chain Management) describes the activities of the supply chain as going from the suppliers' suppliers to the customers' customers. In other words, the activities of sourcing raw materials, sourcing components, delivering the materials or components to a factory and once the products are made, the delivery of the products to the ultimate final customer. It also includes, as we will see in Chapter 13, getting the products back from the customer and replaced, repaired, or disposed of.

The APICS Dictionary defines supply chain management as: "The global network used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution, and cash."[7] This definition is one of the better definitions of the overall supply chain because it hits on a key aspect that is overlooked by most supply chain definitions—cash flow. I don't care how good your supply chain design is, if you cannot get the

[6] APICS Operations Management Body of Knowledge, 2nd edition, APICS, 2009, p. 21.

[7] APICS Dictionary, 13th edition.

cash from the customer in time to pay your suppliers and other creditors, you will not be in business very long. And you have to get the product to the customer in order to expect payment for those products.

After the attacks of 9/11/2001, there were several Anthrax laced letters delivered to politicians and other public officials. After the Anthrax scare in Washington, DC, in 2001, the US Postal Service location that received and processed one of the tainted letters was closed. The trickle-down problem from this closure was not discovered for about six months. It appears that the electric company that serves the District of Columbia had the payments for its services sent to a Post Office box in this closed down Post Office. About six months after the Post Office was closed, the electric company was trying to determine why it was losing money. The resultant research revealed that even though the Post Office building was closed to customers, apparently the mail was still being delivered there and the electric company's customers' payments were all at the closed facility.

Cash-to-Cash Cycle time is critical to supply chain success. This is a measure of how long after you receive payment for the products you sell that you pay your suppliers. In some cases it may be a positive cycle time which means your company is paying for the products before you receive them and sell them to the customer. If the Cash-to-Cash Cycle time is negative, it means that the suppliers are paid after your company is paid by your customers. At one point when Dell Computers was still in the Assemble to Order model in Texas, they had a negative 35-day Cash-to-Cash Cycle time—in other words, Dell was paying their suppliers on average 35 days after their customers paid Dell for their new computer.

Most textbooks tell us that the term supply chain management first appeared in *The Financial Times* about 1989. However, the term was first used in a series of papers published in the United Kingdom in 1982 by R.K. Oliver and M.D. Webber to describe the future of logistics and transportation. However, these papers remained internal to Booz Allen (the consulting firm was known as Booz Allen Hamilton at the time). It was not until a book was edited by Martin Christopher in 1992 that the public was able to read the papers that predicted that the new concept that Oliver and Webber called supply chain management would be the future of industry. Prior to this point the components that are now considered part of the supply chain management umbrella were stovepipe managed functions that reduced the efficiency of the overall system. By the late 1990s almost every company had adopted the concept of supply chain management.

By the mid-1990s everyone was wondering what this supply chain thing looked like and how to define what a supply chain was. In 1995, the Supply Chain Council[8] was formed as a partnership between commercial companies and major consulting firms to establish standards for this new corporate function. The Supply Chain Council developed the Supply Chain Operations Reference Model (SCOR) to describe the supply chain. The SCOR model is designed to provide a cross-industry standard for supply chain operations and metrics to improve and benchmark supply chain operations regardless of the industry.

[8] The Supply Chain Council was merged into APICS (now ASCM) in 2015.

The SCOR model depicts six basic functions that the Council deemed to be inherent to every supply chain. The original model contained four functions—Plan, Source, Make, and Deliver. With Version 9.0 of the model a fifth critical function was added—Return. This version of the Supply Chain Council model appears in Figure 2.1. In 2013, version 11.0 of the SCOR model added the function of Enable. The Enable functions includes all those activities that help to enable the supply chain activities. 2017 saw the release of version 12.0 of the SCOR. Each new version adds additional metrics, benchmarks and best practices to help better manage and measure supply chain management activities.

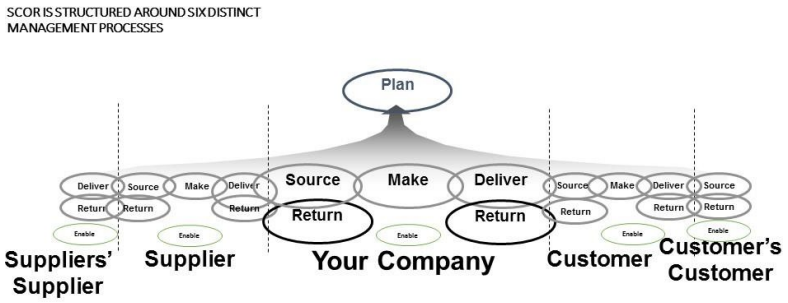

Figure 2.1: Supply Chain Operations Reference Model (reference: ASCM)

Why Is Supply Chain Management Important to Operations Management?

Supply chain expenses account for the majority of the expenses of a company. From a customer perspective, the supply chain may be all the customer sees of the company outside of

the Web site. The late Peter Drucker, a management guru of the twentieth century, wrote in 1982 that logistics and distribution was most likely the last frontier for cost reductions in business. According to most studies, the rule of thumb for most companies is that it takes approximately twelve dollars in increased sales to equal the same value from saving one dollar in the supply chain operations.

The ability to successfully operate supply chain functions is closely watched by Wall Street. The inability to distribute goods to the customer is very closely watched by financial analysts. In 1999, Hershey's had a problem delivering chocolate products to customers during the Halloween season, significantly impacting their stock price and earning them a place on the *Supply Chain Digest*'s "Top Supply Chain Disasters of All Time." Toys R Us experienced similar supply chain problems with the delivery of toys for Christmas in 1999.[9] Like Hershey's, this inability to meet customer due dates impacted their stock price and also earned them a place on the *Supply Chain Digest* list of disasters. In order to achieve supply chain excellence, it is important to carefully plan (part of the SCOR model) the synchronization of all supply chain functions to help the company achieve a competitive advantage. Lowe's firmly believes that their supply chain operations provide them with a competitive advantage over their competition. Apparently, their competition believed so also. In late 2009, The Home Depot announced a

[9] Toys R US outsourced their online sales distribution to a rather new company after this debacle. They outsourced to Amazon. Amazingly, when Toys R Us closed their doors in 2018, one of the reasons cited was the impact on their sales from Amazon.com. The biggest issue was their inability to pay their suppliers for delivered products

major revamping of their supply chain operations in order to become more competitive. By 2016, this program had once again elevated The Home Depot to the top of the home improvement store ladder. The synchronization of activities and functions has to link the flow of information, the flow of materials, and the flow of cash in order to achieve a competitive advantage.

With the panic buying of 2020, the supply chain has become front page news. Everyone now wants to talk about supply chain management and its ability or inability to support customers.

Supply Chain Information and Supply Chain Uncertainty

The globalization of supply chains is one of the themes of Milton Friedman's best seller, *The World Is Flat.* Friedman makes a good case for the flattening of the globe through the Internet and supply chain globalization. He concludes that the outsourcing and off-shoring of operations is what has leveled the playing field for all companies. As companies continue to globalize the supply chain operations of sourcing, making, and delivering of products (Source, Make, and Deliver from the SCOR Model), there are inherent risks that accompany the complexity of global operations. The risks will be addressed in the discussions and chapter on Supply Chain Security and Preparedness. Along with these risks are the inherent complexities of global operations.

Supply chain risks include forecasting and information flows. We will look at forecasting in greater detail in another chapter. The longer the supply chain is extended globally, the more fluctuations, uncertainty and information flows can impact the overall forecasts. At the same time, the more extended the supply chain is, the chances for distortion of information along

the supply chain becomes the greater. As we will see in later discussions of inventory management, this distortion of information is known as the Bull Whip Effect.

Other uncertainties in the supply chain come from customer ordering patterns. With the advent of the Internet, customers can order from the store or from the Internet sites of the suppliers. Along with this comes the batching of orders by brick and mortar retailers rather than placing an order every time a customer places an order. The result is that suppliers get batched orders from retailers and individual orders from their corporate Web sites. The ordering patterns of the customers, coupled with the batched orders of the retailers, impact the ability of the suppliers to accurately forecast demand patterns. The result is the need to carry insurance in the form of inventory.

The flow of information in the supply chain will help to reduce some or all of the uncertainties associated with supply chains. As supply chains have become more complex and global, the need to pass information digitally and capture information digitally has become more important. Coupled with this increased reliance on information systems is a need to protect the cyber systems and information.

Today's supply chains require a centralized and coordinated information system. World class communications is critical for supply chain success. FedEx has a world class communications system that allows it to track each package, every plane, and every truck. They also have the through their Digitally Assisted Dispatch System to communicate with every driver. BNSF railroad has a similar system to monitor the movement of every train in their system and communicate with the trains while in motion.

A world class supply chain communications system is critical for supply chain management success. Such a system enables companies to integrate their distribution management system, inventory management system, and inbound transportation systems with the production management systems and warehouse management systems. Because so many systems are necessary for a successful supply chain, the lines between Supply Chain Management and Execution Systems and Enterprise Resource Planning Programs have become blurred over the past decade. The supply chain information systems must provide visibility throughout the entire supply chain and provide the customer the ability to track the item through the delivery end of the supply chain once an order has been placed. Sometimes the tracking process is not accurate or does not provide detailed information as seen in Figure 2.2 and Figure 2.3.

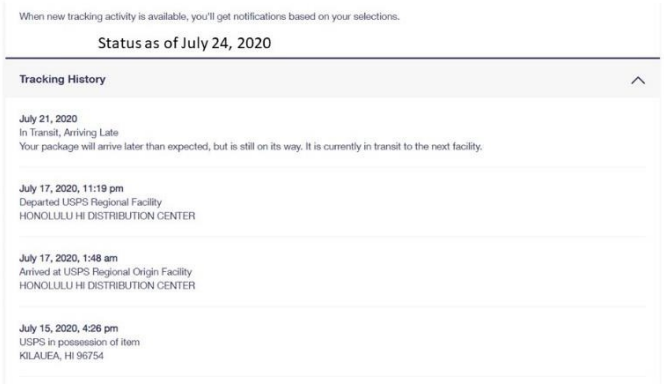

Figure 2.2 Status Update from USPS

Figure 2.3 Amazon Status Update

Radio Frequency Identification Tags are one method of tracking items in the supply chain and the use of Bar Codes allows UPS and FedEx to track every single package and parcel shipped and provides the customers the status of their respective packages.

Information within the supply chain may be passed in the form of **Electronic Data Interchange (EDI)**. The APICS Operations Management Body of Knowledge provides the following additional information on Electronic Data Interchange: "EDI is a way for a business to communicate with customers and suppliers. In North America, various industry groups establish and publish standards for standard transaction sets."[10] EDI is "the electronic communication of business transactions, such as orders, confirmations and invoices, between organizations. Third parties provide EDI services that enable organizations with different equipment to connect.

[10] The APICS Operations Management Body of Knowledge: Electronic Data Interchange

Although interactive access may be a part of it, EDI implies direct computer-to-computer transactions into vendors' databases and ordering systems."[11] Prior to the advent of the Internet, EDI was transmitted via private networks and in set formats. The order forms used for online ordering put the transaction information into a set EDI format for use by the company.

Wal-Mart uses their information system to pass supply chain information through their networks and to their suppliers. Wal-Mart's information system is so sophisticated that they are linked to the Center for Disease Control in Atlanta, Georgia to pass information on pharmaceutical related sales and issues.[12] Wal-Mart is able to use the point of sale data at the stores to pass information to its headquarters at Bentonville, Arkansas, and from there to Wal-Mart suppliers to help reduce the friction and bullwhip effect in their supply chains. This allows Wal-Mart to consolidate sales data from all the stores into one order to the suppliers. At the same time it allows Wal-Mart to pass the information to their suppliers as soon as a product is sold to assist the suppliers in preparing for the next resupply activity.

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[11] Electronic Data Interchange, http://www.answers.com/topic/electronic-data-interchange, accessed August 16, 2010.

[12] This makes one wonder what the CDC was doing with all of the information that Walmart was passing to them in February and early March 2020 concerning the sales of Lysol, Clorox, disinfecting wipes, toilet paper and other cleaning products. If the CDC was monitoring this information, maybe the warnings would have changed from "nothing to worry about" to "something to be concerned about" a little sooner.

The Bull Whip Effect

The bullwhip effect gets its name from the fluctuations evident in the movement of a bullwhip. You may have seen this type of whip used in some of the old cowboy movies. Basically, a bullwhip is about eight to ten feet long, made from braided strips of leather with a short (about 8-12 inches) wooden handle (think Indiana Jones). A small movement at the handle causes huge fluctuations of the end of the whip. An example of a bullwhip can be seen in Figure 2.4. This analogy is applied to the supply chain where small movements in customer demand at one end of the supply chain leads to huge fluctuations at the other end of the supply chain. The better the flow of information in the supply chain, the less distortion or fluctuations in the information flow results in less inventory in the system to cover the huge fluctuations previously seen in the supply chain.

The mantra in supply chain management in the late 1990s and early 2000s was "replace inventory with information." At first glance this seemed strange – "I can sell inventory, but I can't sell information." What was really being said here was that if we could get a handle on the distortion of information, we could reduce the inventory needed to cover the fluctuations and prevent stockouts.

Figure 2.4: A Bull Whip

Another critical use of information in the supply chain is to keep accurate information on the levels of inventories in the supply room or distribution center. A good information management system will update the inventory availability and inventory levels with every transaction. Why is this important?

Here is scenario that will help to make this aspect clearer. I recently purchased an item from a company's website. The company confirmed the order and even provided shipping status for the product. The day the product was supposed to arrive: "Thank you for your order. We are so sorry we are out of stock of the Item 7422. We issued a credit for them." If their system automatically updated their inventory levels, the initial order would not have been possible. This leaves you wondering, 1. How did this happen? And 2. How can you provide shipping status for a product that is out of stock?

If the inventory management system updates the balance and availability with each transaction the customer will know for sure that the item ordered is available. However, if the inventory management system does a batch update or in some cases a daily update, the items may have been sold and the inventory depleted before the update occurs. In this incident, the customer will receive the confirmation screen only to receive a message the next day that the item is not in stock and will be back ordered and shipped at a later date if the customer does not cancel the item.

Supply Chain Information and Electronic Commerce

With the dependence on supply chain information management systems and more and more companies moving from a strictly "brick and mortar" company to a hybrid company with both "brick and mortar" and e-commerce capabilities the dependence on a quality supply chain management information system is even more critical.

Karl von Clausewitz wrote about military theory in the early 1800s. His work, *On War,* is mandatory reading in most advanced military schools. From a commercial industry perspective, one of the things that Clausewitz said, all things change when you go from the abstract to the concrete, simply means that academic theory does not always work in the real world. Some of the theoretical advantages of electronic commerce from a supply chain perspective sound great in theory, however they do not sound as good when we move from the abstract to the concrete.

- Theoretically, the information systems available coupled with globalized supply chains connected via the Internet should provide companies with reduced prices and costs. The reduction in prices should come from the ability to increase competition for the raw

materials and products as more suppliers become available via the Internet. The theoretical reduction in costs should come about as a result of the reduction in travel expenses and the ability to outsource manufacturing to developing companies. These theoretical cost decreases could be passed on to the consumer or retained as profits for the company. Additional cost reductions should come about as a result of automating previously manual systems and processes.

- Savings from automating manual processes assumes that the manual processes were actually necessary. If the processes are not needed under the automated system, there will not be any savings to the supply chain. All too often when automated systems are put into place, there is not a good analysis of left of baseline and right of baseline requirements resulting in unnecessary automated processes.[13]

Savings from automation also assume that the proper system is implemented. If the new Enterprise Resource Planning program does not improve the overall supply chain operations of

[13] For every conversion from manual to automated processes a detailed analysis is required of all the processes. The first step is to determine if the processes are value added and needed under the system (known as a left of baseline analysis). After non-value-added processes are eliminated, a test run is necessary before going "live" and then a detailed analysis of the new automated system to make sure everything worked as planned and is a necessary step in the process (known as the left of baseline analysis). When the US Army went to a more modern automated supply chain system in the mid-1990s, a careful analysis of the processes and a process walk determined that some of the processes that were included in the automated systems were outdated and not needed with the new system. This required an Engineering Change Package to update the new system without the unnecessary processes.

the company, then there will be no cost savings. For example, Digital Equipment Company spent approximately $35 million on an ERP system only to find out that the new system was not as good as the old system.

- Electronic commerce has enabled supply chain companies to shorten order cycle times by enabling customers to place orders online. Prior to this the only options for ordering items from a company was to order from the catalog, order and pick up at the retail facility, or place the order at the distribution center or factory. Supply chain information systems shorten this ordering process thus shortening the entire customer order cycle time. Reducing the customer order cycle time produces more satisfied customers, thus producing more commerce.

Bar Codes and RFID Tags

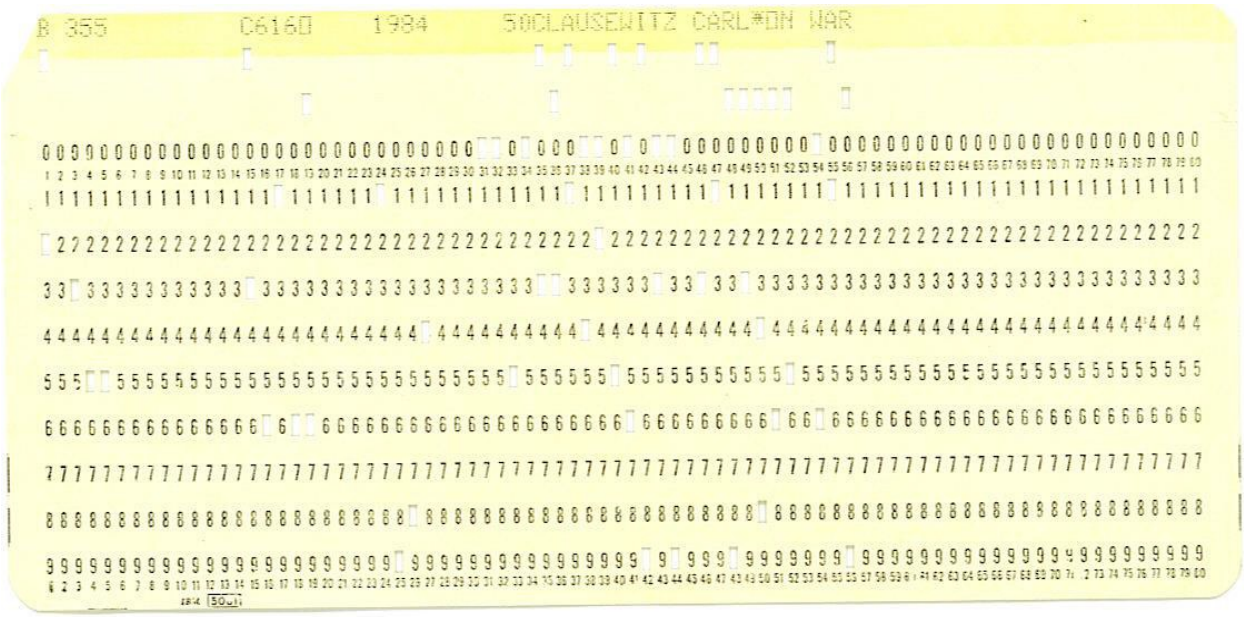

Figure 2.5: 80 Card Column Punch Card

Before the use of Bar Codes and Radio Frequency Identification Technologies to track items in the supply chain and provide "visibility" in the supply chain items were tracked, inventoried, and ordered using the IBM 80 card column punch cards as shown in Figure 2.5. The problem with the punch cards was that they came in a box of several hundred cards to the box. For a warehouse with several thousand items to be inventoried it required printing/punching a card for every stock numbered item prior to the inventory. Usually the punch card "printer/reader" was not in the same location as the warehouse. This resulted in having to transport the boxes of cards to the warehouse.

> On one particular day in Hawaii, I watched a box of cards get blown out of the hands of the warehouse worker who was transporting the cards. As strong as that wind was, I am convinced that the cards were scattered all across the islands. The result was a day delay in starting the inventory process.

Bar codes made their appearance in the early 1960s. The US Army started the use of bar codes to track and inventory equipment. The goal of the Army's systems (LOGMARS – Logistics Marking System) was to put a bar code on every vehicle before it was shipped to Viet Nam. The process proved to be cumbersome and expensive and was dropped before it could prove its value. Perhaps a little testing would have prevented the loss of visibility of products being shipped into Viet Nam.

Bar codes are a series of vertical lines and spaces. The Universal Product Code has a series of digits. Prior to 2005, the United States and Canada used a 12 digit product code but

moved to the Universal Product Code (UPC). The digits in the bar code identify the country of origin, the company that made the product, the product itself and a digit that is assigned to verify that the code was properly read (Figure 2.6). The UPC is a one-dimensional bar code meaning it can only be read in a certain sequence. The use of the bar code enables the company to capture point of sale data that can be used to reduce some of the uncertainty in the supply chain and provide information to suppliers. Figure 2.7 is an example of a two dimensional or 2D bar code that can be read from multiple angles (some references call this form of bar code a QR Code). Figure 2.7 is an example of a two dimensional or 2D bar code that can be read from multiple angles. Bar codes are also used for item identification purposes as shown in Figure 2.8.

Figure 2.6: Example of a Universal Product Code

Figure 2.7: 2D Bar Code (also known as a Quick Response or QR code)

Figure 2.8: Identification Bar Code

Radio Frequency Identification Technology and Supply Chain Information Systems

Radio Frequency Identification Tags will be discussed in greater detail under process design; however, these tags have a large part to play in today's supply chain systems. The use of RFID tags has been the promise of the industry for several years as the best way to track and identify items in the supply chain. The use of RFID provides the benefits of scanning that bar codes provide but also enable quicker inventories and more accurate inventories through the use of the scanners. The problem with RFID tags is three-fold. The first major problem is the cost of the tags and the infrastructure to read and store the tag data. This is no small investment. The second problem is that RFID tags cannot be read through liquids, can only be read from close distances, and may not be compatible with products such as cell phones. The third problem is that until 2018 no one was working on an encrypted RFID tag to protect company information.

Gillette started a program in 2001 to track Mach 3® razors in the supply chain. The company was losing visibility of the product and was losing money on these loses. The cost of

the tags was about $0.75 a piece making the test an expensive one. However, the company discovered that the losses were not a result of internal or even external theft. The test with the razors revealed that the expensive razors were being mishipped to retailers. As is usually the process in supply chain issues the customers that received too many were not complaining and the customers that were shorted were quick (as they should be) to identify a short shipment. This test enabled Gillette to solve their supply chain problem. Figure 2.9 shows an RFID tag on a pallet in Kuwait.

Figure 2.9 RFID Tag on a Pallet

Information Benefits and Drawbacks

A good supply chain information system will enable the company to replace inventory with information. This always sounds like a bold claim. How is it possible to sell the customer a product if all we have is information? The goal is not to get rid of inventory all together but if a company can get better information in their supply chain operations and between their supply chain partners, the need to have excessive piles of inventory to cover the fluctuations in information flow in the supply chain will be reduced. If the need for the piles of stuff is reduced throughout the supply chain, then as the inventory levels decrease across the supply chain it gives the illusion that the inventory has been replaced by information. Actually, it is not an illusion, the better and the more accurate the information the ability to reduce inventory is enhanced and supply chain costs are reduced.

Better supply chain information systems lead to a better flow of information. This leads to better collaboration between supply chain partners. Better information flows, better collaboration, and reduced variability in the supply chain lead to shorter cycle times to make and distribute products. Shorter cycle times lead to greater customer satisfaction and this usually leads to higher profit levels.

However, there are downsides of sophisticated supply chain information systems. The first is that they are more vulnerable to cyber security issues. As we will see in the chapter on Supply Chain Security, security/preparedness is a very large problem in today's supply chains. Cyber security risk is an ever-increasing problem. Another downside of e-commerce and supply chain information systems is that more and more companies are learning that just having a great Web site is only part of the success equation. The other half of this success equation is the ability

to get the product delivered to the customer. There is a direct link between the capability of the supply chain information system and success of the company.

Sourcing—Finding Suppliers, Cultivating Suppliers, Partnering with Suppliers

"Sourcing decisions are important within the supply chain and rely on standards and policies being maintained."[14]

As purchased supplies, parts, components, and materials account for almost half of all manufacturing costs it is important to pick the right suppliers and sources of supply. It is equally important to collaborate with suppliers to share information to reduce the variability in the supply chain and it is also important to cultivate your suppliers.

Just what does cultivating suppliers mean? Part of the cultivation process is to get suppliers to work with your company. It also includes working closely with the suppliers to get win-win terms and better products. By working with the suppliers, it strengthens the supply chain. Because the supply chain is only as strong as its weakest link, by working with suppliers and helping suppliers develop their employees while understanding the needs of your company better, the company ensures that they are not the weakest link. Cultivating suppliers means seeking to understand what drives them and establishing long-term relationships with the suppliers.

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[14] APICS Operations Management Body of Knowledge, 2nd edition, APICS, 2009, p. 12.

Partnering with suppliers makes sense when a holistic view is taken of the supply chain. In the days when all of the functions of what is now called a supply chain were under separate silos, partnering was not always sought with suppliers. When the entire supply chain is viewed as interdependent, it becomes obvious that supply chain partners should work together. As we saw in the product development phase, by partnering with suppliers may very well produce better quality products.

Sourcing is important whether it is for purchasing raw materials, component parts or services that the company needs in the process of manufacturing products. Sourcing is also important in the form of outsourcing when a company makes the strategic decision to outsource processes or services that are not deemed to be the core competencies of the company. Outsourcing has become a strategic decision and not just a short term fix for capacity or manufacturing shortfalls.

Single sourcing can trace its roots to Just-in-Time and the 14 points of quality set forth by Dr. Deming. One of the concepts of Just-in-Time is the idea of establishing long-term relationships with suppliers. This is the concept of single sourcing. Single sourcing is often confused with sole sourcing. So, it is important to explain the difference between the two.

Single sourcing occurs when there are multiple sources for the product, raw material, or service. However, even though there are multiple suppliers or sources of supply, the company or purchasing agents choose to go with one supplier. It is like going to the grocery store – there are multiple grocery shopping options in almost every town. However, most consumers shop the same store habitually. It could be because of the selections, the prices, the fuel points, or simply

because it is convenient and on the way home. Whatever the reason, choosing to do business with one source when there are several or many sources is still single sourcing.

Single sourcing has advantages and disadvantages. The obvious advantage is the partnering with one supplier. The fortunes of both companies may be tied to this partnership and single sourcing decision. The biggest disadvantage of single sourcing is putting all of your eggs in one basket. If there are multiple sources but the company chooses to use only one source and that source goes out of business or has financial difficulties as several automobile manufacturers recently discovered, there will be a big problem. If the company does not do any business with the other available suppliers or sources and then is forced to do business with them, the company may find out that the capacity is not there to meet the needs for manufacturing or may end up paying more for the product or service than was originally budgeted for.

Ok, so what is sole sourcing and how does it get confused with single sourcing? Sole sourcing is when only one supplier or source of supply is available for the commodity or product that the company needs. The limit to a sole source may come as a result of a patent or scarcity of the commodity or product.

In US Government procurement and sourcing there is a law that anything over $10,000 has to go out for competitive bid. However, there is often a misuse of “sole sourcing” to get around this law. The term sole source is often used when in fact there is a desire for single sourcing but as a way to get past Government contracting regulations. Although legal, it is not necessarily ethical. Care is needed in sourcing to ensure that ethics are applied to the supplier sourcing decisions.

Distribution

Here is an example from a recent posting to the Federal Business Operations Web site. One particular US Government office wanted a course in leadership for its executives. In order to bypass the guidelines of the Federal Acquisition Regulation for competition and bidding, this particular agency stipulated that this contract was to be a sole source contract as only one company had taught this particular course in the past. A little research revealed that this particular course had only been taught once before. Was this sole source company the only company capable of teaching a leadership development course for new executives? Of course, not. But since this course had only been taught once before, by stipulating that the company had to have taught the course before made this a de facto sole source contract when it should have been a single source decision.

This is the supply chain function most frequently referred to as logistics. Distribution is the physical movement of products forward in the supply chain. It includes the movement between storage facilities and from storage facilities to the end users. The receipt, storage, picking of the product, and the shipping of the products are part of the distribution functions. In order to be successful in today's supply chain operations, speed is critical in distribution operations.

Under the Distribution umbrella is the operation of warehouses and distribution centers. Warehousing and distribution are often used interchangeably. They are not the same thing and

should not be used as interchangeable terms. We will look at distribution in greater detail in another chapter.

Warehouses focus on the storage aspect of the distribution umbrella. Warehouses are usually smaller than distribution centers. Warehousing is not a new industry. Prehistoric drawings indicate that early man stored food to get through the long winters. In Biblical times, Joseph ran the warehouses for the Pharaoh in Egypt as early as 1718 BC, leading to the Israelites' journey to Egypt and the resultant Exodus led by Moses back to Israel. History is filled with stories of warehousing of various goods and food stuffs.

Warehouses can take the form of product-focused warehouses such as a cold storage and wet storage warehouses for food or a dry storage warehouse for items with longer shelf lives that do not require wet or cold storage. Warehouses can also be long-term storage facilities. These facilities may be collocated with a distribution center or feed the distribution centers but should never be confused with distribution centers. For example, the Federal Emergency Management Agency operates warehouses for storage of disaster contingency operations. Some of these items may remain in storage for over a decade.

Distribution centers, on the other hand, focus on the rapid movement of the goods through the supply chain. Some of the largest industrial buildings are distribution centers. The average new distribution center today is in excess of one million square feet. In 1998, at the Warehousing Education and Research Council Annual Conference in Anaheim, California, a large number of distribution executives were heard to complain that warehousing was going to

become obsolete as a result of the advent of the Internet and online retailers selling direct to the consumer. It was similar to Chicken Little running around crying, “the sky is falling in.”

These executives were partially right. Warehousing and Distribution as it was known in the 1990s went away but resurfaced as a totally reformed industry. The advent of the Internet and the ability of the customer to order individual products online changed the distribution industry in two large ways. The first change in the distribution industry and distribution centers came as a result of the individual customer order quantities.

With customers ordering directly from the companies’ web sites a new organization for the distribution centers was required. Now distribution centers were required to have a single item pick area, a case lot pick area, and pallet storage or bulk storage. A single pick area is where distribution workers can pick individual items to meet customer orders for eaches. This is an addition to the traditional case lot pick areas to support retail store orders and the pallet storage or bulk storage areas in the facility supports the restocking of the case pick and single pick locations in the distribution center. Some companies have moved to fulfillment centers or distribution centers that only serve e-commerce sales rather than try to mix e-commerce support with brick and mortar store support operations.

The second impact to the distribution centers as a result of websites is the addition of a returns area as a result of customers returning items ordered over the Internet that did not meet their needs. The impact of reverse logistics will be discussed in greater detail in the chapter on Reverse Logistics.

The addition of the single picking area and the returns processing areas to the distribution centers not only added more responsibilities to the distribution centers it also added a requirement for more space to the distribution centers. So, the executives may have been wrong about warehousing and distribution going away, but in a way, they were right in saying that distribution centers and distribution operations have changed dramatically with the advent of the Internet.

Another change is the concept of postponement. The change started with the increased competition in the distribution industry because of Third Party Logistics providers—known as 3PLs. A Third Party Provider is a company that only focuses on supply chain and logistics operations as their core competency. Postponement is a value-added service provided by the distribution center. These value-added services may be a simple as placing price tags on the products before shipping from the distribution center.

Distribution Information Systems

Warehouses and Distribution Centers are not the same thing. Warehouses tend to store products for longer periods of time. While warehousing (storing products) takes place in Distribution Centers, the storage period is much shorter. Some of the confusion comes from the fact that the term warehouse has been around for almost four thousand years. And part of the confusion between distribution centers and warehouses comes from the fact that both type facilities are managed by sophisticated automated management systems that are simply referred to as Warehouse Management Systems or WMS. These automated systems started out for the management and automation of warehouses and as warehouses starting morphing into distribution centers, the name of the system did not change.

These systems have become very sophisticated over the past 20 years. A good WMS will not only provide the distribution center with instructions on what should be placed where in the center (this is known as slotting[15]) but will also provide the workers with the picking lists. A pick list provides the workers with the instructions of what items on the shelves need to be "picked" and prepared for shipment to the customer. The newer WMS will also provide the workers with the packing instructions and a good WMS will also provide the loading plan for the outbound trucks.

In addition to automating the receiving, storage, picking, packing, and shipping of the goods in the warehouse or distribution center, a WMS may provide management of the outside storage areas and may also provide a system for time and attendance accounting. In one implementation we used the WMS in conjunction with an RFID system to track workers arrival and departure times as well as tracking productive time and break times. This data not only identified nonproductive activity by some of the workers, but it also enabled the distribution center to forecast employee requirements and scheduling needs.

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[15] Slotting is the process of placing items in the distribution center or warehouse. Slotting may be either random where any vacant slot can be used for the next inbound item or the slotting may be dedicated slotting. In dedicated slotting, every item has a set location in the facility which leads to worker familiarity of the locations. In random slotting the primary advantage is that spaces do not sit empty waiting for its assigned goods to be replenished. This helps to optimize space utilization but also takes away the advantage of the dedicated slotting of knowing where items are always located.

Transportation

A very important part of the supply chain umbrella is Transportation. The US Army transporters have a saying, “Nothing happens until something moves.” This is true in the commercial supply chain. You can have the best distribution center, you can have the best manufacturing facility and the best product on the market, but if your company cannot deliver the product due to a lack of transportation assets, your supply chain is a failure.

The supply chain is a system of interrelated activities. The key here is that the system is a chain of operations that depend on each other to be successful. Transportation is part of this system of interrelated activities. In the transportation world there are modes of transportation and transportation nodes.

The modes of transportation include railroads, highway transportation, water transportation nodes (to include ocean movements and barge movements), and air transportation. The nodes within the transportation network are the locations where shipments are placed on one of the modes of transportation. Nodes include rail sidings, ocean terminals, rail terminals, airports, distribution centers, and cross-docking facilities.

Transportation may take the form of intermodal operations. Intermodal operations are simply freight moving by more than one mode of transportation. Intermodal could be rail to truck, ocean carrier to truck to rail to truck or even truck to air to truck. International freight most commonly becomes intermodal freight as the ISO (International Standards Organization) twenty- and forty-foot containers move from a ship docking on the West Coast to a train for movement

East and then by truck to the distribution center or retail facility. Figure 2.10 shows intermodal operations on a train transporting containers that were initially transported via ship.

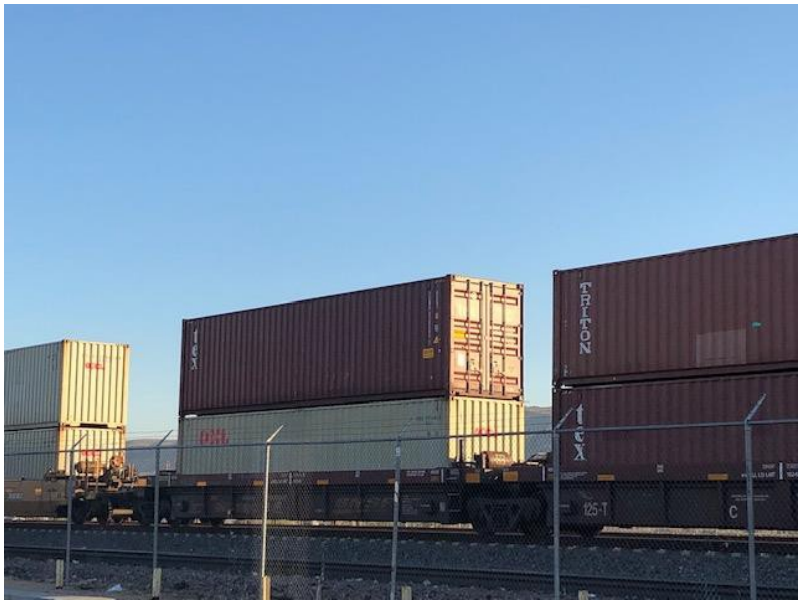

Figure 2.10: Intermodal shipment of containers in Barstow, CA

Rail

There are certain commodities that can only move by rail. Coal is an example, and some chemicals can be more safely transported by rail than by truck. Having worked for the railroads for a short time, I know that the major rail companies are working hard to become more user-friendly. BNSF, for example, established a contract in 2004 to work with the US Military to provide better service while determining the real transportation requirements. The use of double stacking of rail cars is another example of efforts to improve service. Another example of the rail

companies working with their customers to improve service is the covered, bi-level car carrier rail cars. The automobile companies complained to the rail companies about the damages that their cars were incurring during the shipment from the West Coast to other parts of the United States. With the threat of losing this lucrative business, the rail companies designed the covered car carrier to protect the cars while in transit on the trains. Figure 2.11 shows rail operations at Yermo, CA. In this picture, military vehicles are loaded onto the rail cars for shipment back to their home stations after being used in desert training at the US Army National Training Center. These vehicles are moved via truck to the National Training Center and then by truck back to the Yermo Rail Yard.

Figure 2.11: Rail Operations in Yermo, California

One of the disadvantages of rail is that it is slower than other modes of transportation. Although weight-wise the majority of freight in the United States moves by rail, rail movements

are considered inflexible. Rail is considered inflexible because in order to use rail as a mode of transportation requires a rail siding. Whereas a truck can deliver almost anywhere, a shipment by rail requires a rail siding in order to offload the shipment. Figure 2.12 shows a rail siding/spur for loading and off loading equipment and vehicles from the rail cars.

Figure 2.12: Rail Siding for Off-loading Equipment and Vehicles from Rail Cars

On the flip side the advantages of rail include the fact that as mentioned earlier, certain commodities and oversized products can only move via rail. With the advent of the ISO shipping containers in the late 1970s, the use of rail for intermodal shipments increased dramatically. Because of the cost, intermodal shipments can move across the country on rail cheaper than

trucking the goods across country. Another advantage of rail is the concept of trailers on flatcars or moving semi-trailers on the flatcars and then hooking a tractor to the trailer at the off-load site. Figure 2.13 shows commodities that can only move on rail cars (737 air frames) loaded on special rail cars for shipment to the assembly plant in Washington State.

Figure 2.13: Airframes on Rail Cars for Shipment

Ground/Road/Truck Transportation

The majority by volume (not weight) of the freight in the United States moves by truck.[16] The trucking industry is divided between Truckload and Less Than Truckload companies. Truckload companies only move full truckloads of freight. Customers receive a flat rate for the entire truck. This rate for the full truck load is less than the cost of shipping less than truckloads. This is possible because the customer is only having the products delivered to one location.

Less Than Truckload (LTL) firms charge the customers a piece rate based on the weight and cube of the items. LTL firms usually consolidate multiple shipments to form a full load. LTL is advantageous to those companies that do not need to hire a full truckload (TL) for their products. LTL companies can team up with freight consolidators like Freightquote.com to get full shipments. Companies like Freightquote.com[17] use computer software programs to match the excess shipping capacity of shipping companies with shipping requirements of customer companies to provide a win-win-win situation. The shipping companies win because they get full loads and fill up their excess capacities to help optimize profitability. The customers win because they get basically TL equivalent rates for their shipments. And, Freightquote.com gets a commission for matching shippers with customers. Over the past few years Freightquote.com has

[16] Approximately 70-75% of all of the individual items that move in the US move by truck at some point in the supply chain.

[17] For more information on freightquote.com go to www.freightquote.com

moved into matching shipping requirements for international and intermodal shipments in addition to LTL and TL shipping.

The advantage of truck transport over rail transport is the ability to move smaller packages and the ability to deliver to almost any site as long as material handling equipment and a dock or mobile ramp is available. The disadvantage of truck transport is that certain items are not transportable by truck. The advantages of truck are the disadvantages of rail and the advantages of rail are the disadvantages of trucking. Another problem with trucking in the twenty-first century is the aging of the truck drivers. The projection is that there will be a shortage of ten thousand drivers within the next ten years. The growth of e-commerce only adds to the shortage of drivers.

Small Package Carriers and Air Transport

Federal Express (now known as FedEx) was formed by Frederick Smith in 1971 and started providing express shipments in 1973. FedEx established its headquarters in Memphis primarily because the weather in Memphis. As FedEx expanded its operations through expansion and acquisitions, the services and options to deliver "the world on time" became more expanded. To ensure the overnight delivery promise, FedEx controls all operations from their Worldwide Operations Center in Memphis in the facility previously housing the Holiday Inn Reservations Center. This facility has multiple large screen displays of weather, flights, and package shipment information.

FedEx flies an empty plane from the Northwest United States (Seattle/Tacoma, WA) daily down the West Coast and then across the country to Memphis as a precaution and an empty

plane from the Northeast United States (Portland, ME) down the East Coast and across to Memphis as backup in case one of the scheduled FedEx planes is forced to make a precautionary landing or has mechanical problems. These planes help ensure that FedEx can deliver the "world on time."[18]

As operations are expanded to International deliveries, "the world on time" can be defined by the customer—the options include next day morning, next day before 10:00 a.m., before noon, afternoon, second day, and now FedEx ground. One of the value-added services that FedEx now provides is customs clearance for International shipments. In fact, in the Memphis Hub for FedEx there is an entire floor dedicated to customs.

United Parcel Service has been delivering packages for over 100 years. Although started in 1907, it was not until 1982 that UPS started offering second day air service in addition to its package service. Another small package carrier, DHL, was originally formed in 1969 in California. In 1998, DHL was purchased by the Deustche Bundespost, the German postal and communications company.

The growth of Internet companies coupled with the desire of customers to have their products "now" have led to the growth of the small parcel and air transport companies. These companies offer the ability to ship relatively small packages (usually under 400 pounds) with

[18] During the 2020 COVID-19 Pandemic and corporate shutdown by government decree led FedEx to temporarily suspend their on-time guarantees.

relatively accurate shipping and delivery. In addition, the ability to track the packages not only makes this service popular with customers but also increases customer expectations and satisfaction. Some of the companies offer better online tracking than others.

Small parcel shippers offer this service at a relatively high cost when compared to other modes of transportation. However, this is relative. If the customer wants a product tomorrow or needs the product by tomorrow, then the question becomes, “is it better to pay for premium air transportation or let the customer go somewhere else?”

Water Transport

Figure 2.14: Barge Movement

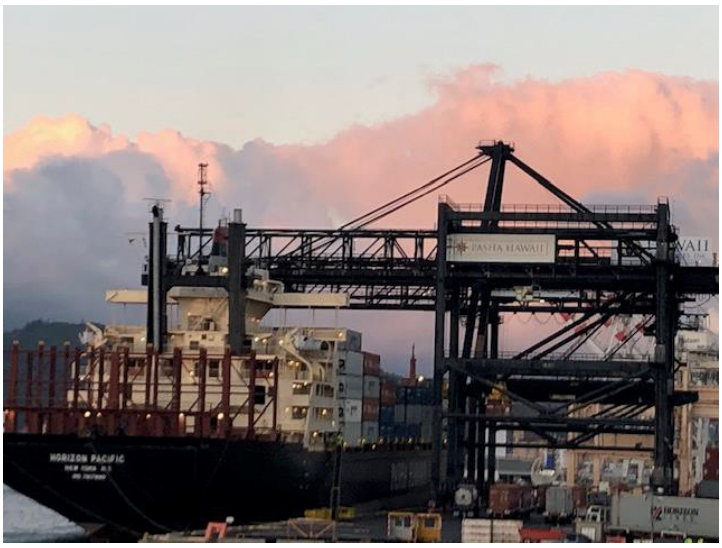

Figure 2.15: Ocean Movement – A cargo ship being off loaded in the Port of Honolulu

Water transportation is one of the oldest forms of transportation and may take the form of barge movements as shown in Figure 2.14 in Honolulu Harbor and used with great frequency in the United States on the inland rivers and throughout Europe to clear the major ports and move goods inland to the interior countries. There are over 900 barge movements daily out of the Port of Rotterdam into Central Europe.

Water transportation may take the form of ocean shipments as shown in Figure 2.15. This figure shows a ship being off loaded in the Port of Honolulu. Ocean shipments are the most common form of International shipping with over 500 million containers (Twenty Foot Equivalents) moving around the world on ships.

Some products must be moved via water. The sheer volume of materials coming out of Asian Countries prohibits movement via air. The Panama Canal recently completed construction of new, wider locks to accommodate the larger vessels moving this cargo around the globe. Figure 2.16 shows one of these ships moving in the newer Cocoli Locks.

Figure 2.16: Ship moving through the expanded Panama Canal locks

When it was constructed in 1912-1913, the canal was built to accommodate the widest military ships at the time. This constraint from one hundred years ago limits the size of ships through the canal to about 5,000 containers. The expanded canal now accommodates ships up to 14,000 containers. After the construction started on the new canal locks, Maersk Lines introduced a new cargo ship that can move up to 18,000 Twenty Foot Equivalent containers. The picture in Figure 2.17 shows a ship moving through the older locks of canal.

Figure 2.17: Movement through the Panama Canal Gatun Locks (Pacific to Atlantic Transit)

The advantage of water transportation is that it can move bulky items internationally and intra-nationally. Water transport is inexpensive compared to trying to ship items internationally via air and obviously movement between continents is easier and, in some cases, only possible using water. The disadvantage of water movement is that it is slower than other modes of transportation. This disadvantage became exacerbated in 2009 when the Maersk Lines announced that they could save $1 billion (USD) by cutting transit speeds in half. This immediately doubled the shipping times and at the same time increased dramatically the amount of goods in transit and not available to the customers. Couple this decrease in shipping speeds with the slowdowns resulting from security concerns and the movement of goods via water becomes a longer supply chain with increased risks.

Pipelines

One other mode of transportation should be discussed to complete the transportation aspect of supply chains—the movement of products via pipelines. Although experiments have been ongoing for years to move slurry coal via pipelines, the most common use of pipelines is for liquid products such as water or petroleum products. The advantage of pipelines over other modes of transportation is that the pipeline can be put in place and move large quantities of liquid products over any type of terrain and in almost any weather condition. The use of pipelines is relatively secure except when folks take pot shots at over ground pipelines as happened in Alaska a few years ago. When this happens, there are problems. Security is not always assured as the US Army discovered during the war in Viet Nam—during this operation, the Army lost as much product to pilferage and theft as it delivered every day.

Pipelines have a relatively high initial cost to dig the foundation and lay the pipeline. However, after the pipeline is in operation, the costs of operations are low. A little pipeline maintenance is needed occasionally as seen in the James Bond movie, *Diamonds Are Forever*, in the early 1970s. An occasional welding job inside the pipeline is needed and some minor preventive maintenance is needed on the pipeline and its pumps but for the most part the pipeline needs very low maintenance. There is a pipeline that runs through Leavenworth County in Kansas (Figure 2.18) and the Central European Pipeline provides product throughout the European Continent.

Figure 2.18: Pipeline running through Leavenworth County, Kansas

Illegal Supply Chains

No discussion of supply chains would be complete without at least a short discussion of some of the illegal supply chains in operation. Figure 2.19 and 2.20 are two of the animals that are illegally hunted for some of their parts. The rhino in Figure 2.19 is hunted and killed for the horn. The rest of the animal is left to rot. In 2019, a group of hunters seeking to poach and kill rhinos accidentally stumbled into a pride of lions – these hunters became a readily available food source for the lions. Apparently in some cultures, the rhino horn is seen as an aphrodisiac – problem is that the horn of the rhino is the same collagen in your fingernails. The elephant shown in Figure 2.20 is hunted for the ivory in their tusks.

Figure 2.19: Rhino in the wild – illegally hunted for their horns

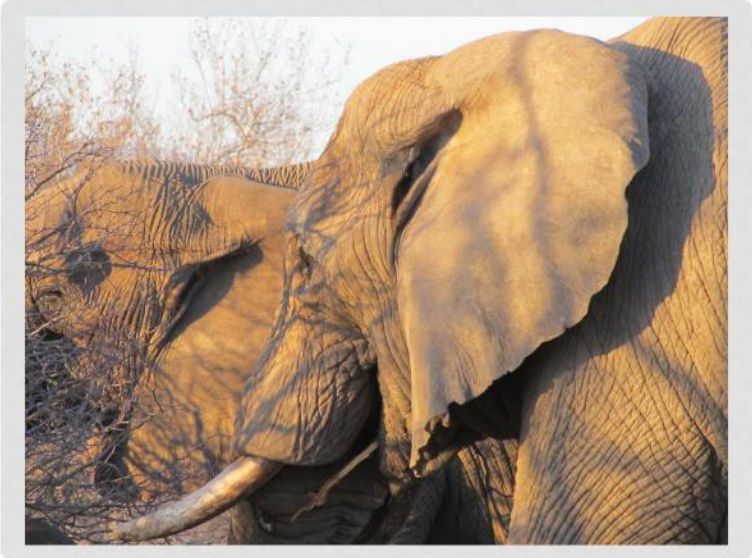

Figure 2.20: Elephants – illegally hunted for the ivory in their tusks

This concept of hunting animals for a part of their body is not new. Some estimates place the Buffalo population in Kansas in the 1860s at approximately 16 million. Buffalo tongue was

considered a delicacy on the east coast of the US and hunters would kill the buffalo, cut off the tongue and leave the rest of the animal to rot. Compare this to my ancestors who would only hunt for food and other needs and would use the entire animal for their needs. Today there are only a few buffalo in Kansas – there are some outside the gate of Fort Leavenworth, a few at Fort Riley and some herds raised for meat. We have to be conscious of what we are doing in the supply chain and think about sustainability.

Summary

In 2005 (updated in 2007), Thomas Friedman wrote *The World Is Flat*. This *New York Times* best seller postulated that the globalization of supply chains has significantly contributed to the "flattening" of the world. The globalization of supply chains has opened the doors to many companies and countries using the Internet. The opening of trading partners and trade agreements has helped to extend supply chains. The European Union is a good example of a trading partnership/trading bloc that has helped to globalize operations by creating stronger bonds and using the trading blocs to help take advantage of the advantages of economies of scale to improve supply chain operations.

The downside of globalized supply chains is tied to security and quality. The sheer numbers of containers moving around the world contributes to supply chain security issues as does the extended supply chains that are more open to terrorist interdiction and disruption of the supply chain. Sourcing from unknown sources around the globe can and in some instances creates quality issues and concerns.

Everything is supply chain related from sourcing to delivery of the finished product. The SCOR Model describes the supply chain as reaching from the suppliers' suppliers to the customers' customers and includes the basic functions of Plan, Source, Make, Deliver, Return and Enable (this textbook is organized around those functions). Everything we do in any part of Operations Management is related in some form or fashion to Supply Chain Operations whether we are in the business of providing goods or services to the customer. To be successful in Operations Management, a company has to be successful in supply chain management.

Discussion Questions

1. What is the difference between warehouses and distribution centers?

2. Many discussions of supply chains use the terms logistics and supply chains interchangeably. Is this accurate or are the two different? If they are different, how do they differ?

3. What are the advantages of the different modes of transportation?

4. Logistics was derived from the Military as a concept. In today's supply chain, what function is closely associated with the military logistics concept of moving supplies and personnel?

5. What is intermodal transportation?

6. How has the distribution center been impacted by the increase in customers ordering direct from the manufacturer via the Internet?

7. What is the mode of transportation most common for International shipping? What impact does this have on the supply chain?

8. What are the functions of the Supply Chain Council's "Supply Chain Operations Reference" Model?

9. Describe the supply chain for an item of clothing in your closet.

10. What does cash-to-cash have to do with supply chain operations?

11. What is the difference between single sourcing and sole sourcing? Define each of the concepts.

12. What part does information have in the operation of supply chains?

13. What is the role of bar codes in today's supply chains? What does an RFID tag provide supply chains that a bar code does not? If no improvement or advantage, why would you use an RFID tag?

Section 2: Introduction to the SCOR Function of Plan

The Plan Function is inherent in every organization. Someone or some department has to plan what products, what markets, what customers, and what suppliers the organization will use or have. This section of the textbook includes those functions that are part of the planning functions.

Strategy and Decision Making

Ethics – this topic cuts across every action of operations management and supply chain management. However, we will cover under the Plan function topics

Forecasting – like ethics and capacity, this topic cuts across several functions in operations management. Because capacity is based on forecasts and manufacturing and distribution are based on forecasts, we will list it under the Plan function.

Capacity Planning – this topic could just as well fit under the Make function and the Deliver function.

Facility layout and location selection

Project Management

Sustainability – this topic really cuts across every aspect of business today. It could just as easily be part of Make, Source, Deliver and Return functions.

Introduction to the SCOR Function of Plan

Chapter 3

Strategies: Developing Strategy and Converting Strategy to Actions Through Decision Making

In Chapter 1 we looked at the foundations and history of Operations Management. In this chapter we will look at the link between Operations Management systems and Strategy and Decision Making. To lead the processes that are involved in the production of a product or delivering a service, a company must have a long-term strategy and must make the right decisions. A company's strategy may define its competitive advantage.

Mission/Vision/Strategy

What is strategy? How does a company develop strategy? Why does a company need a strategy? What is a core competency? What is a competitive advantage and how does a company develop a strategy and a competitive advantage? Does a competitive advantage differ from a core competency? What is a core competency and why is that important to operations management?

Let's start by looking at some definitions to lay the foundation for our discussion of strategies and decision making.

- **Mission**: This is what the company does. The mission of The University of Kansas is "To educate future leaders."

- **Strategy**: according to dictionary.com, "a plan, method, or series of maneuvers or stratagems for obtaining a specific goal or result."[19] The Merriam-Webster Dictionary defines strategy as: "the art of devising or employing plans or stratagems toward a goal."[20] For our discussion of strategies in operations management, this definition provides a good starting point.

- The APICS Dictionary app defines strategy as "how to satisfy customers, how to grow the business, how to compete in it environment, how to manage the organization and develop capabilities with the business, and how to achieve financial objectives."[21] The APICS Dictionary ties the term strategy to strategic plan and defines that as "The plan for how to marshal and determine actions to support the mission, goals, and objectives of the organization."

- **Decision making**: "the cognitive process of reaching a decision."[22] A company's leadership needs to have a cognitive process to guide them to making decisions. In this chapter we will look at decision making under uncertainty—when we really have no idea of what will happen in the future; and we will look at decision making under certainty—where we have some idea of what may happen in the future.

- **Core Competency**: "a defined level of expertise that is essential or fundamental to a particular job; the primary area of expertise; specialty; the expertise that allows an organization or individual to beat its competitors."[23] For our

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[19] Strategy. Dictionary.com. *Dictionary.com Unabridged (v 1.1)*. Random House, Inc. http://dictionary.reference.com/browse/strategy . Retrieved July 20, 2020

[20] Strategy, http://www.merriam-webster.com/dictionary/strategy. Retrieved July 20, 2020.

[21] APICS Dictionary, 2020.

[22] Decision Making. (n.d.). *WordNet® 3.0*. Retrieved September 21, 2019, from Dictionary.com website: http://dictionary.reference.com/browse/Decision Making

[23] Core competency. (n.d.). *Dictionary.com's 21st Century Lexicon*. Retrieved September 21, 2019, from Dictionary.com website: http://dictionary.reference.com/browse/Core competency

discussions, a core competency is that area that a company excels at and does better than the competition. The latter part of the definition: "the expertise that allows an organization or individual to beat it competitors," best fits our discussions.

- **Vision**: The best definition I could find of a business vision comes from a former professor of mine, Gene McCoy. Gene defined the business vision as where the company wants to be in the future. With this as a definition, Gene also, viewed the strategy as the leader's bridge between the "as is" situation, where the company is today and the destination situation or where the company will be in the future (the vision).

In the first chapter of the *Art of War*, Sun Tzu states, "The Way is what causes the people to have the same thinking as their superiors" (Sonshi, 2012). The vision and the corresponding strategy of the company is "the Way" that Sun Tzu speaks about that allows all of the members of the company to understand the thinking of the leadership.

A company's strategy is the road map that guides the direction of a company. Just as a road map and plan are needed to make a family vacation or trip to the beach successful, a company needs this same road map to get the company to its destination. Without a map or plan, you will not get to where you are going or know you are there when you get there. Without a strategy to guide the company, the company will not reach its goals or destination.

If you get lost or do not reach your destination, you can stop and ask for directions to get back on track. If a company does not have a map to lead them to excellence and profitability, they cannot simply stop and ask directions and there is no Garmin or GPS to guide the company as there is for the boat or family car.

And long enough without a viable strategy may very well result in the collapse of the company. In the military the lack of a strategy leads to defeat, in business the lack of a strategy leads to corporate defeat. A good corporate strategy is as important to the success of the corporation as a good military strategy is to the battlefield commander.

A company's strategy and core competency may focus on short delivery times, speed to market, quality products, or simply cost. A company's core competency and strategy determine how the company will position itself. In order to properly position the company another key

aspect is necessary—what does the customer want? The first step of the Motorola approach to Six Sigma is Define. Define who the customer is; define what the customer wants; and define how we can service the customer better than the competition.

SWOT Analysis

Another way of determining our strategy and meeting the customers' requirements is through a SWOT Analysis. Just what is a SWOT analysis? SWOT is an acronym that stands for Strengths, Weaknesses, Opportunities, and Threats. This analysis will assist the company in a variety of ways. An example of a SWOT format is shown in Figure 3.1. The key to a successful SWOT analysis is to be brutally honest. This sometimes makes a SWOT analysis an ugly exercise in companies. Everyone loves to hear what they are strong at but get emotionally upset when you try to identify weaknesses.

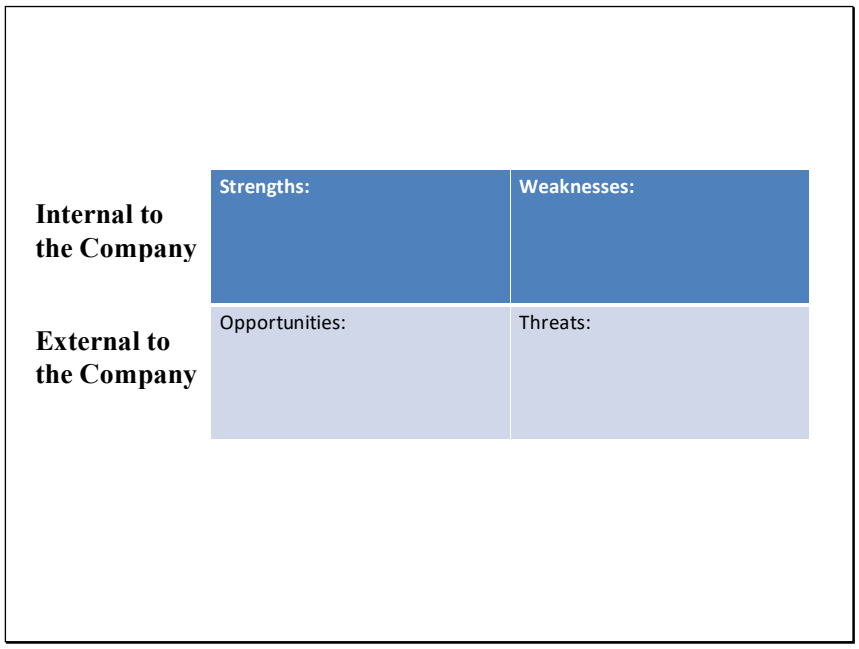

Figure3.2: SWOT Analysis

The strengths part of the SWOT analysis will help the company to truly identify what their strengths are. Obviously, the strengths of the company better include those areas that the leadership of the company has previously identified as the core competencies of the company. If the company has not already identified their core competencies, an accurate and detailed strength

analysis will identify those areas of the company that are the core competencies. The preferred methodology is to identify the core competencies prior to the SWOT analysis.

Strengths identified by the SWOT analysis may include brand awareness or company reputation. In the 1980s and 1990s the brand reputation of IBM resulted in a situation where regardless how much was spent on computers, if they were IBM, no one complained. Apple enjoys the same brand reputation today in many companies. Another strength that should be discovered in the SWOT analysis may the company's real estate value. K-Mart discovered this a few years ago, thus giving the company a new advantage in the marketplace allowing them to buy Sears. Amazingly, in the late 1990s Sears contemplated buying K-Mart and decided it was not a good acquisition. History now shows that the acquisition of Sears by K-Mart was not a good acquisition either as the K-Mart real estate was not always in desirable locations and the debt and lack of customer service coupled to kill both K-Mart and Sears. Which is amazing when you consider that into the early 1980s, Sears was the largest retailer in the world. A company's products and or patents should be a strength identified in the SWOT analysis. Although as A.H. Robbins learned with the Dalkon Shield, sometimes the patent or product is a weakness.[24]

The weaknesses analysis should identify those areas that are not core competencies. A thorough SWOT analysis may very well identify an area that the leadership thought was a core competency that in actuality is not a core competency at all and may be a candidate for a process improvement program or contracting out (we will discuss this concept in greater detail in another chapter). The purpose of the weakness portion of the SWOT analysis is to identify those areas within the business or corporation that is not a strength that may need additional focus and attention in order to convert that particular area into a strength. Not every weakness needs to be

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[24] A.H. Robbins purchased Dalkon, the developer of an Inter-Uterine Device (IUD) and continued the development, testing, and eventual sale of the Dalkon Shield IUD. The tests showed that the IUD caused uterine and cervical cancer in the test animals but was discounted as an anomaly. In fact, the Dalkon Shield was later proven to have a causation effect in the development of uterine cancer in humans and the result was very large class action suit and settlement charges as a result of the numbers of uterine cancer caused by the Dalkon Shield. This should have surfaced during the SWOT analysis prior to buying the company and could have preserved one of the oldest pharmaceutical companies in the United States.

outsourced or contracted out. Some weaknesses may be the result of a lack of emphasis by the management or leadership of the company. We all know that we only do well the things that are either on the annual performance appraisal or that the boss checks on. A weakness may just need attention in order to turn it into a strength. Because of this, the SWOT analysis, contrary to some text books, is not a onetime analysis; the SWOT is another form of continuous process improvement.

Weaknesses identified in the SWOT analysis may identify the weakness of the brand. A potential weakness may be the ability to get products to the market or access to distribution systems. This weakness certainly raised its ugly head during the COVID-19 pandemic when companies demonstrated a weakness for getting products to the stores. Recent experiences off the coast of East Africa with piracy may indicate a weakness in the routes used to get products to market. This form of weakness—supply chain security—will be addressed in detail in another chapter.

Strengths and Weaknesses can be looked at from a personal perspective as well. Strengths are those skills that you bring to the table that make you more qualified than other candidates for a job. Weaknesses are those personal areas you need to improve on. For example, if you are multi-lingual then that is a strength and if you do not speak another language, that may be considered a weakness.

Where the strengths and weaknesses portion of the SWOT are internal looking analyses, the rest of the SWOT—opportunities and threats—are external looks at the company.

The opportunities portion of the SWOT analysis is conducted to identify those areas or products/services that we have the capability to produce or provide to improve our company. These may fall into one of four categories—they may be weaknesses of the competition and thus a way to expand market share or introduce new products or services; the opportunities may be areas that we have fallen behind the competition but have the strengths identified earlier in the SWOT analysis to compete in that market; the opportunity identified by an unmet customer need; or, the opportunity to take over or acquire a competitor or other aspect of business. This can be seen in the mergers of package delivery companies and the formation of the Amazon delivery system to compete with UPS/FedEx/USPS/DHL.

The threats analysis is a wider area than the first three phases of the SWOT analysis. In this phase of the SWOT, the company needs to identify those areas where the competition is

stronger and therefore may identify an area of weakness that may impact the profitability of the company. An area of threats that is important, especially if conducting this analysis on supply chains, is the concept of security threats and risk analysis. We will cover both of these topics in the chapter on supply chain security. During the threats analysis a company needs to look at the entire operations management chain for weak links and threats to the strength of the operations management chain. One threat that may be revealed by a detailed SWOT analysis is a change in customer preferences for the company's products.

The SWOT is useful in helping the company leadership prepare for the development of the corporate strategy. The strategy is where the leadership sees the company in the future. The strengths, weaknesses, opportunities, and threats identified will assist in shaping the future of the company. The key to SWOT analyses is to be brutally honest. This sometimes creates issues with companies. Everyone loves to hear what they do well, but no one wants to hear that they are not as good at something than they thought they were.

The SWOT analysis is also a valuable tool for personal analysis. Everyone, especially those moving to the workforce, should conduct an honest and thorough personal SWOT analysis to identify personal strengths and weaknesses and those opportunities and threats that should be considered in the work place and job search. We will discuss this form of SWOT analysis in the class discussions.

STEEPLE Analysis

Another popular tool to assist companies in analyzing the external environment and developing strategy is known as the STEEPLE Analysis. STEEPLE is an acronym for:

Social – What is the societal view of our products or services? How does society view the company? What is the view of the company's policies?

Technological – What is out there for technology? What do we have? What should we add to our company to be competitive with our competitors? Is our technology obsolete?

Environmental – What impacts does our company and products have on the environment? What can we do better to be a better steward of the environment? What is the competition doing that impact the environment? Is the move to sustainability or the circular economy impacting how you do business?

Economic – Where are we in the business cycle and how is the economic picture affecting our company? How is the pandemic affecting your company?

Political – What are potential political actions that may impact our operations? Is the competition supporting some political action? Are the actions of the parties in power impacting your business?

Legal – Are there any legal implications that may arise from our actions (refer to the previous discussion of the Dalkon Shield)? Are there laws in the areas that we want to expand to that may impact our operations? Wal-Mart discovered that local laws in China required them to buy a certain percentage of their products from the local merchants. Are there any new laws that are going into effect that will impact your company?

Ethical – This should always be part of any strategy and decision making. Are the actions we are planning ethical and will the public perceive them as ethical actions? Or, is your company doing the easy wrong rather than the harder right?

What exactly is strategy? Dictionary.com defines strategy as, "a plan, method, or series of maneuvers or stratagems for obtaining a specific goal or result."[25] For a company, this plan or method leads to the goals of the leadership for the direction that they want the company to take for the future. Strategy should include goals and plans for expansion or retrenchment for the company, growth for the company products, what the products for the company will be in the future and the focus of the company. Does every company need a strategy? Absolutely! Without a strategy the company will be much like a rudderless ship moving in whatever direction the wind or current pushes it.

Once the leadership of the company sets the strategy and direction for the company, it has to be communicated to the workforce and the shareholders. This is accomplished through the vision of the leadership. The vision is the method of communicating where the company is (as is situation), where the company is going (destination situation) and how the strategy the company will use to get there.

Often companies confuse vision and mission. The vision is where the company will be in the future. The corporate mission states the reason for the existence of the organization. This statement provides the customers, the employees, and the shareholders a clear statement of that

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[25] strategy. (n.d.). *Dictionary.com Unabridged*. Retrieved October 02, 2009, from Dictionary.com website: http://dictionary.reference.com/browse/strategy

purpose. The corporate mission coupled with the strategy to accomplish the mission serve as guides for decision making. We will look at decision making models later in this chapter.

Here are a couple of examples of company mission statements:

- Google: to organize the world's information and make it universally accessible and useful

- Apple: to bring the best personal computing experience to consumers around the world through its innovative hardware, software and Internet offerings

The vision and the guidance of how to accomplish the mission and goals of the company have to be clearly stated, clearly communicated, and clearly understood by the workforce that has to implement the strategy and vision. This is similar to one of Covey's "7 Habits of Highly Effective People"—seek first to understand and then be understood. Just because it makes sense to you does not mean that it will make sense to your workers.

Why is a clearly stated vision necessary? Every employee in every organization needs to know the mission, vision and strategy of the company. It needs to be clearly stated, clearly articulated, and clearly understood by everyone in the company and should be understood by the suppliers. Look at the guidance of Yogi Berra— "When you come to a fork, take it." I am sure that was clear to Yogi when he said it but could be somewhat confusing. Outside of Raleigh, North Carolina when I was growing up was a small crossroads village known as Six Forks (this crossroads is well inside the city limits today). As the name would imply, at Six Forks you could go six different directions. At that time you could go to Raleigh, Durham, Creedmore, Wake Forest, Oxford, or the middle of nowhere. Choosing the wrong fork could put you miles into the middle of nowhere before you realized that you chose the wrong fork. The crossroads still exists within the Raleigh City Limits; and you can still go six different directions. Although none of them no longer leads into the middle of nowhere, using Yogi's guidance, which fork do you take? There was also a shopping and residential area in Raleigh called Five Points. As that name implied there were five different roads that came together – which fork you take depends on where you want to go.

In 1962, President John Kennedy made his famous proclamation, "We endeavor to go to the moon and return safely by the end of this decade." This vision seemed quite clear to the President, was seen as ridiculous by many because of the problems with getting a man into space

at all and was perceived as quite clear by the folks at McDonnell, Douglas (later McDonnell-Douglas) and Rockwell as achievable. On July 16, 1969, the first man stepped on the moon and all three astronauts in the Apollo Spacecraft returned safely to earth.

In *The Art of War,* Sun Tzu states, "one who is confused in purpose cannot respond to his enemy." The vision is the way corporate leaders ensure that their employees know what their purpose is. Although the customer is not the enemy, if the employee does not understand the vision of the company, there is no way she/he can respond to the needs of the customer.

Compare Yogi Berra's guidance with the analysis of General U.S. Grant by one of his aides after the American Civil War. General Grant had pretty much been a failure at everything he attempted, except for being a drunk, prior to being called back to active duty in the US Army at the start of the American Civil War. After the war, one of his aides was questioned about how General Grant went from failure to becoming the greatest battlefield commander in the US Army. General Grant's aide said what made the General so successful was that he made sure that his subordinates knew "exactly what he wanted, why he wanted it and when he wanted it."

Think about that for a second. How much easier would life be if our bosses made sure that we knew exactly what they wanted done (not how), when it had to be done and why we were doing it? For that matter, think about college. How much more rewarding and easier would your studies be if you knew exactly what was expected of you, why it was expected (how to use it or why it is important) and when you had to do it by?

The key with the vision is that not only must the vision be vital to the organization and the direction that the company needs to take; it also needs to be perceived as achievable by the people that have to implement it. Some years ago the US Army established goals and a vision of where the leadership wanted to take the supply chain operations. The goals were imperative to prevent outside intervention in attempting to improving operations.[26] Unfortunately, for the first two years of this program the goals for US Army had one set of goals for the entire Army. At the time, the Army was divided into two major components—the Active Army (those soldiers that

[26] Just like most companies, the US Army has a board of directors. In the case of the US Army, the board of directors number 535—the 100 US Senators and the 435 members of the House of Representatives. As most taxpayers know, it is better to keep this board of directors out of any business.

were full time soldiers and worked every day in the Army's supply chain operations) and the US Army Reserves/Army National Guard (those soldiers that had other full time jobs and only worked as soldiers two days a month and 14 days in the summer). One set of goals for both components did not work. The Active Army perceived the goals as achievable, but the Reserves and National Guard did not perceive the goals as achievable and went the wrong direction with order processing times. It was not until two years later that a separate set of goals were established that everyone perceived the goals as achievable and started making progress in the right direction. In fact, the Reserve Components exceeded the goals for the Active Army when they perceived their goals as achievable. This is the second part of a successful vision, not only is it clearly stated, clearly articulated and clearly understood; it has to be perceived as achievable if the vision and strategy are to be successful.

How does your strategy tie to a competitive advantage for your company and how does that tie to operations management? A company's strategy also looks at how a company is going to be positioned. How the leadership decides to position a firm may very well determine if the company is going to be competitive.

This competitiveness goes back to the first step of Six Sigma—defining who the customer is, what the company can do to meet what the customer wants, and how to do it better than the competition. Creating a competitive advantage for the company includes:

Traditional Positioning Strategies:

- Flexibility. If a company is competing on flexibility has to possess the ability to change rapidly between products; have to offer the customer various options; has to be adaptable to change; must offer the customer a wide variety of products, options, and models. In order to this, a company competing on flexibility has to possess the capability to cross train their personnel to accomplish various missions and make the wide variety of models and options to meet the customers' demands.
- Quality. In order to compete on quality, the entire organization must focus on quality—this will be discussed in greater detail in the chapter on Quality. In order to compete on quality or use quality as the way to position the company, the company has to know what

the customer wants and how the customer defines quality. Competing on quality—real or perceived—has its roots in the works of Dr. W. Edwards Deming and the quality revolution based on the techniques that the Japanese learned from Dr. Deming. Certain brand names such as Mercedes-Benz, Cadillac, IBM, Rolex, and Dell are considered quality products based on the brand reputation. Ritz Carlton hotels compete on the quality of customer care coupled with luxury.

I had the opportunity to do a couple of seminars at the Ritz Carlton in Pasadena, California. The first year that I did the seminar, there were no problems. I drove my Ford Escort to the front door—not exactly the standard car at a Ritz Carlton. I did notice that when I went for my evening run that my car was parked on the lowest level of the parking deck out of sight of the road or front door.

The second year I was there I was greeted by the front desk by name, welcomed back to the hotel and made to feel very welcome. I did encounter a small problem and not because I drove my little Escort again. When I returned from the evening session and dinner, I found my key card did not work. My first thought was that after a glass or three of wine that I was at the wrong room. A quick check showed I was at the right room but the key card did not work. Suspecting that the card may have been demagnetized, I went to the front desk and got a new card. The new card did not work either. I called the front desk from the hall phone and an Assistant Manager came up only to discover that his master key card did not work either—seems when the battery in the door goes out, no matter how hard to yank on the door or kick the door it will not open or how high you are in the management if the battery is dead you access card still will not work. Having had a similar experience in Florida a few years earlier, I was aware that the door will not budge when the battery in the lock is dead. (A few of my former students had the same problem at a hotel in Panama the semester after having heard this story and had a similar experience getting the battery changed).

After finding a maintenance man to fix the door, I finally got into the room an hour later. Because of the inconvenience, I was given a free breakfast (about $25, which was part of the contract for my seminar anyway) and a bottle of wine (worth about $35). It seems that the Ritz Carlton chain has a policy to do whatever it takes to make the customer happy and employees can spend up to $1500 to make the guest's experience a

good one. There are reports of opening the kitchen after hours to make food for late arriving guests. This is one way that the Ritz Carlton chain strives for quality and positions themselves apart from their competition. Had I known at the time that the manager could have spent up to $1500 to make me happy, I would have had a round of golf, a massage at the Spa, and my free breakfast and bottle of wine.

- Speed. Competing on time is critical in supply chains. FedEx,[27] UPS,[28] DHL, and the US Postal Service have determined that competing on speed is critical to the positioning of their companies. In order to compete on speed a company has to walk their processes, identify non-value-adding processes and measuring the time for every process in the supply chain or manufacturing chain. Streamlining the process and reducing wasted movement, wasted waiting time, and wasted production quantities are necessary in order to compete on speed. Speed and time are relative terms and FedEx and UPS have defined time spans to meet the time requirements of the customer. Amazingly, some companies have stopped some of their on-time guarantees in the face of the COVID panemic.

- Price/Cost. To compete on cost or price a company must reduce waste in the processes. Just like the competition on time, you cannot compete on cost if there are inefficiencies and waste in your system. Every process adds cost but not every process adds value. To identify these non-value-adding processes requires walking the process and identifying non-value-added processes—a good process map is necessary to accomplish this (we will discuss process mapping and value chain mapping in greater detail in another chapter). It is also important to point out that after walking the process and identifying these non-value-added processes, improvements must be put in place and not just changes for the sake of change. The difference here is that every improvement is a change, but not every change is an improvement. Some managers come in and have to change everything that

[27] Go to Fedex.com to see how they compete on speed and time.

[28] To compare UPS to FedEx, go to UPS.com

their predecessor did just to make a mark on the operations. This usually impacts the entire operations management chain.

Southwest Airlines competes on cost successfully against the other major airlines. One of the ways Southwest is able to compete on cost is by flying one type of airplane for the entire fleet. This facilitates easy and rapid crew changes because of the familiarity of the equipment; one type of aircraft eases the record-keeping by having only one format of books; simplifies the maintenance operations because only one set of mechanics is necessary; and inventory costs are reduced because Southwest only has to maintain repair and service parts for the Boeing 737 rather than the wide variety of parts required to maintain multiple model fleets.

Southwest also reduces costs by having more direct flights. Fewer transfers of passengers mean fewer baggage transfers thus baggage handling costs and personnel. One other way that Southwest has cut costs is by changing the way reservations are made. Southwest saves $30 million annually in travel agent commissions by requiring customers to use the Southwest Web site to make reservations rather than paying the monies to other sites such as Expedia, Orbitz, and Travelocity.

- Hybrid Positioning Strategy. You can make a good argument that the traditional strategies are being mixed together is today's business environment. Amazon and Walmart are both trying to compete on speed, flexibility, and cost. While FedEx and UPS are competing on flexibility and speed by offering other services besides the basic freight options.

Are there other competitive opportunities in today's society and business world? What about electronic business and the Internet? Can this assist a company in developing a competitive advantage? Every brick and mortar business has to make a strategic decision on how to posture the company on the Internet and what aspects of electronic business the company should be part of. In today's business world if you are not doing business electronically, you will not be in business very long. The question is not a matter of if but how much of the company should be involved in electronic business and how much of the company should be involved in the brick and mortar portion of the company or should the company be totally electronic.

All of the other aspects of competitiveness and posturing discussed earlier also contribute to the competitiveness of an electronic commerce company. A company can have the sexiest Web site possible and still not be competitive on price, cost, speed, flexibility, or quality. In brick and mortar businesses, these competitive aspects may be mutually exclusive but in the electronic world they are not necessarily exclusive aspects of competition.

What about e-business? What advantages does that do for you? The biggest advantage is that it opens your product to a whole new market. Teaching a class provides the ideas to a class of students but putting the ideas in a book opens the doors to a new market. The Internet does the same for companies. Polo has eight Rugby stores located near college campuses. These stores only allow those students close to these stores to purchase the products, but putting the products online opens the market to everyone.

What are the theoretical and actual impacts of e-business and can you survive today without a Web presence?

Theoretically, doing business on the web should enable companies to:

- Provide better customer service—in actuality, fewer companies are providing quality customer service as a result of doing business on the Web. Some companies are content to sell products via e-commerce and never follow up with the customers. One prominent computer company has sold my company five computers over the past seven years and has bothered to follow up only once to see if I got what I ordered and was satisfied with the purchase. However, they are very good at letting me know when my extended warranty was expiring.
- Lower costs of materials—some companies do pass on the reduced costs of materials to their customers. These lower costs of materials are possible for several key reasons. The first reason that e-commerce provides the opportunity for lower costs is that companies can now find materials on the Web without having to travel to the source. Another reason for possible lower costs of materials is that the Internet now provides online market places and exchanges that allow companies to have alternatives and options to compare and bid on materials.
- One concrete advantage of e-commerce and the Internet is the availability of information that provides potentially better decision making. Prior to the advent of e-commerce and

the Internet, the only available information was in the catalogs or in the store. Gathering all the necessary information not in the catalogs required going to all the stores or sources of supply to see the products and compare them.

Examples of e-commerce success and lack of success are Toys-R-Us, Borders, and Barnes and Noble.com. Borders jumped into the e-business world with big fanfare while the competition Barnes and Noble took their time in developing the supply chain to support the e-business storefront. Today, Borders does not even exist. They blamed Amazon but interestingly enough, like Toys-R-Us, they outsourced their e-commerce to Amazon. Amazon started out to be a storefront with no assets but quickly discovered that owning the entire supply chain produced a competitive advantage. Wal-mart.com is another good example of capitalizing on the electronic business. In fact, Walmart reported a 74% increase in e-commerce during the first two months of the COVID-19 pandemic. The successful e-business companies are the ones with a successful supply chain to support their operations.

- Can your supply chain produce a competitive advantage for your company? We will discuss supply chain operations in a later chapter. However, the above discussion on electronic businesses shows that a good supply chain is necessary in order to be competitive. Lowe's believes that the competitive advantage that they have over The Home Depot is their supply chain operations.

  This may be true as Home Depot completely revamped their supply chain about ten years ago to compete more effectively against Lowe's and other home improvement companies. Lowe's did several things to improve their competitive advantage above and beyond the supply chain and improved their total operations management chain. Lowe's surveyed customers and determined that the majority of home improvement projects are designed or approved by the females in the household. To meet the needs of these customers, Lowe's added more pastel colors and more small appliances. Then they added more consumer electronics.
- Part of developing a competitive advantage is customer relationship management. What is it and why is it important? Customer relationship management is not a new concept. My uncle was a highly successful high-end furniture salesman. He maintained a deck of cards with all of the store salesmen that he called on, a card deck with the sales managers,

a card deck with the store owners' information. He used these cards to refresh his memory before calling on a store. The information enabled him to call the customers by name, remind him of their interests, and their birthdays. The goal and the results were a very successful career and loyal customers.

Customer Relationship Management has the goal of creating relationships with customers, know what the buying habits of the customer are and use that data to create "customized" offers to the customers. Amazon has taken this one step farther by using predictive analytics to stage items closer to customers when Amazon thinks they may be ready to buy a product based on past purchasing history.

Casinos have been doing predictive analysis with their slot club cards for decades. The goal of these cards is to develop trends to provide individual programs tailored to customers. Casinos use slot club cards as a way to capture customer data. Grocery stores do the same thing with their loyalty cards and credit cards. Cabela's initially went into the credit card business to gather data on where their customers were shopping and what the customers were buying that maybe should be stocked in Cabela's stores.

Decision Making and Operations Management

What does decision making have to do with Operations Management? Everything! Every aspect of the Operations Management Chain requires decisions. Decisions in Operations Management include:

- What products should the company make, buy, stock, or sell? What products should the company stop making?
- What services should the company provide to the customers?
- What processes should be used in the manufacture or delivery of a product or service?
- What capacity should the company have and how that capacity should be expanded and if it should be expanded?
- What type of personnel should be hired and how many personnel should be hired?

- What level of quality should the company aim for and how will the quality be measured?
- What type of facilities the company should have? And where should these facilities be?
- How should the company source parts, products, and materials? Where should these parts, components, and materials be sourced from?
- What markets should we be in?
- What are the companies that we can acquire?

The answers to these questions will be discussed in detail in the subsequent chapters. Decision making is inherent in all operations. This chapter will cover decision making and decision-making techniques.

Strategy Development and Decision Making

Included in the decision-making process is knowing if a decision is necessary; when a decision is necessary; and what needs to be decided. This concept is like the Theory of Constraints (we will look at the Theory of Constraints in greater detail under capacity discussions and continuous process improvement programs later in the course) premise that a decision maker needs to know what to change, when to change, and how to make the change. Decision making also includes knowing that there are consequences of decisions made. Here is an example of the consequences of decisions:

- When the decision is to drive after drinking there is a definite consequence. I made this example in one class only to have a student tell me the next week that he was picked up for suspected driving under the influence. I was surprised when he told me that after the arrest, he immediately thought about the comment made in class about consequences.

- A decision to use performance enhancing drugs has the unwanted consequence of failed drug tests and the shame and disgrace suffered by athletes that make this decision. Recent headlines involving baseball players, Olympic athletes, cyclists, and American football players confirm these consequences. The decision to use

performance-enhancing drugs falls under the ethics umbrella, but now it also falls under legal ramifications.

The After Action Review Process

Included in decision making is the risk inherent in the making or not making a decision and the follow up on the results of the decision—did we make the right decision, and did we implement the right process or product? This includes using the After-Action Review process. The After Action Review is a staple in Military Operations. Every operation and every plan must be reviewed. The underlying concept of the After Action Review is that every operation has somethings that went right that need to be sustained in future operations and every operation has somethings that could be improved in future operations. The After Action Process uses the following steps:

1. What was the plan or decision? What did we do or what did we decide?
2. What actually happened? What was the outcome? Did it match the expectations from the decision?
3. What went right that needs to be sustained in future decisions or plans?
4. What went wrong and why? It is important to point out that this step looks at what went wrong not fixing blame to anyone. The goal is to fix the problem not the blame.
5. How can we prevent this from happening again in the future?
6. Who is responsible for the fix? This is the only "who" question in the process. The only reason a "who" is looked at here is that we all know that nothing gets done if someone is not checking on it. So, the purpose is to assign someone to ensure that the fix takes place. You will notice that the process does not try to fix blame, only fix issues to make things work better in the future operations.

If an organization conducts an After Action Review on a regular basis and makes this process part of their Standing Operating Procedures, the organization will continue to get better and achieve excellence.

Decision Making Models

The first model we will look at is known as the Military Decision Making Model. Do not get hung up on the title just the process. The Military Decision Making Model is very similar to the Scientific Decision Making Model and the Supply Chain Problem Solving Model designed by Tompkins and Associates, a very successful operations and supply chain consulting company.

The Goals of the Military Decision Making Model are:

- Analyze and compare multiple courses of action (alternative actions) to identify the best possible action
- Produce integration, coordination, and synchronization for any action or decision
- Minimize overlooking critical aspects—did we consider everything?
- Produce a detailed plan

The steps of the Military Decision Making Model are:

1. What is the mission or plan or decision that needs to be made? This mission/plan/decision may come from the boss or from the headquarters staff. To illustrate this process, we will use the mission of expanding/building a new distribution center.

2. Mission Analysis. Exactly what is the boss/headquarters asking us to do? What are the requirements from us to make this happen? What are the specified tasks? Specified tasks are those tasks that are specifically laid out in the guidance or directive from the boss/headquarters. What are the implied tasks? Implied tasks in this analysis are those steps that are not specifically dictated by the boss or headquarters but from your experience or the experience of your staff or coworkers are tasks that must be completed in order to accomplish the specified tasks.

   If the mission is to build a new distribution center, the specified task is to get a new distribution center built. The implied tasks include finding a suitable

location, designing the new facility, and acquire all the necessary permits. It may just mean expanding the current facility.

For our example we will use the alternatives of expanding the current facility, moving to an existing facility, build a new facility, or do nothing.

3. Course of Action/Alternative Development. There is always more than one way to accomplish goals. In fact, the only place that you will ever find only one right or wrong answer is in academia. In the real world, there are options to consider when making a decision. Once the mission analysis is complete it is time to start developing courses of action or alternatives to solve the problem or guide the decision maker to making a better decision. Obviously, one course of action is to do nothing—this is not always a good alternative. I was had an instructor who used to emphasize that a person can make a decision or not make a decision and let someone make the decision for you. Doing nothing may fit into this category. In some instances, doing nothing may be a viable alternative.

   Each alternative or course of action must be distinctive from the other alternatives. Otherwise if the alternatives are not distinctive from the other alternatives, they are basically the same.

4. Once a set of alternatives or courses of action have been developed, it is time to analyze the courses of actions or alternatives. Are the alternatives really different? Figure 3.2 shows the qualities that differentiate alternatives.

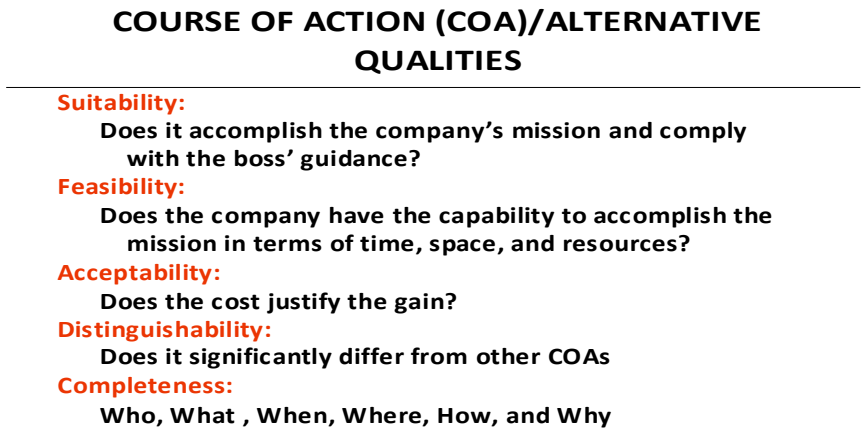

Figure 3.2: Alternative Qualities

5. After analyzing the courses or action, it is time to compare the alternatives. In order to compare the alternatives, it is necessary to establish the success criteria or decision criteria that are important to the desired outcomes. Using a grid and the success criteria of expanding operations, posturing the organization for the future and minimizing long term costs the comparison and analysis will look something like this:

Alternative Comparison and Analysis

Course of Action/Analysis	Expand operations	Posture for the future	Minimize life cycle costs
Do Nothing	-	-	-
Expand Current Facility	+	+	-
Build New Facility	+	+	+
Move into Existing Facility	+	-	+

For this example we will weight the expand operations and posture for the future criteria. Using these criteria and options, the choices are expand current facility or build a new facility. The tie breaker is the life cycle costs.

Figure 3.3 Comparison and Analysis

6. The next step in the process is to brief the boss on the analysis and recommend a solution to him/her to accomplish the mission. This is one model for decision making; in the next section we will look at some other decision making models.

Our courses of action appear to fit the criteria. They will accomplish the mission of providing more distribution space. We will assume at this point that they all are feasible given the current economic and business situations. They are distinguishable and seem to be acceptable given the mission.

Decision Making under Uncertainty

Not every situation will lend itself to the previous decision making model. In some business cases decisions must be made under uncertain conditions. In such a case the following technique may be used. This decision making model may not produce as good a decision as the Military Decision Making Model which is very similar to the Scientific Decision Making Model.

In this technique we will still use a grid to lay out the decision table showing the states of nature and the decision alternatives. The payoff table has three components:

a. The States of Nature across the top of the table. We have no control of these states of nature.

b. The decisions down the left hand side of the table. This is the only part of the table that we can control.

c. The projected payoffs. These are located at the intersection of the state of nature and the decision. For example, in the table below, the projected payoff for the decision to expand operations assuming a good economic condition is $50,000.

The payoffs for a craps table in a casino provide a good example of a payoff table. The craps table has various payoffs based on the number rolled and the probability of that number occurring. Obviously, the highest payoffs come from the hard ways because the hard ways have the smallest probability of occurring. Figure 3.4 is an example of a payoff table/decision matrix.

Payoff Table – Decision Making Under Uncertainty

Decision/State of Nature	Good Economic Conditions	Average Economic Conditions	Poor Economic Conditions
Expand Operations	50,000	175,000	5,000
Contract Operations	75,000	25,000	80,000
Maintain Status Quo	60,000	55,000	50,000

Figure 3.4 Decision Making Under Uncertainty Payoff Table

For this decision using the payoff table above, the following criteria could be used: maximax, maximin, or minimin. **Maximax** is the maximum of the maximum payoffs—a very optimistic approach much like betting on the hard ways; **Maximin** is the maximum of the minimum payoffs; and **Minimin** is the minimum of the minimum payoffs. In the above example these would be computed as follows:

Maximax: maximum payoff for expanding operations is state nature one—average economic conditions or $175,000; maximum payoff for contract operations is state of nature

three—poor economic conditions or $80,000; and the maximum payoff for the maintain status quo is state of nature one or $60,000. The maximum of the maximum payoffs is expanding operations in average economic conditions. Therefore, without any additional information, the decision for maximax is to expand operations.

Maximin: The minimum payoff for option one is poor economic conditions or $5,000; the minimum payoff for option two is average economic conditions or $25,000; the minimum payoff for option three is poor economic conditions or $50,000. Therefore, the maximum of the minimum payoffs is option three—maintain status quo.

Minimin. Using the same minimum payoffs, this decision is to look for the minimum of the minimum payoffs. The minimum of the minimum payoffs is to expand operations and hope for poor economic conditions.

Decision Making under Certainty

The difference between decision making under uncertainty and under certainty is the addition of forecasts for the outcomes. These probabilities are the company's forecast of the probability of that particular state of nature occurring.

Look at this updated payoff tables in Figures 3.5a-3.5c with the addition of forecasted occurrence probabilities. The Expected Maximum Value (EMV) calculation is simply taking the state of nature probability x the payoff for each alternative and then adding across each row as shown in Figure 3.5a. Using EMV as the decision criteria, you will choose that alternative with the largest EMV.

The EMV is really a weighted average over time. So, you may make more over time or less over time depending on the frequency of the states of nature and the accuracy of the probability forecast for those states of nature.

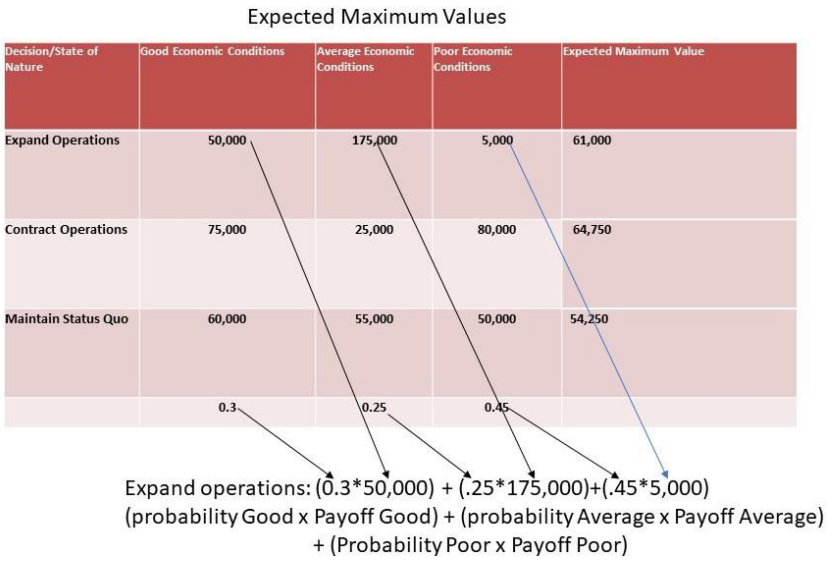

Figure 3.5a Expected Maximum Value Calculation

Decision/State of Nature	Good Economic Conditions	Average Economic Conditions	Poor Economic Conditions	Expected Maximum Value
Expand Operations	50,000	175,000	5,000	61,000
Contract Operations	75,000	25,000	80,000	64,750
Maintain Status Quo	60,000	55,000	50,000	54,250
	0.3	0.25	0.45	

Figure 3.5b Expected Maximum Values

Decision/State of Nature	Good Economic Conditions	Average Economic Conditions	Poor Economic Conditions	Expected Maximum Value
Expand Operations	50,000	175,000	5,000	(B$5*B2)+(C$5*C2)+(D$5*D2)
Contract Operations	75,000	25,000	80,000	(B$5*B3)+(C$5*C3)+(D$5*D3)
Maintain Status Quo	60,000	55,000	50,000	(B$5*B4)+(C$5*C4)+(D$5*D4)
	0.3	0.25	0.45	

Figure 3.5c: The formulas for this calculation are shown in the this frame.

Expected Value with Perfect Information and the Value of Perfect Information

What if you could have perfect information on what the future holds for your company and the economy? Does that information exist? It may exist for the products of your company assuming that the marketing folks are doing their jobs correctly.

If that information is available, what would you be willing to pay for it? We are not talking about insider trading information here, what we are talking about is better economic forecasting or product acceptance forecasting. If such information was available, the most you should be willing to pay for it is the payoff with the perfect information less the maximum payoff you would have without the perfect information. This would be the value of the perfect information.

Using our previous calculation for the expected maximum value, we would choose to expand our operations. Would we make the same decision if we had perfect information? If perfect information was available, we would obviously choose the state of nature that gives us the highest expected payoff. The calculation for the expected value with perfect information is

the probability of that state of nature multiplied by each of the payoffs for that state of nature all added together.

When we calculated the Expected Maximum Values, we used the probabilities and the payoffs across the rows for each alternative. The Expected Maximum Value could also be called the Expected Value with No Additional Information. For the Expected Value with Perfect Information we will use the probabilities and the largest payoff for each column or state of nature. Using the same payoff table, calculating for expected value with perfect information looks like this:

Decision/State of Nature	Good Economic Conditions	Average Economic Conditions	Poor Economic Conditions	Expected Maximum Value
Expand Operations	50,000	175,000	5,000	61000
Contract Operations	75,000	25,000	80,000	64750
Maintain Status Quo	60,000	55,000	50,000	54250
	0.3	**0.25**	**0.45**	
Expected Value with Perfect Information	22,500	43,750	36,000	102,250

For the first state of nature the calculation for the value of perfect information:
(0.3*75,000) = **$22,500**
For the second state of nature: (0.25*175,000) = **$43,750**
For the third state of nature: (0.45*80,000) = **$36,000**
So, EVPI = 22,500 + 43,750 + 36,000 = 102,250

Figure 3.6: Expected Value with Perfect Information Calculation

Perfect Information – Better Information

The next step is to calculate the value of the perfect information (VPI). This is the value that a company would be willing to pay to get perfect information about the future of their product. Realizing that there no perfect information what we are trying to find is how much more we can make with better information and what the information is worth to us in the form of additional income. This could be a stock picking model, a new marketing model, or a forecasting model for the economy. This is not to be confused with insider trading information. Perfect information in this example could be marketing information that tells us what the market thinks

of our product or could be a refined forecast of the future business cycles based on improved forecasting techniques or trends that have emerged. How much should you be willing to pay for this information? This is the Value of Perfect Information. For my money, I really believe that the only real value to this calculation is to let me know how much I should be willing to spend up to in order to get this better information. The calculation for this value is relatively easy:

The Value of Perfect Information = the Expected Value with Perfect Information – the Largest Maximum Expected Value:

VPI = EVPI – Largest EMV

Decision/State of Nature	**Good Economic Conditions**	**Average Economic Conditions**	**Poor Economic Conditions**	**Expected Maximum Value**
Expand Operations	50,000	175,000	5,000	61,000
Contract Operations	75,000	25,000	80,000	64,750
Maintain Status Quo	60,000	55,000	50,000	54,250
	0.3	**0.25**	**0.45**	
Expected Value with Perfect Information **VPI = EVPI – Max EMV** **= 102,250 – 64,700** **= 37,550**	15,000	43,750	36,000	**102,250**

Figure 3.7 Putting the EVPI/EMV/VPI all together

Therefore, in this example an investor or company should not be willing to spend more than $37,550 to get better information.

Summary

The strategy of the company is communicated to the company through the vision of the company's leaders. The direction of the company should be based on the missions of the company, the vision of the leadership, the core competencies of the company, and the results of the Strengths, Weaknesses, Opportunities, and Threats Analysis. This analysis will help the company identify those areas internally that are strengths and weaknesses and the external opportunities and threats. These areas will help shape the strategy of the company and how the company will position itself to be competitive in the marketplace.

Decision making includes the understanding that there are consequences that go along with the decisions. In this chapter we looked at the idea of the consequences that go along with making the decision to drive after drinking. The same is true for companies.

A model for comparing courses of action was developed in the chapter and a refined methodology was presented to assist leaders in making decisions under uncertainty and when more certainty is known.

Decision-making models are not designed to think for the decision maker. Decision-making models help the decision maker make a better informed decision. There is no exact science to decision making. A decision maker should use all information and tools at his/her disposal to help make the best possible decision while realizing that there are consequences to both good and bad decisions.

Questions for Chapter 3

1. Organizations exist
   a. To provide employment opportunities
   b. To meet the needs of society that people working alone cannot
   c. To produce goods in limited quantities
   d. To access the equipment and technology in order to produce goods and services.
   e. All of the above
   f. b and d

2. Operations involves:
   a. The distribution of company products.
   b. The production of goods and services.
   c. Obtaining people, capital and materials.
   d. Accounting, marketing, finance and engineering
   e. All of the above
   f. a, b, and c

3. Production and operations management is:
   a. Managing a company's level of inventory
   b. Managing the inputs to a production process.
   c. Managing the people who work in manufacturing companies.
   d. Managing the transformation process that produces goods and services.
   e. All of the above
   f. a. and d. only

4. Operations managers apply ideas and knowledge in order to
   a. Cut production time to speed new products to market.
   b. Improve flexibility to meet rapidly changing customer needs.

c. Enhance product quality and customer services.
d. All of the above
e. None of the above
f. Only a. and b.

5. Inputs to the transformation process of operations include:
a. Goods and services.
b. Accounting, finance, engineering, and marketing.
c. Production planning, inventory control, and quality management.
d. People, capital, and material.
e. All of the above

6. The outputs of the transformation process of operations are:
a. Accounting, finance, engineering, and marketing
b. Production planning, inventory control, and quality management.
c. Goods and services.
d. People, capital, and material.
e. All of the above

7. An important difference between goods and services is:
a. Only goods are tangible
b. Only goods are produced using materials and equipment.
c. Only services are produced according to customer needs.
d. all of the above
e. None of the above

8. Ethics are set of standards that are generally:
a. Lower than what is legal.
b. Higher than what is legal.
c. Equal to what is legal.
d. Not considered in product safety.

e. a. and d.

f. None of the above.

9. Productivity is the ratio of inputs consumed divided by the outputs achieved.

a. True

b. False

10. An important step in developing a strategic plan is:

a. Short-range forecasting.

b. Measuring productivity.

c. Working with suppliers on product design.

d. Assessing the organization's strengths and weaknesses.

11. What is the maximax decision making criteria?
12. Think about maximax as an optimistic decision criterion; is it possible to be disappointed if this criterion is the basis for a decision from a payoff table? Why?
13. What is the significance of the point of indifference?
14. What is the purpose of the Expected Value of Perfect Information?
15. How do you calculate the Value of Perfect Information?

Ethics in Business Operations

Operations Management and Ethics

Although Ethics is covered under the Plan Section, Ethics cuts across every aspect of business. A comprehensive look at operations management would not be complete without looking at ethics and operations management. Ethics is doing the right things the right way – Always. All too often we see companies and management taking the easier wrong route rather than the tougher/harder right approach.

Recent headlines have placed several states and their leaders in the spotlight for violating ethics. The 2020 Elections campaign ads are filled with ethics violations accusations from all sides. The issues with the COVID pandemic have raised ethics questions in healthcare. And the political unrest raises questions about ethics, integrity and enforcement of laws.

Almost every company has an Ethics Department and Ethics Statements. Just because a company has an Ethics Statement or Ethics Advisor does not mean that they are following ethical behavior. Ethics is usually defined as doing the right thing. There is no right way to do the wrong things. Most people are born with an ethical compass that points true North. However, somehow, some folks have their ethical compasses demagnetized. Have you ever seen a compass that has been demagnetized? It will spin and never point to North again. The same thing happens to some people in business. Greed takes over and "situational ethics[29]" take over. We will look in detail at ethics in supply chains when we discuss supply chain leadership.

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[29] Situational ethics is a term invented to insinuate that ethics can change based on the situation. The reality is that what is right does not change because of being in a different country or location. Situational ethics may be the impetus to the saying "What happens in Vegas, stays in Vegas." What is right in business does not simply change because a business partner has a different viewpoint.

One of the latest views of ethics concerns corporate responsibility and ethics. The Green Movement in businesses is an out cropping of that view. This view states that companies are responsible for the environment as part of their ethics. The Trinchero Family Wineries[30] (http://tfewines.com/tfe-green/) took this concept to the next level. This company plants a tree for every bottle of wine that they sell. To date, they have planted over one million trees. Hopefully, this new ethical movement will not prove to be a fad but a true focus on ethical stewardship of the environment. Imagery Winery[31] in Glen Ellen, CA, has also moved to more responsible wine making to help improve the quality of the wine while sustaining the environment.

Ethics and Decision Making

In business and in our personal lives we are faced with decisions. We can make the decision with the understanding that there are consequences for some of our decisions or we can avoid making a decision and let someone else make the decision for us. Not making a decision is actually making a decision. Allowing someone else to make the decision for you may not work in your favor. If someone else is making the decision, they will most likely make a decision that is favorable to them.

Missing from most definitions of decision making is the mention of Ethics. Ethics is defined by Dictionary.com as: "the rules of conduct recognized in respect to a particular class of human actions or a particular group, culture, etc.: *medical ethics; Christian ethics;* moral

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[30] Go to: http://tfewines.com/tfe-green/ to see how Trinchero is working to improve the environment through ethical practices.

[31] Go to: http://www.imagerywinery.com/index.cfm?method=pages.showPage&pageid=d2ea47ef-c50e-634b-5044-1c9f5b143aa4 to view the actions at Imagery Winery.

principles, as of an individual: *His ethics forbade betrayal of a confidence."*[32] Another definition of ethics is: "The rules or standards governing the conduct of a person or the conduct of the members of a profession."[33] Ethics is simply doing the right thing. We all learn from the time we start crawling the difference between right and wrong.

Just as we all face decisions that must be made; we also all face ethical decisions. What is ethical decision making? The process of applying ethics to decision-making models will enable the decision maker to look at the impacts and the consequences of the decision. Business is filled with decisions that appear that the decision maker did not consider ethics in making a decision or perhaps considered ethics but chose to ignore ethics. There is no situational ethics. Ethics as a benchmark of business leaders is a simple yes or no, ethics do not change as situations change or conditions change. Ethics is a matter of right or wrong according to society. A business leader that compromises his or her ethics in the name of making a profit or personal gain compromises his or her ability to be a competent leader. There is no right way to do something that is ethically wrong. Unethical decisions usually lead to corporate scandal which in turn leads to corporate ruin. The collapse of Enron in 2001 is a classic example of this sequence of events.

Let's take a look at some of the business decisions from the past in Figure 4.1 that have not gone well—even though the decisions appear to be the result of a cognitive process:

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[32] "ethics." *Online Etymology Dictionary*. Douglas Harper, Historian. Accessed April 04, 2010. <Dictionary.com http://dictionary.reference.com/browse/ethics>.

[33] "ethics." *The American Heritage® Stedman's Medical Dictionary*. Houghton Mifflin Company. Accessed April 04, 2010. <Dictionary.com http://dictionary.reference.com/browse/ethics>.

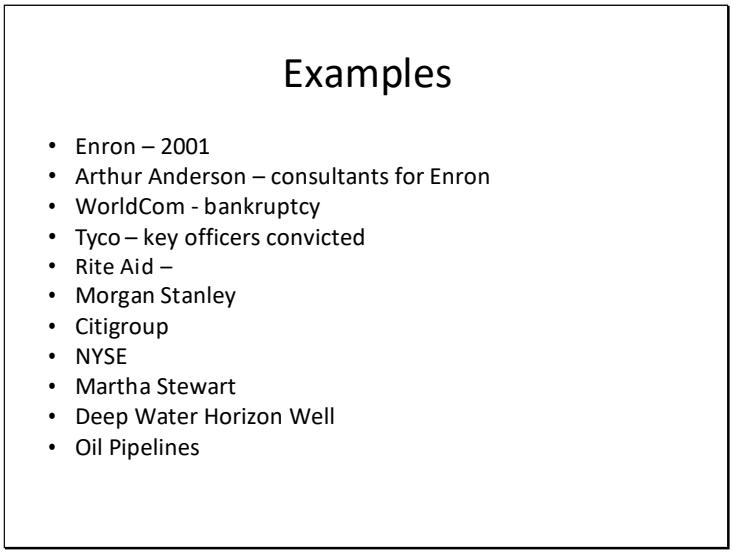

Figure 4.1: Examples of Unethical Decisions in Business

In the Enron case, the investors lost over one billion dollars in stock value as the company collapsed under the strain of the scandal and unethical decisions. The unethical decision making that led to the Enron scandal and collapse also led to the passing of the Sarbanes-Oxley Law that was designed to protect the individual investor. By doing this it also added a new level of bureaucracy to corporations.

The corporate officers for Enron focused on personal profitability and lost focus on the principles that the company was founded on. When corporate officers become so concerned about their own well-being at the expense of shareholders and employees, there will be serious consequences. In the case of Enron, they were assisted in this operation by their accounting firm, Arthur Anderson—once one of the premier accounting firms in the world. The association of Arthur Anderson with Enron and the ethical debacle resulted in the collapse of both firms. The collapse of Enron has ripple effects in bankruptcies, small business closings, even the recall of the Governor of California because of his association with the company and its unethical practices. This recall was responsible for Arnold becoming the Governor of California.

WorldCom, Tyco, and Morgan Stanley all suffered from the unethical practices of their management. Martha Stewart participated in insider trading information and ended up serving prison time. Even the New York Stock Exchange had problems with ethical practices by their officers. Ethics are standards that are higher than what is legal. It is, therefore, possible to be legal without being ethical. For example, the US Supreme Court ruled in 2012 that the Stolen Valor Law was not legal. The ruling stated that falsifying accounts of military valor is not illegal

although lying is unethical. As a result, the House of Representatives passed a new Stolen Valor Act in September 2012 that will at least prevent those that lie about their military records and awards from profiting from their lies.

Consequences result from decision making. Some of the consequences are good; sometimes the consequences are not so good. Decisions may result in the downgrade of a company's credit or the company's bond ratings; still other decisions may result in the collapse of the company. Ethics should help guide the company in making decisions and establishing corporate strategies.

Unethical Decisions in business lead to corporate scandals which as we saw with Enron, leads to corporate ruin. Figure 4.2 shows the Institute for Business, Technology, and Ethics reasons to run a business ethically. I added the last bullet. It would appear that the list is upside down. The most important reason for ethical decision making is because it is right. The rest of the reasons appear to diminish in value as you head up the list. The last reason to act ethically is to avoid litigation.

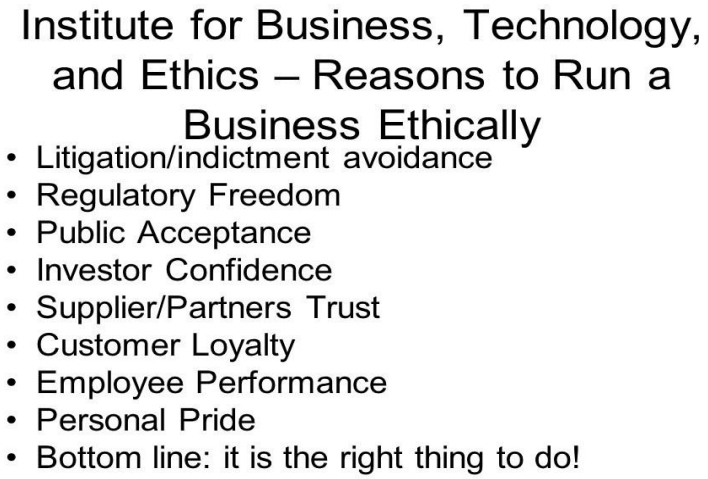

Figure 4.2 Reasons for Ethical Business Practices

Ethics in Product Design

In the 1970s Ford developed the Pinto. The Pinto was Ford's attempt to put an economy car on the Mustang chassis. The Pinto had two problems in the design of the car. The first was that it was a uni-body construction. When rear ended, the doors could be jammed shut.

The second problem was worse. The Pinto apparently had a problem with the location of the gas tank at the rear of the car that would burst into flames when experiencing a rear end collision. The problem was known but not fixed before the Pinto (see Figure 4.3) was introduced. Ford's initial analysis showed that it would cost less than $10 per vehicle to fix the problem but instead decided to place $175,000 times the projected number of deaths into a trust fund to cover liability expenses. The final result was deaths and lawsuits and the removal of the Pinto from the Ford Fleet.

This is why ethics is important in business decision making and in product design. Ford took the easy wrong approach over the harder right approach.

Figure 4.3: The Ford Pinto

Summary

Ethics is critical to business success. Cutting corners is the quickest way to get into trouble in business. Every decision made in business must be looked at from an ethical viewpoint.

There was a poem by Anonymous printed and laminated in my Dad's desk that I read often growing up that sums up ethics very well.

The Man in the Glass

When you get what you want in your struggle for self and the world makes you king for a day,
Go to the mirror and look at yourself and see what that man has to say.

For it isn't your father or mother or wife whose judgement upon you must pass;
The fellow whose verdict means most in your life is the man looking back in the glass.
Some people may think you a straight-shootin' chum and call you a wonderful guy,
But the man in the glass says you're only a bum if you can't look him straight in the eye.

He's the fellow to please, never mind all the rest, for he's with you clear up to the end.
And you've passed the most dangerous difficult test if the man in the glass is your friend.

You may fool the whole world down the pathway of life and get pats on the back as you pass,
But your only reward will be heartaches and tears if you've cheated the man in the glass.

This poem sums up ethics. If you make unethical decisions, no one other than the person staring back at you in the mirror may ever know. You still have to live with that person.

Chapter 4 Thought Questions

1. Why is ethics important in decision making?
2. What company's actions prompted the passing of the Sarbanes-Oxley Act?
3. What is the goal of the Sarbanes-Oxley Act?
4. What are the variables that are included in decision making?
5. What is ethics?
6. Is there such a thing as situational ethics?

Chapter 5

Forecasting

"We are out of stock of toilet paper, hand sanitizer, Lysol and Clorox wipes."

"Expired surplus swine flu vaccines to be incinerated. Another estimated 30 million doses will expire soon."[34]

The above headlines are examples of a forecasting faux pas. Obviously, no one could have forecasted the mass hysteria created by the COVID-19 (corona virus) in 2020. The panic buying did expose flaws in the just-in-time supply chains and forecasting lead times.

The need for Swine Flu vaccine was obviously forecast wrong. The above referenced article states, "About a quarter of the swine flu vaccine produced for the U.S. public has expired — meaning that a whopping 40 million doses worth about $260 million is being written off as trash." This is a very serious forecasting error. This is not the only forecasting error in business. But it does show the need to have a good forecast – especially important in forecasting the need or demand for perishable items such as the Swine Flu vaccine. According to reports on the 2009/2010 Swine flu vaccine approximately 43% of the vaccines will be destroyed.

The story of the swine flu vaccine was the subject of business case studies for the ability to react, forecast and produce the vaccines. The Food and Drug Administration, the Center for Disease Control, and the manufacturers will now become the subject of case studies for the

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[34] Srobbe, Mike, Associated Press, http://www.news-sentinel.com/apps/pbcs.dll/article?AID=/SE/20100701/NEWS/7010342, accessed July 18, 2010

inability to forecast properly and get the product to the market in time to be used by the consumers.

Lessons were not learned from the Swine Flu vaccine issues as the same issue was again seen in 2019 when there was a shortage of flu vaccine again. This time the result came from the move of the preponderance of medical supply manufacture and pharmaceutical production from the US mainland to China and Puerto Rico. The hurricane season of 2018 decimated Puerto Rico's manufacturing capabilities resulting in a shortage of flu vaccine and this was followed by a shortage of plastic bags for fluids in the hospitals. The bag shortage was a combination of the shortage of the vaccine resulting in a flu epidemic that increased the demand for fluid bags in the hospitals to treat those with the flu.

Forecasting Impacts

Forecasting has impacts on multiple areas of operations management. Many of these we will look at in greater detail in this course. Take a look at some of the key areas of the chain impacted by forecasting: (The impacts on each of these areas will be clear by the end of the chapter.)

- **Sales – a forecast of what the company will sale.**
- **Production – a forecast of what should be made to meet the sales forecast.**
- **Inventory – a forecast of how much the company should have in finished goods to meet normal demands and to cover fluctuations in demand.**
- **Facilities – a forecast of how large the facility should be and where should the facility be.**

- **Raw Materials – a forecast of how much should the company have in raw materials to meet the production forecast**
- **People – a forecast of how many people are required to support the customer and to make the products necessary to support the production forecast.**
- **Profits – a forecast of how much profits the company will make based on the other forecasts.**
- **Products – a forecast of what products the company should make now and in the future, as well as a forecast of what products should be retired or eliminated as they reach their planned end of life.**

The issue with using the sales forecast as the foundation for the other forecasts is that historically companies have rewarded sales personnel with bonuses for exceeding forecasts. This practice incentivized the sales force to under forecast in order to get a bonus. The under forecasting result was that the rest of the company was always behind the demand curve trying to catch up.

Forecasting may be accomplished using a number of different models and techniques. We could spend the entire semester on forecasting models and techniques. The goal of this chapter is to provide the operations manager tools necessary to make educated forecasts in order to support decision making and the requirements placed on the managers by their bosses. Forecasts can be presented in graphs, tables, spreadsheets and can even be used in "what if" analyses to improve operations for the company. Regardless of how the forecast is used and presented; regardless of what technique or formula is used, the key is to use a presentation technique that the boss understands and that you understand and can explain in plain language to

the boss and his/her advisors. Regardless of the value of the forecast, if you cannot explain how the forecast was derived, it will be of no value to you, the boss or the company.

Examples of using the wrong forecasting model

- **Iraq Rebuilding.** The original forecast for the rebuilding of Iraq was based on the intelligence provided at the time. This proves that a forecast with flawed information will be a flawed forecast. The forecast was for a very short occupation and a very quick rebuild of the infrastructure. Obviously the infrastructure was in worse shape than the intelligence reported and the strength of the insurgency was stronger than the intelligence reported.

- **Overstock.com/Big Lots.** These two corporations have made a business out of other people's forecasting errors based on flawed forecasting models.

- **End of Season Sales.** These sales are obviously a result of flawed forecasts either by the store or the corporation coupled with a push strategy. The purpose of the end of season sale is to get rid of inventory to prevent having to return the items to the distribution center. We will discuss this issue in the chapter on reverse logistics.

- **Shortage on the shelves of stores.** When a shelf is empty it is usually the result of a forecasting error. The pictures in Figure 5.1 and 5.2 show empty shelves in Florida in March 2020 after the pandemic buying started. Obviously, this could not have been forecasted accurately, but if the forecasters at the manufacturers and distribution centers were looking forward, they would have forecasted increase sales demand as buyers started panic buying. As it was, it took 4-5 months for some supply chains to catch up with demand for the products.

2020 Shelves in Publix

Figure 5.1: Empty Shelves

2020 Walmart Shelves in Florida

Figure 5.2: Empty Shelves in Walmart

- **Going out of Business sales.** A good forecasting model should prevent this type of sale. Obviously, sometimes this type of sale comes from the owners just getting tired

of the business or the owner passes away and the children are not interested in keeping the family business. However, most going out of business sales are the result of bad forecasting on what should be stocked, how much should be stocked and when the stocks should turnover.[35]

What is Forecasting?

Forecasting is simply a prediction of a future even or future demand for products. Most common forecasts involve what will happen with the weather tomorrow or for the weekend. In operations management we are still concerned with forecasts. Depending on the where we are in the operations management chain, the weather forecast may be important. However, we are really concerned with how much we need to have, make, stock, ship or return. In operations management, the true benefits of forecasting will be the amount of inventory remaining at the end of the season or the ability to meet the need of the customer. Forecasting based on historical data assumes that the events of history will repeat themselves.

Joe's Rules of Forecasting

The first and most important rule of forecasting is that **forecasts are usually wrong**. In fact, forecasts are always wrong. There are lots of models and techniques for forecasting, but there is no way to accurately forecast the future. Companies establish a margin of error for forecasts and as long as the "wrongness" is within that margin then the company is satisfied.

Every good forecast should include an estimate of error or margin of error. Actually, every good forecast should and usually does have an estimate of error. The estimates

[35] We will discuss the concept of inventory turnover during the discussions of inventory management.

that are made every election year based on the polls have a margin of error. This margin of error tells the user of the forecast how accurate the forecaster believes the forecast to be.

Forecasts are more accurate for families or groups. This is the rule of aggregation. The forecast for the product family should always be more accurate than the forecast for the individual models or colors. Automobile manufacturers can more accurately forecast the number of a particular car model that will be sold than they can forecast the number of red ones, blue ones or yellow ones that will be demanded by the customer. A printer of college T-shirts should be able to better forecast how many of a particular slogan shirt will sell than they will be able to forecast the colors and sizes that will be demanded by the customers.

Forecasts should be more accurate the closer we are to the forecast period. The closer the event is the more accurate the forecast should be. Even in the weather forecasting business it is easier to forecast tomorrow's weather than to forecast next week's weather. It is easier to forecast the sales for this week than the sales for next year. One company that I recently worked with had a series of forecasts. They forecasted sales eleven weeks out with an accuracy of 59% (there was no reason for a forecast that far out except, "We've always done it that way!" I am guessing somewhere in the past this corresponded to their replenishment times). They also forecasted four weeks out with an accuracy of about 90% (this was tied to their current replenishment cycle time). And, they had a forecast one week out for next week's sales that was about 95% accurate. This company's forecasts help to prove the theory that the closer to the event the more accurate the forecast. The most amazing thing about this company was that the only forecast that they reported to their corporate management was the eleven week forecast (because they had always reported that forecast).

The Importance of Forecasting

The ability to forecast as accurately as possible may very well impact the profitability of the company and the stock of the company. In addition, the ability to improve demand forecasting for customer demands and then sharing that information downstream will allow more efficient scheduling and inventory management throughout the entire operations management chain.

In 1997 Boeing wrote off $2.6 billion as a result of forecasting errors by themselves and their suppliers. They deemed these shortages as not only raw material shortfalls (read that to be a forecasting error) but also internal shortfalls and supplier shortages as well. Each of these shortfalls, internal and external, were the result of forecasting errors, very expensive forecasting errors. This error was compounded about fifteen years later when Boeing once again delayed the shipments of their new 787 Dreamliner aircraft. The excuse they used then was the same one they used fifteen years later – "internal and supplier parts shortages." The most common cause of these issues is a lack of communication in the supply chain.

A few years earlier in 1993, US Surgical suffered from forecasting errors that resulted in excess supplies that ended up costing the company approximately $22 million, representing a 25% decrease in sales. This forecasting mistake came from not knowing what their customers had in stock at the hospitals. Knowing the customer and the customers' requirements is essential to accurate forecasts.

In 2010 a leading sporting goods retailer sent out a flyer for a sale on a Saturday morning. This particular flyer contained an ad for a fly-fishing rod and reel combination. This company had this fly rod for sale for a four-hour period and thought that they had forecasted enough rods to last the entire four-hour period of the special sale. Unfortunately for this retailer, the forecast

was only off by about two hours. The result was having to place another more expensive rod on sale to meet the demands of customers that came from several states to shop the specials.

In 2014 the Kansas City Chiefs, along with the rest of the National Football League, mandated the use of clear bags in lieu of backpacks or purses when entering the stadium. The message went out first to season ticket holders informing them of the change in policies and notifying them of the availability of the bags for free for all season ticket holders -one free bag with the Chiefs logo per season ticket account. The bag is shown in Figure 5.3 below. The demand for the bags was not forecasted well as it was week three of the season before there was a sufficient number of bags to meet season ticket holder demand – which meant a longer delay for non-season ticket holders that wanted a clear Chiefs bag.

Figure 5.3: Chiefs plastic game day bag

Forecasting is essential for smooth operations of business organizations. Forecasting provides the company with estimates of the occurrence, timing, or magnitude of uncertain future events. Forecasting is not free – there are costs associated with forecasting future demand or future events for the company. These costs to provide a smooth operation include the costs of lost revenues from forecasting wrong as we saw with IBM when forecasting on the short side. On the other side of the forecast are the costs of having too many people or too few employees

on the job or in the factory/store; excess materials or material shortages; or having to expedite shipments and paying for expedited freight to meet customer due dates.

If forecasting is so important to the company and the operations management chains how do you ensure that you get the right data in order to improve the forecasts? The first tip is to capture the data in the same way that you will be using the data. If the forecast is for a monthly period, the data capture has to be in monthly time buckets. If your forecast is for daily demand or daily production, monthly data will not work. One company wanted to take daily data and extrapolate hourly production from the daily data. What the company wanted to do was take eight hours of demand data and average it over the day. The problem with this technique is that in actuality none of the hours had the average demand. If there are certain circumstances that may skew the data if not taken into consideration, these should be recorded. An example of this is the impact on building materials after Hurricane Katrina. Building material demand actually increased the cost of materials by almost 10% as far away as Kansas. Another area that may impact the ability to more accurately forecast demand or production may be to separate customers into different demand groupings. This is basically what General Motors used to do with the Chevrolet (the working man's car), Pontiac, Oldsmobile, Buick and Cadillac. If customers are segmented for marketing purposes, their demands and resultant forecasts should also be segmented.

Forecasting inaccuracies (forecasting errors – more on this later in the chapter) can increase the total cost of ownership for the company for products being produced or stored. These increased costs come in the form of:

- Increased inventory carrying costs as a result of forecasting the production of more product than the customer is buying.

- Obsolete inventory (although this may be considered part of carrying costs) as a result of grossly over forecasting to the point that there is so much stuff on the shelf that it becomes obsolete before it can be sold. This is common in the electronics industry where items become obsolete about ninety days after produced and in the fresh foods industry.

- Not forecasting for sufficient quantities of raw materials to meet production levels and having to expedite more materials in or worse accept less than quality materials to make up for the shortfall in the forecast. This particular problem results in the potential of producing substandard quality because of the substandard materials substituted for the forecasting shortfalls.

- The cost of expediting finished products to the customer to meet customer due dates or required delivery dates as a result of the forecasting shortfalls. Because the product is not ready in time to meet normal delivery methods, the company may be forced to ship via expedited delivery in order to keep customers satisfied.

The Role of Forecasting in Operations Management

In supply chain management, as we saw in Chapter 2, forecasting is critical to the overall success of the supply chain and may be tied to the ability of the company to pass accurate information to their suppliers. I am not sure that the panic buying of 2020 could have been predicted or if better information would have prevented empty shelves in that case. But I am certain that the Bull Whip Effect created by the panic buying and attempts to ramp up production to meet the demand will result in excess stocks within a few months.

In the short term, the forecast is critical to the production of products. This includes the forecasting of the raw materials, components, assemblies and sub-assemblies, the forecasting of the personnel necessary to make the supply chain operate effectively, and the forecasting of where the finished goods should be stored based on demand forecasts. In the long term, forecasts are necessary to predict the requirements and demand for new products and how many of the new products should be stocked and where they should be stocked. The processes and facilities necessary for the production and storage of new products is part of the long-term supply chain forecast.

Since the goal of the operations management chain is to add value by satisfying customer demand, a forecast is necessary to meet the production, distribution and quality to meet the customers' demands. The forecast must be robust enough to ensure an uninterrupted flow of products and/or services for the customers. The strategic plan of the company must include some form of forecasting in order to plan where the company needs to be in the future and what capacity the company will have to have in order to meet these forecasts.

This strategic plan and the ability to meet the forecasts in the strategic plan for publicly held companies are very closely watched by Wall Street. Sometimes companies play games with their forecasts and production to meet the forecasts.

Krispy Kreme Doughnuts tried to do this. Several years ago, as Krispy Kreme tried to pump up their production and shipment numbers artificially and the resulting forecasts for future production. Seems Krispy Kreme was not actually selling and shipping the numbers of doughnuts that they were reporting. The company was actually shipping the doughnuts to their retail customers (grocery stores and convenience stores) at the end of reporting periods with the understanding that the retailers would not be charged for the extra number of doughnuts shipped.

After the reporting period was closed out, Krispy Kreme would have the retailers ship the excess doughnuts back. The quantity shipped and the not actual sales quantity was reported thus skewing the forecasts for future sales and drove the stock price through the roof while also creating a huge waste of doughnuts. When this deceptive practice was discovered the price went from approximately $40 per share to $4 per share almost overnight. The darling of Wall Street crashed and seven years later the stock price is still depressed.

Forecasting Techniques

There are basically two commonly used techniques (not methods) for forecasting or predicting future events/demand/production.

- Extrinsic Forecasting Technique. With Extrinsic Forecasting, the forecast for the future is based on external indicators that are related to the product being forecasted. For example, a distributor of refrigerators may use the extrinsic technique to forecast sales of refrigerators based on the historical correlation between the sales of new homes and the sales of refrigerators. Another example: Every summer approximately 800 mid-grade US Army Officers move to Fort Leavenworth, Kansas for a year-long Intermediate Level Education program. These officers and their families transfer to Fort Leavenworth from all over the world and include foreign officers attending the education program. Extrinsic forecasting techniques would allow local merchants to base their stocks of household products on the number of families moving into the area and the historical correlation between families moving into the area and the number of household products such as blinds, cleaning supplies, rugs, etc., are sold.

- Intrinsic uses straight historical data to forecast future demand or production. These techniques are more common and will be discussed in greater detail by looking at the different methods of forecasting used under the Intrinsic Forecasting umbrella.

Intrinsic Forecasting

Intrinsic forecasting basically falls into two categories of methodologies. These methodologies are qualitative and quantitative methods. Qualitative forecasting is based on subjective methods when quantitative data is not available. Conversely, quantitative forecasting is based on mathematical models and formulas.

Qualitative Forecasting

Qualitative forecasting is subjective in nature. It is based on best guesses, opinions and judgment. A Qualitative forecast may be used for marketing, production or purchasing decisions. The problem with opinion-based forecasts or expertise-based forecasts is that it is critical to have a well experienced person making the forecast. Anyone can make a forecast based on an opinion but if the opinion is not based on experience in that particular area, the forecast may not be of any value.

Another qualitative technique used in academia frequently is the Delphi method of forecasting. The Delphi method uses a panel of "experts" to come to a consensus to make forecasts or predictions for the future. The Delphi methodology takes its name from the Oracles of Delphi in Greek Mythology. This technique's validity is obviously dependent on picking the right "experts" for the panel.

Several years ago, I had the opportunity to participate in a Delphi panel looking at the future trends that would affect supply chains into the future. The panel submitted a list of

potential trends. These lists were consolidated and redistributed to the panel members for rank ordering of the trends. The top 25 trends were sent out again to the panel with the goal to get the top 10 trends that would impact supply chain management in the future. We were fairly accurate; however, the panel of "experts" did not forecast the increase in fuel/crude oil prices that hit supply chains in 2004 and again in 2008 or the recession that followed closely in late 2008/early 2009. Had we possessed the "expertise" to foresee these issues, we would all probably be retired now from shorting the stock market and placing the timely puts and calls on oil futures.

No Delphi Panels predicted the market crash in 2020 or the pandemic and mass hysteria caused by the corona virus.

Quantitative Methods

Quantitative methods for forecasting employ the use of mathematical formulas and calculations to predict the future. These models and calculations assume that what happened in the past will happen in some form in the future. Qualitative methods may take the form of a linear trend line, a regression analysis, an average, a moving average, a weighted average or another more complicated method.

Each of these methods looks at the trends, cycles, seasons, random events that may impact the forecast and indices from business that may also impact the forecast. In 2005, the Fortune Business Council conducted a survey on what indices companies used to shape their forecasts. Some of these indices are still used very frequently today and some of them have greater importance now than they did in 2005. The Consumer Price Index is still frequently used, the price of a barrel of oil is much more prominent in shaping forecasts today than it was in 2005 after the $140 a barrel price in 2008. As a result of the recession of 2008-2010, everyone is aware of the unemployment rates and considers these rates as part of the forecasting process. The

improved economy after the recession has produced historically low unemployment levels. This created a new forecasting problem – where will the employees come from and what will be the employee turnover rates?

A **Trend** is a gradual up or down movement in the demand of the product. A trend can be used to predict what will happen in the future. It is important for a firm to know where they are in the trend in order to accurately forecast the future. The ability to spot a trend, up or down, is critical to the forecaster and his/her company. Figure 5.4 and Figure 5.5 show trend lines.

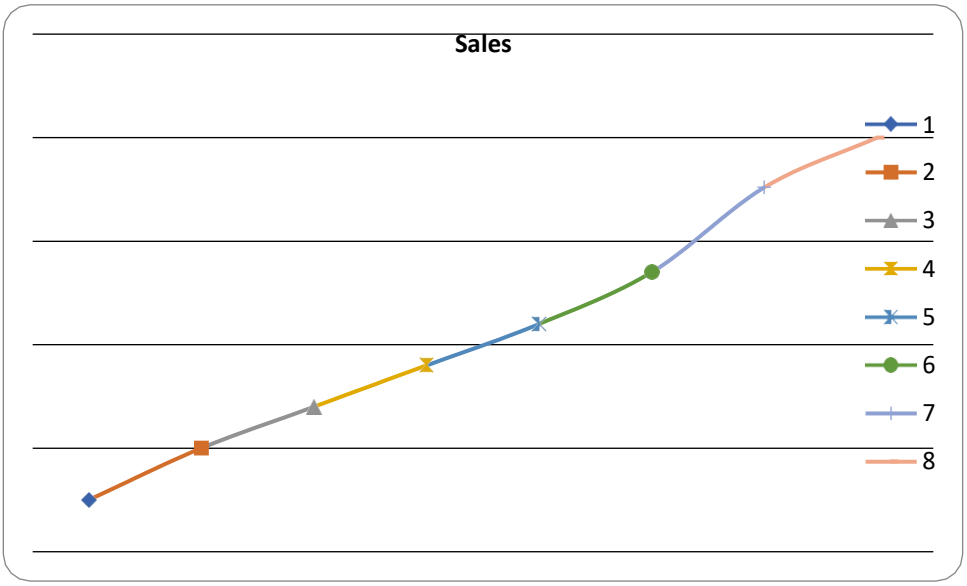

Figure 5.4: Upward Trend Line

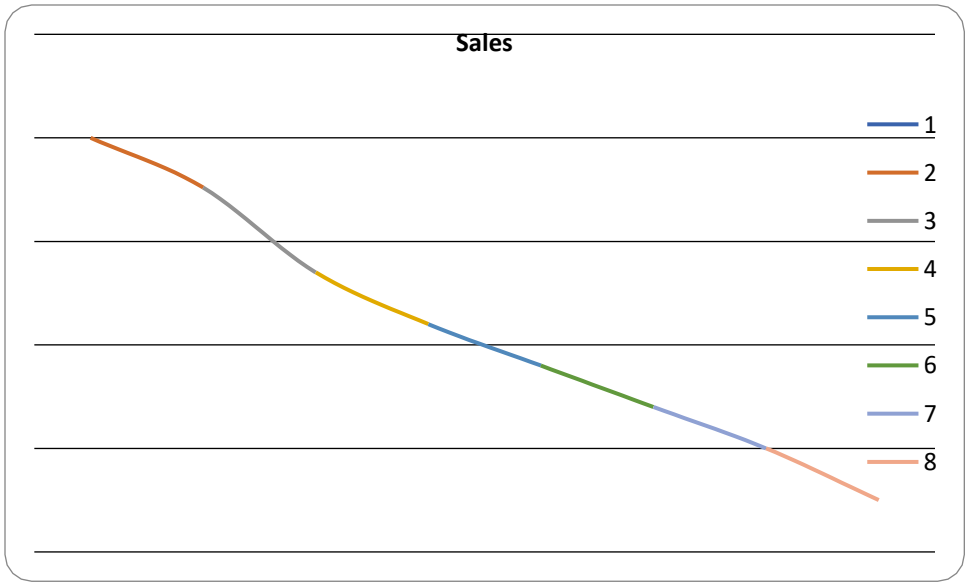

Figure 5.5: Downward Trend

A **Cycle** is usually tied to a business cycle. A cycle is a repetitive upward and downward movement of the production or demand for a product. Just like the trend, it is important for the forecaster to know where in the cycle his or her product or company is at the time of the forecasted period. Not knowing where they were in the cycle is what helped to deepen and lengthen the Recession of 2008-2010. Companies that did not identify where they were in the business cycle continued to produce products based on the previous trend and not the new business cycle that was spiraling downward. Figure 5.6 shows a cycle for the sales of a product.

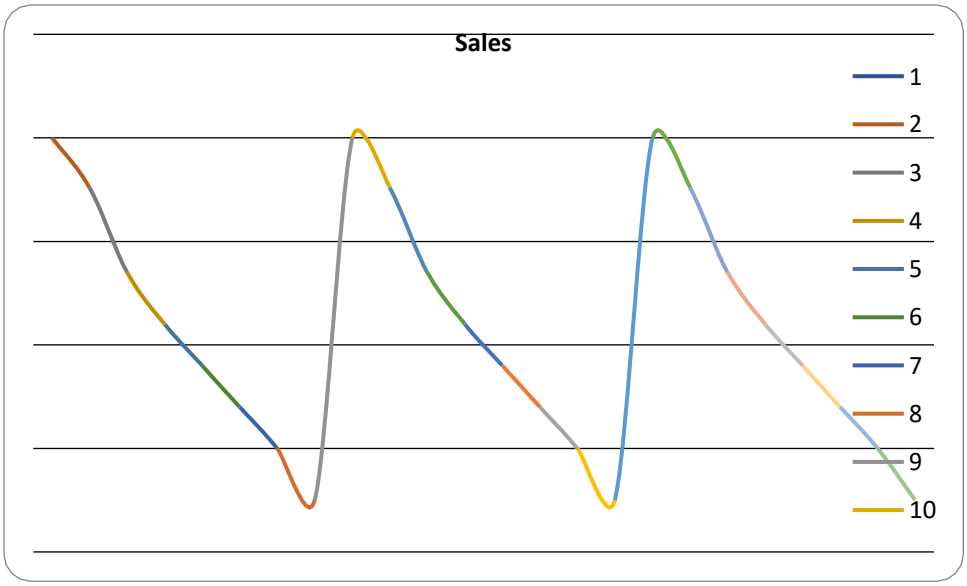

Figure 5.6: Example of a Cycle

A **Seasonal** pattern could possibly be trend line with spikes during certain seasons. Or, the seasonal pattern may be more obvious as shown in Figure 5.7 below. Seasonal items show a propensity to be sold in certain periods of the year. In Kansas, the sale of snow shovels is, thankfully, a seasonal item. Swimsuits in most parts of the country are seasonal items. Winter coats are also seasonal items. The sale of turkeys is seasonal in nature. Most turkeys sold in the United States are sold in the fourth quarter – the largest demand for turkeys comes around Thanksgiving and the Christmas holidays. After the holidays, the demand for turkeys falls off dramatically.

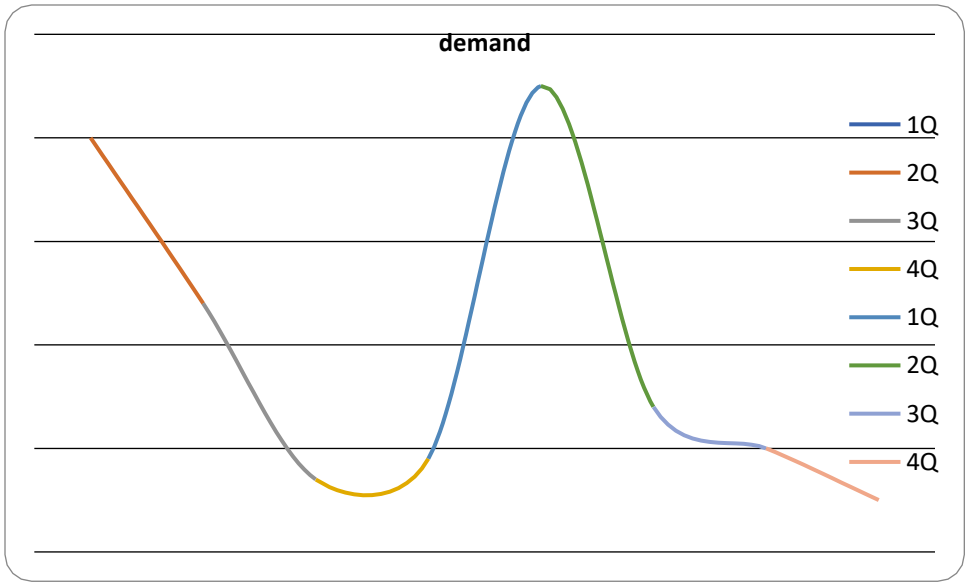

Figure 5.7 Example of a Seasonal Pattern

Time Series Quantitative Methods

Time series methods are statistical methods that use historical data with the assumption that the historical patterns will repeat themselves in the future. For the application of these techniques to operations management and supply chain management forecasting, we will focus on moving averages, weighted moving averages, exponential smoothing and seasonal forecasting.

However, a discussion of forecasting would not be complete without a discussion of the simplest technique of all – the **Naïve Forecast**. The Naïve Forecast is very easy to use. It simply assumes that whatever happened last period will repeat itself exactly in the next period. In Figure 7.6 the use of the Naïve Forecast can be seen. Whatever was demanded in the previous month is forecasted for the next month.

	Actual Demand	Forecasted Demand
January	75	
February	90	75
March	125	90
April	130	125
May	150	130
June	175	150
July	185	175
August	125	185

Figure 5.8: Example of Naïve Forecasting

The **Simple Moving Average Forecast** is also a simple methodology to use to forecast future demand, production or shipments. Stock market analysis usually starts with a moving average to show the trend line for the markets. With this technique all the forecaster to doing is averaging the demand/sales/production for previous periods. **Formula 5.1** is the formula for calculating the moving average:

$$\text{Moving Average} = \frac{\text{Sum of periods data}}{\text{Number of periods}}$$

Formula 5.1 Simple Moving Average

Using the same data as in Figure 5.8, Figure 5.9 shows the forecast using a 3 month and 5 month moving average. Which one is better? That depends on some historical analysis of the forecasts. We will discuss forecast error and comparing the techniques in another section. For example, purposes to understand the calculations, Figure 5.9 shows the decimal places in the forecast, as we move from the academic calculation to the concrete forecast for the business, we need to round to the next whole number. The rationale for this is that we cannot make a 0.666667 of a product, therefore in the example below; the forecast for April using the 3-month moving average should be rounded to 97. The moving average is a good technique when forecasting for products that are in a trend and have relatively stable demand patterns.

	Actual Demand	3 Month Moving Average Forecasted Demand	Calculation	5 Month Moving Average Forecasted Demand
January	**75**			
February	**90**			
March	**125**			
April	**130**	**96.666667**	**(75+90+125)/3**	
May	**150**	**115**	**(90+125+130)/3**	
June	**175**	**135**	**(125+130+150)/3**	**114**
July	**185**	**151.66667**	**(130+150+175)/3**	**134**
August	**125**	**170**	**(150+175+185)/3**	**153**

Figure 5.9 Simple Moving Average Forecast

The Weighted Moving Average

The **Weighted Moving Average** method sometimes creates confusion with students the first time they encounter forecasting. The Weighted Moving Average method does not involve any division as in the Simple Moving Average method. This method is called Weighted Moving Average because weights are assigned to the data. The weighs are usually provided by the forecasting team, marketing department based on the validity of the data or the manufacturing department based on their assessment of the data. The weights may be subjectively assigned which may reduce the value of the forecast. The weights can be used to place more emphasis on the most recent data by placing a higher weight on the most recent data or can be used to place more importance and value on the older data by weighting that data more heavily. All the weights must add up to 1. The weights are multiplied by the corresponding data and all the products of the multiplication are added together to get the forecast. The goal of this method is to consider and account for data fluctuation. The formula for the Weighted Moving Average method is shown in **Formula 5.2** while Figure 5.10 and 5.11 show the forecast using our previous data:

(weight 1 x data 1) + (weight 2 x data 2) + (weight 3 x data 3)

Formula 5.2 Weighted Moving Average

	Actual Demand	3 Month Weighted Moving Average Forecast	Weight	
January	75			
February	90			
March	125			
April	130		0.15	19.5
May	150		0.3	45
June	175		0.55	96.25
July	185			
August	125			
		(.15*130) + (.3*150) + (.55*175)		160.75

Figure 5.10: Weighted Moving Average for July – this forecast must be rounded up to 161

	Actual Demand	3 Month Weighted Moving Average Forecast	Weight	
January	75			
February	90			
March	125			
April	130			
May	150		0.15	22.5
June	175		0.3	52.5
July	185		0.55	101.75
August	125	176.75		
		(.15*150) + (.3*175) + (.55*185)		176.75

Figure 5.11 Weighted Moving Average for August – this forecast must be rounded up to 177

So far, we have forecasted August's demand to be 170 using a 3 Month Simple Moving Average, 153 using a 5 Month Simple Moving Average, and 177 (176.5) using a 3 Month

Weighted Moving Average. Which forecast is best? We will discuss that later when we look at forecasting error.

Exponential Smoothing Forecasting

The **Exponential Smoothing** method is widely used in business to help shape a more accurate forecast. Like the **Weighted Moving Average** method, this method also uses weights to smooth the forecast. And like the Weighted Moving Average, the weights must add up to 1. This method uses a smoothing factor (**α**). The smoothing factor must be between 0 and 1:

$$(0 \leq \alpha \geq 1)$$

The closer the smoothing factor is to 1, the more emphasis that is being placed on the recent data; consequently, the closer the smoothing factor is to 0, the more emphasis that is being placed on the older data. There are four basic steps to applying the Exponential Smoothing method to create a forecast:

1. **The first period** (and only the first period) that will be forecasted using this method will be **the Naïve Forecast** – the actual demand/production/sales from the previous period.
2. (Steps 2-4 will be used for the remaining periods) The next period forecasted will use the first part of **Formula 5.3**, Exponential Smoothing Forecast by taking the ACTUAL DEMAND from the PREVIOUS PERIOD and multiplying the demand by the smoothing factor.

Forecast = (Actual Demand Previous Period x ά) + (Previous Demand x (1-ά))

Formula 5.3 Exponential Smoothing Forecast

3. Using the second part of **Formula 5.3,** multiply the FORECAST from the PREVIOUS PERIOD by (1- the smoothing factor). This is the forecast that you just made in the previous period

4. In step 4, add the results of step 2 to the results of step 3 and round if necessary; this is your forecast for that period.

Figure 5.12a and 5.12b show examples of Exponential Smoothing Forecasting using the same data that we have used for the other forecasting methods.

	Actual Demand	Forecast	
January	75	1	
February	90	75.00	
March	125	84.00	4
April	130	108.60	
May	150	121.44	
June	175	138.58	
July	185	160.43	
August	125	175.17	
Calculations:			
March	(.6*90) + (.4*75)		
April	(.6*125) + (.4*84)		
May	(.6*130) + (.4*108.6)		
June	(.6*150) + (.4*121.44)		
July	(.6*175) + (.4*138.58)		
August	(.6*185) + (.4*160.43)		

2

3

Figure 5.12a: Exponential Smoothing Forecasting with .6 Smoothing Factor

	Actual Demand	Forecast	
January	75	1	
February	90	75.00	
March	125	84.00	4
April	130	108.60	
May	150	121.44	
June	175	138.58	
July	185	160.43	
August	125	175.17	
		3	
Calculations:			
March	(.6*90) + (.4*75)		
April	(.6*125) + (.4*84)		
May	(.6*130) + (.4*108.6)		
June	(.6*150) + (.4*121.44)		
July	(.6*175) + (.4*138.58)		
August	(.6*185) + (.4*160.43)		

2

Figure 5.12b: Exponential Smoothing Forecasting with .7 Smoothing Factor

You will notice that the first step both examples is the same data. The naïve forecast will not change when you change smoothing factors.

Seasonal Adjustments to the Forecast

In some cases, a **Seasonal Adjustment** may be necessary to provide a more accurate forecast for a period. The Seasonal Adjustment is designed to do just that. A Seasonal Forecast and forecast factor is necessary when there is a repetitive increase or decrease in the demand tied to a particular set of periods. The sale of winter sports apparel is seasonal by design but becomes even more seasonal in nature every four years after the Winter Olympics. As discussed earlier, the sale of turkeys is seasonal. When a seasonal spike is noticed then the seasonal factor can be computed, and a Seasonal Adjustment made to the forecast. Computing the seasonal factor is done using Formula 5.4.

$$\text{Seasonal Factor} = \frac{\text{Demand during period}}{\text{Total}}$$

Formula 5.4: Seasonal Factor Computation

Let's look at an example to make this concept clearer.

SALES PER QUARTER

YEAR	*1*	*2*	*3*	*4*	
2018	**172**	**26**	**3**	**125**	**326**
2019	**191**	**23**	**5**	**102**	**720**
2009	**213**	**56**	**1**	**226**	**735**

- **Sales for 1Q = 172+191+213 = 576**
- **Sales for 2Q = 26+23+56 = 105**
- **Sales for 3Q = 3+5+1 = 9**
- **Sales for 4Q = 125+102+226 = 453**
- **Total Sales for all 3 years = 1143**
- **Factor for 1Q = 576/1143 = .503 – this tells us the ~ 50.3% of all the sales for this product over the past 3 years came in the first quarter of the year.**
- **The next step is to compute the Simple Moving Average to forecast 2020 sales = 1143/3 = 381 as the forecast for total sales in 2020**
- **To get the Seasonal Adjusted Forecast: multiply 381 (total annual forecast) by .503 (seasonal factor) = 191.64 = 192 as the forecast for sales in the first quarter of 2020**

Forecasting Accuracy

So far, we have looked at methods and variations of methods to produce a forecast of future demand, production, sales, or shipments. The purpose of looking at various methods is to allow some "what if" analysis to find the most accurate method for our company and our products. Just because one method worked at your last company does not mean that it will work at your new company.

There are many ways of forecasting a forecast error. For our purposes, Forecast Error is a very simple calculation as shown in **Formula 5.5**. Forecasting accuracy is simply the actual sales/demand/production minus the forecast. Figure 5.13 shows the Forecast Error using our original example with the 3-month and 5-month Simple Moving Averages.

Forecast Error = Actual Demand – Forecasted Demand

Formula 5.5: Forecast Accuracy

	Actual Demand	3 Month Moving Average Forecasted Demand	Forecast Error	5 Month Moving Average Forecasted Demand	Forecast Error
January	**75**				
February	**90**				
March	**125**				
April	**130**	**97**			
May	**150**	**115**	**35**		
June	**175**	**135**	**40**	**114**	**61**
July	**185**	**152**	**33**	**134**	**51**
August	**125**	**170**	**-45**	**153**	**-28**

Figure 5.13: Forecasting Error

Note that in some months the forecast was over and in some months the forecast was under. Simply adding up the forecasting errors will give a distorted picture of the impact of the forecasting error. Therefore, to get a more accurate picture of the magnitude of the forecasting error over time, the Mean Absolute Deviation is used to measure the accuracy of the forecast. Figure 5.14 shows the original forecasting example for the 3-month Simple Moving Average and the calculation of the Mean Absolute Deviation. This will tell us on average how much our forecast deviated from the actual sales of our product. It is important to remember that this is an average and you will note that at no point did our forecast actually deviate by 38. This calculation does give us a mark on the wall as to how well we are forecasting.

1. **The first step is to convert all of the forecast errors to their absolute values. This simply removing the negative signs in front of the forecast errors when the forecast was short.**

2. **Sum up all of the absolute values.**

3. **Divide the sum from step 2 by the number of periods that were forecast and you have the Mean Absolute Deviation.**

	Actual Demand	3 Month Moving Average Forecasted Demand	Forecast Error	Absolute Error
January	**75**			
February	**90**			
March	**125**			
April	**130**	**97**		
May	**150**	**115**	**35**	**35**
June	**175**	**135**	**40**	**40**
July	**185**	**152**	**33**	**33**
August	**125**	**170**	**-45**	**45**
			Sum of Absolute Errors	**153**
			Mean Absolute Deviation	**38.25**

Figure 5.14: Mean Absolute Deviation Example

Another method of measuring or gauging the forecast accuracy is called a **Tracking Signal.** A Tracking Signal is used to alert the forecaster of when a forecast is out of tolerance. Remember all forecasts are wrong and a good forecast has a margin of error. The Tracking Signal provides an indicator of when the forecast is not within acceptable limits. One rule of thumb states that band of ± 3 Mean Absolute Deviations (MAD) is an acceptable Tracking Signal. This is also tied to the law of large numbers – the larger the numbers the more accurate the forecast. In our example above, if the ± 3 MADs is the standard then the forecast is not out of tolerance. However, if you are running a small company with forecasts for smaller numbers, ± 3 MADs may not be an acceptable Tracking Signal. In that case, a tolerance level based on a certain number of units may be used as the Tracking Signal. Whatever the technique used to establish a Tracking Signal; it is important to note that the larger the number the more the

forecast is out of tolerance. This is analogous to the upper and lower control limits established in quality control charts or in statistics courses.

Forecast Control

Some events are out of the control of the forecaster or the company but still may impact the accuracy of the forecast. Research is necessary to determine why a forecast is out of tolerance or out of whack. Any number of things can impact the demand for your product and therefore impact the accuracy of the forecast. The following is a short list of potential impacts to the forecast accuracy:

- Politics and political change. In 2008 the United States made history with the election of the first Hawaiian born President and the first surfing President. This caused ripples across the hunting and gun owning world as there was a fear (based on transition and campaign rhetoric) that the sale of weapons and ammunition would be severely controlled or banned. This created a "run" on the sale of handguns, rifles, shot guns and ammunition. Such a run that Cabela's had a record quarter based on the six weeks of sales after the November election. This had a serious impact on their forecasting for that quarter as well as the forecasts for future quarters to show progress. This trend continued throughout the Obama years every time there was a mass shooting. We can see the same impacts from political actions in the past several years with tariffs.

- The appearance of an unexpected business cycle. This is exactly what happened world-wide in 2008. A new and unexpected business cycle appeared. This cycle is now called the Great Recession. Forecasts drove manufacturing and retail stocks based on a continued growth trend. This drove the recession farther down as a result of increased inventories coupled with severely decreased sales. And, when no one is buying basically

no one is selling and the forecasts, based on historical data, become skewed and out of tolerance.

We saw the same thing in 2020 with the mass hysteria buying creating a new business cycle for certain products.

- Changes in the weather. After a hurricane the demand for building and rebuilding supplies goes through the roof, no pun intended. The same phenomenon is seen after a major flood. These weather changes impact the accuracy of forecasts that did not include these events and could very well impact future forecasts for demand if the abnormal demand from the weather change is not backed out of the forecast.

- The appearance of a new competitor. When Lowe's and Best Buy went into the major appliance business it impacted, or should have impacted, the forecasts of Circuit City. Apparently since Circuit City is no longer in business and Lowe's and Best Buy are in the top three sellers of major appliances, Circuit City should have altered their forecasts to consider the new competition.

- Not seeing trends. In the 1970s and 1980s there was a clothier named Merry-go-Round. This chain of stores carried the latest in fashions for the high school, college age and young professionals. It was the darling of Wall Street and consistently outperformed the competition. Then in the early 1990s, Merry-Go-Round did not see a new trend in clothing coming and forecasted the wrong merchandise – a critical and fatal mistake in the fashion industry. As a result of not seeing a trend coming, this company, like Circuit City, is no longer in business.

Summary

Forecasting has the capability to impact positively or negatively the success or failure of a company. Although forecasts are almost always wrong and a good forecast should have a margin of error, forecasting remains critical to smoothing production, getting the right product on the shelf in the right quantities to meet the customers' needs. Because everyone admits that forecasts are almost always wrong, we discussed multiple ways to create a forecast. The different methods of forecasting allow companies to conduct "what-if" analyses to tweak the forecast and get the best method to minimize forecasting error.

Discussion Questions/Thought Leaders/Problems to Assist in Grasping the Concepts

1. A_____is an up-and-down repetitive movement over a long period of time.

2. _____methods of forecasting are based on best guesses, past experience, and other subjective methods.

3. What impacts does forecasting have on the operations management chain?

4. Look at the newspaper or an online article or an Annual Report for a company and see if forecasting is a problem for that particular company.

5. Calculate the 3 and 5 month Simple Moving Average for the following data:

	Actual Demand	3 Month Moving Average Forecasted Demand	5 Month Moving Average Forecasted Demand	Forecast Error
2013	**275**			
2014	**195**			
2015	**250**			
2016	**275**			
2017	**325**			
2018	**400**			
2019	**225**			
2020	**275**			

6. Using the data above calculate the Mean Absolute Deviation for the forecast error for both the 3 and 5 month calculations.

7. Using the table below and the following weights, calculate the Weighted Moving Average starting in 2005. Most recent data = .45; next previous data - .35; next previous data = .2

	Actual Demand	Weighted Moving Average
2013	**275**	
2014	**195**	
2015	**250**	
2016	**275**	
2017	**325**	
2018	**400**	
2019	**225**	
2020	**275**	

8. Using a smoothing factor of ά = .75, calculate the forecast for the following sales data:

	Actual Demand	Forecast
January	**1100**	
February	**1125**	
March	**1125**	
April	**1300**	
May	**950**	
June	**2000**	
July	**2100**	
August	**2500**	
September		
Smoothing Factor = .75		

9. Using the data above, calculate the forecast through September using a smoothing factor of .45.

10. Which of these forecasting calculations provides the company with the most accurate forecast?

11. Think of a situation, politically or otherwise, where the actions may have impacted the forecast.

Chapter 6

Capacity Planning

What is capacity?

The Merriam-Webster Dictionary defines capacity as: "the largest amount or number that can be held or contained."[36] This does not really help when looking at capacity and capacity planning for operations management. APICS defines capacity a couple of ways that are relevant to operations management: "1) The capability of a system to perform its expected function. 2) The capability of a worker, machine, work center, plant, or organization to produce output per time period."[37] A simpler definition for an introduction to operations management is that capacity is the maximum amount of *quality* output that can be produced. It is important to mention the link to quality as any output that is not quality is not productive output.

The capacity of a system is critical to the planning and production phases of products and services. Capacity is not just a production or storage concept. If you think of your favorite restaurant as a service, the capacity of restaurant is not the maximum capacity as determined by the fire department inspection; it is the maximum amount of customers that the restaurant can serve in an acceptable time. This is may explain why you may visit a restaurant and there are vacant tables but there is still a wait time—the capacity is dictated by the number of servers and cooks not the number of tables.

In the manufacturing sector, the first stage in capacity planning is to determine the maximum capacity of the plant or shop floor. The most discussed concept for this phase is known as Rough Cut Capacity Planning (RCCP). RCCP is defined by APICS as: "the process of

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[36] "Capacity." *Merriam-Webster.com*. Merriam-Webster, n.d. Accessed July 17, 2020. <http://www.merriam-webster.com/dictionary/capacity>.

[37] Blackstone, John H., Jr., APICS Dictionary, Fourteenth Edition, APICS, Chicago, IL, 2020, p. 21.

converting the master production schedule into requirements for key resources, often including labor; machinery; warehouse space; suppliers' capabilities; and in some cases, money."[38] RCCP is a preliminary stage to determine, if all resources are available, if the company can meet the needs for the Master Production Schedule. The Master Production Schedule is the anticipated build schedule based on adjusted forecasts and firm orders from customers. Often enough cut capacity planning will indicate that a set production level is doable for the company, but when constrained by available resources the company may find that actual capacity is exceeded.

RCCP leads to capacity planning which is simply determining how much capacity the company needs to meet the production schedule. Capacity planning includes Capacity Requirements Planning. During this phase of the planning process, the company looks at constrained capacity to determine the actual capacity available and how to use that capacity to meet the Master Production Schedule requirements. Constrained capacity takes into consideration worker absences (vacation, sick time, appointments), machine maintenance time, and known material shortages or delays.

Capacity Requirements Planning is the process of establishing the overall level of productive resources needed in the facility or system to meet the demands of the Master Production Schedule (MPS). One of the outputs of this process may be the determination that additional capacity is needed and when it is needed. Failure to properly conduct this phase of the planning process may impact the responsiveness of the company to the customers which in turn could impact the competitiveness of the company and maybe even the life of the company.

Capacity Planning includes a series of decisions for the company as shown in Figure 6.1. The goal is to try to maintain as level a production process as possible. Designing a facility that can be used for manufacturing more than one product is helpful in this goal – this will be discussed in greater detail in Chapter 7.

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[38] Ibid., p. 153.

1. **When do we need to add capacity?**
2. **How much capacity do we need to add?**
3. **Where is the new capacity needed?**
4. **What type of capacity is needed? (labor, materials, machines, etc.)**
5. **When do we reduce capacity? (This is not a good thing but may be necessary if demand for a product or service decreases.)**

Figure 6.1 Capacity Decisions

Do we need to add capacity? When do we need to add capacity? If the demand for the product or the forecasted demand for the product exceeds the company's capacity, the options are to expand the operations or outsource the additional capacity needs. If the demand increase is a short-term increase, it may be better to outsource. If it is a long-term increase in product/service demand, then the answer may be to add capacity to the firm. If the increase is short-term, the decision may be to outsource temporarily.

This leads to the decision of how much capacity to add. The follow-on question to this is does the company add a little capacity at a time on a regular basis or one large increase in capacity and then grow into the new capacity? One distribution center in Southern California after trying the little capacity additions realized that they were constrained in their location and could not expand any more. Their decision was to move about five miles down the road, buy more than enough land for future expansion, and build a facility that was about one and one-half the size of what their immediate needs were and then grow into the facility.

The answer to the question of "where is the capacity needed?" can only be discovered by walking the process. The first place to look is at the system constraint. Every system has a constraint, and the system capacity is the capacity at the constraint. Walking the process will identify the constraint. This leads to deciding what type of capacity increase is needed. It may be as simple as adding a machine or adding another shift or it could be as complex as designing and building a brand new facility. Temporary workers may be the answer. Department stores do this every Christmas season and Parks and Recreation Departments do the same thing every summer. The stores know the sales will be increased from the increase in customer traffic buying for the

holiday season and add seasonal help. Lawn and garden centers and services do the same thing with summer hires to account for the seasonal increase in demand.

The least favorable option for the company when demand exceeds capacity is to backorder the product to the customer. Backordering is not a good option as it forces the company to violate the concepts of perfect order fulfillment and means the customer will have to wait longer for the product. Since most companies do not have a monopoly on products, this may mean losing a customer or an order to a competitor.

When capacity exceeds demand for the product there are a few options to consider. The first and most drastic is to reduce capacity. This may be in the form of plant closures, forced vacations, furloughs or employee layoffs. The second remedy may be to reduce operational hours. Many companies have adopted this option during the pandemic to keep workers employed while meeting the needs of the customers.

Aggregate Planning

Aggregate capacity planning is a long-term look at capacity needs and requirements. Usually aggregate planning looks 18 months or eighteen to twenty-four months into the future. Why should we be concerned that far out? The forecasted demand for the product is going to drive long-term planning for resources. The need to look far into to the future is based on the lead times necessary to increase capacity. This does not happen overnight. An increase in capacity may require a new facility or new equipment. New facilities take time to design and build and time to hire and train the employees to staff the facility. Aggregate planning allows the company to start the process of creating new capacity without waiting until the last minute.

Master Production Schedule

Short-term capacity planning is driven by the Master Production Schedule. This anticipated build schedule helps to formalize the production plan and helps the company translate specific parts/components/finished products requirements into a work schedule and capacity plan. The near-term capacity plan has to extend out at least as long as the longest lead time (lead time is the time from you order a product or component until the time you receive it) for the components or materials for the product (this ties to the inventory concept that we will discuss in Chapter 16 and the Bill of Materials concept that we will discuss in Chapter 13).

System Capacity versus Department Capacity

When calculating a capacity for a system or facility it is important to look at the total system as well as the capacities of individual operations. The Theory of Constraints (as discussed in Chapter 18 in more detail) states that the throughput capacity of a system is the capacity at the constraint or bottleneck. Therefore, it is important to look at the total system by walking the process starting with the capacities of the component operations. The Theory of Constraints states the adding capacity anywhere but at the constraint will not increase the capacity of the system – it must be increased at the constraint.

For example: the US Army has a system known as the Fuel System Supply Point. Each individual system contains up to six 50,000 gallon fuel containers. However, the capacity of the system is not the total of the storage containers (up to 300,000 gallons) but the capacity of the fuel hoses, the filters and the pumps that deliver the fuel from the containers to the customers' fuel trucks. The system uses a series of hoses and pumps to distribute the fuel. The primary constraint is the capacity of the filter separator which is only 150 gallons per minute.

Capacity Utilization versus Capacity Efficiency

What is Utilization? Utilization is a manufacturing measurement of how much of a company's available capacity is being used. Many textbooks will make you believe that the closer a company is to 100% utilization the better the company is managed. Figure 6.2 shows calculations for utilization.

Utilization Rate =

(Actual output rate/available capacity) x 100

Or

(Hours worked/hours available) x 100

Figure 6.2: Utilization Calculation

Then, why is 100% or as close to 100% not always a good number? The utilization rate should match the consumption rate or sales rate. Consider the following scenarios:

- What if producing 100% utilization at one workstation in the system creates a buildup of work in process inventory at the next workstation because the line is not balanced (we will look at line balancing in Chapter7) or due to a constraint? This will result in excess work in process inventory – products that are between raw materials and finished goods.
- What if producing at 100% results in producing more product than the customers are buying? This would result in excess inventory.

The push for 100% utilization usually comes from the finance offices that use the justification "you wanted a new machine; we found the money and now you are not using it to peak utilization." The same personnel will come back next month and ask why there is so much excess inventory on the shelves.

Another consideration for not producing at 100% utilization may be the actual hours worked compared to the hours available for work. This calculation must take into consideration the warm-up time for machines and cool-down times for machines before and after production runs. Some machines may need to warm up to a certain operating temperature before efficient production occurs. And some machines may need to cool down before completely shutting down at the end of the workday. If this is not taken into consideration, their utilization rate calculation may be impacted.

What is efficiency? Efficiency is the measure of how well a worker, workstation, or machine produces compared to a standard output as shown in Figure 6.3. Examples of measuring efficiency include pieces produced per hour compared to the set standard for outputs.

Efficiency = output (pieces per hour)/ standard pieces per hour

Figure 6.3: Efficiency

Demand Planning and Balancing as Part of Capacity Planning

One of the goals of facility planning (more on this in Chapter 7) is to provide for the future and provide flexibility in operations. One of the goals of capacity planning is to have a smooth level production rate. A methodology for accomplishing both goals is to try to manage

the demand rate for products. This can be accomplished in a variety of ways. Demand planning, production planning, product design and capacity planning must be balanced.

Shift demand into slow periods. This may be the result of sales promotions or advertising campaigns to convince the customer to buy the products or services in an off period. Disney used to do this with their Florida Resident Salute Pass. This pass allowed unlimited visits during the periods that Disney had identified as off-peak periods. This provided a win-win. Disney had guests in the park and Florida residents got to enjoy the park in less-crowded times.

Offer the product or manufacturing in off cycle or counter-cyclic times. Burlington Coat Factory made an entire market this way. They started off by offering winter clothes in the summer and summer clothes in the winter. Toro attempts to balance the workload in the manufacturing. They make lawn mowers in the winter and snow blowers in the summer on the same assembly line. Another variation of this model is to work with customers to offer them incentives to commit to the purchase of seasonal items in the off season with guaranteed delivery in time for the seasonal sales.

Requiring Reservations. From a services perspective, demand planning and capacity planning can be seen in restaurants that require reservations. The use of reservations allows the restaurant to control the capacity of guest coming into the restaurant. It can also be seen at Disney World with the use of the queues for rides. Disney is a master of this concept by continuing to move the guests through a series of rooms as part of the queue to keep the wait from seeming as long as it is. This can be seen in Figure 6.4.

Figure 6.4: Queueing System at Disney World

Scheduling

Scheduling may be the most difficult part of the planning process. Scheduling operations must consider capacity. But it also must consider personnel and personnel skills, materials availability, machine availability, and customer priorities. This makes scheduling difficult.

In the absence of any other guidance, the best method of scheduling operations is first in and first out. This means that the first order received is the first order worked on and completed.

Summary

Capacity planning is critical to the success of the operation whether it is a service industry or a manufacturing industry. The Theory of Constraints states the throughput capacity of the system is the capacity at the bottleneck. It is important before embarking on a capacity planning activity to walk the process and identify any bottlenecks or constraints. The entire capacity planning process is driven by the Master Production Schedule and if there is an

imbalance between capacity and the schedule, the planner has to make some critical decisions on how to balance the scheduled production with the necessary capacity.

Discussion Questions/Thinking Questions on Capacity

1. Why or why not is 100% utilization important?
2. What are some of the reasons for not working at 100% utilization?
3. Why is it important to have a plan for when there is more capacity than demand?
4. What is the difference between utilization and efficiency?
5. From your perspective, what is one example of the Theory of Constraints?
6. What is the purpose of the Master Production Plan?

Chapter 7

Facility Layout Design and Location Analysis

Facility location analysis and facility layout design is critical to the success of operations. The layout may dictate the profitability of the company and should be carefully considered during the product design and process selection/design decisions. The layout should not dictate the processes. However, in older facilities this may be the case. Ideally, the processes should dictate the layout. Customer locations may drive the decisions on the location of the facility and the site selection decisions dictate part of the layout plan.

The major goal of facility planning is to minimize material handling within the facility, regardless of the type of facility being planned. If material handling can be reduced, the opportunity to mishandle, mislead, or damage the product is minimized. If the material handling can be reduced, costs can be reduced and if costs can be reduced one of two things can happen: either the profits for the company can be improved or the price for the products can be reduced. Figure 7.1 shows a facility that was located near major interstate highways, major rail yards and near several major airports and seaports. There are advantages to locating facilities such as warehouses, distribution centers and cross docking facilities close to major supply chain nodes.

Figure 7.1: Cross Docking and Trans-loading Facility—Located near Major East-West and North-South Roads and Major Rail Yard

The next goal of the layout design process should be to layout the facility to improve the efficiency of the space and workers. In a distribution facility, the majority of the worker's time is spent moving from one location to the next picking location. If the layout can be designed to better utilize the space and use the employees' time more effectively, the amount of time spent walking from one location to the next can be reduced. This can be accomplished by storing fast moving items closer to the shipping and receiving areas or through the use of robotics such as the Kiva System used by Amazon.

One of the biggest complaints in the distribution and warehousing world is that is a shortage of space – "We don't have enough storage space!" Primarily because most facility managers measure their space on the square footage of the facility vice cube footage utilization. Almost everyone in the industry falls into this trap. Look at a *Modern Materials Handling* Magazine[39] and you will see articles about distribution centers—almost each one of them lists the square footage of the facility. Efficiently utilizing the space of the facility may mean utilizing the cube footage of the facility. Very few distribution centers or warehouses only stack supplies and materials one pallet high, therefore cube footage may provide more space. And, placing like

[3939] Go to http://www.mmh.com/ for more information on Materials Handling and facility layout models.

items close in the facility may very well reduce the movement in the facility, thus using employee time more efficiently. Using common sense in laying out the facility also helps produce more usable storage space.

To more efficiently layout the facility it is necessary to eliminate bottlenecks in the facility. This is much easier to do when designing a new facility than when inheriting an older facility. We will look at the Theory of Constraints in more detail in the discussion of Just-in-Time. However, it is imperative to get rid of all bottlenecks in the facility to produce a more efficiently run facility. Any bottleneck will reduce the efficiency and effectiveness of the operation. The principles of the Theory of Constraints and the principles of Just-in-Time—reducing waste—will improve the efficiency of the facility.

Early in the course we said that anything that does not add value is waste. We will see in future discussions that the goal of Just-in-Time is to eliminate waste. If waste is removed from the operations, there will be less movement. If there is less movement, we have achieved the primary goal of the layout design: reducing the need for material handling. If reducing material handling is achieved, the need for material handling equipment is reduced and therefore the costs of operations are reduced and again profits should be increased.

A good facility layout should consider the interaction and communications between the workers and management. If communication is improved, the quality of the outputs will improve. If the management can communicate directly with the workers, less will be lost in the communications process. One facility that I was in recently had all of the management on the second floor with two-way mirrored glass on the walls so that they could look down on the workers. This provided the management team with visibility of what was happening on the shop floor but violates the idea of facilitating communications.

The World Wide Operations Center for BNSF Railroads[40] has the same layout design. The BNSF facility is an awesome facility. From the floor (and from the windows on the second level) everyone can see the large screens that show the location of every train on the system and the contents of the trains as well as a weather screen and a listing of freight by commodity. The problem is that when on the operations floor, you feel like you are in an old

[40] For more on BNSF go to http://www.bnsf.com/

Western/Horror/Comedy where the eyes are cut out of the painting and you feel like someone is always watching you. This also impeded the ability to communicate face to face. Conversely, FedEx[41] has a World Wide Operations Center in Memphis, Tennessee that is similarly set up on the operations floor—large screens with tracking for every plane and the FedEx Weather Station. The difference is that the offices are on the operations floor to facilitate communications.

The final goal of the facility design process is to facilitate reduction of cycle time. In a distribution facility the goal of the layout design the goal is to reduce the processing times in the facility to reduce the customer wait times for the products the customers have ordered. If the facility is laid out for efficiency, it should also improve responsiveness to the customer.

In a service operation the goal should be to maximize the exposure of products to the customers depending on the type of operations. In some operations it may be better to design the process to minimize the travel and movement of the customer through the facility. Figure 7.2 shows the entrance to Ron Jon Surf Shop in Cocoa Beach, Florida. There are three ways to enter the store and at every entrance is the display of the newest shirt designs to encourage the impulse buy.

[41] For more on the operations of FedEx go to fedex.com

Figure 7.2: The South Entrance to Ron Jon Surf Shop – T-Shirt display to expose products to the customers

Grocery stores have the concept of maximizing exposure of the products to the customer. Almost every grocery store has the same layout. You go into the store and the fresh fruits and vegetables are on one end of the store, the meats and seafood are along the back, the frozen foods and breads are in the middle, and the dairy products are at the other side of the store. Even the Wal-Mart Supercenter grocery layout concept has the same basic layout only from front to rear rather than left-right or right-left orientation.

Starbucks stores are laid out to maximize the exposure of the products such as cups, accessories, coffees, and teas to the customer before reaching the counter to order a drink or pastry. Another coffee chain needed assistance with their layouts in 2005. This West Coast chain was looking for suggestions from consultants to improve the sale of the complementary items to their coffees and teas. Figure 7.3 shows their typical layout and analysis of the layout.

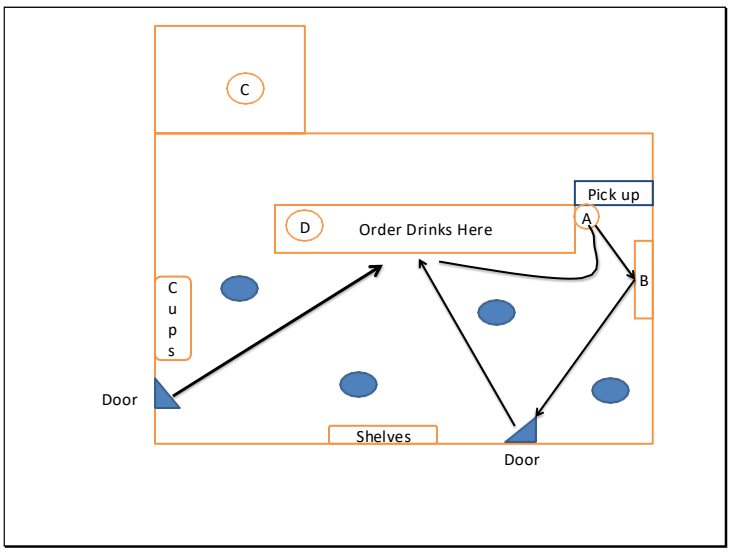


Figure 7.3: Coffee Shop Layout

The first observation of this layout is that the customers could enter either of the doors without ever seeing the cups and mugs for sale or the coffees and teas for sale on the shelves. This violates the idea of maximizing exposure to the products. The next problem with this layout is that after ordering the drink, the customers go to the pickup area to get their drinks. Located by the pickup area at A was the menu of what drinks were available. This probably should be placed in clear view of the ordering area and not where you pick up the drinks. After picking up the drinks and getting cream and sugar at B, the customer could leave without seeing the other items for sale.

If the customer came in the door on the bottom of the diagram, they could reach the ordering area without ever seeing the pastry area at D. The area shown at C was actually a tasting area that featured the newest flavors and the coffees of the day. This area was not clearly marked and was not obvious to the customers and therefore not really utilized, thus losing the marketing value of the area. Compare this to a typical Starbuck's layout (see figure 7.4) where cups and bags of coffee are exposed to the customer to encourage the impulse buy while waiting in line.

Figure 7.4: Starbuck's layout to expose products to the buyer

Other Considerations for Layout Planning

Safety and Security

Safety always must be a consideration in the design of the facility or the layout of the facility. A company can design the most efficient production layout but if it places the employees at risk or places the product at risk from the layout, it cannot be implemented. Granted providing a quality product with the least amount of movement and material handling is important, but the most important asset that any company has is its employees. If the safety of those employees is put at risk, the design is a no-go.

In California, the Occupational Safety and Health Administration (Cal OSHA) has certain rules and regulation that may or may not be applicable in other areas of the country. But these rules to protect the workers may be applicable in other states and to other countries that have Earthquake threats. Cal OSHA requires distribution centers that stack materials more than two pallet positions high to be bolted to the ground for Earthquake protection. This is important when designing a distribution center or warehouse layout. Why? Once the pallet racks are bolted down it is not only not practical but possibly not cost effective to move the racks—so, it is important to get the racks in the right place the first time.

It is also important to consider security of the facility and controlled access for visitors and employees as part of this design process. Most facilities have a controlled entrance and may have security guards at the entrance to ensure that employees are coming and going from the

controlled access point. The other reason for this controlled entry point besides the safety and security of the employees is to ensure that a dishonest employee is discouraged from taking stuff out of the facility.

Product Quality

Obviously, as the process design is for producing a quality product, the layout of the facility has to support that goal. If the layout design's primary goal is to minimize material handling, the corollary benefit of this goal is that the chances of producing a quality product are improved if the product is handled as little as possible. The fewer times a product is moved the smaller the probability that it will be damaged or misrouted, thereby reducing the impacts on the quality of the product.

If a product needs a certain environment for production such as a painting facility or the manufacture of computer chips, there may be impacts to the layout and/or the location of the facility. For example, when the Harley-Davidson Plant was in Kansas City, Missouri, the painting of the gas tanks was accomplished in a controlled environment that contained an air dam to blow particles off the workers to prevent defects in the paint. This process also has restrictions on the foods that the workers can eat to prevent defects in the painting of the tanks as a result of oils from the foods.

Flexibility for Future Operations

Every plan should include a consideration for the future of the operations. Whether it is a manufacturing facility that needs to consider future products or variations of the same product or a distribution center that needs to consider future storage requirements and product configurations, as well as the ability to expand capacity in the future, the company has to consider posturing for the future. This is an example of facility planning linked to capacity planning.

In the mid-1990s, Grainger designed and built a new distribution center in Ontario, California. By 2001, this facility had outgrown its capacity and needed to expand the operations. However, in the 5+ years that the facility was open, the facility had become blocked in—there was no place to expand the facility. Grainger decided to design and build a new facility a few miles down the road in Mira Loma, California. This time the facility was built larger than the current capacity by about 1.5 times. This allowed the company to slowly expand into the facility

as the need arose. The other flexibility that Grainger built into this facility was to buy the land around the facility to allow for the flexibility of future expansion and prevent being blocked in again.

Types of Layouts

Process Layout

A process layout places all of the like machines in the same area of the facility. As processes are completed the products are moved to the next process. In the facility diagram below (Figure 7.5), each of the areas shown represents the groupings of like machines or processes.

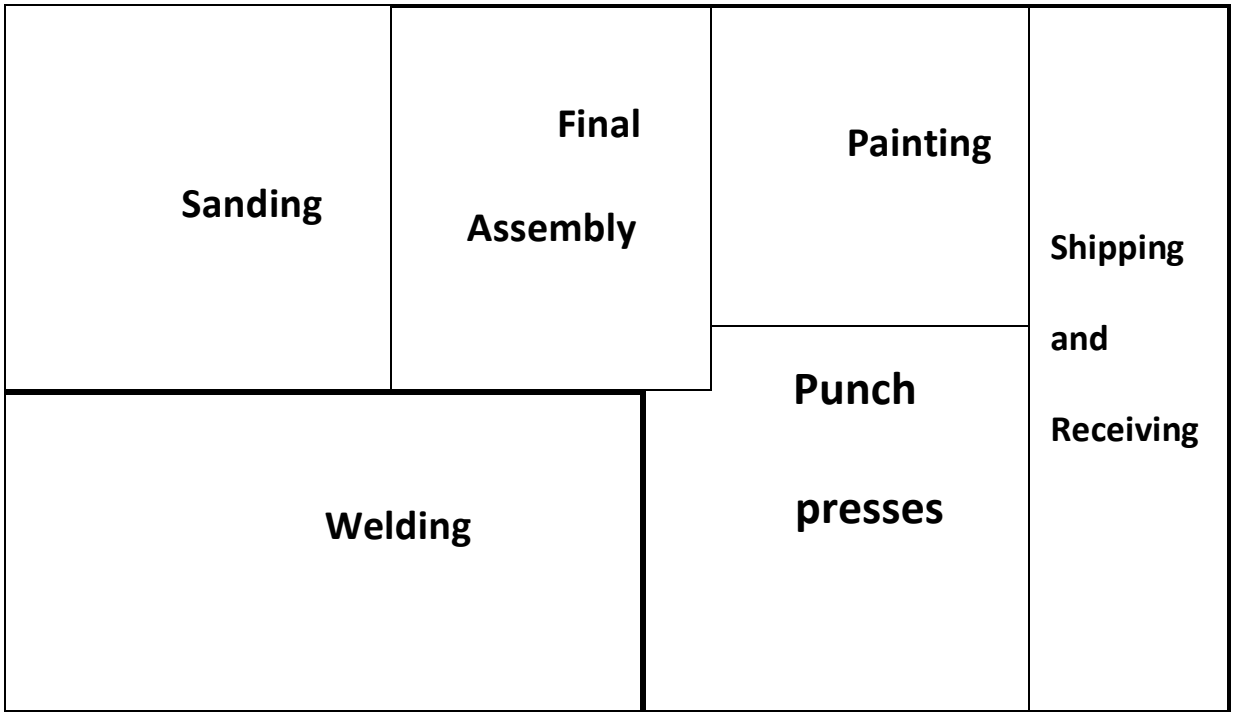


Figure 7.5: Process Layout Example

In order to improve the layout of a facility it is necessary to analyze the flow of materials or work in process from one process to the next. This flow analysis may show that the layout is flawed and not producing an efficient use of personnel and is causing an inordinate amount of moving of the materials and work in process. Take a look at Figure 7.6. This example shows a similar process layout that may not be as efficient. Look at the flow of the materials and work in process through the facility. This analysis shows that the layout may not be as efficient as it

could be and may be requiring more material handling and movement as is necessary or should be necessary. This layout has work in process moving across other process sectors. This is not an efficient layout. The goal of the process layout analysis is to find the optimal layout that will meet the goals of layout design.

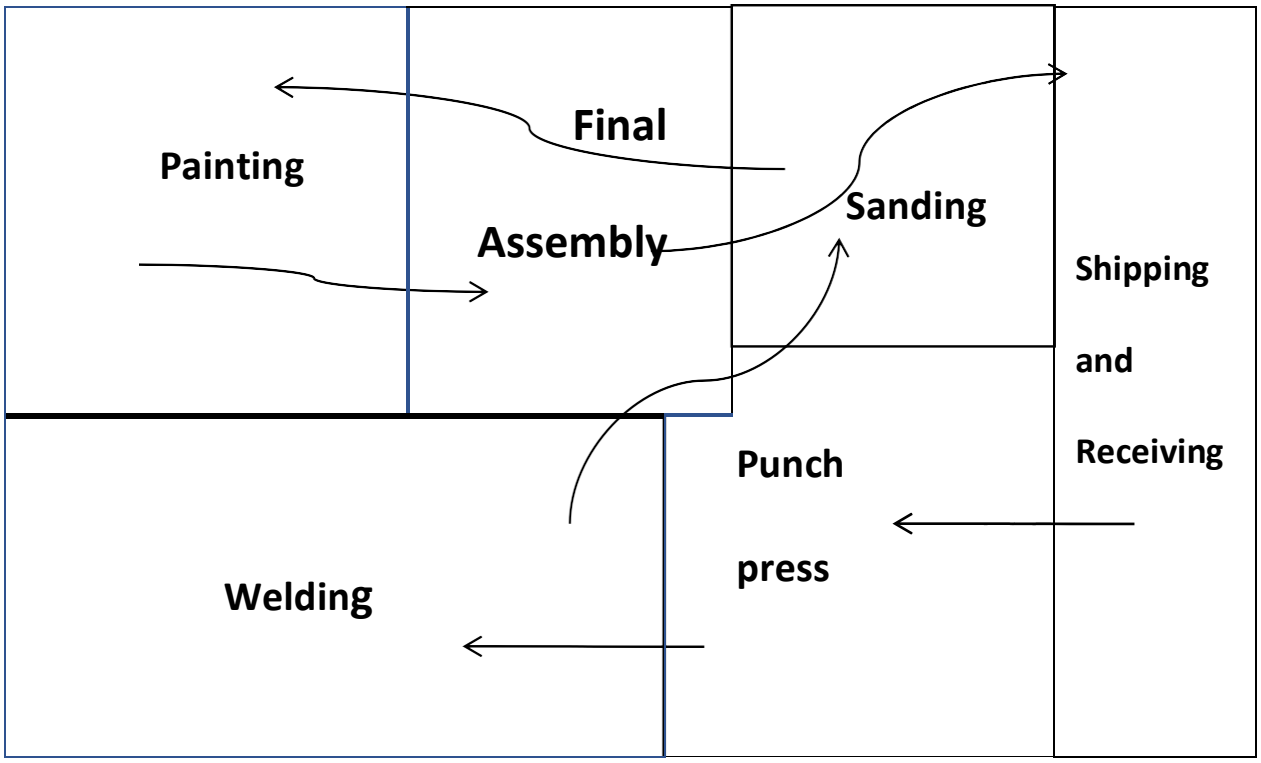


Figure 7.6: Process Layout with flow analysis

Product Layout

The product layout is the traditional linear manufacturing layout. Raw materials or subassemblies enter at one end of the manufacturing line and a finished product comes out the other end of the product layout.

The first thing that has to be considered in designing the product layout is to know or determine the assembly order or precedent of activities. This is important to make sure the layout is in a logical format based on what needs to be done first. (We will see this same methodology when we look at the Critical Path Method and Project Evaluation and Review Technique for Project Management.)

The next step in the product line design is to consider if work stations or work cells will be used for the product line. Either way the design has to consider how much work will be

assigned to the workstation or work cell to ensure a smooth flow through the line without delays or a buildup of work in process. In order to do this, it is important to measure the cycle time for the entire line (For example: Harley-Davidson knows it takes 54 minutes for one bike to be made on one of their product lines). Then the cycle time for each work station or cell must be calculated.

Cellular Layout

What is a cellular layout? A cellular layout is an attempt to balance the line and reduce material handling through a facility. This can only be accomplished by measuring the cycle times for each cell to ensure that the cells are balanced internally and externally. A cellular layout groups like machines into a cell. This sounds a lot like the definition of a process layout and may very well be a process layout within a product layout. Parts families may be grouped together within the product line and passed from one process cell to the next process. This produces a hybrid layout or a line within a line production.

The advantages of a cell are all based on proper planning and analysis. To achieve the benefits of cells requires balancing within and between cells. When properly designed the cell will minimize the need to constantly change set ups along the product line by grouping the like activities together much like the process concept.

Cellular layouts, although perceived by some advocates of Just-in-Time as the best way to produce goods and services, may not be appropriate for all products or services. If there are not enough processes or enough parts families in the operation, it may not be feasible to move to a cellular layout. Computer models are great for analyzing the available data to determine whether cells are right for the product or service.

Cellular layouts are not just for manufacturing. Cells can be seen in services and retail operations. When I lived in Hawaii there was a family-owned store in Waipahu, Arakawa's, that was broken into cells based on the "family member" that ran that particular department. The family saw this as efficient, but from the customer perspective the need to pay for items at every cell was seen as a bit inefficient.

In the fast food industry cells play a big part. In hamburger fast food restaurants there are cells that focus on the making of French fries, a cell that focuses on "grilling" the burgers, another cell that focuses on putting the burger together and another cell that is focused on taking

the customers' orders. The goal is to reduce the customer wait time and improve efficiency of the operations.

Project Layout

Project layouts are fixed position layouts. Remember back to the discussions on projects earlier in the text, projects are onetime operations. In a project layout it is not feasible to have a product layout. The manufacture of airplanes is an example of a fixed position or project layout. It is not feasible to have an assembly line for such a large product. Usually in a fixed position layout the largest costs are the variable costs associated with bringing highly skilled labor into the operation and then taking them back out after they have completed their work. The materials are brought to the product assembly area in time for the laborers to apply them. Conversely, the fixed costs for the production are relatively low.

Hybrid Layout

When Harley-Davidson had their assembly plant in Kansas City, Missouri, they had a hybrid layout. The manufacture of the gas tanks was a process layout—from the cutting of the blanks to the forming of the gas tank halves to the welding to the paint operations. Once the fuel tanks and the powertrains were complete the remainder of the assembly was a product line with four assembly lines—three basic models (V-Rod, Sportster, and Dynaglide) and one custom made (Screaming Eagle) assembly line.

Concerns and Issues to Consider

Balance. The assembly line needs to be balanced – every station in the line must have the same amount of work taking place (time wise) or else there will be a buildup of work in process at a workstation.

Flexibility. Part of the problem with the Kansas City Harley Davidson Assembly Plant was the lack of flexibility. This may be one of the underlying reasons that it was closed down. The three product assembly lines were not flexible. Each line could only produce one model of motorcycle. When the demand went up for one model and down for another model, they could not shift work to one of the other lines. Product lines need to be flexible. For example, Toro uses the same assembly line for lawn mowers (in the fall and winter) that it does for snowblowers (spring and summer).

Process Design

Now that we have the basic layouts defined, it is time to look at the methods for determining the optimal layout.

Block Diagramming

Look back at Figure 7.7. A block diagram could be applied to the layout. The goal of the block diagram is to establish with **quantifiable data** the number of items moving from one process or machine to the next process or machine and what if any is moving backward to be redone. Figure 7.7a shows a facility looked at recently that could have used a block diagram to determine the optimal layout based on flow analysis and quantifiable data to determine which processes should have been placed adjacent. This particular facility was "focused on Lean initiatives." However, the primary goal of Lean as we will see later is to reduce waste. One of the wastes that Lean seeks to reduce or eliminate is the waste of movement. This particular facility could have improved operations by using the data that they had available and the use of a block diagram.

In this particular aircraft parts repair and rebuild facility items came in through each of the three doors and went to Area A, Area B, or Area C for initial analysis and repair. Then items moved from the initial area to one of the other two areas for additional work and then to one of

the other areas for more work before being shipped out to the customers.

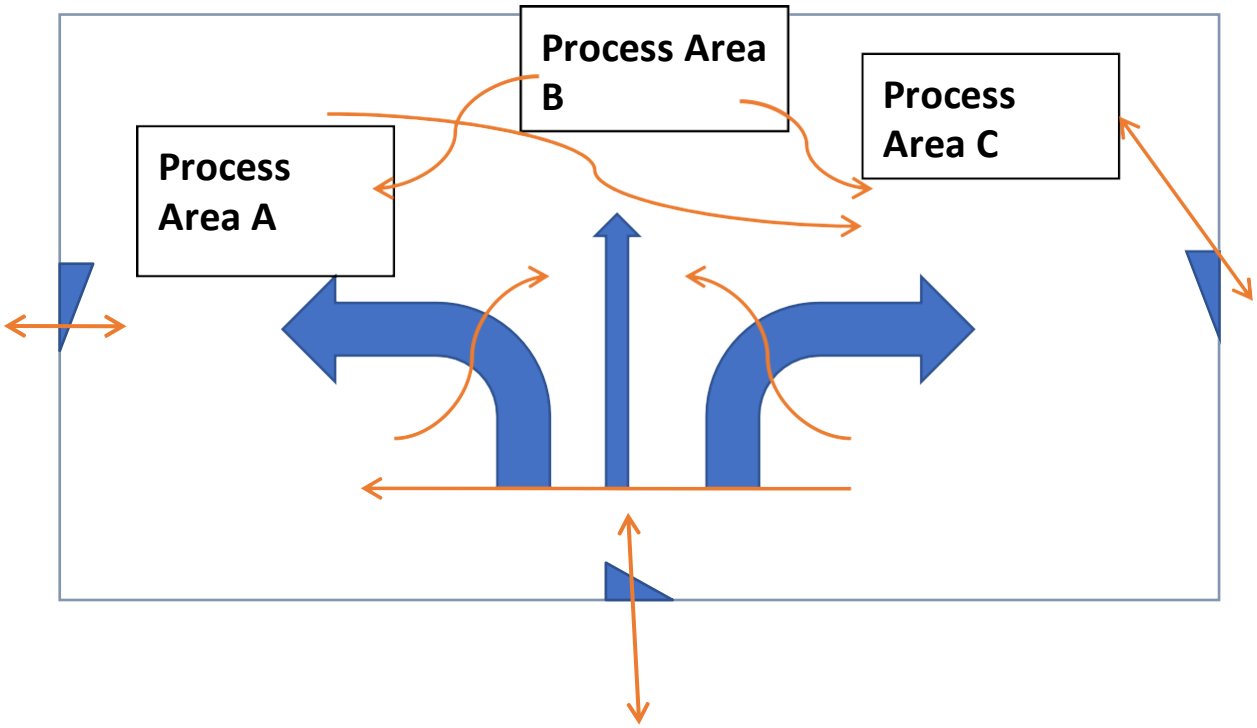


Figure 7.7a: Flow Analysis Using Block Diagramming

Using the quantifiable data of the movements from one area to the next and analyzing the data to determine the movements between adjacent areas a more optimal layout is possible. Look at Figure 7.7b and the redesign based on adjacent sector movements. This new layout not only allows for movement from each area to the other areas without passing through Area B in the middle which slowed operations. Also the new design provides an area strictly for Quality Assurance and Shipping Area which was handled throughout the facility in the previous design.

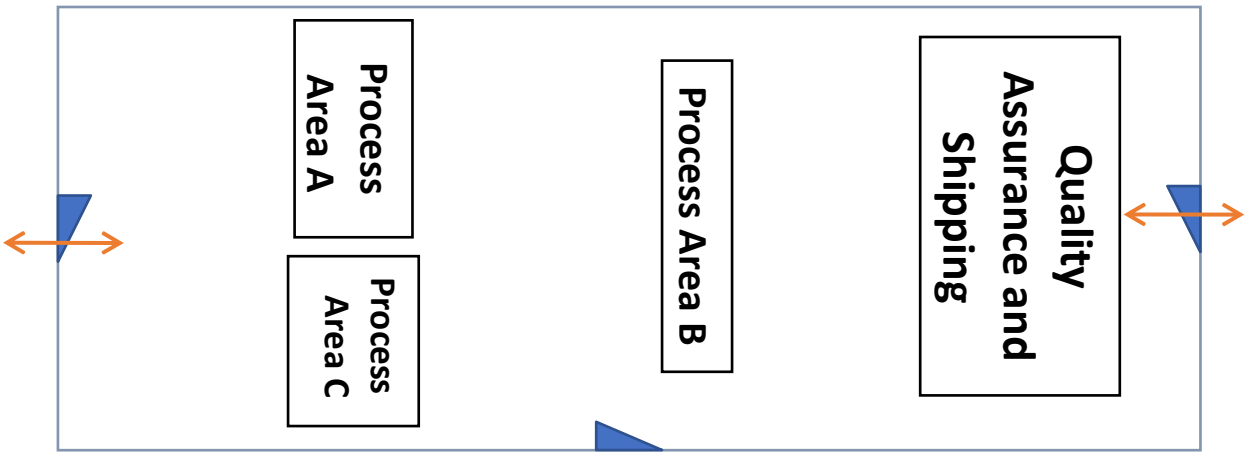


Figure 7.7b: Redesigned Facility Using Block Diagramming

Figure 7.8 shows the US Navy's methodology for determining the flow of materials between departments in a distribution center. The chart allows the organization to create an easy to understand methodology to establish the flow from department to department.

ACTIVITY FROM \ ACTIVITY TO	RECEIVING	INSPECTION	AS/RS	BULK STORAGE	PALLET RACK STORAGE	RACKABLES ORDER PICKING	BINNABLES ORDER PICKING	SHIPMENT STAGING	EMPLOYEE SERVICES	DATA PROCESSING	TOTAL
RECEIVING	–	30	5	2	10						47
INSPECTION		–	15		8	3	4	3			33
AS/RS			–		7	4		9			20
BULK STORAGE				–	1			1			2
PALLET RACK STORAGE					–	6		20			26
RACKABLES ORDER PICKING						–	7	4	1	1	13
BINNABLES ORDER PICKING							–	11			11
SHIPMENT STAGING		3						–			3
EMPLOYEE SERVICES									–		0
DATA PROCESSING										–	0
TOTAL		33	20	2	26	13	11	48	1	1	155

NOTE:
Activity units expressed as frequency factor equal to units moved (pallets, pounds, cu. ft. etc.) times distance per move (usually feet).

Figure 7.8: US Navy Methodology for Establishing Flow of Materials between Activities

Figure 7.9 shows another method from the US Navy to establish activity between departments. This chart shows the affinity between departments: The activities with three lines have strong movements between the departments meaning they have to be in close proximity, the activities with two line have substantial movement and therefore should be in close proximity to each other, the activities with one line have some movement and those activities not connected at all have no movement and therefore have no need to be closely located in the facility.

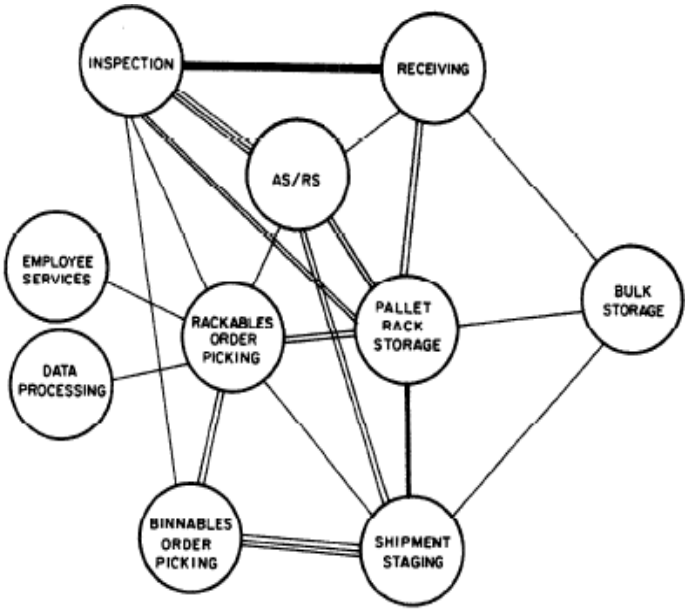


Figure 7.9: Activity Diagram

Relationship Diagrams

One of the most common relationship grids is the Muther's Grid. This technique was originally developed by Richard Muther. The relationship grid is designed to be used if when

quantifiable data are not available. Therefore, this technique is not used if the data shown for the block diagram or the affinity diagram are available. A relationship diagram is based on someone's opinion of what should be located close to other activities. In 1980 the warehouse that I was responsible for was destroyed by a large tropical storm in Hawaii. Although this warehouse was a showplace warehouse that was included on every distinguished visitor tour in Hawaii, there were some areas that could be improved. The data was not available to show what moved from where to where. So my smart guys developed a rough draft relationship diagram. We were not aware of Muther's work but used the same ideas of what we thought should be close to which when designing the new facility. The problem with a relationship diagram is that it is subjective. It is someone's opinion or best guess. A Muther's Grid when blank looks like Figure 7.10. Notice that it looks a little like the old mileage charts on a paper map shown in Figure 7.11—and is read the same way. The intersection of the lines is the relationship and shows what should and should not be placed close to other activities.

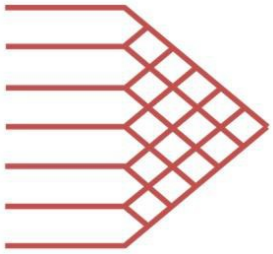


Figure 7.10: Blank Muther's Grid

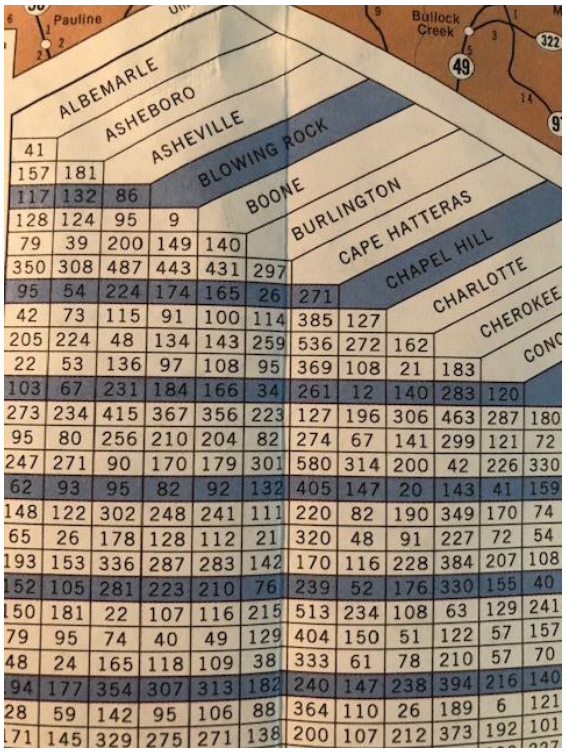


Figure 7.11: Example of Grid from Old Paper Maps

In Figure 7.11, if you are travelling from Chapel Hill, NC to Cape Hatteras, NC, you find the two cities and at the intersection you can find the mileage. Reading a Muther's Grid is the same methodology. You find the two areas that you are concerned about and at the intersection you can find the recommendation for the location of those areas or activities.

Using the Muther's Grid

There are three methods of analysis using the Muther's Grid to establish relationships for improving the layout design that I have seen used. The first methodology I call the "Vowel Method"—for obvious reasons. The relationships are shown using the following scoring system:

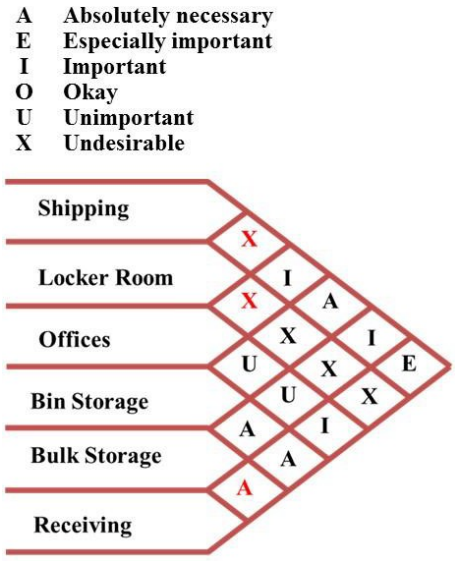


Figure 7.12: Vowel Methodology Muther's Grid

In Figure 7.12 the Vowel Methodology is applied to the Muther's Grid. Using this Grid it is easy to see that the subjective analysis deems the relationship between the shipping department and the offices is Undesirable (X)—the rationale for this decision is because the need to have privacy in the offices to talk to potential employees and talk with current employees is critical to operating a business. At the same time it is important to have privacy in the locker room to talk among the employees.

Bulk storage and Receiving is deemed to be Absolutely Important (A) because of the desire to reduce material handling costs and the waste of unnecessary movement. The same is true in this example for bin storage (small items) and shipping. The rationale for determining that shipping and locker rooms should not be close (Undesirable—X) is to prevent the temptation to move nice to have items to the locker room vice the shipping dock.

Figure 7.13 shows the same rationale using the "Numbering Methodology." This methodology is very similar except that instead of using letters or vowels, numbers are used. The importance with using this method is to make sure the decision maker and the recommender understand the numbering system. This is why it is important to have the scale close by when looking at the grid. This is important because the decision maker needs to know the scale—is a 1

good or bad? The rating scheme of one system may have 1 as good and 6 as bad (the lower the better, like a golf score) or may have 6 as good and 1 as bad (the more points the better, like a good basketball game). The intersection between bulk storage and receiving is a 1—Absolutely Important to reduce movement.

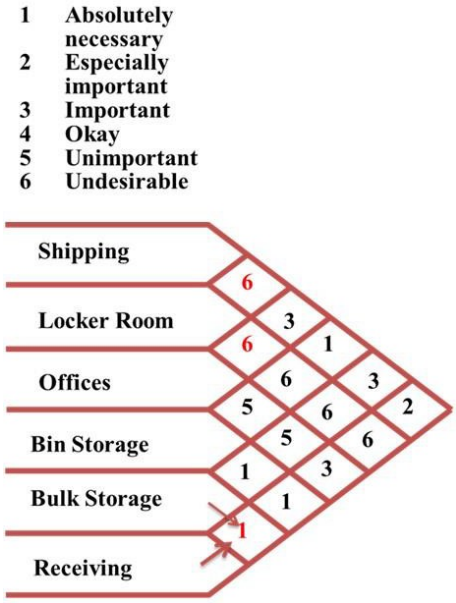


Figure 7.13: Muther's Grid Using Numbering Methodology

Hybrid Methodology

The Hybrid Methodology comes from the US Navy's Manual for Warehousing Layout.[42] This methodology combines the two previous methods to provide a much better relationship diagram. The hybrid method not only shows what the recommendation is but the rationale of the recommender and the thought process for the recommendation. Figure 7.14 shows this

[42] Navy Supply Publication 529, Warehousing Modernization and Layout Planning Guide, 1985. Although this publication is almost 40 years old, it is still considered by many to be the best publication available to guide a planner to design the most optimal warehouse or distribution center layout.

methodology. Looking at Data Processing and Employees Services, the recommendation is Absolutely Necessary and the rationale is because they share office space.

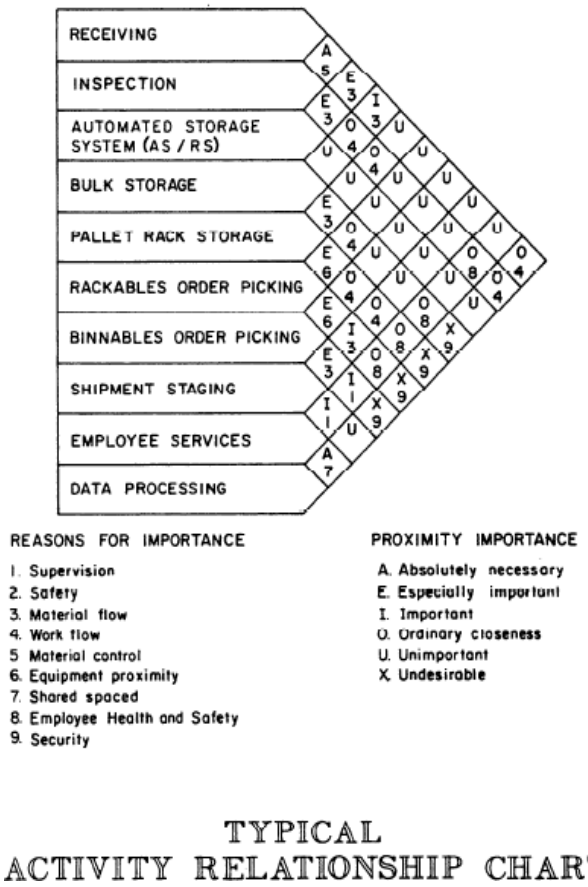


Figure 7.14: Hybrid Methodology for Relationship Planning

Layout Summary

The layout of the facility may provide a competitive advantage and improve efficiency of the operations. The facility layout will determine capital expenditures and flexibility, and may constrain the capacity of the company.

Layout design is just as important in services as it is in manufacturing. If quantifiable data is available a block diagram may be the best tool to improve the layout design and efficiency. When **quantifiable data is not available** a Muther's Grid or Relationship Diagram may be more useful to design or redesign the operations. A process walk is necessary to determine what operations precede other operations based on the walk and the process charts.

The layout for a facility may be constrained by the location and what is available in a location. This is why location and site selection are critical to good layout designs.

Location Analysis and Models

Whether a company is involved in heavy manufacturing such as automobile manufacturing and high tech manufacturing or distribution centers, there are some considerations that are common to the process and some considerations that are unique to certain industries. Land costs, utility costs, and construction costs are common to any facility.

In **Heavy Manufacturing** decisions and considerations to be analyzed before choosing a location for a new facility include:

- **What is the availability of labor in the desired area?** Is there sufficient labor available and is there sufficient skilled labor to staff the facility or will the companies have to bring employees in from other locations. Although there is currently almost 10% unemployment throughout the United States it does not mean that the skills necessary for operations will be available.
- **Raw Materials**. Is it better for the company to locate the manufacturing facility closer to the source of the raw materials or is it better to locate the facility closer to the customers? If the raw materials have a short shelf life, it may be more advantageous to the company to have the manufacturing plant close to the source of the raw materials. If the raw materials can only be delivered by rail, the facility must be located near or on a rail siding.
- **The mode of shipping the finished product may dictate the location of the facility**. Certain products must be shipped by rail, therefore the manufacturing facility should be located on a rail siding or rail spur. Access to transportation networks is a requirement for

all facilities—the type of network is driven by the raw materials and the finished product. Several years ago there were sufficient potatoes in the field in Russia to feed the entire country and make all the Vodka the country could drink only to have the produce rot in the field because a lack of sufficient transportation networks to get the produce to the factories.

In **Light or High Tech Manufacturing** the biggest concern after the land, construction and utilities costs is the education base of the area. There is a good reason why the Research Triangle Park (RTP) area in North Carolina is located where it is and has a large number of high tech firms in the RTP. Within a little more than an hour of the RTP are four world class research universities providing a well-educated workforce. North Carolina State University, Wake Forest University, Duke University, and the University of North Carolina are all nearby. The Silicon Valley area in California provides the same education-rich environment to support the high tech needs of the industry. There are several areas that I have been stationed during my military career that will never be high tech hubs because of the lack of quality secondary and post-secondary education programs.

The driving factor for the location of a warehouse or distribution center should be proximity to the customer or to the manufacturing facility. A decision has to be made as to whether or not it is better for the company to locate their storage facility close to the manufacturing plant or close to the customer. Wal-Mart has a good model for where to place distribution centers to support its "more than 8,446 retail units under 55 different banners in 15

countries."[43] The purpose of warehouses and distribution centers is to put the product closer to the customers and reduce the customer order cycle time. This being the case, the distribution center or warehouse should probably be placed as close to the customer base as possible.

Chicago Consulting Company provides an annual survey of warehouse locations to best meet the population base of the United States. This study is available at http://www.chicago-consulting.com/10best.shtml and is updated every year. The study bases its recommendations on the road networks and the population centers of the United States. This study is based on the center of gravity location model. This model is based on plotting the customer locations on a grid and placing the facility as close to all of the customers as possible to reduce travel time to the customers. This model can be weighted to place the facility closer to higher priority or higher volume customers. This model can be used for retail locations or for distribution centers. A center of gravity calculation using Excel looks like Figure 7.15. This example shows a non-weighted example. Figure 7.16 shows the same information using weights to favor the stronger customer locations.

[43] http://walmartstores.com/AboutUs/. "We have more than 40 Regional Distribution Centers. Each one is over 1 million square feet in size. They operate 24/7 to keep our fleet of tractors and trailers rolling. Inside each DC, more than five miles of conveyor belts move over 9,000 different lines of merchandise. Each DC supports between 75 and 100 stores within a 250-mile radius."

Center of gravity

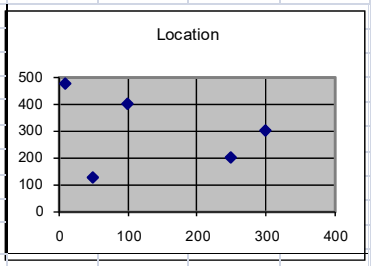
Enter the weights and coordinates in the data area.

Data

	Weight	X coord	Y coord
Location	0.2	100	400
Location	0.2	250	200
Location	0.2	50	125
Location	0.2	300	300
Location	0.2	10	475

Results

Sum	1	710	1500
Average		142	300
Weighted Average		142	300



Distance table

			X coord	100	250	50	300	10
			Y coord	400	200	125	300	475
X coord	Y coord			Location	Location	Location	Location	Location
100	400	Location 1		0	250	279.5085	223.6068	117.1537
250	200	Location 2		250	0	213.6001	111.8034	365
50	125	Location 3		279.5085	213.6001	0	305.1639	352.2783
300	300	Location 4		223.6068	111.8034	305.1639	0	338.7108
10	475	Location 5		117.1537	365	352.2783	338.7108	0
		Total		870.269	940.4035	1150.551	979.2849	1173.143
		Weighted Total		174.0538	188.0807	230.1102	195.857	234.6286

Figure 7.15: Center of Gravity Example

Center of gravity

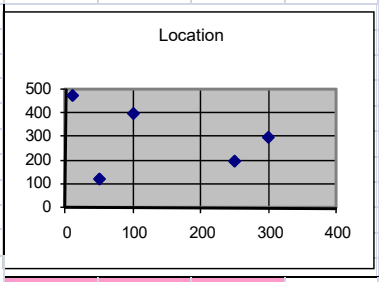
Enter the weights and coordinates in the data area.

Data

	Weight	X coord	Y coord
Location	0.3	100	400
Location	0.25	250	200
Location	0.1	50	125
Location	0.2	300	300
Location	0.15	10	475

Results

Sum	1	710	1500
Average		142	300
Weighted Average		159	313.75



Distance table

			X coord	100	250	50	300	10
			Y coord	400	200	125	300	475
X coord	Y coord			Location	Location	Location	Location	Location
100	400	Location 1		0	250	279.5085	223.6068	117.1537
250	200	Location 2		250	0	213.6001	111.8034	365
50	125	Location 3		279.5085	213.6001	0	305.1639	352.2783
300	300	Location 4		223.6068	111.8034	305.1639	0	338.7108
10	475	Location 5		117.1537	365	352.2783	338.7108	0
		Total		870.269	940.4035	1150.551	979.2849	1173.143
		Weighted Total		152.7453	173.4707	251.1271	176.3559	229.3661

Figure 7.16: Weighted Center of Gravity Example

In addition, there is now a regular publication, *Site Selection,* that is dedicated to helping companies determine where to place a facility. The magazine is basically a marketing tool for regions to help promote the capabilities and advantages of an area for companies considering relocation or expansion.

Distribution Center/Warehouse Considerations for Layout and Location

The considerations for location for the distribution center should include the location proximity to the customers besides other factors in the layout. These include:

- **Cross-docking—**will the facility use cross docking as a technique? Cross-docking has been discussed in greater detail under supply chain management. Cross-docking is simply planning the inbound shipments to the facility in coordination with the outbound shipments so that the items never go on the shelf but from the inbound truck to an outbound truck within 24–48 hours. From a layout perspective this requires a holding area to be designed but may mean less shelf storage space will be needed in the design and layout.

- **Dock doors—how many?** If moving into a current facility this may not be a consideration; however, if the company is designing a new facility this may be a consideration that will drive the layout. Is it possible to have inbound on one side of the facility and outbound on another side of the facility? If so, this may impact the layout as well as the traffic flow pattern.

- **Vehicle flow—**how will the trucks come into the facility and leave the facility? This is an important consideration to the layout. The optimal solution would be to have one way traffic flow; however, because of land constraints and security issues this may not be always feasible.

- **Picking techniques—**how will the items be picked in preparation to shipping to the customer? There are various picking techniques used in distribution centers to include the use of Automated Storage/Automated Retrieval (AS/AR) systems that do not have any human involvement with the put away and picking operations. Pet Foods in Topeka, Kansas uses a total AS/AR system for their state of the art facility. The Defense Logistics Agency uses AS/AR systems for their small high volume items. The type of picking technique and the analysis of fast moving items will drive the layout of the facility.

- **Bulk storage—**how much bulk storage will be kept and will it be kept close to the other storage areas or in a separate facility will drive the layout of the distribution center.

- **Safety/backup stocks—**safety stocks are a level of stocks above the normal stockage levels to cover variations in demand patterns. Will the company have safety stock at each location for every item or will there be a central location with the safety stocks? This will drive the layout and size of the facility needed. (We will cover safety stock in greater detail under the discussions on inventory management.)

- **Customer proximity –** obviously, if the goal of distribution centers is to put the product closer to the customer, the location has to be in close proximity to the customer base.

Other Location Factors

Just as there are common factors to the different industry locations, there are some common factors to the choosing the global or regional locations.

For companies considering locating overseas—whether that overseas is Asia, Europe, South America, Africa, or North America, depending on the location of the corporation—there are certain areas that need to be considered before relocating operations.

- **Culture**—obviously, or at least it should be obvious, that countries have different cultures and what are the norms and mores in one country are not necessarily the social norms and mores in other countries. Even Wal-Mart found this out when they tried expanding to Germany. Wal-Mart bought Wertkauf as the point of entry into Germany. Wertkauf was the German equivalent of Wal-Mart and would appear to be a good match. However, Wal-Mart discovered that there were cultural differences between the shoppers in Germany and the shoppers in the United States; now there is no Wal-Mart in Germany and no Wertkauf either.

  Wal-Mart learned the same lesson again when they moved into China. Shoppers' behavior in China is apparently different from shoppers' behavior in other areas served by Wal-Mart. According to my students from China, they go to the store more often and buy what they need. One student reported that his family would go to Wal-Mart up to four times a day to get fresh foods. Wal-Mart also learned that the culture/laws in China dictated that a certain percentage of the items in the stores had to come from the local area—which should not have been a problem as most of what is in the Wal-Mart stores in the United States is from China.
- **Language**—the typical American attitude is that everyone will speak English. And if they don't seem to understand English the first time the typical American attitude is SPEAK SLOW AND SPEAK LOUD and they will understand. When I was stationed in Germany the common attitude was: "If you speak three languages, you are tri-lingual; if you speak two languages, you are bi-lingual; and if you speak only one language, you are probably American." Companies have to ensure that employees

that they are sending overseas understand the native language and can communicate in the native language.

- **Exchange rates**—how stable is the Dollar against the local currency and what is the exchange rate? Or, if a company outside the United States is looking to expand, how stable is the company's native currency against the Dollar or the Euro or other foreign currency. The wine makers in South Africa are very concerned about the stability and the exchange rate of the Rand against the Dollar. The wine makers are working hard to eliminate waste in their systems in order to compete cost-wise head-to-head with the California Wineries.

- **Trade agreements or blocks—**if the company tries to expand into another country, will they have to compete against protections from trade agreements or trading blocs such as the recent US Canada Mexico Agreement the European Union? If so, will that include tariffs or duties for importing products or can the company take advantage of Free Trade Zones to reduce tariffs or duties? *The APICS Operations Management Body of Knowledge* defines a Free Trade Zone (or Foreign Trade Zone) as: "an area considered outside of the host country's territory but supervised by its customs department. Material may be brought in to the FTZ without paying import duty taxes and assembled or manufactured into a finished product. Duties and taxes are then paid when the finished good is moved outside the FTZ for retail sale."[44] Figure 7.17 is just

[44] *APICS Operations Management Body of Knowledge*, APICS The Association for Operations Management, 2nd edition, 2009, p. 26.

a part of the Free Trade Zone, Colon in Panama. In the FTZ, Colon, there is a commercial area with store fronts for businesses to make purchases and then there is a warehousing district for the storage of products without having to pay customs and taxes.

Figure 7.17: Part of the Commercial Area, Zona Libre, Colon, Panama

- **Commercial travel—**this is an area that is often overlooked when making the analysis for off-shoring operations. The cost of flying employees and management back and forth to distant locations and the time involved in the travel is a critical component of the analysis that should not be overlooked.

- **Supply chain/Transportation costs—**one of the critical areas that should be considered in the off-shoring analysis is the cost of moving products around the globe. For example if a company with a primary market in North America, moves operations from North Carolina to China, there is now a cost of moving the products from China back to North America. In 2009, Maersk Lines announced that they were going to save $1 billion a year in fuel costs by cutting shipping speeds in half. From a

manufacturing perspective, this just doubled the shipping times and doubled the inventory in motion.

Hilton Hotels has a goal of making the furnishings in each of its chains look the same for each room in the chain regardless of the location. For example, if customer is a loyal Hampton Inn guest, the goal is for every Hampton Inn room to look the same so the guest feels at home. After a very detailed analysis, Hilton determined that it was actually cheaper to buy the materials in the United States, ship them to Southeast Asia, have the furniture made, and shipped back to the United States than they could have the furniture made in the United States.

One issue surfacing in 2020 is the increased dependence on other countries to supply critical products to the USA and other parts of the world. This became an issue with the rise of the coronavirus pandemic. One consideration has to be what is critical to national survival? And how much of these critical items should be made in the USA as opposed to overseas?

However, recent studies have shown that it is only about 5% more expensive now to make products in the USA than it is to make them in Asia and ship them to the USA. Part of this is based on the rise of transportation and part of it is based on the rise in the cost of labor in other countries.

- **Labor—**unfortunately, this is the only aspect considered in too many off-shoring analyses. When the cost of oil rose to $140 a barrel in 2008, many companies started questioning the analysis that based the off-shoring on labor alone. Recent studies show that the cost of labor increases in some Asian Countries coupled with fuel costs now put the difference between producing in Asia and producing in North America at

approximately only 5%. With the steep decline in oil prices in 2020, one has to wonder why the costs of transportation have not decreased as well. The answer may be tied to long term price contracts for fuel – leaving companies paying way too much for fuel based on the 2020 prices.

Regional Location Considerations

Many of the considerations for overseas location analysis impact regional decisions as well. However, a few other considerations must be taken into account for regional location decisions.

- **Quality of Life—**when considering other locations for operations this must be taken into account. In 1972, Amoco Oil Company decided to move its credit card operations from Chicago. The location decided upon was Raleigh, North Carolina. The primary reason given for the selection was the quality of life in the Raleigh area which included cost of labor, cost of housing, better education, and the overall cost of living in the Raleigh area. Quality of life also included better Bar-B-Que in the Raleigh area and closer proximity to the beach.

  Amoco knew when they moved into the area that they would probably move in approximately ten years based on their models. One of the things that Amoco did was work with the State of North Carolina on the location and **incentives** to move into the Raleigh area. Amoco received local incentives to move into the area and in exchange the State of North Carolina was promised the facility when Amoco moved on. The facility was ahead of its time with its own cooling ponds, lots of trees around the building and parking lots, and tinted windows that reflected sunlight to reduce the

cooling requirements during the day and reflected lights in at night to keep reduce lighting requirements and heating requirements.

Another example of local/regional incentives is the Wal-Mart in Kansas City, Kansas. Twenty years ago, the Kansas City, Kansas area was a relatively depressed economic area and did not merit a new Wal-Mart. Then the Kansas Speedway was built, Nebraska Furniture Mart opened, Cabela's opened and quickly became the number one tourist attraction in the State of Kansas, followed by the opening of the Legends Shopping Center. All of this made the Kansas City, Kansas area the fastest growing shopping and economic district in the Midwest. However, Wyandotte County and Kansas City, Kansas had to offer tax incentives to the largest company in the world to move into the area.

- **Local/regional regulations—**are there environmental concerns or local tax concerns such as in California? The tax rates, environmental regulations and OSHA regulations are driving companies into Nevada. More and more companies are moving operations into the Reno/Sparks, Nevada area for distribution centers. This location provides rapid response to California customers and the Interstate 80 corridor without paying California taxes or having to comply with California environmental regulations. The same trend is becoming a reality in Las Vegas, Nevada. The proximity to Southern California and the lack of state taxes makes it a logical choice for distribution centers.

- **Transportation networks—**just like the previous discussion about distribution center location analysis, the availability and access to rail, air, and road networks is important to the decision of where to locate a manufacturing facility. This is why Ontario, California is such a popular place for distribution centers – it is close to the

ports of LA and Long Beach, close to LAX and Ontario airports, and at the intersection of Interstates 10 and 15 while not far from Interstate 5.

- **Income levels—**deciding to put a high-end retail operation such as Nordstrom's will or at least should have as part of the decision process a consideration of the income levels of the area. In Kansas City a high-end company called Digi's Karma opened in an area that was not economically postured to support the company and the store closed its doors less than three months later.

- When all else fails and relaxed government oversight or incentives are not available, you can always start your own government. This is what Disney did in Florida. They could not get incentives or full support for infrastructure improvements, so they started the Reedy Creek Development Authority and formed their own government, police, fire, sewage, and infrastructure. Amazing that in 1967 when Disney World was announced that no one in Florida wanted anything to do with it and now the state depends on the Disney tourist trade for survival.

Summary

Location analysis is a complicated process that enables the company's decision makers to balance costs of off-shoring such as building a new facility and increased inventory costs with cost savings from incentives, labor savings, and potential entry to new markets. The basics of location analysis and layout design can be used for any operation from a small gym to a large multimillion square foot distribution center.

Discussion Questions and Thought Questions on Layout Design and Site Selection

1. Go to a retail activity and look at their layout. What is the store trying to do with their layout? Is there an obvious pattern to their layout?
2. Based on your visit to a retail facility, is there a better way to layout the facility to maximize exposure to products?
3. Visit a Home Depot or Lowe's and look at the warehouse layout that they have. Is there a pattern to their layout?
4. Create a Muther's Grid to improve the layout of the Home Depot that you visit.
5. What is the difference between a product, process, and fixed facility layout?
6. What is a hybrid layout and what advantages does it provide?
7. When should you not choose to use a cellular layout?
8. Can the layout of the facility become the bottleneck for the company?
9. Why is site selection so important to the success of the company?

Chapter 8

Program Management and Project Management

A project is a onetime operation. According to the APICS Dictionary, a project is "An endeavor with a specific objective to be met within predetermined time and dollar limitations and that has been assigned for definition or execution" (APICS, 2020). "Project management is a carefully planned and organized effort to accomplish a specific (and usually) one-time objective, for example, construct a building or implement a major new computer system."[45]

Project management and program management are often used interchangeably. These are not interchangeable terms. APICS defines a program as: "a coordinated set of related projects usually including ongoing work" (APICS , 2020). A program may run forever.

This chapter will focus on project management and the tools that the operations manager needs to be a successful project manager.

The first discussion of a project management topic really comes in 33 AD. A documented comment from that time basically said a person would be called a fool if they started a building (a project) without having enough money to finish it. Here are some examples from the past several years that seem to show that this lesson from 2000 years ago has not been fully learned by builders today. All three of these facilities were started in 2007-2008 as new resorts/mega resorts in Las Vegas and then ran out of money during the recession. The construction depicted in Figures 8-1a and 8-1b was to replace the old Westward Ho Casino, the Stardust Hotel and

[45] Lonergan, Kevin, http://managementhelp.org/plan_dec/project/project.htm, accessed October 22, 2010.

Casino and the New Frontier Hotel and Casino. The projected completion date after the restart is now sometime in 2021.

The building in Figures 8-2 and 8-3 show another building started about the same time that was stopped and then finally completed in 2015. The builders for the building in Figures 8-4 and 8-5 ran out money, sold the property for a huge loss, the property was resold and the proposed mega resort still has not been finished. One recommendation in 2018 was to tear it down and start again. Work resumed in later 2019 but it is still under construction.

Figure 8-1a: Major Construction Project in Las Vegas Started in 2008 - Projected Completion 2021

Figure 8-1b: Status of Building as of February 2020

Figure 8-2: Incomplete Building 2012

Figure 8-3: Finally, Complete After 8 Years, 2015

Figure 8-4: From this angle the resort appears to be near completion. This particular building was started in 2007. This view is from 2020 with an unknown completion date. This building has been sold at least three times since starting. The latest estimate is 2023.

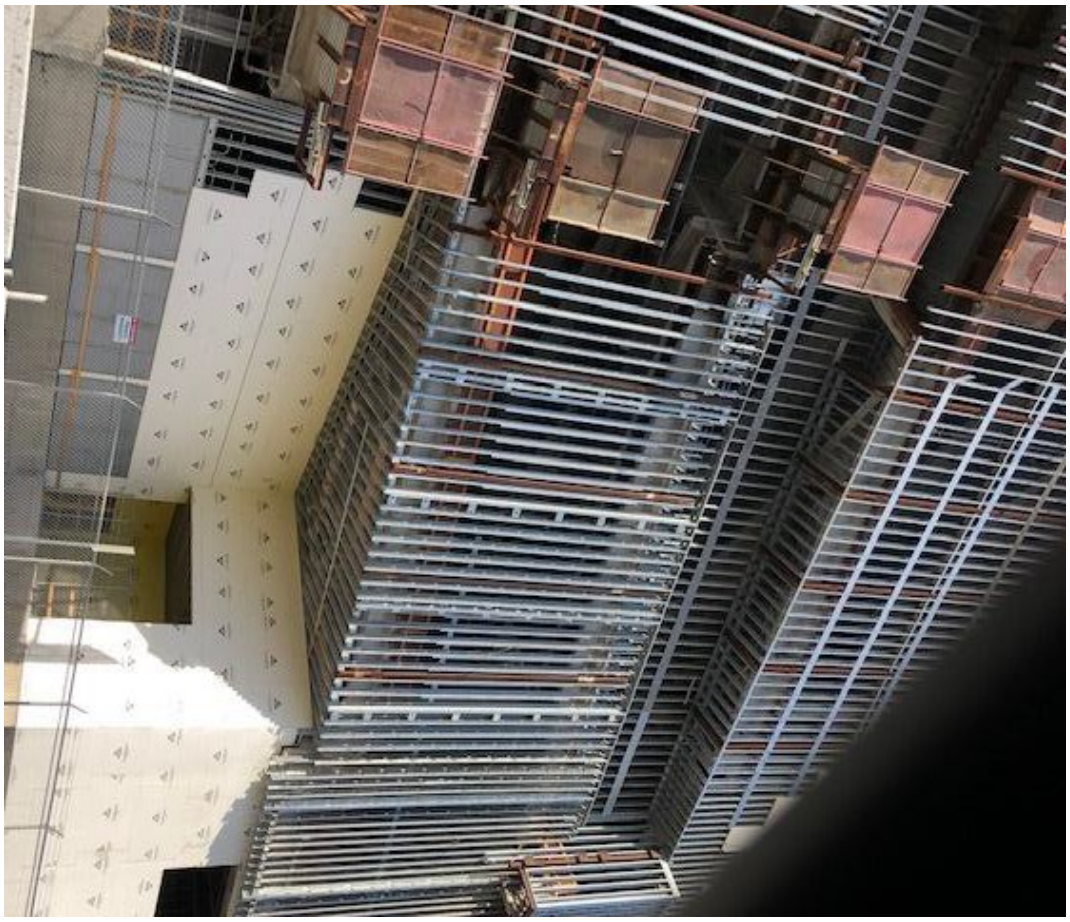


Figure 8-5: From the backside of the building it is obviously not close to completion. This is the view as of February 2020

The first written account that actually uses the term project management comes from "An Essay Upon Projects" written by Daniel Defoe in 1697. This essay on project management starts the discussion with "The building of the Ark by Noah, so far as you will allow it a human work, was the first project I read of."[46] Defoe goes on to use the building of the Tower of Babel and describes the tower project as "for indeed the true definition of a project, according to modern acceptation, is, as is said before, a vast undertaking, too big to be managed, and therefore likely

[46] http://infomotions.com/etexts/gutenberg/dirs/etext03/esprj10.htm, accessed October 22, 2010.

enough to come to nothing." Defoe demonstrates a very good understanding of projects given the amount of information known at the time.

The first "modern" article about project management appeared in the *Harvard Business Review* in a 1959 article, "The Project Manager." While not necessarily modern, it is modern when compared to Defoe's writing in 1697. The first Department of Defense publication to guide military project managers was published by the US Air Force in 1964, which parallels with the expansion of the US Space Program and the associated projects under that program umbrella.

Project Management is an industry unto itself, has its own published Body of Knowledge, and has its own certifying body – The Project Management Institute. This institute serves as the clearing house for project management concepts and practices and provides the certification as a Project Management Professional.

Project Management is defined by the Project Management Institute as: "Project management is the application of knowledge, skills, tools, and techniques to a broad range of activities in order to meet the requirements of a particular project."[47] Wikipedia defines a project as "a **temporary and one-time endeavor undertaken to create a unique product or service** that brings about beneficial change or added value."[48] A project is a one-time operation with a defined beginning and a defined end. This chapter is designed to give the potential project manager the knowledge, skills, and some of the tools necessary to successfully lead a project.

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[47] Source: Project Management Institute - http://www.pmi.org/info/PP_AboutProfessionOverview.asp?nav=0501, accessed on June 2, 2009.

[48] http://en.wikipedia.org/wiki/Project_management,

Thus far we have emphasized that projects are a onetime operation. Programs on the other hand are not onetime operations. Programs may go on forever and some government programs seem to go on forever even after the program has outlived its intended purpose. A program could conceivably have thousands of projects under the program.

Project Planning

A project must have a plan in order to be successful. A survey of professional engineers showed that the lack of a project plan was the second most common reason for project failures. The only factor more prevalent than a lack of planning was simply not following basic management principles by focusing on the systems vice the plan and the goals of the project. A good plan will help prevent having a constraint in the areas of personnel and resources after the project is started.

The first document that drives the project planning is the **Charter**. The Charter is the document that establishes the project and provides the project manager with his/her authority to make decisions and start the planning process.

The next important document is the **statement of work**. This document describes the goals of the project, the timeframe for completing the project, and the work to be performed. A poorly written statement of work will lead to project frustration and maybe even the inability to complete the project on time and within budget. A good statement of work will help the project leader to identify the manpower requirements, help establish a valid budget, and show the relationship among the activities in the project. In addition, the statement of work should specify the completion date of the project. Without this completion date, one of the critical aspects of a project is missing. The statement of work enables the project leader to analyze exactly what is

being asked for and determine the real resources requirements and develop a valid timeline for completion of the project.

Once the statement of work is analyzed, the project leader can develop the objectives for his/her project team. The project leader can establish the precedence of events and the associated time frames for each event, and from that listing of events the project leader can forecast the completion time frame for the project. From a good statement of work the project leader will be able to do a detailed mission analysis of the project and identify all tasks—those that are specified in the statement of work and those tasks that may not be specified but are implied. An implied task is one that the project leader knows from experience must be accomplished to accomplish the specified tasks. For example, if the specified task is to pour the foundation for a building, there are some implied tasks such as grading the land, putting the forms in place, and roughing in the plumbing before the foundation can be poured. The more specific the project statement of work is, the more detailed the planning and allocation of resources will be.

Determining the implied and specified tasks enables the project leader to determine what the US Military calls a "troop to task analysis." This analysis is necessary for the project leader to select the proper skills and personnel for the team as well as determining the right number of members to have on the team. Too many team members may lead to project failures and too few project team members may lead to project delays and not meeting the project deadlines. By carefully analyzing the statement of work, the project leader can develop a work breakdown structure that details exactly what each team member will do and may be able to break the project into modules to assist in scheduling and completing the project on time.

Determining the right mix of personnel is also important to ensure the team is functional. One of the problems with project teams is that they are not permanent members of the team. The

team members belong to another operation, department, or program. This creates a **matrix management organization** and a challenge for project leaders.

The challenge here is that the team members know that their annual performance appraisals will be written by someone other than the project leader. Therefore, their allegiance is to their real boss because that boss determines the success or failure of their careers. This is not an insurmountable challenge, just one more consideration when choosing teams and team members. This is also why a project manager needs to have leadership skills to lead the project team and prevent personnel issues arising from the matrix organization.

Project Control

Project control involves all the activities to ensure the successful completion of the project. The success of the project is based on the detailed analysis and identification of all important tasks. Once the tasks are identified, it is important to make sure the order of precedence is established to make sure supporting activities are completed before the next activity starts. Back to our example of pouring the foundation—all of the implied tasks must be completed before the task of pouring the foundation can be started.

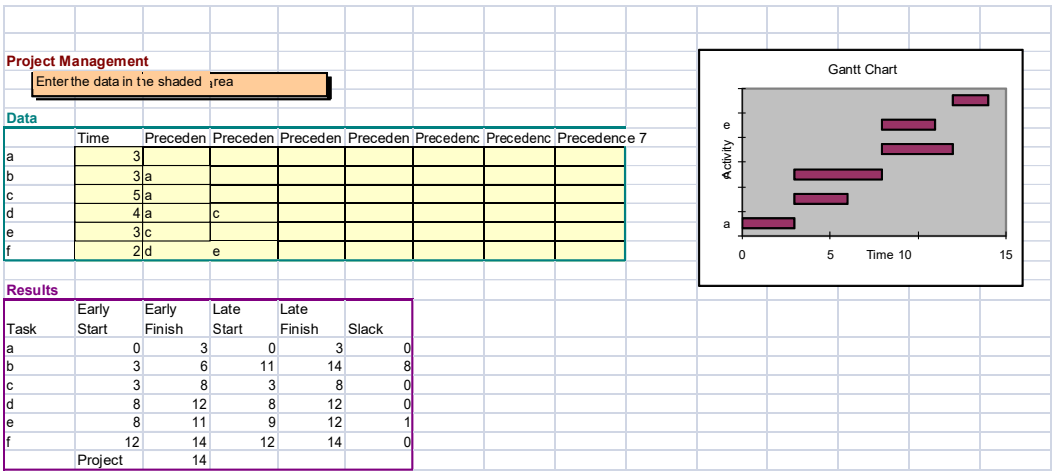
The next step is developing the budget for the project. The statement of work usually provides a budget amount the company is willing to spend on the project. This is only a guideline, but that does not mean that the entire amount needs to be spent on the project. The analysis by the project leader will enable the development of the budget.

Once a budget is established, project controls are necessary to ensure that the project is completed within or even under budget. One of the greatest sins of project management is busting the budget for the project. The only worse sin of project management is not completing the project within the specified time frame.

Gantt Charts

One of the common methods of providing project control is the Gantt chart. Developed by Henry Gantt early in the last century, these charts have been in use for projects for almost one hundred years. The Gantt chart is a simplistic approach to project management. The chart is a bar chart that is easy to understand. Using the bar chart, a company can quickly identify if they are on schedule or behind schedule. The old ABC television show, *Extreme Makeover—Home Edition*, used Gantt charts to track their progress in building a new home for the featured family. On this show the goal was to demolish an outdated home or a home that did not meet the needs of a family and then rebuild a dream home within a week. Project control was critical for the completion of the house. A Gantt chart allows the project manager to quickly check the day and hour and see if the team is on track.

Before the days of computers and automation, the Gantt chart was critical in the control of projects such as the Interstate Highway System and the building of the Hoover Dam. The chart shows the time frames and the amount of work that should be completed in that time frame. Although over one hundred years old, it is still a popular tool for project control because of its simplicity and ease of reading. In order to develop a Gantt chart, the project leader needs to know the tasks, the time to complete each task, and the order of precedence for the tasks. Figure 8-6 shows an example of a Gantt chart.



Project Management

Enter the data in the shaded area

Data

	Time	Preceden	Preceden	Preceden	Preceden	Precedenc	Precedenc	Precedence 7
a	3							
b	3	a						
c	5	a						
d	4	a	c					
e	3	c						
f	2	d	e					

Results

Task	Early Start	Early Finish	Late Start	Late Finish	Slack
a	0	3	0	3	0
b	3	6	11	14	8
c	3	8	3	8	0
d	8	12	8	12	0
e	8	11	9	12	1
f	12	14	12	14	0
	Project	14			

Figure 8-6: A Gantt Chart Developed Using Excel

PERT/CPM Charts

There are two other commonly used techniques for tracking and controlling projects. The Critical Path Method (CPM) and the Project Evaluation and Review Technique (PERT) are very similar. Both provide a network diagram of all the actions necessary to complete a project. The CPM and PERT diagrams are a little more complex than the Gantt chart.

The Critical Path Method (CPM) was developed in 1956 by Remington Rand. The CPM provides tradeoffs between project duration reduction and the increases in project costs and activities. CPM uses deterministic times and shows the times on the nodes of the network. Figure 8-7 shows the CPM diagram that corresponds with the Gantt chart in Figure 8-6. The CPM shows a "Dummy" activity—the "Dummy" is an activity with activity that does not impact the critical path but must be completed before the next activity can be started. The CPM diagram also displays if there is any slack in the network.

Slack is where moving the activity forward or backward will not impact the completion time. There is no slack on the critical path. In the diagram below the critical path is A-C-D-F. Any slack that will allow for an earlier or later start time will not be on the critical path. So, in

this example, there is no slack for A, C, D, or F. The CPM network calculations are shown in Figure 8-8. For the diagram in Figure 8-7, the completion time is 14 periods. The project cannot be completed in a shorter time without changing the inputs and resources for the project. The critical path is the longest pass through the network.

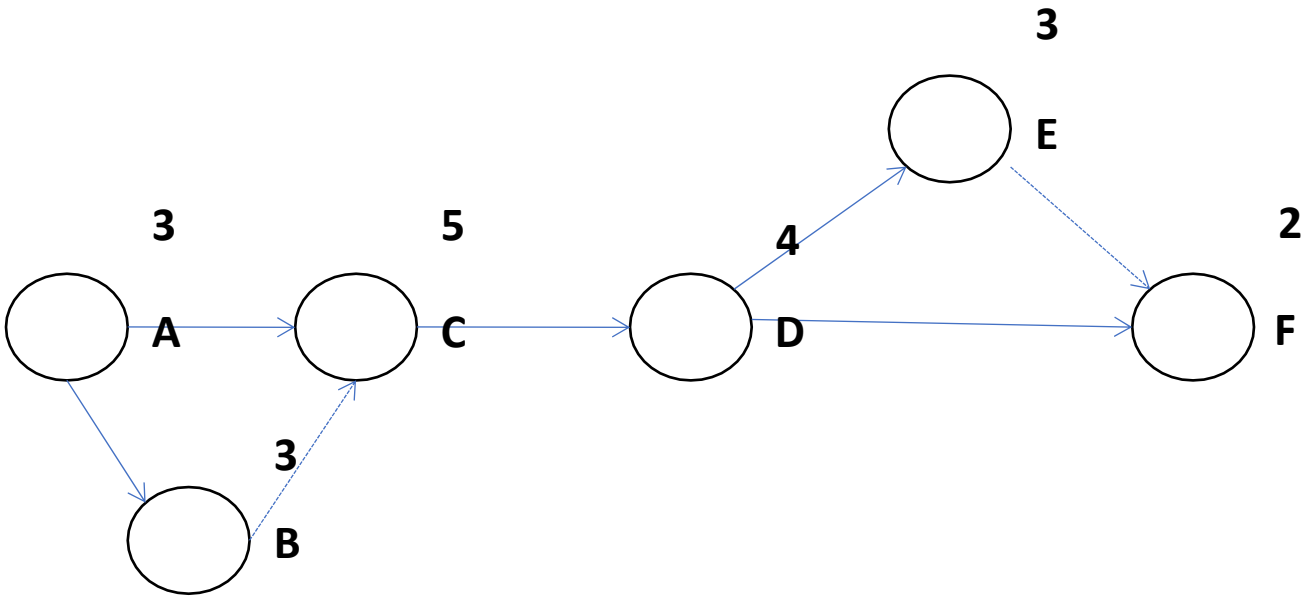


Figure 8.2: Critical Path Method Diagram

ACTIVITY	EARLIEST START	LATEST START	EARLIEST FINISH	LATEST FINISH	SLACK	CRITICAL ACTIVITY
A	0	0	3	3	0	YES
B	3	11	6	14	8	
C	3	3	8	8	0	YES
D	8	8	12	12	0	YES
E	8	9	11	12	1	
F	12	12	14	14	0	YES

Figure 8-8: Using the Management Scientist Software to Calculate Slack, Earliest Start Times and Latest Start Times for the CPM

The Project Evaluation and Review Technique (PERT) was developed in conjunction with the US Navy for the building of the Polaris Submarines in the 1950s. The PERT chart provides three time forecasts to account for uncertainty in completion times. There is a lot of discussion about the differences between a CPM and a PERT chart – most of this is centered around the concept of the activity on the node or the activity on the arrow. What really separates the two diagrams is the number of time estimates provided.

The number of time estimates is the biggest difference between the CPM and PERT diagrams. The PERT has an optimistic time, a pessimistic time, and a most likely time. In addition, the PERT diagram has the time estimates on the arrow vice the node as in the CPM diagram. Either diagram will enable the project leader to control the operations. Figure 8.9 shows a PERT diagram with the time estimates. As there is a range of time estimates for the PERT network, the equation in Formula 8-1 is used to calculate the estimated completion time for the entire network.

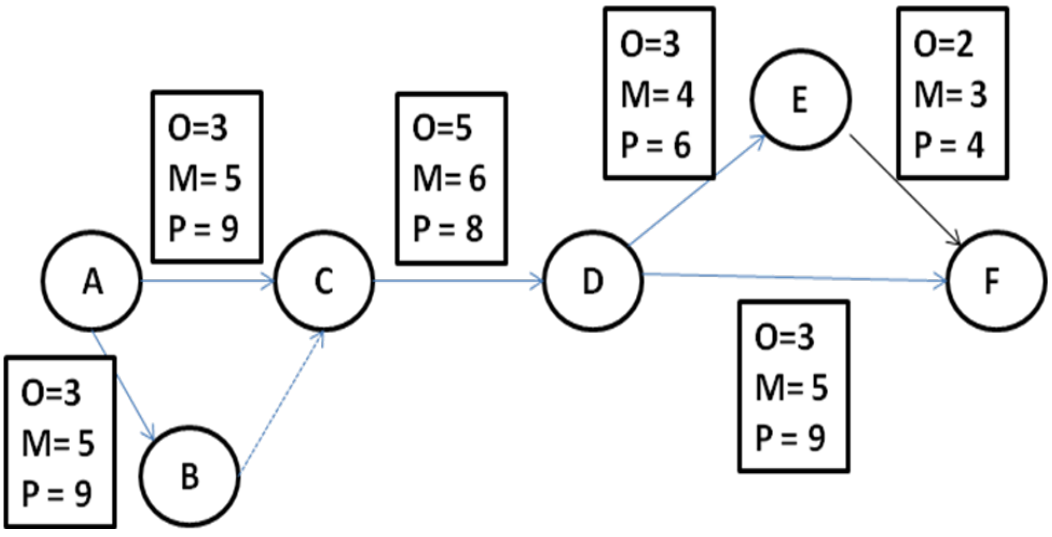


Figure 8.4: PERT Chart

$$\text{Estimated Completion Time} = \frac{(\text{Optimistic Time} + (4 \times \text{Most Likely Time}) + \text{Pessimistic Time})}{6}$$

Formula 8-1: Calculation of Estimated Time for the PERT Network

For example, using the times to complete A-B, the estimated completion time for that activity shown in Figure 6.4 will be (3 + (4x5) + 9)/6. Therefore, the estimated completion time for activity A-B will be 5.33 periods.

From a customer perspective the Gantt Chart or the CPM Chart are better as it allows the customer to know exactly when the project will start and when it will end. From a supplier perspective, the PERT Chart is better since it provides the supplier with a greater range of times to complete the project and provides the supplier with some flexibility.

Project Crashing

Project crashing must be part of the initial project planning phase. Can the project be finished sooner than planned? The project is running behind schedule, can we finish on time?

The answers to these questions come from the concept known as project crashing. Project crashing is a methodology to reduce the project completion time by expending additional resources. The crash time is the amount of time that an activity can be reduced. However, there is usually a cost of crashing a project as more resources are added to the project. The closer a project is to the planned completion time, the greater the cost to crash a project. The goal of project crashing is to complete the project earlier or on time at a minimum cost. Reducing a project's length is acceptable if the cost of crashing the project does not exceed the indirect costs. In some projects, there is a penalty assigned to not completing on time. In this case, there is a

trade-off analysis necessary to determine if the penalties for not completing on time exceed the costs of crashing the project.

For example, in 2012, there was a major Heating/Ventilation/Air Conditioning (HVAC) upgrade to Murphy Hall at the University of Kansas main campus. This project was supposed to be a two-month project. However, since the building was an old building, asbestos had to be removed before the actual project could start. The asbestos removal caused some delays in the project. The project manager decided that the cost of crashing the project by paying union scale overtime was more expensive than paying the daily penalty for not finishing on time. As a result, the company paid $1000 per day in penalties for finishing late. There was a downside to saving money on the project crashing.

Another consideration in the contracting world for projects is the rise in looking at past performance as a criterion for winning new proposals. A company that habitually chooses to pay a penalty rather than crash the project may find themselves on the outside looking in on future projects.

Life Cycle Management

Life Cycle Management is part of the project management umbrella. It is also part of the product design considerations. Life Cycle Management looks at the long-term costs of the project and not just the short-term costs. In some organizations this is known as the care and feeding of the project. Life Cycle Management would look at the life of a product if the project charter was to develop a new product for the company. The project is focused on the product development; however, a successful project leader will also focus on the lifetime costs of the product to the company.

Life Cycle Management looks at the acquisition costs, the development cost, the production costs, and the costs to sustain the product after it is introduced to the public and may also include the costs of disposal of the product at the end of life of the product.

Summary

This chapter provided an overview of project management. The goal of the chapter was not to make you a Project Manager Professional. The goal was to present the ideas to you which will hopefully make you a better project manager and project team member.

Projects are onetime operations with a defined beginning and defined end. Project management success depends on the initial statement of work and the planning involved before starting the project.

Projects can be controlled using Gantt charts, PERT diagrams, or CPM diagrams. The Gantt chart provides an easy to use visual display of the activities and project completion progress. Without delving into the Activity on Arrow vs. Activity on Node discussion, the CPM and PERT diagrams provide the same basic display with the biggest difference being the deterministic times of the CPM and the three time estimates for the PERT network.

Discussion Questions/Thought Questions

1. Think about your last (or current) group project. Were any of the principles of project management used in that project?
2. How does the PERT Chart differ from the CPM Chart?
3. What does the Gantt chart do for a project manager?
4. What purpose does the charter provide?
5. What part of the project management plan does the statement of work provide?
6. What is the difference between projects and programs?
7. What are the goals of project management?
8. What is life cycle management?

Chapter 9: Sustainability

The APICS Dictionary app defines sustainability as "an organizational focus on activities that provide present benefit without compromising the needs of future generations."[49]

Sustainability has become a focus of companies around the world. As we discussed in the product design chapter, this idea of being concerned about the environment is not a new idea since Clemson University was working on a compostable Coca-Cola bottle as early as 1969. And Sun Chips produced a compostable chip bag as early as 2008 (only to pull it off the market quickly because of customer complaints of being too noisy).[50]

The concern for the environment can trace it roots to the Clean Water Act of 1972. The impetus for the Clean Water Act was several incidents. The first was the fires on the Cuyahoga River near Cleveland, Ohio in 1969.

> "On June 22, 1969, around 12pm, floating pieces of oil slicked debris were ignited on the river by sparks caused by a passing train. Specifically, following an investigation, the cause was determined to be the oily debris trapped beneath two wooden trestles, rigid support frames, located around the Campbell Rd. hill in Southeast Cleveland. The fire was determined to have reached heights of over five stories and lasted between twenty and thirty minutes. There was reported to be around $50,000 of damages including: $45,000 from the destruction of the bridge owned by Norfolk & Western Railway Co. and $5,000 from the Newburgh & South Shore Railway trestle."[51]

It was not until 2019, fifty years later, that the Cuyahoga River was cleared for fishing again. The second impetus was the contamination of the James River near Hopewell, Virginia, as a result of the dumping of Kepone, the key ingredient in the manufacturing of Agent Orange

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[49] For more on the APICS Dictionary app, go to the Apple Store or the Android Store.

[5050] See: https://channelsignal.com/blog/what-ever-happened-to-the-sun-chips-compostable-bag/

[51] https://ohiohistorycentral.org/w/Cuyahoga_River_Fire

used in the Viet Nam war as a defoliant. Kepone was determined to be a strong carcinogenic agent. Like the Cuyahoga River, it took decades to clear the James River for fishing.

ISO 14000 Family of Standards – Environmental Systems

"ISO 14001 sets out the criteria for an environmental management system and can be certified to. It maps out a framework that a company or organization can follow to set up an effective environmental management system.

Designed for any type of organization, regardless of its activity or sector, it can provide assurance to company management and employees as well as external stakeholders that environmental impact is being measured and improved."[52]\

The ISO 14000 standards help companies monitor, improve or establish environmental programs. "ISO 14001 is an internationally agreed standard that sets out the requirements for an environmental management system."[53] These standards are not the end all or panacea for environmental issues but at least provide a start point for improving environmental standards.

What is Sustainability?

Sustainability is a focus on what is now being dubbed the "Triple Bottom Line." For centuries companies have focused on making a profit. The labor movement of the early 20th Century brought to light the need to fairly treat employees – although one could argue that this issue got its start with the abolition movement in the United States in the 1800's. And one could argue that we still have labor treatment issues today.

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[52] https://www.iso.org/iso-14001-environmental-management.html

[53] https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100371.pdf

The "Triple Bottom Line" is a focus on the profits, the people in the organization and the environment. This is a relatively new term that started appearing around 2008. This new focus on more than just profits is critical to future success. Native Americans have asserted for centuries that actions taken have impacts on seven generations in the future. This focus on trying to protect the planet is critical to future generations. It is more than just the lip service given to carbon emissions and green house gases.

Sustainability is a corporate responsibility to ensure that there will be a livable planet in the future. It is not an overnight action as can be seen by the efforts to clean up the Pacific Trash Gyre – if it can be cleaned up, the estimates are for more than five years to clean up this area in the Pacific Ocean where the currents move the trash dumped in the ocean.

Electronic Waste as Part of Sustainability

Electronic waste is simply anything that is disposed of that has a plug or a battery. Electronic waste is a rapidly growing problem globally. "One-half of all **e-waste** is personal devices, such as smartphones, screens, computers, tablets and TVs, and the rest is household appliances and heating and cooling equipment."[54]

The European Union established directives in early 2000s to restrict the use of hazardous substances in manufacturing as well as the disposal of waste electronic equipment. The Waste Electric and Electronic Equipment Directive (WEEE) as originally released in 2002. It has since been updated several times with the latest version released in 2012 and went into effect in 2014. "WEEE is a complex mixture of materials and components that because of their hazardous

[54] https://sdg.iisd.org/news/un-report-highlights-environmental-health-risks-from-e-waste-urges-circular-economy-shift/

content, and if not properly managed, can cause major environmental and health problems. Moreover, the production of modern electronics requires the use of scarce and expensive resources (e.g. around 10% of total gold worldwide is used for their production). To improve the environmental management of WEEE and to contribute to a circular economy and enhance resource efficiency the improvement of collection, treatment and recycling of electronics at the end of their life is essential."[55] The WEEE Directive ties back to our discussions of designing for the environment in product design and our discussions of reverse logistics. The goal of WEEE is not only to prevent hazardous materials being dumped into landfills, but to get companies to start thinking about the reuse of products when they reach their end of life. Designing for the environment and end of life will reduce. the e-waste contributions to landfills.

While only 2-5% of landfill materials are e-waste, approximately 95% of the toxins in the land, air, water, flora and fauna in the areas of landfills comes from the toxins found in electronic products.[56] The WEEE Directive sought to reduce this landfill contribution by mandating free return/recycling of electronic equipment and placed the onus on this free recycling on the manufacturer.

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[55] https://ec.europa.eu/environment/waste/weee/index_en.htm

[56] Walden, Joseph, *Environmental Impacts Associated with Current Methods of Re-Use, Recycling and Reclamation of Personal Computers and Cell Phones,* The University of Kansas, 2012

In 2014, approximately 41.8 million metric tons of electronic waste was generated.[57] In 2016, there was over 44.7 million metric tons (a metric ton is 1000 kilograms or 2240 pounds) of electronic waste generated.[58] By 2020, that total has risen to 50 million metric tons.[59]

The United States does not have a national e-waste directive or regulation. There are statewide regulations in 28 states. However, the good news here is that those companies that are doing business with the European Union must be WEEE and RoHS Compliant.

Restriction of Hazardous Substances Directive (RoHS)

The European Union also implemented the Restriction of Hazardous Substances Directive to drive down and eliminate (with exception of medical and Military) the use of hazardous substances in the manufacturing of electronic products. Most of the substances on the RoHS listing are added to electronic products as fire retardants but are also carcinogenic in nature.

The latest revision of RoHS went in to effect in 2017 and had the goal of "The legislation also requires certain hazardous substances (heavy metals such as lead, mercury, cadmium, and hexavalent chromium and flame retardants such as polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE)) to be substituted by safer alternatives."[60]

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[57] https://tcocertified.com/news/global-e-waste-reaches-record-high-says-new-un-report/

[58] https://www.itu.int/en/ITU-D/Climate-Change/Pages/Global-E-waste-Monitor-2017.aspx

[59] https://tcocertified.com/news/global-e-waste-reaches-record-high-says-new-un-report/

[60] https://ec.europa.eu/environment/waste/rohs_eee/index_en.htm

Sustainability Functional Areas

Environmental stewardship

Every company has to take responsibility for their actions. This is especially critical when considering the impacts to the environment. This also includes looking at ways to reduce energy requirements, reduce packing requirements, reducing waste produced and reducing land fill contributions.

The Walt Disney Company takes this environmental stewardship very seriously. The company prepares an annual sustainability report to let shareholders and customers know what their goals are and how they are doing as shown in Figure 1 from their 2018 report.

Figure 9.1: Walt Disney Company Environmental Goals and Achievement[61]

[61] The Walt Disney Company, Social Corporate Responsibility Update, 2018, p. 4

In addition, Disney now has eleven resort hotels in Florida that have been LEED Certified (Leadership in Energy and Environmental Design). Prior to the closure from the 2020 pandemic concerns, Walt Disney World was contributing 50,000 pounds of food weekly to the local food banks and were working towards they goal of zero landfill contributions.

Conservation of resources

This aspect ties back to our discussions of product design and designing for the environment. Natural resources are finite. Anytime a company can reduce the energy requirements for manufacturing, take advantage of solar or wind power, or reduce the packaging requirements for a product, they are helping to conserve natural resources.

Reduction of carbon footprint

This one has received a lot of attention over the past decade as companies have worked to reduce their carbon footprints. It also gave rise to the idea of carbon footprint credits and the ability to sell these credits to other companies. This appears to be a zero net gain or lack of improvement if one company can simply sell their credits to another company thus no real reduction in the carbon footprint.

Financial savings and viability

Consumers want to do business with companies that practice ethical business practices as we discussed in earlier chapters. They also are moving toward wanting to do business with companies that are actually working on green initiatives. This move by consumers to green companies is producing more business. At the same time, the move to green activities is saving the companies on waste removal and in the case of companies that are donating products it also provides a tax break.

Social responsibility

Amazingly, almost every company's ethics statement contains something about social responsibility. As more companies adopt green practices and focus on the triple bottom line, there is more pressure for other companies to do the same.

The Circular Economy

The latest buzz word in business is the **circular economy**. Just what is a circular economy? This concept ties to our previous discussions on product design and reverse logistics. The circular economy is "an economic system intended to minimize waste and maximize the use of resources through a regenerative process achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, recycling, and upcycling."[62]

What does that mean? The circular economy ties in product design, life cycle analysis, end of life analysis and disposition, and sustainability. The circular economy seeks to eliminate land fill contributions, carbon emissions and e-waste while seeking to reuse as much of the components of a product as possible. An example of this can be seen in Figure 9.2 with the stop signs and other road signs being produced from the recycle printer cartridges. These road signs are more durable than the traditional aluminum signs and because they are not aluminum, they are not stolen as often as traditional signs.

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[62] APICS Dictionary app, "circular economy"

Figure 9.2: Road Sign from Recycled Printer Cartridges

Summary

This area of operations and supply chain management is becoming more important daily as more consumers become concerned about the future of the planet. Everyone in business will need to become a sustainability manager in the future. Figure 9.3 shows the relationships between sustainability and business success.

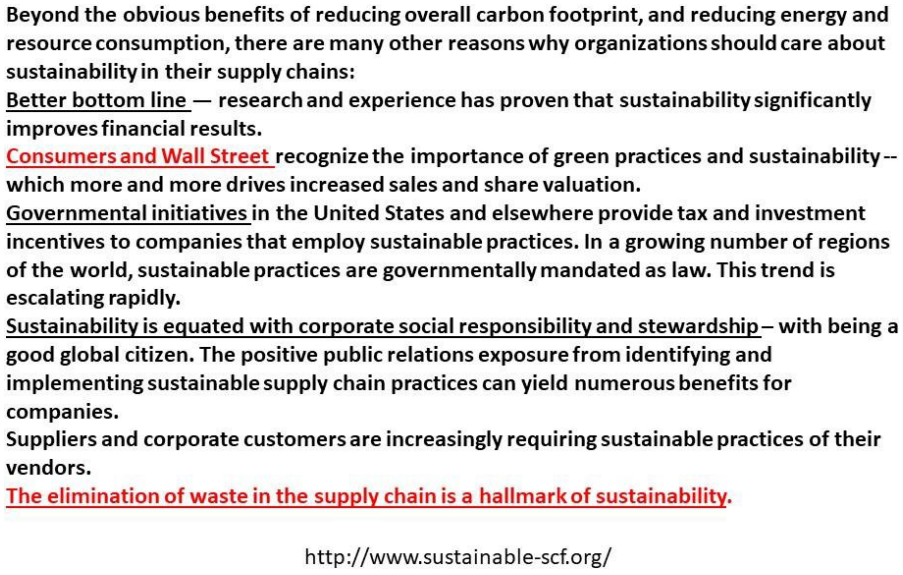

Figure 9.3: Summary of Sustainability

Thought Questions and Ideas:

1. Research the Great Pacific Trash Gyre. What can be done to help reduce/eliminate this issue?
2. Research your favorite company. What is their corporate social responsibility program? Do the even have one?
3. Why is ethics and corporate sustainability linked?
4. Think about the discussions of JIT, product design and sustainability: how are they related?
5. Why is sustainability important?

Section 3: Source

Source in the SCOR Model is anything that involves the procurement, sourcing and for our discussions will include quality. While quality cuts across all of the SCOR functions and could very easily be part of the discussions related to planning, we will place it here with Source as it is critical to source quality products and components.

Chapter 10

Quality and Operations Management

Everyone involved in the manufacturing of products or the provision of services is or should be involved in the quality of the product or service!

The goal of operations is to add value. We can add value through improvements in bottom line profits, improvements in the customer experience or by adding value to the quality of the product.

What is quality and what is the impact of quality or a lack of quality on operations management and operations management?

It could be that quality is like love; everyone has a different definition of what quality is in a product or service when they see it but may have trouble defining quality. Ask a class of twenty-five students and you will get twenty-five answers.

"If quality is to be managed, it must first be understood."

—David Garvin

One simple definition states, "Quality is a measure of goodness that is inherent to a product or service." Another definition from Webster's Dictionary defines quality as "the degree of excellence of a thing." Neither of these definitions provides clarity in operations management of what quality is or the impact of quality on the outputs of operations. The American Society for Quality defines quality as "The totality of features and characteristics that satisfy needs." Even this definition leaves a little to be desired when looking at operations management.

Perhaps a better working definition of quality for the study of operations management is: ***fitness for use—as defined by the customer***. Telling the customer that you have a quality

product or service is not enough, the customers must experience the quality of the product or service for themselves. The Association for Supply Chain Management defines quality as "conformance to requirements or fitness for use… Also, quality has two major components: (1) quality of conformance – quality is defined by the absence of defects, and (2) quality of design – quality is defined by the degree of customer satisfaction with a product's characteristics and features."[63]

Obviously, the fitness for use of the product is fitness for use as the product was intended. Using a screwdriver as a chisel will leave the customer thinking that the screwdriver is not a quality product as the handle of the screwdriver breaks when hit with the hammer. Conversely, using a chisel as a screwdriver will most likely leave the customer thinking that the chisel is not a quality screwdriver. Trying to drive a nail with a shoe will most likely result in a damaged shoe. The user of the shoe would be led to believe that the shoe is not a quality product—however, the shoe is not designed to be used as a hammer. One of my US Navy friends makes this point a little better. The Navy has ships that are designed to seek and destroy mines in the water. These ships are known as mine sweepers. Not every ship is designed for this purpose but, "every ship can be used as a mine sweeper.....once."

There are multiple facets of quality that impact the customer's perception of the product. Quality cannot be inspected into a product, contrary to the beliefs of many companies. Quality has to be designed into the product (we will look at this process in greater detail in the chapter on

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[63] ASCM/APICS Dictionary online, "quality," accessed 29 March 2020. The APICS dictionary of supply chain management terms is available through the App Store for all devices. For more information on the Association for Supply Chain Management go to http://www.ascm.org. ASCM offers free membership for all students.

product development) and may very well be impacted by the process layout and manufacturing/service layout (we will look at this in greater detail in process development chapter).

Many companies have quality assurance offices, quality control offices, and quality inspectors. All of these are necessary for the assurance of providing a quality product or service to the customer. However, everyone involved in the design, manufacture, and delivery of a product is involved in the quality of the product. In the service industry, everyone associated with providing the service is responsible for the quality of the service. In the food service business, everyone from the manager to the buyer of the foods to the cooks to the servers to the host/hostess has a part in providing a quality service to the customer. In the retail world, everyone involved in retail operations management chain from the corporate buyers to the store managers to the salespersons to the delivery personnel have a part in providing a quality experience to the customer. In today's online environment, you can even add the delivery person to the quality management team. If the delivery person is rude, does not handle the package properly or simply delivers to the wrong address, customer satisfaction will be low. Even if contracted out, the delivery company or driver is an extension of the company.

Dimensions of Quality

To adequately discuss quality, it is important to look at the dimensions of quality within operations management. These dimensions of quality are linked to the APICS definition above. APICS defines the dimensions of quality as: "An aspect of quality that is specified to enhance the ability to define quality."[64]

[64] Ibid.

The first dimension of the quality of a product is the reliability of the product. This reliability includes the availability of the system. When I was in the Research and Development process for the US Army the first time, the basic measure of a system was simply the reliability of the item. The reliability of the item was usually measured using the Mean Time Between Failures (MTBF). The MTBF is simply the average time between the breakdowns or failures of the product. When using the MTBF as a measure of reliability, the testing procedure simply averaged the times between the failures of the system.

As the systems became more complicated and new testing and measuring procedures were put into place for the products, a new methodology was adopted to look at the system reliability—systems availability. Systems availability considers the time necessary to repair an item. This repair time is called the Mean Time To Repair (MTTR). When measuring the quality of a product using systems availability, the measurement looks like Formula 10-1.

$$\frac{\text{Mean Time Between Failures}}{\text{Mean Time Between Failures + Mean Time to Repair}}$$

Formula 10.1: Systems Availability

Example 10-1: Using the Mean Time Between Failures as the measure of the quality of the products or systems available would lead the company to choose product C since the Mean Time Between Failures is the greatest at 40 hours. However, when Systems Availability is used as the measure of quality, the choice for the quality product is now product D with a Systems Availability of 95.2%. Although this product breaks more often, the time to repair it is less thus giving the customer more time of operation on average for the product.

	MTBF	MTTR	Systems Availability
System A	30 hours	2 hours	0.938
System B	25 hours	3 hours	0.893
System C	40 hours	4 hours	0.909
System D	20 hours	1 hours	0.952

Example 10.1: Systems Availability

The second dimension of quality is responsiveness. This dimension of quality is usually associated with a service or with the customer support provided by the company after the sale of the product. How responsive is the company to the needs of the customer after the sale of the product? Customer service seems to be a dying art form in most businesses today. So, the measure of the product may be more than just the product itself and include how well the company supports the customer when there is a problem with the product.

The same is true for service quality. How responsive is the company to unusual situations requiring service support? When I was finishing a basement in my house in Virginia, a nail for the paneling hit a water pipe. I knew the sound was not quite right when the nail hit the pipe and pulled the nail out only to reveal a hole in the pipe. This produced a nice little fountain of water where no fountain should be. After turning off the water, we called a plumber listed in the Yellow Pages with an ad for "24-hour service." Apparently, this company only had a 24-hour answer service, and I was informed that they could be there the next morning. The next plumber ad in the Yellow Pages also advertised "24-hour service." This plumber company had a plumber on the scene within 30 minutes and fixed my mistake. When the time came for finishing the

bathroom for the downstairs, I realized that plumbing is not one of my core competencies. So, the first call was to the company that really did have the ability to respond to service outside the normal business hours.

In the retail industry, especially with the increasing numbers of e-commerce sales and the proliferation of e-commerce, the responsiveness of the company making the sale is a measure of the dimension of quality of the company. This is most evident when there is a problem or perceived problem with a product purchased over the Internet. In some cases, after a detailed search of the Web site to find a contact number, the result is a series of automated phone responses before the customer gets the opportunity to talk to a customer representative who can discuss the problem and, in some cases, even more frustration before an acceptable solution can be reached and the problem solved.

The third dimension of quality of a product or service is measured by how the company solves a problem or provides a service. Is the company empathetic and caring about the customer or does the company act as if a favor is being done? A quality-focused company will show concern for meeting the customer's needs. How many times have you gone to a restaurant or retail store and the servers or salespersons simply act as if they are doing you a favor by being there? Or, do you have to trash the company on social media to get the problem solved?

The fourth dimension of quality deals with the knowledge of the company to help the customer with the use of the product or service. In the service and retail industry, can the person helping the customer provide the customer with enough knowledge to make the right choice? Bass Pro Shops/Cabela's is a good example of this. Cabela's boasts that they are "The World's Foremost Outfitter." In order to live up to that boast, Cabela's trains its employees to ensure that they have the necessary knowledge to assist the customer in choosing the proper gear for

whatever outdoor activity the customer is interested in. Cabela's sales staff does not work on commission which allows them to make recommendations on what the customer needs without the customer feeling like the sales staff is trying to make a bigger commission by recommending certain products. In the food service industry also, this is important. If you go into a restaurant, you expect the server to know about each item on the menu if you have questions. This is a measure of the quality of the service. Here is an example of service quality: At the APICS International Conference in the Wynn Las Vegas resort in 2010, Francisco, a server at the evening reception, discovered that I really liked one of the hors d' oeuvres that they were serving. He then went and found another server with those particular hors d 'oeuvres and sent the server to me. Francisco then went to the kitchen and got another tray of the item and brought it by my table several times. Francisco epitomized quality of service. No surprise when I talked with his supervisor and discovered this was the level of service that Francisco provided all guests.

If you call a help desk, you expect the person at the other end of the line to be able to help you. This is a measure of the company's quality. The last thing a customer wants to hear from a help desk is "That is a very good question, but I have no idea what you are talking about." Knowledge of products and service is a dimension of quality.

Another dimension of quality is the perception of the product. This may be influenced by advertising or the reputation of the product. There was a time in the IT world when no one questioned your purchase or the price if the product was IBM. The perception of Lexus, Cadillac, Rolls Royce, and Rolex are intangible dimensions of quality based on reputation and advertising.

Another way of looking at the dimensions of quality is based on users, products, manufacturing, and values. User-based quality dimensions are simply based on the fact that the user is satisfied with the product. No matter how great or how good the quality of a product is

according to the manufacturer, if the user perceives the quality as less than adequate, then the product is not a quality product. Conversely, if the user is satisfied with the product, regardless of the intended quality, it is still a quality product.

Product-based quality dimension is based on the product's attributes, which simply means does the product do all of the things that it is designed to do? As we discussed before, this is based on the prudent use of the product. Will the product's attributes meet the needs of the customer?

Manufacturing-based quality dimension is based on the ability of the product to conform to certain specifications. An example of this is the use of military specifications for a product. The ability to meet military specifications may be the order winner for a product and the determination of quality. Another aspect of manufacturing-based quality is meeting construction specifications – when building a new facility there are certain industry standards for construction such as tensile strength, pounds per square foot capacity or thickness of walls.

Another way to look at manufacturing specifications as a measure of quality dimension of a product is to look at the requirements to work in a certain environment or for a specified period of time. The Sears Diehard battery for example used to advertise that it could be left on all day and still power the lights of Candlestick Park (Candlestick Park was the home of the San Francisco Giants before they moved to Oracle park in 2000). Although, the ability to light up Candlestick Park may be taking it a bit far, the ability to leave your car lights on and still be able to start the car was a strong selling point for the battery and set an expectation of specifications for the product.

Value-based product quality dimension is based simply on whether or not the consumer perceives that the cost of the product is a value for the customer based on his or her perceptions of the product.

Garvin and the Dimensions of Quality

One of the Quality Gurus of the twentieth century was David Garvin. He was one of the first to discuss the dimensions of quality. In his discussions, the dimensions of quality are similar to those already discussed but are important enough to mention here.

1. **The Performance Dimension**: Does the product conform to basic operating characteristics? This is similar to our previous discussion on whether or not the product performs as intended when used by the prudent individual. If the product has certain basic operating characteristics set forth by the manufacturer, does it do these basic functions? Windows Vista is an example of this, if it really met all of the advertised functions, two things would not have happened. The first is the number of patches and changes required to make the system work properly. The second is that Windows 7 would not have been rushed to market as quickly.

2. **The Features Dimension**. Is there anything added to the basic characteristics or features? Does it do more than is required of the system? Here are a couple of examples. The first is my computer. My first computer was a Tandy 1000 with a single 5.25 inch floppy drive and an external 3.5 inch floppy drive. When it became available, I upgraded my computer to add a 300 baud dial up modem (not long after Al Gore invented the Internet). In those days, all of Lotus 1-2-3 fit on one 3.5 inch floppy drive; the Tandy had a program called “Desktop” (later bought by Microsoft) and when it came out, Harvard Graphics fit on a 3.5 inch floppy. Today most people use their computer for graphics,

spreadsheets, word processing, and accessing the Internet. Granted, the computers today are faster than my Tandy 1000, but for the most part computer users still only use their computers for the same things that my Tandy 1000 was used for. Is there an added features dimension of quality to my new laptop over the Tandy? That is a good question. My Tandy lasted eight years before being replaced. Even then it was not for lack of quality, but the update was dictated by the growing requirement for disk space that outgrew my dual floppies.

The second example of the features dimension of quality where a product does more than required is my one of my former cell phones. This phone was the top of the line when I purchased it. When I got that phone, I was offered a package that allowed me to watch football games and NASCAR races on my 1.5 inch phone screen. This was a fascinating option, but when I tried to watch the Daytona 500 for fun on my phone, I was unable to determine which of the 43 cars going almost 200 miles per hour around the 2.5 mile track was leading, passing, drafting, or even in the race. This was a dimension that was not needed—an extra feature that exceeded the requirements for the phone. (This was several years before the advent of smart phones).

3. **Durability**. Will the product reach the advertised life expectancy before it has to be replaced? How durable product is can be viewed as a measure of product quality. Is your product like the "Energizer Bunny?" Does the product last as long as advertised? The Merriam-Webster dictionary defines durability as: "able to exist for a long time without

significant deterioration."[65] This dimension of quality is evident in the "Lifetime Warranty" light bulbs. The advertisements for these bulbs lead one to believe that the bulbs will last a "lifetime." However, unlike the bulbs that have "an estimated life of 1000 hours," these bulbs do not have a set life expectancy. The "lifetime bulbs" I used in my garage lasted about three months. My first reaction was anger that my lifetime bulbs did not last a lifetime (whatever that was supposed to be). My second reaction was concern that my lifetime was soon coming to an end. Then I realized that the bulbs lasted their lifetime—unfortunately, their lifetime was not near what I expected when I bought them.

Durability also refers to the ability of the product to perform under hard and frequent use while still meeting the specifications dimensions of the product. The Kevlar vests used by Soldiers and Police every day in all climates and conditions; the users of the vests trust the quality of the materials and manufacturer to protect them day in and day out.

4. **Reliability** is the next dimension of quality according to Garvin. How well will the product operate over time? As discussed earlier, the reliability of the product is a measure of quality. We will look at reliability of products when we discuss product development and process development in subsequent chapters. In order to ensure systems reliability for cellular phone coverage at NASCAR events, as long as Sprint was the primary sponsor

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[65] durability. In *Merriam-Webster Online Dictionary*. http://www.merriam-webster.com/dictionary/durability

for NASCAR's top racing series, Sprint (Sprint is now a part of T-Mobile) provided towers to help with the additional coverage needs at the events.[66] These mobile towers disappeared after Sprint was no longer the sponsor for NASCAR's top series.

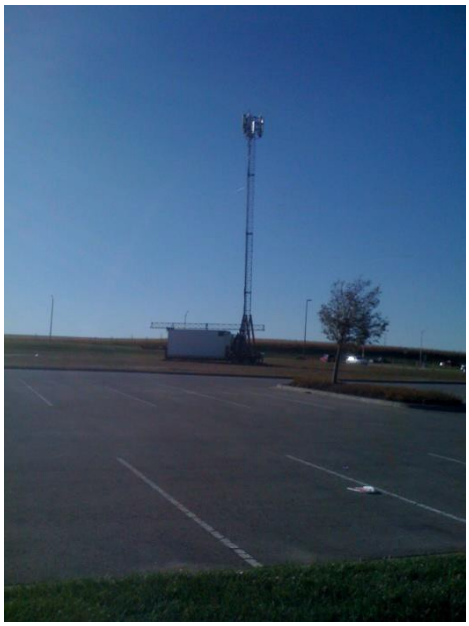

Figure 10.1: Sprint Mobile Communications Tower at a Kansas Speedway NASCAR Event

5. **Conformance**. Are there pre-agreed upon specifications? As a measure of the dimensions of quality, conformance looks at the required specifications for the product. As discussed earlier, manufacturing specifications may be stricter than consumer specifications. As quality is defined by the customer, if those specifications exceed normal specifications, they must be met in order to be considered a quality product.

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[66] The towers were actually designed for use at natural disaster sites such as hurricanes to restore cell phone coverage when towers are destroyed. The mobile towers also provide a great backup at NASCAR events.

An example of conformity as a measure of quality can be seen at NASCAR events. Every frame for every car that is allowed on the track is inspected by NASCAR technical inspectors to ensure that every part used conforms to the NASCAR specifications for tensile strength. This is to ensure the safety (another service dimension) and to ensure that the frames meet the prescribed thickness. After the inspection, Radio Frequency Identification tags are placed in the frames by the inspectors so that a later inspection can be done electronically to ensure no changes have been made in the frames. Then every car is inspected before and after the races to ensure adherence to the standards.

6. **Serviceability**. How easy is it to repair if necessary, how quickly can it be fixed, and how good are the repairs? If for some reason the product needs service, whether from breaking or just scheduled service, how easy is it to repair or service the product. (We will look at this in greater detail when we discuss Reverse Logistics.) Another aspect of the serviceability of quality is the quality of the repairs. If the product needs to be repaired because it did not meet the durability dimension, how good are the repairs? This is another measure of quality. If the product is easy to fix but the repairs are not of quality, then not only is the dimension of durability not met, but the dimension of serviceability is not met either and the product will never be seen as a quality product.

In the late 1970s and early 1980s Chevrolet had a car called the Monza 2+2. The Monza was a popular car in Europe and was rushed into production in the United States. The problem with this car (remember, Chevrolet billed themselves as the "working man's car" during this time period) was that to change the spark plugs required actually pulling the engine—which means "the working man" could not tune up his car without having an

engine hoist (not something the average working man has in the tool box). As a result, the Monza did not last very long in the marketplace.

7. **Safety**. Is the product safe to operate and use? How safe is the product to operate? Even some products that are considered quality do not meet this dimension of quality. Three-wheeled off-road vehicles meet most of the dimensions of quality yet do not meet this dimension of quality. Merriam-Webster defines safety as: "the condition of being safe from undergoing or causing hurt, injury, or loss."[67] Without picking on the ATV industry, the safety dimension of quality is not met if the number of accidents on ATVs is a measure of quality—even if the use of the vehicle may not be in the manner intended by the manufacturer.

8. **Aesthetical dimension of quality**. This dimension is concerned with the look, the feel of the product, the smell of the product, or perhaps even the taste of the product if the product is food. Several years ago, in the Dilbert comic strip, the Elbonians were tasked to build an MP3 player. This player turned out to be 5 feet tall. Obviously, this does not meet the product specifications as discussed above. The solution was to add lips to the MP3 player to make it look like Angelia Jolie and then it was assumed that the aesthetical dimension of quality would be met.

   In the food service world, you can have the best food in the business but if the smell of the facility is not aesthetically pleasing, you will probably not want to enter my

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[67] safety. (2020). In *Merriam-Webster Online Dictionary*. http://www.merriam-webster.com/dictionary/safety

facility. There was a fish house in Wiesbaden, Germany, that was supposed to be one of the best in town. However, this fish house had the smell of day-old fish—a smell that I could not get past every time I walked toward the restaurant.

Another example of this is a restaurant in Kissimmee, Florida that I used to frequent when I lived in Florida. The last time that I visited this restaurant was during the traditional spring break weeks. The restaurant was designed with the rest rooms near the front doors and apparently someone had stomach issues in the rest room as the front part of the restaurant smelled of vomit – my family and I could not get past the smell when we opened the front door and have not been back since.

Services and Quality Dimensions

There are seven basic dimensions of quality for services. Measuring the quality of services is a little more difficult than measuring the quality of products as the quality of services is more subjective than the quality of products.

1. The first dimension of quality for services is **timeliness and the time to receive the service**. From a supply chain perspective this may be the measure of customer wait time. How long from the time that your customer orders a product until they receive it? (We will look at this concept in greater detail when we discuss supply chain management – this is known as the lead time or customer wait times.) Another aspect of this dimension of services quality is the time to complete a service. If the service manager at a car dealership's service department tells you that the repair job will take four hours, you expect the job to be ready in four hours and will most likely plan your return to the shop accordingly.

The same dimension of quality is applicable to the food service industry. How long does it take to get a seat at the restaurant, and then how long does it take to get your complete order delivered to your table? The airline industry is another example of this dimension of quality. Every airline is measured on on-time arrivals. If the airline actually posts transit times that are much longer than the actual flight time and they arrive early, is this really an on-time arrival or simply a misrepresentation of facts? Conversely if the plane backs away from the gate on-time but sits on the tarmac for forty-five minutes, is it really an on-time departure?

In the fast food industry this dimension of service quality may very well be the differentiation between food chains. If one fast food restaurant can get you into and out of the store quickly with a complete order, they may have an advantage over their competition. McDonald's experimented with speed and order completeness in Missouri several years ago. In fact, it was a very successful experiment. They outsourced the order process to a call center in Colorado. The quality of the timeliness and order completion increased dramatically. Customer satisfaction increased as a result of the decreased time in the drive through line and increased order completion rates.[68]

2. **Order completion** is another dimension of service quality. How often have you driven off from a fast food restaurant only to find that the order was not complete or was not accurate? How many times have you received a shipment from an online retailer only to find that something is missing from the shipment? Order completion

[68] For more on this experiment read Freidman's book *The World is Flat*.

and perfect order fulfillment are measures and indicators of service quality and will be discussed in greater detail when we discuss supply chain management.

3. **Employee courtesy** is another dimension of service quality. With the exception of "Dick's Last Resort," customers to restaurants and retail establishment expect to be treated with courtesy by the employees. Regardless of the quality of the product or service that the company is providing, the courtesy of the employees will determine if the customers stay or come back again.

   When I was in college, most of my clothes had to be tailored as I was preparing to enter the US Army. For some reason at five foot five inches and 195 pounds, I was not able to buy ready to wear clothes off the rack. The tailor that I used was very competent but complained every time I went to see him to get something altered. As soon as I could find another tailor close by, I switched tailor shops to one that seemed to appreciate my business. When you are providing a service it is imperative that you remember the customers are paying for the service and you probably do not have a monopoly; therefore, customers should be treated with respect and not as if you are doing them a favor.

4. The **consistency and accuracy** of the service is another dimension of service quality. Does the service provider provide consistent service every time? If the provider is a tailoring service, do they provide quality tailoring consistently or do they only provide quality service sometimes? A shop close to Fort Leavenworth, Kansas specialized in tailoring and sewing military insignia on military uniforms. When I was promoted in the military, I would buy new insignia for my Battle Dress Uniforms and before that my fatigues. The theory behind that was that the branch insignia and

the rank insignia would be the same level of fade. My last promotion came in 2000. For that promotion, I took four sets of Battle Dress Uniforms into the sewing shop to have the new insignia and rank sewed on the uniform. Three of the four were done correctly and the fourth was sewed on upside down. Their quality was not consistent or accurate.

Another example of consistency and accuracy of service is In-N-Out Burger© on the West Coast. This restaurant has a cult following that goes back to the beginning of the company in the 1940s. In-N-Out makes each order as the order is taken. The burgers are made from daily ground beef and daily cut potatoes for the French fries. Each order is then checked before giving it to the customer. Figure 10.2a shows the fresh French Fries and 10.2b shows the operations in an In-n-out restaurant.

Figure 10.2a: In-n-out

Figure 10.2b: In-n-out Restaurant

Consistency as service quality dimension also includes—does every customer get treated the same? However, there are exceptions to this dimension. In Las Vegas, the gambler willing to lose lots of money will get better treatment than those willing to lose $20-30 dollars. Is this an aberration to the consistency dimension? Not really. When the Superbowl was hosted in Phoenix in the mid-1990s, the management of the Las Vegas Casinos stratified their customer base and identified over 20 gamblers capable of losing over $2 million in a weekend, another 50 or so willing to lose about a million dollars in a weekend and several hundred capable of losing over $500,000 in the course of the weekend. The casino operators targeted those gamblers and flew them to the game on a private plane, paid for their tickets, and brought them back to Las Vegas. The rationale was that if the gamblers were going to lose that much money, the operators wanted the gamblers to lose the money in their casinos. These gamblers got “comps” in rooms, tickets, meals, and airfare. I got a few free drinks. Was this consistent? Yes, if the casinos are going to stay in business, they have to cater to the folks

willing to lose big money. But my theory is if you are willing to lose several million dollars (1) you are not getting anything for free and (2) you have already paid for the food and room.

5. **How easy it is to obtain a service** is a dimension of service quality. This includes where the service facility is located as well as the hours that the service is provided. When I was finishing a basement room in Virginia, I was nailing up the paneling when the sound of the nail did not sound right. Upon pulling the nail out, I discovered I had punctured a water pipe. Not a good thing to do at 7:00 p.m. on a Friday. The first "24 hour" service that I called informed me that what they really had was a 24-hour answering service. The next call resulted in a company with an on call 24-hour service. They were on site within fifteen minutes. Needless to say, when the time came to add a bathroom to the basement, the company that had the real 24-hour service was the company called to do the work.

   Conversely, if a food establishment is hard to get to and not easily accessible, it will not stay in business very long no matter how good the food is. For the company to stay in business it has to have a service that is easily accessible.

6. **How easy is it to get the service**? This is another dimension of service quality. Cooter's garage in *The Dukes of Hazzard* was in the middle of nowhere but everyone took their vehicles there. That is fine in the movies and on TV but in the real world, a service—no matter how good—must be accessible to the customer if the service is going to survive. At the same time the service must be offered at times convenient to the customer.

One installation that I was stationed at while in the US Army had a Post Exchange[69] that closed about the time that most soldiers on the installation got off work. Although the facility was easily accessible geographically, it was not accessible to the primary customers during the hours that the customers could access the store.

7. **Responsiveness** of the service is the final dimension of service quality. How responsive is the service provider to unusual situations? The plumbing company discussed above was able to respond to an unusual situation. This led to them getting not only more business from me but my recommendation when my neighbors worked on their basements.

Deming and Quality

There are numerous gurus of quality that influenced Operations Management theory and thought. There is a big difference between theory and execution. To paraphrase the military theorist Karl von Clausewitz, all things change when you go from the abstract to the concrete. In the world of operations management there are many theorists from the twentieth century that impact the theory of quality management, but the biggest concrete impact on the execution of quality is Dr. W. Edwards Deming. Dr. Deming left the United States after World War II to help the country of Japan rebuild their manufacturing after the devastation enacted on the country as a result of the destruction Japan created during the war.

[69] The Post Exchange is a system that provides a department store operation at every military base. It started as a service to the soldiers in outposts as the United States expanded west and has remained a part of military life ever since.

In the 1950s and into the 1970s, “Made in Japan” meant poor quality. And then overnight it seems, “Made in Japan” stood for the epitome of quality around the world. When the United States became enamored with Japanese quality, everyone started wondering where they learned to produce such quality. The quality award in Japan is the Deming Prize. As more study of Japanese management philosophies and the quality movement took place, the name of Dr. Deming surfaced. Then it was discovered that the Dr. Deming in question was an American.

Dr. Deming established his 14 Points as a road map to quality in any organization. The work of Dr. Deming led to the Toyota Production System and what is now known as both Just-in-time and Lean (these topics will be discussed in greater detail in the chapter on JIT/Lean). These 14 principles are the foundation for most quality programs today. His 14 Points are:

1. **Create a constancy of purpose**. What is a constancy of purpose? If everyone is working on the same goal and same purpose, quality will be achieved. We talked about vision and strategy in Chapter 3. A leader with a clearly stated and clearly understood vision and strategy will create a constancy of purpose in his or her workforce.
2. **Adopt a philosophy of prevention**. This is accomplished by designing a quality product rather than trying to inspect the quality into the product after it is produced. (We will look at product design and process design in greater detail in another chapter). Prevention means ensuring quality materials, quality processes, and a trained workforce. The quality of the product has to be built into the product and that starts with the design process.
3. **Get rid of mass inspections**. Mass inspections of products do not produce quality products. As we discussed above, the quality of the product will not be improved by

inspections. However, having said that, there is a company in Missouri that knows that it has to inspect every product from one of its Asian suppliers because of quality problems. The testing and inspections do not improve the quality of the product; they simply identify the problems with the products before the items reach the consumer.

4. **Minimize the number of suppliers**. This sounds a lot like one of the principles of Just-in-Time that will be discussed later. Although many suppliers may be available for the materials to make a product, long-term relationships with fewer suppliers will help to bring the supplier into the manufacture of the products.
5. **Implement continuous improvement in the manufacturing system and in the workers producing the product**. If a system of continuous process improvement is implemented in any corporation, the quality of the product or service will (or at least should) improve. At the same time if the company is working to improve the knowledge and skill level of the workers, the level of the quality of the product or service will improve.
6. **Train the workers**. Look at the FORTUNE© "Best Places to Work in America." The majority of the companies that make that list produce quality products or provide quality services. If you look at the companies profiled in this list, you will see that most of them provide more than the average training to their employees. The Container Store (a consistent member of this list) used to require several hundred hours a year for their employees to ensure that the employees could answer the questions of the customers.

The Toyota North American Parts Distribution Center in Ontario, CA, has a very low employee turnover and requires over 80 hours a year in employee training to

keep the employees up to date on new systems and provide refresher training to make sure the employees remain current on techniques and procedures in the distribution center.

If you go to work for Disney, the first thing to do is go through a basic course at Disney University and then classes related to your job. Every time you change jobs, you have to go back to additional classes at Disney University.

The US Army (as well as the other Services) has a series of courses and schools that Soldiers have to attend in order to get promoted to the next level. The purpose of these courses is to ensure that the Soldiers remain trained for new levels of responsibility.

7. **Implement leadership development programs for new leaders**. How often does a good worker get promoted to supervisor and then fails because no additional leader training is provided to the new supervisor? What Deming is telling us is not only do we need leadership in companies to provide quality products and services, but we need to train those leaders in order to make sure that they are successful as leaders.
8. **Get rid of employee fear**. Why do employees have fear? Fear is an acronym for False Expectations About Reality. Primarily employees are afraid because too many companies spend too much time trying to find employees doing something wrong rather than catching the employee doing something right. This mindset tends to produce less than quality products or services as the employee focuses too much on not doing something wrong rather than focusing on producing a quality product or providing a quality service. This ties to another of the points—employee pride.

9. **Get rid of the barriers between departments**. As we will see in Chapter 5, breaking down the barriers between departments not only speeds the product to market but helps to have more involvement in the product design resulting in a better quality product.
10. **Get rid of Slogans**. A slogan has never produced a quality product. This goes back to the constancy of purpose. If the leader of the organization is successful in communicating his or her vision and strategy to accomplish the vision, the employees will not need a slogan. Leadership is providing purpose, direction, and motivation to employees. If this is accomplished, a quality product will be produced, or a quality service will be provided without a slogan.
11. **Numerical quotas are not needed**. What has been discovered over time with quota inspections is that if three inspectors are looking at a quota of items, problems occur. Initially Inspector 1 does the inspections, as Inspectors 2 and 3 also do the inspections. After some time, either Inspector 1 decides that 2 and 3 will do the work or 2 and 3 figure Inspector 1 has checked the items and do not bother to do a good inspection. Eventually, no one is doing the inspection.

    The other impact from numerical quotas is that the employee is rewarded or disciplined for the number of products that they produce. The emphasis has historically not been on how many quality products are produced. The result all too often is many defective products requiring rework (one of the costs of quality we will discuss soon).

12. **Improve worker pride**. This one ties to the previous principle of eliminating employee fear. The key is to get your employees to understand that every product that they produce has their name on it.

    In a previous job, I was trying to get my mechanics workforce to put their name on their repair jobs. Because of their experience with getting beaten up for mistakes, they were fearful of putting their names on the jobs. In actuality, because of the electronic systems in place, I knew who was doing what on what equipment. It took over six months to get the attitude of pride and have the employees put their names on the jobs.

    This was not an original idea; I got the idea from the cars in Germany. Every Mercedes has a sticker with the signature of Mr. Daimler in the front window. Every job done has a signature on it—is it there because of electronic systems or because the employee is proud of what they did?

13. **A quality program needs a program of training and education for the employees**. There is a difference. Training is hands on and is necessary in order to ensure proficiency. Education is a classroom program and is also necessary—but sometimes hands-on training is needed to supplement the education. A well-trained employee is much better equipped to make a quality product or provide a quality service than one that is haphazardly trained or assumed to be trained.

14. **A sponsor**. Quality is not a grass-roots program. For any improvement program and any quality program, a company sponsor is needed to ensure the success of the program or project. This sponsor is critical to ensuring the implementation of the other points of Deming's process. Some companies call this a "champion for the

cause." The bottom line is that for a quality program to work there must be a leader at the senior levels of the company who supports the program. Jack Welch's support and leadership for implementing Six Sigma at General Electric is a good example of this.

The Costs of Quality

Like freedom, quality is not free. There are costs to both good and bad quality. The costs of quality include the costs to prevent quality breakdowns. These include the costs upfront to design a quality product and the costs of training of the employees to produce a quality product. The cost of quality also includes the cost of sampling to ensure a quality product or process. This may very well include the test equipment and the labor costs for the sampling inspectors.[70]

The costs of a lack of quality can be broken into internal and external costs. The internal costs of a lack of quality include stopping the line to fix a machine that has not been properly maintained, the cost of internal rework to fix problem products that are discovered in the manufacturing facility, and the possibility of having to downgrade the price of the product to sell it as a "second" in an outlet.

The external costs of quality include the cost of bringing the defective or broken product back from the customer. External costs include warranty repairs, lost sales, and in some egregious situations—product liability lawsuits and settlements.

[70] For more on the costs of quality see Crosby's book *Quality is Free*

International Standards for Quality—ISO 9000

The ISO 9000 family of standards represents ***an international consensus on good quality management practices****. It consists of standards and guidelines relating to quality management systems and related supporting standards.*[71]

For companies that want to compete globally, the ISO 9000 series of quality management standards are a necessity. The basic tool for any ISO 9000 series certification is the process map. The process map will be discussed in greater detail when we discuss process design in another chapter. The goal of the process map is to provide a visual display of the processes involved in the company's operations. The latest addition to the ISO 9000 series is ISO 9001:2015. The International Standards Organization describes this new standard as:

ISO 9001:2015 **lays down what** requirements your quality system must meet but **does not dictate how** they should be met in any organization. This leaves great scope and flexibility for implementation in different business sectors and business cultures, as well as in different national cultures.

1. **The standard requires the organization itself to audit** its ISO 9001:2015 - based quality system to verify that it is managing its processes effectively - or, to put it another way, to check that it is fully in control of its activities.

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[71] ISO 9000 Series, (2015).

http://www.iso.org/iso/iso_catalogue/management_standards/iso_9000_iso_14000/iso_9000_essentials.htm

2. In addition, **the organization may invite its clients to audit** the quality system in order to give them confidence that the organization is capable of delivering products or services that will meet their requirements.
3. Lastly, the organization may engage the services of an **independent quality system certification body** to obtain an ISO 9001:2015 certificate of conformity. This last option has proved extremely popular in the marketplace because of the perceived credibility of an independent assessment.[72]

This latest quality standard differs from previous standards that required an audit by an independent audit agency. The lack of auditors delayed the certification of many companies. The problem with this is that companies can now certify themselves without an independent audit team to validate the quality of the processes or products. This may very well be like the fox watching the hen house. With previous standards such as ISO 9001-2008, an independent audit was required. There are discussions to remove this external audit requirement completely, but this would most likely reduce the significance of the certification.

The first step of the "certification" or compliance is to walk the process to document your as is situation. Once the process is mapped, validated, and analyzed, a destination situation can be determined. With the destination situation in hand, a leader can then develop the strategy and vision to reach the destination situation. This may very well include

[72] Ibid.

benchmarking operations against the best in class companies to help determine what the destination situation should look like.

ISO 9000 series standards assess whether or not you or your suppliers really do what you say you do according to the process maps, Standard Operating Procedures, and procedural manuals. Is the company customer focused? Are the employees involved in the quality initiatives and ensuring a quality product is produced? The ISO standards provide a process-based approach to assessing and improving the operations of the company and its suppliers.

In addition to process maps, the Ishikawa or fishbone diagram is an important tool to assess quality issues and find the root cause of any potential quality problems. The Ishikawa diagram was first used by Kaoru Ishikawa. The four basic parts of the Ishikawa diagram are Manpower, Materials, Methods, and Machines. Usually, the causes of the problems or potential problems fall into one of these four categories. An Ishikawa diagram looks similar to this:

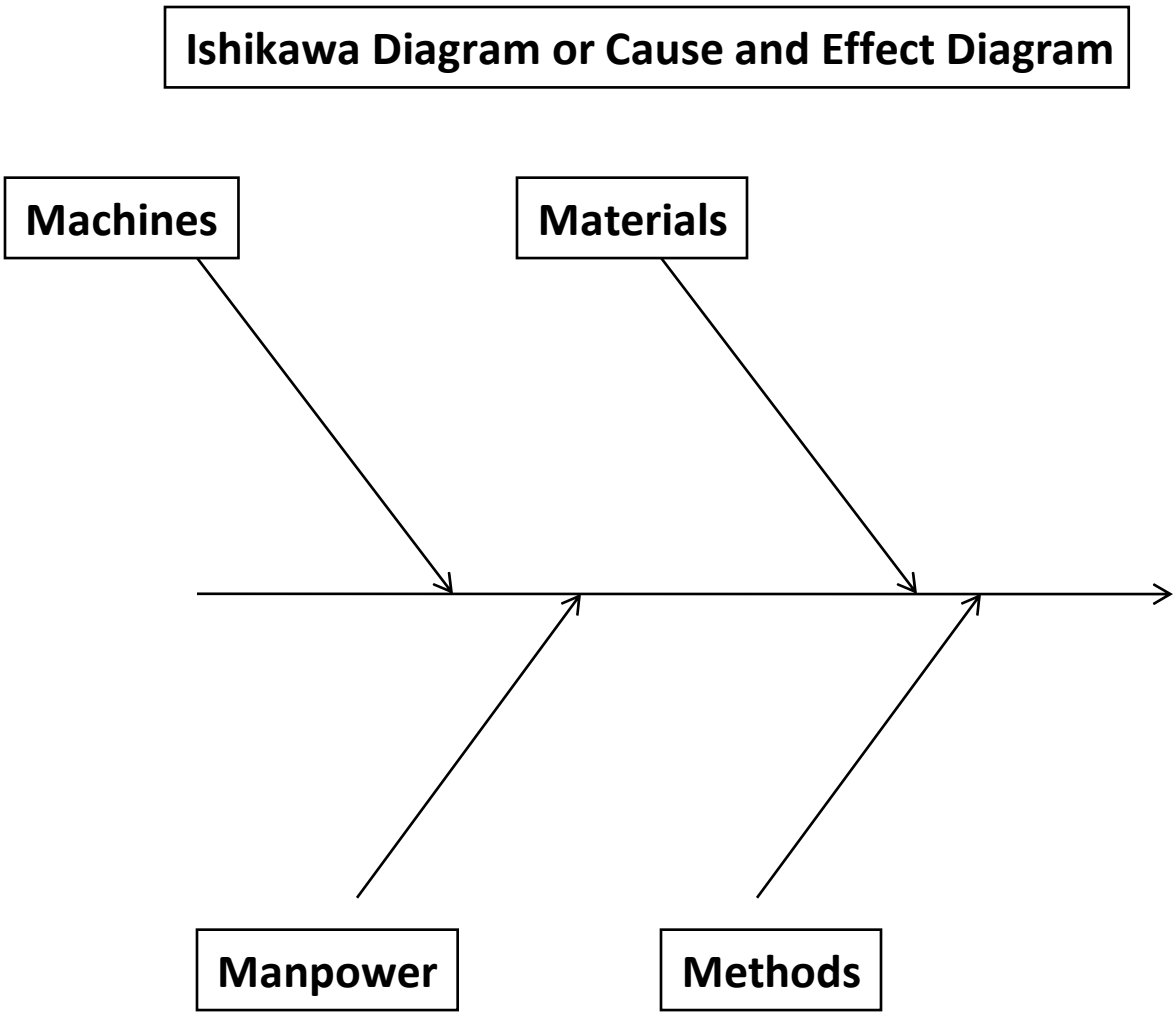

Figure 10.3: Ishikawa Diagram

With a process map and a blank Ishikawa diagram in hand an Operations Manager can start the process of improving the quality of their operations. You could even add environment and processes to this diagram.

Summary

In this chapter we looked at the foundations of quality and the definitions of quality. In defining quality, we looked at the dimensions of quality from the products and services perspectives. We also looked at the ISO 9000 series of standards to measure and improve

quality. The quality tools of process maps and Ishikawa diagrams will be valuable to our discussion later in the course of the product and process design methodologies.

Questions for Thought

1. Why is Quality important from an Operations Management perspective?
2. Recall a situation that you have been in, which would have benefited from the use of a process map.
3. Use your current job or a recent job and prepare a process map of the operations.
4. How could you use an Ishikawa diagram to improve your operations?
5. Look at an Annual Report for a company and review the report to see if the company is ISO 9001:2015 compliant for their quality programs. Are they ISO 14000 certified?
6. Why is it important to be ISO 9000 compliant? Who cares?
7. Is ISO 9000 series compliance/certification an order winner or an order qualifier? Explain your answer.

Chapter 11

Material Requirements Planning (MRP)

Materials Requirements Planning could be easily located under the planning section of this text, in the deliver section, or here in the sourcing section. It is related to inventory management and sourcing.

What is Material Requirements Planning? The APICS Dictionary app defines MRP as: "A set of techniques that uses bill of material data, inventory data, and the master production schedule to calculate requirements for materials. It makes recommendations to release replenishment orders for material. Further, because it is time phased, it makes recommendations to reschedule open orders when due dates and need dates are not in phase."[73]

Investopedia defines it as: "a computer-based inventory management system designed to improve productivity for businesses. Companies use material requirements-planning systems to estimate quantities of raw materials and schedule their deliveries." It further explains: "MRP is designed to answer three questions: *What* is needed? *How much* is needed? *When* is it needed?" MRP works backward from a production plan for finished goods, which is converted into a list

[73] APICS Dictionary app, "Material Requirements Planning," accessed 14 September 2020.

of requirements for the subassemblies, component parts, and raw materials that are needed to produce the final product within the established schedule."[74]

Ok, what does that really mean in plain language? MRP is a system that has been around since the early 1960s that assists planners to answer the manufacturing and inventory questions of what needs to be ordered, how much needs to be ordered and when to place the orders. MRP is closely related to the discussion of inventory management in chapter 16 and will be discussed in conjunction with the inventory management class.

Master Scheduling

The master scheduling process is a complicated process to balance capacity requirements with customer demand requirements with on hand or on order inventory requirements. The process starts with the Master Production Schedule. APICS defines the Master Production Schedule (MPS) as: "A line on the master schedule grid that reflects the anticipated build schedule for those items assigned to the master scheduler. The master scheduler maintains this schedule, and in turn, it becomes a set of planning numbers that drives material requirements panning. It represents what the company plans to produce, expressed in specific configurations, quantities, and dates."[75]

The master schedule takes into consideration the forecast, customer orders, capacity and material availability to help develop the Master Production Schedule. The process looks like Figure 11.1. It is imperative to success to ensure that the MPS is doable.

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[74] Investopedia.com, "Material Requirements Planning," accessed 14 September 2020.

[75] APICS Dictionary, "master production schedule," accessed 14 September 2020.

- Do we have the materials to make the products?
- Do we have the capacity to make the products?
- Can we make enough products to meet the demand of the customers and the marketing forecasts?

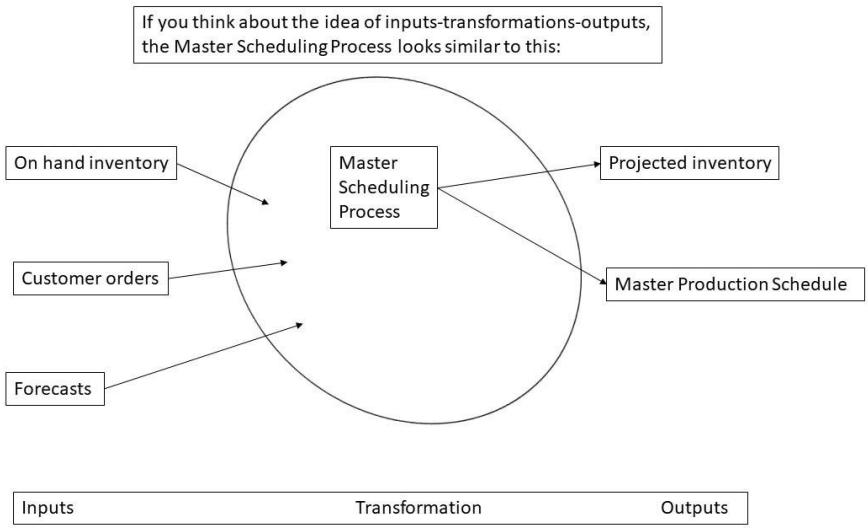

Figure 11.1: Master Scheduling Process

The MRP Process

The planning process for the MRP must exceed the longest lead time for components for the product being produced. The Bill of Materials is the component list or ingredient listing for a product. Every product has a Bill of Materials. Included in the file for the items on the Bill of Materials is the lead time (time from placing the order until the order is received) for each component of the product. The planning process must consider each item on the list and the lead times for each product.

When should a company use MRP? It is a great tool when:

- There is dependent demand for discrete components

- Complex assembly/manufacturing jobs
- Assemble to order operations

MRP consists of the following sub-processes:

- Exploding the Bill of Materials. This sounds dangerous but really is nothing more than taking the Bill of Materials to the lowest level possible. For example, if we are assembling a piece of equipment for the gym, the explosion of the Bill of Materials would include taking the components all the way the down to the bolts, nuts, screws and washers for the assembly and accounting for the number of each required for the assembly. We are simply answering the question, what do we need and how many of each do we need?
- Netting out inventory. In plain language, this is determining from the MPS and the exploding of the Bill of Materials, determining the delta between what we have and what we need to produce the numbers in the MPS.
- Lot sizing. This may or may not be an issue. Some suppliers package their products in preconfigured quantities. For example, screws may come in a lot size of 100 in a package and the supplier does not sell anything less than 100 and only in quantities that are multiples of 100. So, if you need 125, you must buy two lots of 100. In some cases, the lot size is based on the quantity that can be safely packaged in a container.
- Time-phasing requirements. This is simply backing off the required number of days, weeks, or months specified in the Bill of Materials under the lead time. MRP works on a just in time logic. If the lead time is 12

weeks, then the item needs to be ordered 12 weeks before it is needed, and the system assumes it will show up just in time for use.

Applying the MRP Logic to the MPS

Figures 11.2 through 11.5 show the calculation for the MRP requirements. Step one is to determine what is needed to make the quantity shown in the MPS line on the grid. There will be one MRP grid for every component or ingredient on the Bill of Materials. The next step is to determine if there is a short fall of inventory on hand. Then if there is a short fall, back off the number of periods shown in the lead time and place an order for that quantity if there is no lot size (Figures 11.2 and 11.3). If there is a lot size, then the order quantity must be the lot size or multiples of the lot size (Figures 11.4 and 11.5).

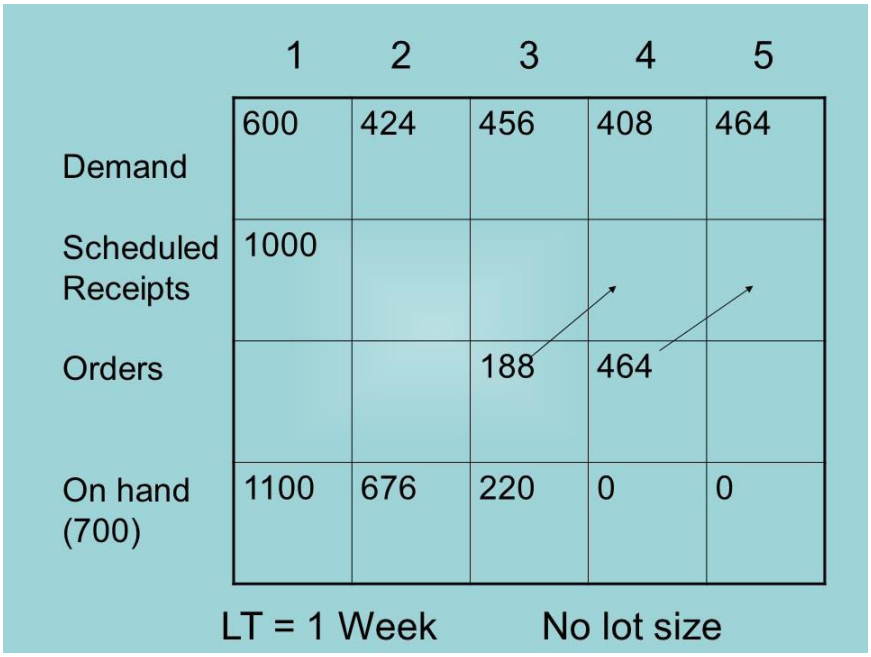

Figure 11.2: MRP Grid Example

In Figure 11.2, we have 700 on hand today of this component. In week 1 we are planning on making 600 of the end-item that this component is a part of. In step one the requirement does not exceed what is on hand, so, simply subtract what we need from what we have on hand plus

any scheduled receipts to get the projected on hand balance at the end of week 1 ((700 on hand + 1000 due in) – 600 needed) = 1100 projected on hand at the end of week 1. Continue this process across the grid. For week 2 we are projecting a demand for 424 – the calculation for this week is 1100 on hand – 424 projected to make; this leaves a projected 676 on hand at the end of week 2. The same procedure is followed for week 3. In week 4 there is a shortfall of 188 when comparing the on hand inventory to the anticipated build schedule. Since the lead time is 1 week, we need to back off 1 week and order the needed quantity to arrive in week 4 as shown in Figure 11.3. We follow the same logic for week 5 by placing an order 464 in week 4 to arrive in week 5.

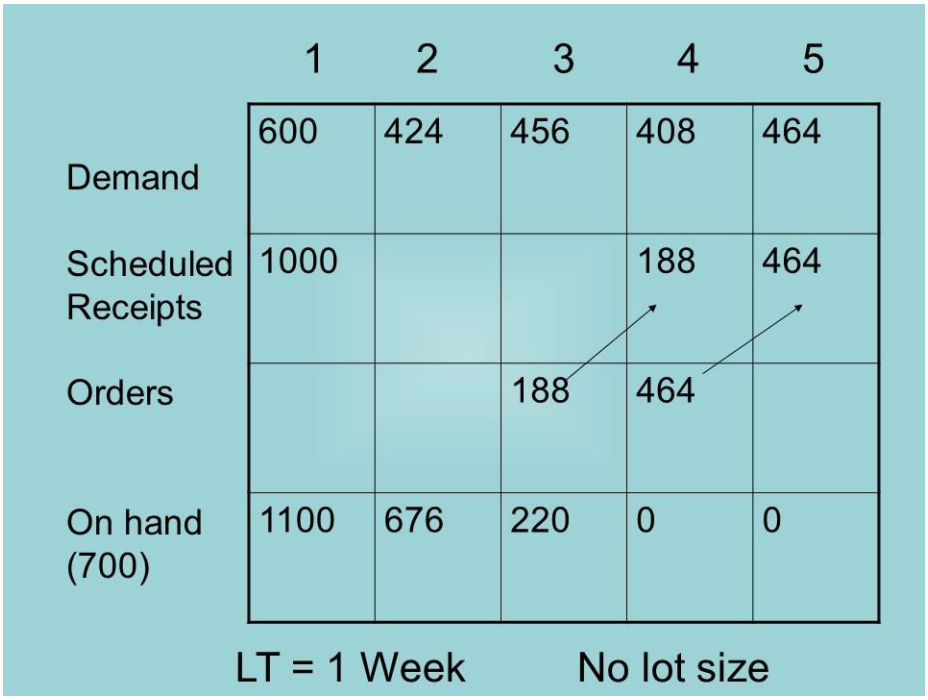

Figure 11.3: Completed MRP Grid Example

If there is a lot size as shown is Figures 11.4 and 11.5 the calculations look a little different and the use of lot sizes may impact inventory carrying costs and inventory storage area requirements. The calculations for the first three weeks in this example do not change since there is sufficient quantity on hand to meet the anticipated build schedule. The calculations change in

weeks 4 and 5. Now we must order a lot size or multiples of the lot size. In week 4 we are still short 188 but the lot size is 400, so we have to order 400 in week 3 to be available in week 4. This changes the projected on hand quantity at the end of week 4 to 212. This means we will have a projected shortfall of 252 for week 5. However, because of the lot sizing we will have to order 400 again in week 4 to arrive and be available in week 5. Figure 11.5 shows the completed MRP grid.

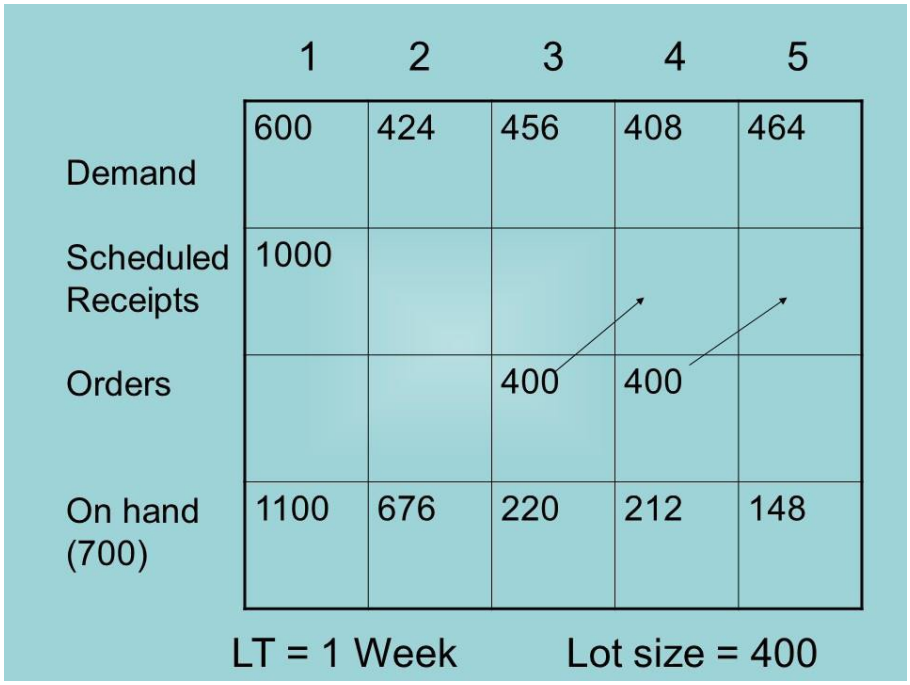

Figure 11.4: MPR with a Lot Size Requirement Example

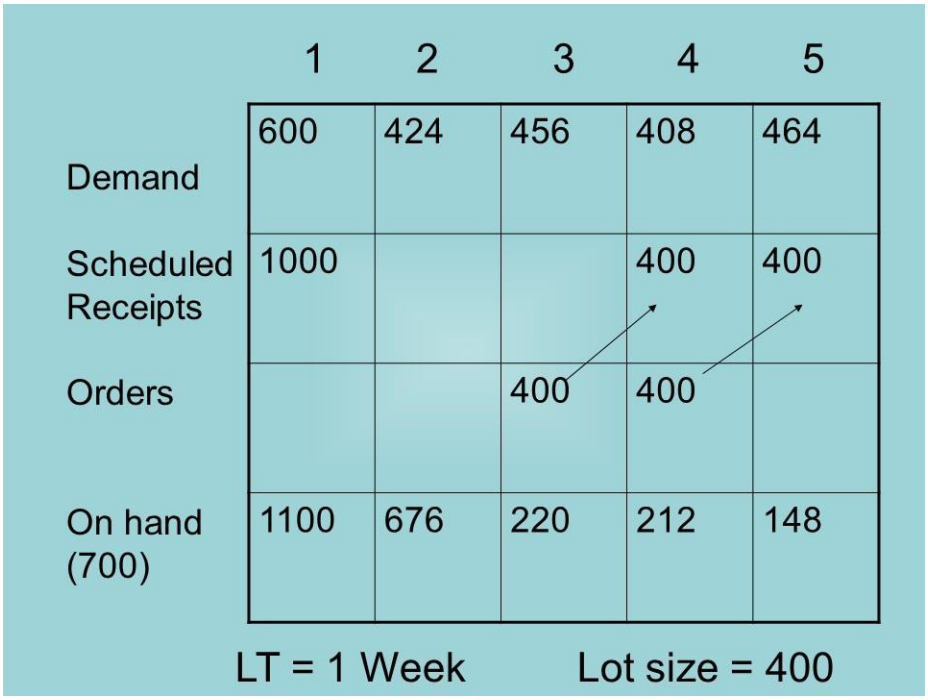

Figure 11.5: Completed MPR grid with Lot Size Example

Summary

Material Requirements Planning is a great tool to use in complex assembly operations or for dependent demand calculations using the Bill of Material as the foundation for how many of an item are needed for each end-time and the lead time for ordering and receiving the components.

If a lot size is mandated by the supplier, then the ordered quantity has to be the lot size or multiples of the lot size.

Section 4: Make

This section includes all of the functions that relate to the manufacturing or making of a product. This includes not only product design but process design as well.

Chapter 12

Product Design

Why is product design important to operations management? What is product design? What about process design? “Don’t most textbooks discuss these two topics as separate chapters?” Most textbooks do address these as separate issues and in separate chapters (although we are addressing these topics in separate chapters, the two activities should be conducted simultaneously or concurrently). The two topics are interrelated because they impact each other. The design of the product and the design of the process should be worked concurrently. The goal of this chapter is to show the importance of product design to overall operations management and to the process design/improvement activities.

Product design is tied to the strategy of the company as discussed in Chapter 3. A company’s future products are not only strategic decisions but also have to be in sync with the strategy and focus of the company. Obviously, if the company is focused on reducing carbon footprints and producing sustainable, environmentally friendly products, the company will not want to produce ozone-depleting products. (We will discuss the idea of designing for the environment later in this chapter).

Product design or product development and the ability to continually produce new products to meet the needs of the customer may be the company’s competitive advantage. For example, Rubbermaid has a goal of 300 new products developed each month. All these products will not see the shelves of stores, but the ability to continually produce new products produces a competitive advantage for Rubbermaid. 3M encourages employees to experiment on the clock to

produce new products. The Post-it Notes was a result of one of these experiments. The employees were not trying to create the Post-it Notes but it did turn out to be a very profitable invention for 3M.

Goal of Product Design

Product design has a primary goal of producing a quality product that meets the needs of the customer. The product design operation is where the ideas for the product are generating; it is where the look of the product is conceived; it is where the components of the product are decided. This function of operations management is critical to the success or failure of the company. If a quality product is designed, tested, and produced in a production process that is well designed, and if the product meets the needs of the customers, the company will be successful. So, as you can see there is a direct link between product design and our earlier discussions of quality management. Obviously, this link ties to the internal costs of quality and relates to Crosby's ideas in "Quality is Free."

In order to design a product that meets the customers' needs, we need to know what the customer wants. The first step of the Motorola Six Sigma methodology is to define the customer, define what the customer wants and define how the company can do it better than the competition. So, how do we define what the customer wants? What if the customer needs a service and not a product? The design process is similar as we will see under the discussions of Design For Six Sigma.

Impacts on Product Design

Impacting the product design process is the fact that customers are demanding new products at an alarming rate and those products have decreasing product life expectancy and increasing technology with increasing complexity. I call this the "Apple Effect." Apple comes

out with a new iPhone every year and everyone wants the new phone This leads to issues of inventory management, distribution, reverse logistics and end of life issues for products.

The availability to consumers of a wider variety of products through e-commerce also fuels the demand for new products. All of this means that the company must be more flexible than in the past. Remember that flexibility was discussed as a strategy for positioning the company to be competitive (hopefully as we continue to move through operations management, you will see that most of the topics are related).

The product design process should provide the company with the desired appearance of the new or improved product. The latest trend has been for "*new and improved*." There is no way that a product can be both new and improved. If the product is new there is no reason to improve it already. And if the product is improved, doesn't that imply that the product has been around and was deemed to need an improvement to keep it competitive in the marketplace?

The product design process should not only address how the product will look but how the product will be supported after the sale. A product design that does not consider this aspect may end up costing the company more over the life of the product than the company is planning for.

The product design must also consider the life cycle of the product. This includes not only the marketing, sales, and support of the product but also the forward and reverse logistics infrastructure to deliver and bring the product back if necessary.

Life Cycle

Another aspect of the product design is to plan from the beginning the end of life aspect of the product and what actions the company will eventually have to take to phase out the product and when support for the product should be stopped. Somewhere in the life cycle of the

product, demand for the product will decline and may even stop. This must be considered as part of the product design process. The Giga Pet in Figure 12.1 is a good example of a short life cycle (The Giga Pet was the first virtual pet). The fidget spinners from a few years ago is another example of a short life cycle.

Figure 12.1: The Giga Pet

The Giga Pet became the "have to have" product in 1995. Every child had to have one. When we came back from Germany in July 1995 it was the toy of choice for every child—of my neighbor's children had as many as ten on their belt loops. This was a great product for the summer. The Giga Pet had a puppy/kitten that had to be fed, watered, bathed, and played with on a regular basis. As the child played and fed the puppy or kitten, it grew to be a full-size dog/cat. The problem came when school started, and the dog was not fed and watered as regularly as during the summer.

When a Giga Pet was not fed and watered, like a real pet that was not fed and watered, the pet died. This could be traumatic for a young child, but with the press of a button, a new pet was created. A few days into the school year a note was sent home from the principals: "Giga Pets are not allowed in school and will be confiscated if brought in." Initially, parents helped by

playing with the pets but for those children with ten Giga Pets this became a chore. The result was that when the child came home from school the pets were dead. This was traumatic for the child. Of course, the Giga Pet could be restarted but when it died again, the thrill wore off. The result was the forecasters did not see the end of life of the Giga Pet and continued to produce the product. The Giga Pet went from the end caps and a price of $19.99 to the Dollar Tree and 99 Cents Only Stores. The same phenomenon was seen in 2018 with the spinners – everyone had to have one to play with but then some genius decided to make spinners with blades on them and quickly the spinners fad died.

Materials

The appearance of the product (how it will look) may dictate the materials needed for the product or may be impacted by the materials available to make the product. The product design process not only will determine how the product will look but how it looks may be determined by the performance specifications for the product and may be influenced by the dimensions or tolerances for the materials that will make up the product. Conversely, the materials needed to meet the desired tolerances may dictate the appearance of the product. How the product is supposed to be used may very well dictate the appearance of the product itself. Where the product being designed is going to be used may very well dictate the design of the appearance of the product.

Services

The design of a service is not that different from the design of a product. The same planning process is necessary to design a product or a service. Both design processes require the designer to understand what the customer wants in order to provide the customer with a product or service. What benefits should the customer get from the product or service? How will we

determine that? A good service or product design will determine how to match the answers to these questions with a service or product that will meet the customers' needs or wants.

Making a Profit

The goal of the design process should be to not only design a service or product that meets the needs of the customers, but this product or service should be designed to be provided or produced as efficiently and cost effective as possible. Remember the primary reason for being in business is to make a profit. If a company cannot make a product efficiently and, in a cost, effective manner, the company cannot make a profit. The same is true of services; if the company cannot provide the service in a cost-effective manner the company will not be in business very long.

A quality design process will focus on getting the product to the market as quickly as possible. There is a difference between speed to market and haste to market. Speed to market is important. Speed to market means getting a quality product to the market as quickly as possible. Haste to market is getting a product to market quickly but not a quality product. Certain software companies are really good at getting products to market quickly, but they may not be quality products. This results in many revisions to the product to make it better. Apple did this with the iPhone 4G. To get the product to market quickly, Apple rushed the new iPhone to market knowing that there may be a problem with the reception. Seems in a haste to get this new product to market they knew that the reception was possibly flawed because of the placement of the antenna in the edge of the phone. If held in a particular way this antenna would be blocked thus preventing reception. The fix? Give each user a cover that will enable the reception no matter where the phone is held. This is haste to market. Almost every example of haste to market vice

speed to market results in a reverse logistics operation and after sales service support. Speed to market vice haste to market results in few if any revisions to a product.

The Steps of Product Design

Most textbooks will lead you to believe that product design is a sequential and lock step process. However, for an effective product design the following steps must be conducted as close to concurrently as possible.

Traditional product design has all these steps working in a lock step sequence. Traditional design is much slower and more time consuming which can impact the availability of the product to the customer. Concurrent product design breaks down the barriers between departments (like one of Deming's 14 points) and works with cross-functional/project management teams to help speed the product to production and to the market. We will discuss this in greater detail later in this chapter.

- **Idea Generation –** Where do the ideas for products or services come from? What role does the voice of the customer play? Can you create your own market?
- **A Feasibility Study –** Can we make this product with the specifications that the customers want? Can we make a profit?
- **Prototyping and Testing –** Building the initial prototype of the product and testing (and maybe revising and retesting).
- **Finalize the Design and Plan for the Production Process –** Will the process be a make to order, make to stock, assemble to order, assemble to stock, or a project. Will the product be mass produced, mass customized, or produced one at a time?

Let's look at each of these parts of the product design individually. Although we will look at the steps individually, they are interrelated and need to be not only synchronized but must be conducted as close to concurrently as possible.

Idea Generation: Ideas can come from almost anywhere.

Suppliers and Sales Force

The suppliers should be able to assist in getting ideas for improvements to the current product or new products based on the availability of different materials. Another source of ideas should be the sales force. These are the people that should have the ear of the customer. Therefore, the sales force should be the best source of what the customer wants which should then drive the generation of ideas for new or improved products.

Trade Shows

One source of ideas for products may be trade shows. There is no shortage of trade shows in operations management; everything from new product shows to emerging product shows to experimental trade shows. These shows allow company representatives to see what other companies are doing and can gauge the interest in the products from the number of people at each of the booths at the shows. Unfortunately, my experience watching people at trade shows is that too many attendees are more interested in what is being given away free rather than trying to find out what the emerging trends or products are.

Returns/Warranty Work

As we will see when we discuss Reverse Logistics, every company should be mining data and information from the returns process. This information should include why the product is coming back. Also included in this information are customer thoughts about the product and customer complaints. Another source of new product or improved product information from returns comes from warranty work. What is breaking on the current product and how can we improve the product or come out with a new product to solve these problems? This is a great source of information but should never be the primary source as this data is only available after there is an issue with the product. Another link between product design and quality.

Field Testing/Trial Users

Field tests and trial users provides companies with not necessarily the ideas for new products but provide feedback on which products the customers prefer thus giving the company an idea on which products to move forward with. Golf companies use this technique frequently. Several golf equipment companies allow golfers to "join" the companies' testing panels. The companies then randomly select from this pool of testers to send new and trial equipment for

testing. Thus far in over nine years of being on the testing panel, I have had the opportunity to "test" a golf glove. And I was allowed to keep the glove even though I "did not like it." I did not like it because they sent me a "Men's Extra Large." There was enough leather in the fingers of the glove to make another glove as my normal golf glove is a Men's Small. My friend had the opportunity to test a new Driver.

McDonalds' uses field testing to determine the acceptability of new products. For example, they tested the McRib sandwich in the Midwest. Why? Barbecue is a big deal in the Midwest. Ribs are very popular in the Midwest. Therefore, if the McRib could not sell in the Midwest there was no reason to try to sell it elsewhere (although I am not sure that the McRib is really rib meat – could be Spam with barbecue sauce). They did the same for the breakfast burrito. This was tested in the Southwest with the theory that if a breakfast burrito cannot sell in the Southwest then it will not sell in the Northeast either. They also field tested the concept of 24 hour breakfast before fielding it nationwide. In fact, Lawrence was one of the testing sites for the 24 hour breakfast.

McDonalds' has tested other products and promotions worldwide, but although they have done well in other places outside the Mainland United States, they are not staple menu items on the Mainland. In Hawaii you can buy eggs, spam, and rice for breakfast. Although this sells well in Hawaii it has not made its way to the Mainland United States yet. In Germany you can buy a Big Mac and a beer. For some reason this has not made its way to the US yet.

It used to be a common practice to place trial samples of different products in the package with the Sunday newspaper. These products included cereals, soaps, dishwashing detergent, and washing powders. The goal of these samples or field trials was to get customer feedback on the

product by enticing the customer to buy more of the product and capture that data from the use of the attached coupon.

Research and Development

The most common method of generating ideas for new products and services comes from the Research and Development Departments of the larger corporations. The problem with R&D is that when the economy goes south as we saw in the 2008-2010 recession (and as it is during the COVID-19 pandemic), companies have a tendency to cut R&D expenses to save money and improve the immediate bottom line. It will be interesting to see what impacts the total shut down of 2020 will have on R&D projects.

Reverse Engineering

Reverse engineering is one method of getting ideas for products or ideas of how to make a product better and less expensive than the competition. Japan is noted for this. In the 1950s and 1960s "Made in Japan" usually meant that the product was junk. Then after a couple of decades of taking US-made products apart and reverse engineering the products, the stamp "Made in Japan" become synonymous with high quality. Japan did not invent the automobile, but they certainly learned how to make a better one; the same is true for the camera.

Benchmarking

Benchmarking may be beneficial as a means to generate ideas for improving products or processes. Benchmarking is not commercial tourism. There must be a goal of the benchmarking process. Benchmarking starts with the corporate admission that the company may not be the best at what they are doing and start the search for the "best in class" companies (companies have a problem with admitting this – think about discussions earlier of the SWOT analysis). If you are benchmarking products you must go to a competitor to benchmark against. However, if you are benchmarking a service you may be able to go outside your industry to benchmark. Many companies look to Disney to benchmark customer service. Southwest benchmarked their ground operations against the pit crew operations of NASCAR and Formula 1.

In benchmarking you sometimes need to think outside the box – maybe look outside your industry. Southwest is a good example of going outside their industry to benchmark services. Southwest has learned that to be successful in the airline industry it is imperative to have people in the seats and the planes in the air. Planes sitting on the ground can cost an airline several thousand dollars an hour. So, Southwest went to NASCAR to observe pit crews. Their rationale was that (at the time) if a Winston Cup (the top tier program in NASCAR is now just called the Cup Series) team could change four tires, make a track bar adjustment, add a round of wedge to the springs, and add 22.4 gallons of fuel in 13.9 seconds, just maybe they had some ideas that could be translated to turning planes around quicker. If the planes could be turned around quicker, more people could be flying, and more dollars could be made. They also went to Formula 1 Racing to observe their refueling operations as Formula 1 and Southwest used the same fuel nozzle for refueling operations. This is a good example of thinking outside the box for benchmarking.

Perception Maps

One final technique for determining customer desires and wants is through a perception map. Customer perceptions can be placed on an "X,Y" axis chart. The goal of the perception is to get the product into the upper right hand quadrant so that it is perceived by the customer as beneficial to them and a value for the price. Look at Figures 12.2a and 12.2b. During the product development process, a strategy must be developed to shape the perceptions of the potential customers to move the perception to the upper right hand quadrant so that the customers perceive the product to be of high quality and high value. A perception map to get the customers' perceptions of breakfast cereals could be responsible for the plethora of cereal options. The more options available, the better the probability that the perceptions of the customers will be positive and in the upper right-hand quadrant. Cheerios used to have one flavor of cereal. The issue was that although Cheerios was perceived to be good nutritionally, it was perceived to be poor from a taste perspective; as Figure 12.3 shows, Cheerios now has multiple options for their breakfast cereal influenced by perceptions and the need to design different products.

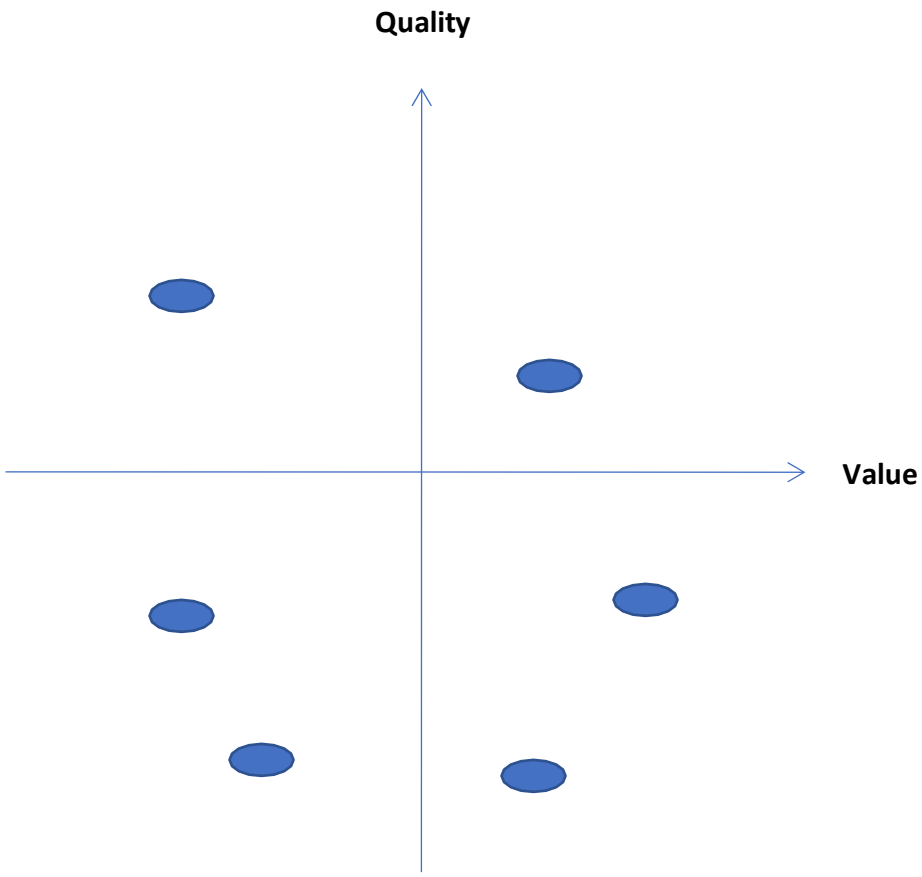

Figure 12.2a: Example of a Perception Map

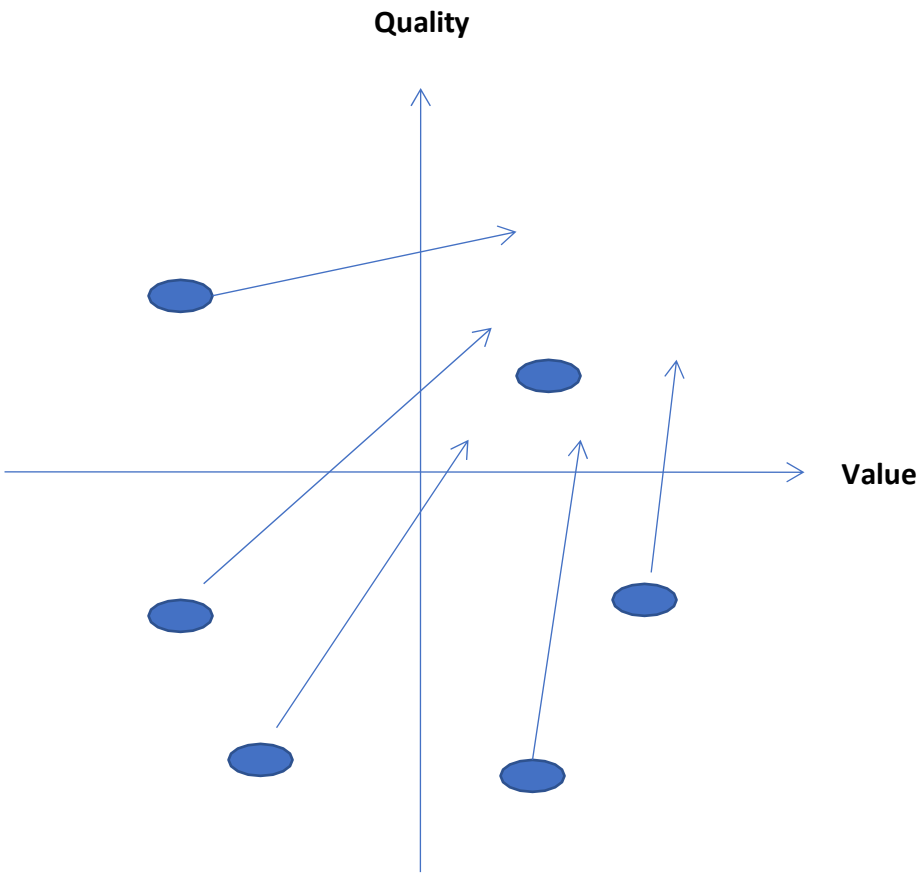

Figure 12.2b: Shaping the Perceptions of Potential Customers

Figure 12.3: Options for Cheerios

Feasibility Study

What is a feasibility study and why do we need one here? The *APICS Dictionary* defines a feasibility study as, "An analysis designed to establish the practicality and cost justification of a given project."[76] So the reason a feasibility study is needed at this point in the product development cycle is to determine the practicality of producing the new product or service.

In order to do an effective feasibility study for our product we may need to **segment our market** to determine the feasibility of producing the product for different segments of the market. General Motors used to be very good at segmenting their markets. They had Chevrolet, the "working man's car;" Pontiac, which is gone now; Oldsmobile which has been gone for a while now; Buick; and Cadillac (a winner of the Malcolm Baldrige National Quality Award) was considered the top of the line car.

Part of the feasibility study must consider the **economic analysis** of the product. In other words, can we make this product or provide this service and make a profit? If not, we cannot stay in business. This does not mean that occasionally the company will not offer a loss leader to entice customers into the store, but we cannot afford to design a product that will lose money out of the gate.

Break Even Point Analysis

While conducting the economic analysis, one of the questions that must be asked is can we produce this product and sell the necessary quantity of this product to make a profit? If so, how do we find this point (we must cover all of our fixed costs and variable costs)? This is the Break-Even Point. Equation 12.1 is the break-even point calculation. The goal is to cover all the

[76] feasibility study. APICS Dictionary app

expenses for this product (see Equation 12.2)—this is another way of looking at the break-even point.

$$\textbf{Break-Even Point} = \frac{\textbf{Fixed Costs}}{\textbf{Sales Price} - \textbf{Variable Costs}}$$

Fixed Costs = Sunk Costs (incurred even if nothing is made)
Sales Price = At what price can this product be sold?
Variable Costs = labor, electricity, materials, operating costs

Equation 12.1: Break Even Point Calculation

Total Costs = Total Revenues

Equation 12.2: Another Look at the Break-Even Point Analysis

Example 12.1 Break Even Analysis:

A company wants to design and build a new stand up paddle board. The Fixed Costs (FC) for the company are $170,000; the Variable Costs (VC) for this product (materials, labor, and overhead) are $200 per board; the projected Sales Price ($S) is estimated to be $900 each.

Break Even Point = FC/ ($S-VC)

$$\frac{\$170{,}000}{\$900/\text{board} - \$200/\text{board}}$$

= 242.86 boards (this has to be rounded to 243 as we cannot sell 0.86 of a board)

Example 12.2 Total Revenues Analysis:

Using the above information, we can do a revenue analysis for break-even analysis using Equation 12.2:

Total Costs = FC +VC(x)
Total Revenues = Sales Price(x)
Equation 12.2: $170,000 + $200(x) = $900(x)
$170,000 = $700(x)
242.86 ~ 243 = (x)

The important thing to remember about a breakeven point is that it is simply a mark on the wall. Without a good forecast to compare it to, the breakeven point means nothing. When the forecast is compared to the breakeven point, now the company can make an educated decision on moving forward with production, cancelling the product or possibly outsourcing the manufacture of the product.

The next part of a good feasibility study is to determine whether the company has the **technical skills** available to make the product. Although the company may have the capability to produce the prototype this part of the feasibility study will determine whether the company can produce more than just the prototype or may determine that the company may be capable of designing a product that they did not have the capability of producing even the prototype. Part of this process has to be to determine whether the company can produce the product with the technical specifications of the design.

Risk Analysis

The last part of the feasibility study has to be a risk analysis of the product. In other words, can the company produce a safe product? What is risk analysis and why should you conduct a risk analysis and how should the analysis be conducted? The risk analysis must consider how the product may be used and not just the intended usage. A good risk analysis must

look at the probability of something going wrong with the product and if it does, what are the severities of the impacts if something does go wrong? Part of the product development risk analysis must include identifying all of the possible hazards and if a hazard is discovered, waiting for the problem to hit the front pages of *USA Today* or on CNN is not a good idea. If a problem is identified during the testing and development, it must be addressed before the product is introduced to the public.

The steps for a risk analysis should follow this outline as provided by the US Army.

- **Identify the Hazards –** What are the potential hazards for this product? This analysis has to consider not only if the product is used as intended but must also consider the potential hazards if the product is not used as intended. For example, while designing a toy for small children, the designer must consider if children will put the product in their mouths and the associated hazards such as choking.
- **Assess the hazards to determine potential risks –** After identifying the hazards, it is important to determine the probability of the hazard occurring and the impact if the hazard does occur. Unfortunately, many risk analyses stop here because of the perception of a very low probability. For example, there was a study of the impacts on New Orleans if a Category 3/4/5 hurricane hit directly on the city. This study was done in 2004 with a caveat in the executive summary that the probability was very low – about the probability of winning the lottery. Nothing was done with the study and almost a year to the day after the study was presented to the US Army Corps of Engineers Hurricane Katrina hit New Orleans and the predictions of the study were spot on and the results matched the study

almost exactly. If the probability of an issue is greater than ZERO, the analysis must move to the next step.

- **Develop controls and make risk decisions –** What controls need to be put in place to help mitigate, minimize, or even eliminate the hazard. One option to eliminate the potential hazard may be to decide not to produce the product. If the decision is made to produce the product and the hazard cannot be eliminated, the lawyers will have to be part of the control process an help write the small print that must accompany the product inserts.
- **Implement controls –** Once the risk decisions have been made, controls must be put in place to ensure that the hazards are minimized or eliminated throughout the design and testing as well as during the manufacture process.
- S**upervise and evaluate –** This step makes the risk assessment similar to a continuous process improvement program. The goal of this phase of the risk assessment process is to make sure the decisions and controls are working. This is analogous to "we only do well what the boss checks." This step of the risk analysis process is the quality control check. Theoretically, all the risk assessment steps will be completed before the preliminary design is finalized.

Prototype Design Process

Concurrent to the risk analysis and feasibility study is the design of the product. We have already established that part of the design process is to determine how the product will look. Now we need to build the prototype. Once the prototype is completed it is time to start the testing process. This process may identify some hazards in operations that were not considered or identified during the risk assessment.

The testing of the prototype and the problems or hazards identified may lead to revisions to the design or scrapping the project all together. Sometimes as requirements change or problems are identified the prototype has to be redesigned and then retested. Sometimes the product gets stuck in a testing do-loop.

Here is an example of the testing do-loop and changing requirements. In the late 1980s the US Army was developing, testing, and was ready to produce a new variable reach forklift. This military forklift was like the blue forklifts shown in Figure 12.5. The forklift passed through the prototype development based on the requirements submitted by the potential users.

This forklift was ready for manufacture and issue to the units in the field. This was going to be the Rolls-Royce of forklifts. It was hardened against chemical attacks, nuclear attacks, and it had an enclosed cab with air conditioning and heat.

Figure 12.5: Example of Commercial Variable Reach Forklifts in Action in Kuwait, April 2003

First the Iron Curtain fell in 1989. This reduced the need for chemical and nuclear hardening of the forklift. Then Saddam Hussein invaded Kuwait in August 1990. This invasion was the impetus for Operations Desert Shield and Desert Storm. After the buildup, the short war and the redeployment process was complete, the Army decided what they really needed was a variable reach forklift that was capable of being shipped in a standard 8x8x20 foot ISO container. This would allow the forklift to be shipped in a container and be in the last containers loaded on the ship. Upon arrival as the Port of Debarkation, the containers with the forklifts would then be the first containers off the ship and then be ready to roll out and start the process to un-stuff the other containers. This required the designers to go back to the prototype design, make some alterations, and retest the redesigned prototype.

When I returned to the R&D operations for supply chain equipment in 1997, the same folks that were working on this forklift were finally ready to move the item from the testing stage to actual operations in the field for the Army. Some Department of the Army Civilians invested a large part of their careers moving this forklift through the design, prototype, testing, redesign, re-testing, redesigning and final approval of the forklift. This new forklift was ready for use for the Second Gulf War and was used along side the commercial forklifts shown above.

Reliability, Availability, Maintainability

The first time I was in the R&D operations for the US Army, the focus on designing equipment was on the Reliability and Maintainability of the equipment and not on the Availability. In retrospect this was interesting since we had a team of RAM (Reliability, Availability, and Maintainability) Engineers that were supposed to analyze every product that we designed. All three of these areas must be considered in a good design process.

Reliability

Reliability is usually expressed as a probability that the product will perform the stated time length and perform the designed and intended function during that time period. This is important to the design of the product and the claims the company will make about the product. Reliability is usually measured using the Mean Time Between Failures (MTBF)— or the average time between breakdowns or failures in the system.

Computing the reliability of a system is much like the computation some of us are familiar with from high school physics. Capacitors in a series provide a reliability that is less than any of the capacitors individually. The reliability of each capacitor is multiplied by each of the other capacitors. For example, if three capacitors are in a series with reliabilities of .95, .94, and .90 respectively would result in a reliability of 0.8037. This is like the old Christmas tree lights. If one bulb went out, the entire string would not light up and every bulb had to be tested to find the bad bulb.

Conversely, if capacitors are placed in parallel the actual reliability is greater than the capacitors individually. This is like the newer Christmas light strings that bypass the burned-out bulb with built in redundancy and finding the bad bulb becomes very easy. Part of the design process is to consider whether the added expense of built-in redundancy will make the product more reliable.

Example 7.3

If two capacitors are placed in parallel with reliabilities of .95 and .92 respectively, they will have a reliability of the first capacitor plus 1-the reliability of the first capacitor multiplied by the reliability of the second capacitor (.95 + (.92(1-.95)). In this example the reliability of the

two capacitors will be: .95 + .92(.05) = .95 + .046 = .996. This increase in reliability is the result of built-in redundancy; if the first capacitor fails, the second one will kick in.

Maintainability

Maintainability tells the company and the customer how easy it is to maintain a product or piece of equipment. The maintainability of the product may include how much it will cost the customer to fix the product or how much it will cost the company to repair the product while it is still under warranty. The metric of maintainability is known as the Mean Time To Repair (MTTR)— or the average time to fix the product if it breaks or fails.

Availability

Availability is a combination of the Reliability and Maintainability. Availability describes the total time the product is available to the user. In the 1980s the Chevy Monza 2+2 was reliable as the MTBF was lengthy, which is a good thing, but to change the spark plugs required pulling the engine to reach the plugs. This made the MTTR rather lengthy. The metric for Availability is Systems Availability. Formula 12.3 shows the calculation for Systems Availability.

$$\textbf{Systems Availability} = \frac{\textbf{Mean Time Between Failure (MTBF)}}{\textbf{MTBF + Mean Time To Repair (MTTR)}}$$

Formula 12.3 Systems Availability Calculation

Example 7.4

A product sampling shows that the MTBF for the prototype A is 200 hours. During the testing, this product experienced several failures that resulted in an MTTR of 25 hours. The prototype B experienced an MTBF of 275 hours and the failures of prototype B resulted in an MTTR of 50 hours.

Based on the MTBF alone, the testing would have led the decision makers to choose prototype B. However, using the Systems Availability equation would lead the decision makers to choose prototype A. Always look for the highest Systems Availability – that percentage of time that the customer can use the product.

Calculations: Prototype A: Systems Availability = 200/(200+25) = .89

Prototype B: Systems Availability = 275/(275+50) = .85

Product Design and Order Winners

The product design may very well be the order winner that provides the competitive advantage. Here is an example of an order winner in the design phase—Figure 12.6 is an example of order winning advantage and taking the customer into account in the design process. The label of the bottle of wine in Figure 12.6 is printed not only in normal print but also has the label printed in Braille.

Figure 12.6: Braille Label

While the product design is ongoing, the process design must be ongoing as well. These are related events. If the two are not conducted concurrently the company may find that they have a great product and a good prototype but do not possess the ability to produce more than one of the items.

Process Design—How the Product Will Be Made and Product Design

The goal of the process design phase is to design a process of manufacturing the product that is as simple and cost effective as possible. This may mean taking the process from raw material to finished product or assembling the product from subassemblies or from modules. As the product is designed and the product design reaches the desired end state, detailed drawings or blueprints should be developed.

From these blueprints a logical production design can be developed that may drive the facility design discussed in Chapter 7. The product design and the blueprints will help develop the requirements for the tools and equipment needed to make the product. At the same time the

product design and blueprints will help determine the sequence of events or activities in the manufacture process.

Traditional Product Design and Concurrent Product Design

Traditional product design is a lock-step process that moves from idea generation to engineering to manufacturing to marketing to supply chain to production. This could be a lengthy process that could be sent back to the previous step for any reason thus making the process longer.

Concurrent product design is a rather recent concept that has the goal of getting a quality product to the customers faster. Concurrent product design puts all of the players at the table together. When creating the concurrent design team it is important to have representatives from all of the stake holders' departments. By placing the right people on the team concurrently, the barriers between departments are broken down and the "do loops" that hinder product development are short circuited.

A good concurrent design team will have the engineers, the R&D folks, the manufacturing and marketing departments and the supply chain elements on the team. Accountants need to be on the team to conduct the breakeven analysis and because of the nature of today's society, the concurrent design team needs to have lawyers on the team to help draft the small print about the possible side effects or potential hazards from misuse. Some of the identified side effects of drugs advertised on television appear to create more severe problems than the original problem. It is also a good idea to improve the design of the product to get the suppliers and potential customers involved in the process.

Design For Six Sigma (also known as Design for Manufacture)

Design For Six Sigma is different from the traditional Six Sigma DMAIC steps. The goal of the design activity is to design a quality product. The goal of an individual design process is the eventual product that the team is designing. To design the right product, it is important to know what the customer wants (very similar to the first step of Six Sigma—define the customer, define what the customer wants) and how the customer defines quality. The steps of DFSS are shown in Figure 12.7.

- **Define – the goals of the design activity**
- **Measure – customer input to determine what is critical to quality from the customers' perspective – what are customer delighters? What aspects are critical to quality?**
- **Analyze – innovative concepts for products and services to create value for the customer**
- **Design – new processes, products, and services to deliver customer value**
- **Verify – new systems perform as expected**

Figure 12.7: Design for Six Sigma

Designing for Six Sigma (DFSS) or Designing for Manufacture and Assembly (DFM) includes trying to minimize the number of parts included in the manufacture process. This may be accomplished by assembling the product from modules or subassemblies, designing the product for easier assembly, and designing the manufacturing process to minimize material handling.

Care has to be taken when using DFSS or DFM. Returning to the Ford Pinto, the goal of Ford was to place an economy car on the Mustang chassis – thus keeping with the horse motif.

As we saw above, this effort to simplify the manufacture and assembly backfired on Ford. GM saw the same issue in the 1980s with the Chevrolet Cavalier, the Pontiac Sunfire and the Cadillac Cimarron. They were the exact same cars with different medallions on the front and different price tags.

Value Analysis

Before selling the product on the open market, the company should conduct a value analysis. The goal of this analysis should be to determine if the product is perceived as a value for the price according to the customers. In assessing the value, the company needs to determine the following:

- Is there something within the product that the customer can do without? Today's computers are good examples of this. The average computer user today uses the computer for word processing, graphics, spreadsheets, and communications. There is much more that most computers can do that are not used by the average user. For the most part, today's average computer user uses his/her computer for the same purposes that my Tandy 1000 did almost 30 years ago. My Tandy 1000 had a desktop software package that had word processing and spreadsheets. This was supplemented by Lotus 1-2-3 and Harvard Graphics. Both of these programs fit on one 3.5 inch floppy disk. After Al Gore invented the Internet (he said he did while running for President in 1990 and we know a politician would never lie to us), the addition of a 300 baud modem allowed me to access the Internet. Obviously, the computer I am using today to write this is much faster and more capable, as well as much cheaper. And yet, every year a large number of users buy new computers because of the marketing campaigns and advertising for the new bells and whistles that may never be used.

- The value analysis should identify if the product is perceived as not worth the price—this may drive a different conclusion to the break-even analysis calculations.
- Is there a less expensive material or component that could be used in the manufacture of the product that will increase the value or reduce the cost of producing the product?
- Can someone else make the product cheaper or better or faster? We will discuss the options for this in Chapter13 when we discuss the make or buy decision process.
- The analysis should identify if there is another product that does the same function that is already on the market. If so, the design process needs to consider how to make this product with more value added or made more reliable and durable.

Designing for the Environment—New Trend, New Fad, or New Name for Old Process?

Designing products for the environment is nothing new. In 1969, Clemson University was trying to design a Coke bottle that would disintegrate on the side of the road after being thrown out of a vehicle. This was before "Littering Fines" became enforceable. The problem was that they could not keep the bottle from disintegrating on the shelf—which is not a good thing for grocery stores.

The latest trend in manufacturing is to design and build products that are environmentally friendly or sustainable. This is a good thing because we only have one planet to leave behind for the future generations. Designing the product that can be made from recycled or recyclable materials is an example of designing for the environment. Designing the process to make the product to use less energy is an example of designing for the environment. Or designing the packaging for the product to use fewer materials is also designing for the environment. Figure

12.8 is an example from Panama of a grocery bag that is designed to compost. Even recycling of bags is not new as grocery bags were recyclable in Germany in the early 1990s.

Figure 12.8 Compostable Bag

The Green Laws in Europe are designed to force companies into considering the environment in the design and manufacturing processes. The Europeans have been more environmental conscious than Americans for decades. While stationed in Europe in the mid-1990s it was clear that there was concern for the environment just from the amount of items that were part of the mandatory recycling program—some of which are not recycled in the United States even today. We will discuss this greater in our upcoming discussions of reverse logistics and sustainability.

Here are some examples of environmental design issues. Hewlett Packard and Xerox have determined that it is cheaper to pay for customers to return printer cartridges than it is to make new cartridges. On the flip side of this view is the disposal of carpets. Every year there are approximately four million pounds of carpets (all manmade products and recyclable) that are dumped into landfills.

Design for Distribution

This is a newer consideration in the design process. Can we design the products for ease of shipment or to get more products into the containers for overseas shipments? Think about Ikea. Almost everything that they sell is disassembled. The primary reason for this is ease of shipment. They even went as far as redesigning their coffee cups to make them stackable in the boxes in order to get more cups per box and more boxes per container. Figure 12.9 is an Ikea distribution area. You pick out the items that you want in their showroom, punch in the item SKU into a computer and an employee helps get the item for you. Consider a coffee table; if shipped disassembled it takes about ¼ of the space of the assembled table. When you start stuffing a container, the additional numbers of tables that will fit into the container is about 4 times more – thus reducing the shipping per item costs.

Figure 12.9 Ikea Distribution Area

Summary

The goal of the design process is to provide a quality product that meets the needs of the customers in a cost effective and efficient manner. While designing the product it is important to consider the Reliability, Availability, and Maintainability of the product and to design a product that will meet the necessary specifications while ensuring that the product does not fail due to poor product design.

It is the responsibility of the company to assess the needs of the customers and then determine whether the company can profitably make the product and at what point will the company start to make a profit from the product.

While designing the product it is imperative to consider how the product will be made or assembled and how the product and the production process will impact the environment. A

concurrent design team should get the quality product to the market quicker with fewer, if any, necessary revisions to the product.

Thought and Discussion Questions

1. Why is designing for the environment becoming more important? Is this a recent occurrence? Provide examples of designing for the environment.
2. If a product has fixed costs of $2,000,000 with variable costs of $1200 per item with a sales price of $3,500; what is the break-even point? Why is this important?
3. Using the data from above what are the total costs at the break-even point?
4. What are the goals of the product design process?
5. Should the product and production plan be developed consecutively or concurrently?
6. What is the difference between traditional and concurrent product design?
7. What is Design for Six Sigma and how does it differ from the Six Sigma process discussed in reference to quality?
8. Can the design process provide the company with a competitive advantage?
9. What is the difference between Availability and Maintainability?
10. What is meant by the term Mean Time Between Failure?
11. What is meant by the term Mean Time To Repair?
12. If Product A has an MTBF of 175 hours and an MTTR of 25 hours; Product B has an MTBF of 250 hours and an MTTR of 60 hours; and Product C has an MTBF of 150 hours with an MTTR of 20 hours, what is the Systems Availability of the products and which one should the company select for production?

Chapter 13

Production/Process Design

The process design strategy sets the corporate strategy for the production of the products that were designed in the product design process. Part of the process design may include how vertically integrated a company wants to be. Vertical integration is defined as: "When a company expands its business into areas that are at different points of the same production path."[77] In the 1980s Anheuser Busch tried to become completely vertically integrated and own the entire supply chain and operations management chain. They moved into the bottle and glass making business, can and aluminum making business in addition to the beer making business as was discussed in Chapter 3; once they realized that their core competency was making beer, they divested themselves of the other aspects of the operations management chain.

The production or process design is critical to the future of the company and the profitability of the company. The product of this design phase may very well determine the future capital investments in equipment and facilities. How the product is to be produced may dictate the flexibility to produce other products.

Per our previous discussions on strategy and processes, the production process can take the form of mass production, continuous production, assemble to order, make to order, batch processing, or projects (one at a time production such as dams, planes, or bridges).

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[77] vertical integration. (n.d.). *Investopedia.com*. Retrieved August 03, 2010, from Dictionary.com website: http://dictionary.reference.com/browse/vertical integration

Timing of Product Release

Timing the release of a product is tied to process design. When should the product be released to the customer? This is a difficult decision and is about as easy as trying to time the stock market. If a company releases the product too soon, it may not be ready for prime time and may have to be recalled. Hewlett-Packard did this with their tablets when the iPad was introduced. They had to pull it back, rework it and then re-release it.

Companies have to decide if they want to be the market leader or the market follower. Timing the entrance to the market is like trying to time the jump off the big rock formation at Waimea Bay in Hawaii (see Figure 13.1). During the winter months when the waves are 15-20 feet timing of the jump is critical. If you jump in too soon, you get swallowed by the wave and think you are going to die for about 45 seconds. If you jump in too late, you will miss the wave all together and have to swim like crazy to the shore before the next one arrives. But, if you jump in just at the right moment, you get a great ride all the way to the beach. The same thing in business, if you jump in too late, you miss the market all together. But, if you jump in just at the right time, you can garner a significant market share without having to spend enormous amounts on marketing a brand new product.

Figure 13.1: The rock formation at Waimea Bay, Hawaii

Planning the Process and Design

One of the products of the product design process is the **Blueprints.** The product design should produce detailed drawings of the proposed products. These blueprints will allow the design team to properly design the process to produce the product and should provide the producer an idea of the skills needed to make the product.

From the blueprints the design team can determine all of the components of the product. This list of components is known as the **Bill of Material (BOM)**. The BOM is much like the ingredients listing on a recipe card for baking a cake. They both serve the same purpose. Bills of Material can be flat BOMs which only list the primary parts or assemblies. A multiple layer or indented Bill of Material shows the components of the assemblies and may be detailed down to the screws and washer level. According to the APICS/ASCM Body of Knowledge, a Bill of Material is defined as: "The BOM is the document that specifies the components needed to produce a good or service. It lists the parts, raw materials, subassemblies, and intermediates

required by a parent assembly. A BOM specifies the quantity required to make one item, specifies units of measure, and quantifies phase-in and phase-out dating."[78]

The next piece of planning data that comes from the product design process will be the **Assembly Chart** also known as a product structure diagram. The assembly chart is like the diagram in the box with the latest piece of gym equipment that I assembled. Inside the box was the Bill of Material (a listing of all the parts in the box), the assembly chart that provided a graphic of what the equipment should look like as it was assembled, an **Operations Process Chart** that listed each of the steps in the shelves assembly, and a **Routing Sheet**. The routing sheet showed the proper sequence of events to assemble the equipment from ingredients listed in the Bill of Materials.

Using the original analogy of baking a cake, a good recipe card not only lists the Bill of Materials to make the cake, the recipe card has a picture of the finished product, the assembly chart or steps in the baking of the cake, and the routing sheet that shows the proper sequence of what to do to assemble and then bake the cake. Just as these diagrams and listings are important in baking a cake, they are just as important in manufacturing or assembling a product.

Make or Buy Decisions

While concurrently conducting the product and process designs, a decision may become necessary as to whether or not a product should be made in house. Remember in the discussion of the product design one of the considerations was "do we have the technical expertise to make

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[78] *APICS Operations Management Body of Knowledge Framework*, 2nd edition, APICS The Association for Operations Management, 8430 West Bryn Mawr Avenue, Suite 1000, Chicago, IL, p. 51. For more on the Operations Management Body of Knowledge or APICS – The Association for Operations Management go to http://www.apics.org

this product?" Another consideration was "can we sell the product at a sufficient level to make a profit (breakeven analysis)?"

This analysis of the product design may lead the company to decide to not make the product themselves. Designing the product may be a core competency but making the product may not be a core competency. Before looking at why the company should not consider outsourcing, it is important to understand that in some situations it is not feasible to outsource. For example, if there is a barrier to making a make or buy decision such as "Buy American" or "Buy European." In some businesses, there may be "classified" or proprietary information such as the "Colonel's 11 herbs and spices" in Kentucky Fried Chicken that precludes outsourcing.

Let's take a look at some of the criteria that may lead a company to decide to outsource their manufacturing to a Third-Party Provider. None of these considerations are stand alone issues. Each of theses are related and should be considered in the make or buy decision.

Cost – Can someone else make the product cheaper with the same quality? It may be beneficial to outsource the manufacture of the product. One company that provided portable equipment batteries discovered that another company could not only make their batteries cheaper than the parent company could but could also make the batteries with the same quality. A little more research proved that the outsource company could also apply the company's labels to the batteries before shipping. The battery company was able to transform the manufacturing plant to a larger warehouse, create a workout room for employees, and establish a day care facility within the original plant location for the employees.

Keep in mind that cost is not a stand-alone factor. Almost any product can be made cheaper or less expensive. However, that does not mean that it will be of the same quality that our customers have come to expect from our brand name. For example, in the late 1990s and

early 2000s Sears outsourced the manufacturing of Craftsman Tools. This decision looked good on the surface until the number of returns for substandard tools started rising. If cost is the factor driving the make or buy decision, it is critical to ensure that quality is not overlooked.

Capacity – If a company does not have the capacity to make the projected demand of the product, it may be an effective strategy to outsource the manufacture of the product. We will look at capacity decisions in greater detail in a later chapter. This may be a temporary decision for short term spikes in demand or could very well be a long-term outsourcing decision based on forecasted increases in demand that exceed the capacity of the company.

Another factor related to capacity is: does the company we are looking at have the capacity to produce the product if the demand increases? For example, in 1990 a contract was awarded to a small, disadvantaged business to make a chemical packet that would allow Soldiers to heat their Meals Ready to Eat (MREs). At the time of the contract the numbers needed for annual training for the Army was not significant. However, within a few months of the contract award Operation Desert Storm (the first Gulf War) kicked off when Saddam Hussein invaded Kuwait. The result was an exponential growth in the need for these MRE heaters. The initial contract company did not have the capacity to expand operations, so another company ended up with the contract.

Quality – Can another company make the company's product better than the designing company? If another company can make the product and make it better, why not outsource? However, if the quality improvement creates a price that prohibits the value proposition then obviously it is not wise to outsource. As we mentioned earlier, this consideration is linked to cost.

Speed – Can someone else make the product faster? The second part of this question is – can they make it better or cheaper than the designing company? If the cost is not increased, if the quality is the same and the product can be produced faster and delivered to the customer faster, then it is logical to outsource the manufacture of the product.

Expertise – Does the company that can make the product faster or cheaper actually have the expertise to make the product? As a response to the escalation of the second Gulf War (Operation Iraqi Freedom), the US Government eased some of the research and development requirements and went to a streamlined procurement model. One company in Florida won several contracts to provide equipment to the deployed forces. It turns out that their expertise was not making anything, but they were experts in writing proposals to provide equipment. In fact, they were so good at writing and winning proposals that they were able to get start up monies up front for the contracts that they won. They never produced anything and when the General Accounting Office looked into their operations, they were found negligent and fraudulent in their operations. The investigation led to a conviction – these folks are now experts at making license plates in prison.

Equipment Selection/Process Selection

Part of the production and process design is the selection of equipment. This is another reason that the process and product designs need to run concurrently. If the product design identifies new or specialized equipment that must be ordered, it is imperative to get the equipment ordered as soon as possible. You never know when there will be a long lead time for the equipment.

When I was a young officer at Fort Gordon, Georgia, the installation decided to outsource the maintenance of all facilities as a test for outsourcing commercial operations. Seems the

mechanic who was responsible for maintaining the air conditioning systems for all of the buildings in the block that I was working on was not offered a job by the incoming contractor. It also seems that this individual knew that the air conditioning system for the block was not functional when he was let go in February. As he was not offered a job, he did not think it was his job to worry about something that would not be needed until long after he was gone. So, when the thermometer topped 95^{o} and 95% humidity (as is common in Georgia in the summertime), it was discovered that this block of buildings that were built with windows that did not open because the "modern" HVAC system had no air conditioning. The real kicker was the lead time for the part was over four months since it was only made in Sweden. Although a little different, that same principle is important when buying new equipment.

When considering the purchase of new equipment there is always some risk and uncertainty. The first consideration always seems to be the purchase cost of the equipment. Because of this some companies choose to piecemeal their purchases. This is like the old Johnny Cash song, "One piece at a time." In the Johnny Cash song, he worked at the Cadillac factory and took home one piece at a time. The problem came when they tried to put the car together after about twenty years. All of the pieces did not fit. The same thing happens when ordering equipment one piece at a time vice ordering all of the equipment at one time—by the time the last piece of equipment is purchased, it may not be compatible with the earlier purchased equipment.

Another consideration that may lead to an equipment decision may be the operating costs for the equipment. This may also play into a decision point if the operating cost in energy costs does not sync with the company's goals of being green.

If a decision is made to buy new equipment there may be some annual savings realized by using more modern equipment. There may also be some government revenue breaks or tax rebates for using more environmentally friendly and modern equipment.

Keep in mind that the process selected may impact fixed costs and variable costs. Therefore, if product design and process design are not conducted concurrently, this may mean having to relook the break-even point. This relook is necessary to make sure we have not moved the break-even point out of our favor resulting in making a product that we cannot make a profit from; or to see if the new process moves the break-even point in our favor resulting in a relook of the make or buy decision.

Process Analysis

The goal of process analysis is to analyze the processes to determine if there is waste or no value addition in the process. The usual tools for this are process maps, flow charts, and process charts. This is done with the understanding that every process adds cost but not every process adds value. And as we stated in Chapter 1 that the primary goal of Operations Management is to add or create value, it is important to know which processes are adding value and which ones are simply adding cost. If a process does not add value to (a) the customer experience; (b) the quality of the product; or (c) the bottom-line profits, why do it?

According to the APICS Operations Body of Knowledge process mapping is: “a visual form for documenting the details of a process. Depending on the map’s objective, the level of detail will vary. Process maps can take many forms, including flowcharts; relationship maps;

cross-functional maps; and supplier, input, process, output, customer (SIPOC) diagrams."[79] A process map serves several purposes, the first of which is applicable to this discussion—providing a visual picture of the process. The second important function of a process map is to use it as a teaching tool for new employees on the processes of the company. Figure 13.2 is a simple example of a process map for receiving operations.

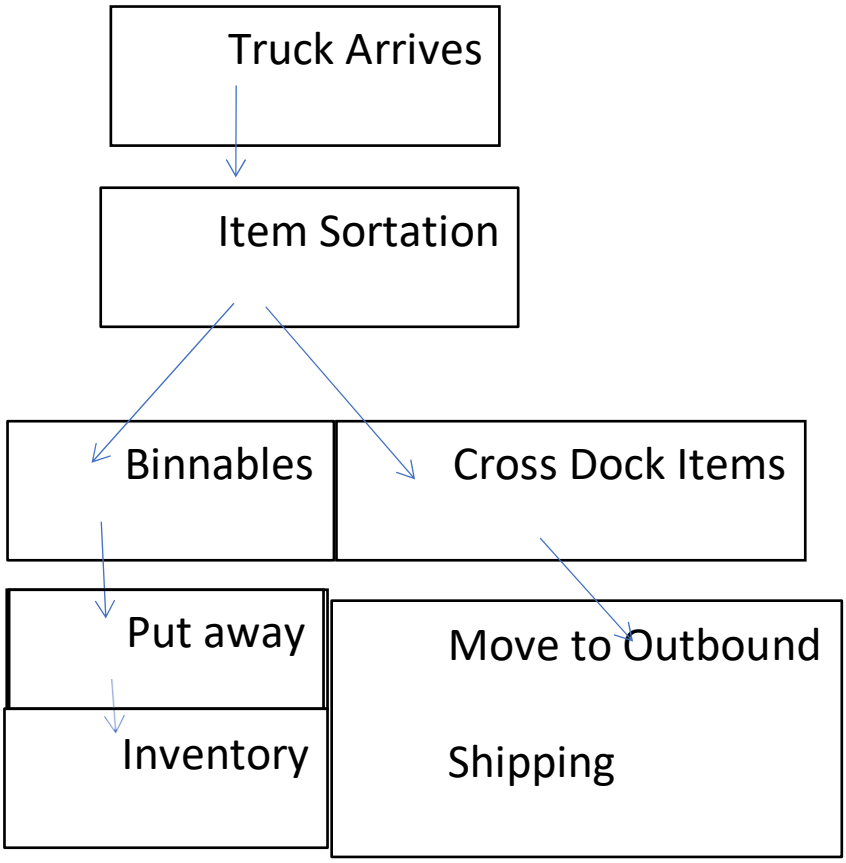

Figure 13.2: Sample Process Map

[79] *APICS Operations Management Body of Knowledge Framework*, 2nd edition, 2009, APICS The Association for Operations Management, 8430 West Bryn Mawr Avenue, Suite 1000, Chicago, IL, p. 33.

The goal of the process redesign operations is to get the waste out of the process. At the same time as the waste is identified and eliminated, thus streamlining the process, the process map links the processes to value creation. Once a process map is developed, the next step is to start capturing data and placing dates and time stamps on the process map. This will further enhance the ability to use the process map to improve efficiency and benchmark the processes against industry standards and company past performance to determine whether the changes are actually improvements. Remember every improvement is a change, but not every change is an improvement. The goal of the process mapping is to identify improvements you can believe in and not simply change.

Another, less costly method of improving the process is to personalize the process. Here is an example of personalizing the process. This is a process called "naming the aisle." Naming the Aisle is a simple process to talk about and relatively easy to implement. In a distribution center each aisle has a location placard at the end of the aisle. By placing the team names that are responsible for the maintenance of the aisle or the team leader's name on the aisle and then putting the metrics such as picking accuracy, inventory accuracy and orders picked per hour on the end of the aisle adds pride to the workers. This also adds a little internal competition to see which aisle is better. The combination of pride and competition improves the overall operations of the process.

Another method of improving the process is through the use of Six Sigma. The goal of Six Sigma is to reduce variability in the process. If the variability is reduced, the process should be improved. Motorola introduced the world to the Six Sigma concept in the early 1980s with the steps of:

Define

Measure

Analyze

Improve

Control

This methodology became known as the DMAIC method. Although Motorola introduced Six Sigma, General Electric received more attention with their use of Six Sigma. Even with the publicity that GE received for its use of Six Sigma, it was not until Jack Welch tied the implementation of Six Sigma to the bonuses of the executives that Six Sigma became successful in both the manufacturing and services sector of the company.

The US Army introduced a similar program to improve its supply chain processes in 1995. This program was called Velocity Management. The methodology for Velocity Management was Define, Measure, and Improve. The D-M-I methodology was basically "six sigma light." Like Six Sigma, this program sought to reduce the variability of the supply chain and as a result significantly improved the customer response by the supply chain systems. It was successful in that the D-M-I process resulted in saving the US Army over $300 million in annual expenditures for repair parts. The success of the D-M-I process led to similar programs in the US Navy, the Air Force and the Marines Corps.

Improving the process is also possible by simply varying the entry point of looking at the process. A different entry point provides a different perspective of the situation. The US Army conducted an After-Action Review of the initial supply chain operations for Operation Iraqi Freedom approximately one year after the invasion started. The first point here is that the After-Action Review should have been conducted closer to the event to get a good review of the processes to improve them.

Every senior leader that spoke at the After-Action Review had a different perspective and from each perspective they felt that what they did was good but everyone else came up short in their performance. Amazingly, there was overlap in the areas of responsibility, so the different perspectives were parochial in nature and not true perspectives. So, when changing perspective, it is important to get a true perspective of your own and not a jaded perspective or parochial point of view.

When Lieutenant General Gus Pagonis left the US Army and became the Vice President of Supply Chain Operations for Sears, he made each of his employees spend time in a store or distribution center on a regular basis. The point of doing this was to make sure the employees could see from other perspectives the actions based on their decisions and allow them to modify policies based on their work experiences. Sometimes things look like good ideas in the corporate headquarters but don't actually make sense in practice.

When I was in Kuwait, I regularly jumped on a forklift to unload trucks, move supplies, and load outbound trucks. By seeing things from the workers' perspective, I was able to understand the impacts of certain events on the operations such as rain impacts on a largely outdoor, unpaved facility and heat and dust related impacts to operations. I also put on coveralls and crawled under vehicles at the US Army National Training Center in the Mojave Desert to see the impacts of policies on maintenance to better understand how to support my customers. Some policies look good at the corporate office but do not translate well from the abstract to the concrete and result in vague or imprecise guidance at the worker level.

The hit television show, *Undercover Boss*, sought to do the same thing—provide CEOs a different perspective of their operations. The result of the bosses going undercover to do some of the work at different locations seems to have provided great insights to improve operations. One

of the ideas that may come out of changing perspectives and varying the point of entry into an operation may be a change in automated systems.

Before moving to a new automated system, it is imperative to evaluate the systems and the current operations. By evaluating and documenting all current activities it may become apparent that some of the current processes may not be needed in an automated environment and are thus non-value-added with the new systems. The analysis may point toward the use of an Enterprise Resource Planning program or ERP.

Enterprise Resource Planning Programs

The main goal of an ERP system is to take all of the old stovepipe data bases and information systems into one enterprise wide information system. Once all of these systems have been consolidated data mining is possible and the ability to hide information and data is eliminated within the company. This allows the company to have all employees working from the same data and forecasts. Figure 13.3 shows the feed of all other data bases to the ERP system.

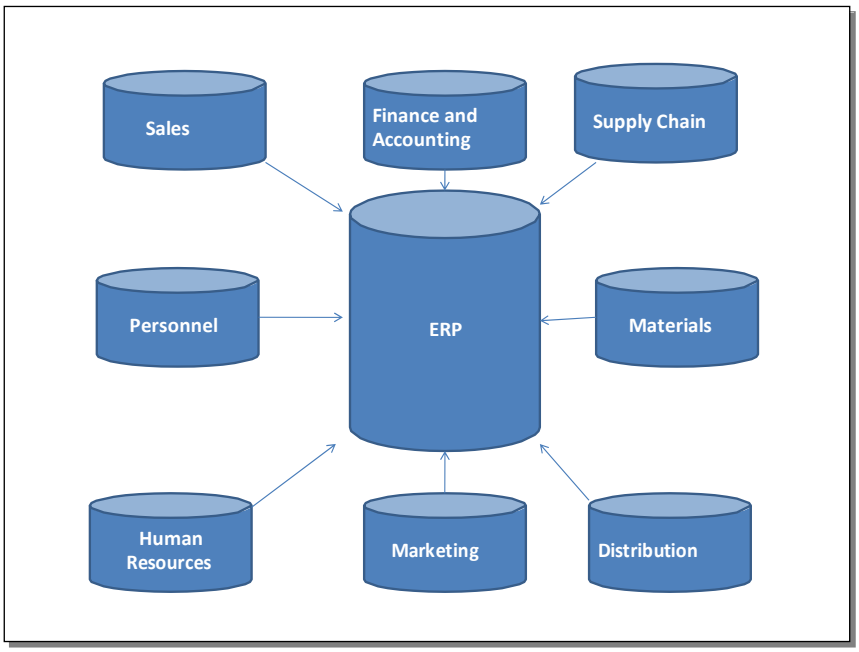

Figure 13.3: Example of an ERP Database

SAP (Systems, Applications, and Programs) is the largest provider of ERP software with over 22% of the market.[80] Oracle is also a strong player in providing ERP systems with approximately 15% of the market share. Oracle realized several years ago that they needed a good personnel and finance module for their ERP systems. Rather than develop a new set of software modules, Oracle purchased PeopleSoft and incorporated what was at the time the best available standalone module into their system.

ERP is not always the end all solution to systems and process improvements. Although it is getting better, for every good news story on the implementation of ERP systems there is always a horror story or a company such as Dell that spent millions of dollars only to pull the plug and go back to the old system. In 1999, Hershey's implemented an ERP system. The result was missing the majority of their Halloween candy shipments due to a glitch in the software.

[80] http://www.businessnsoftware.com/erp-market-share/

This incident placed Hershey's on the *Supply Chain Digest* list of the worst supply chain disasters of all time.

Radio Frequency Identification (RFID) Tags

RFID tags have been around for over 20 years. In the late 1980s the US Army looked at using what was then being called MITLA chips or Microprocessor Technology with Logistics Applications to track the shipment of supplies and equipment worldwide. In 1994, the US Army started tracking the shipments of materials and supplies using the SAVI tags as shown in Figure 13.4. The newer generation of tags are about the size of an iPhone 8.

Figure 13.4: SAVI RFID Tag on a Pallet in Kuwait

The research into the use of this particular tag started before the completion of Operation Desert Storm (the First Gulf War) but picked up steam immediately after the War. When this operation was complete there was over 27,000 twenty foot equivalent (TEU) containers on the

dock at Dhahran, Saudi Arabia with no clue what was in them or who they belonged to. The US Army wanted to reduce or eliminate this problem for future operations. With the RFID tag the Army was able to track every shipment from origin until final destination.

This particular tag is an active tag. An active tag is always on and can be read from up to 300 feet with an interrogator. With the proper software, this particular tag can be fed into the ERP system and tracked worldwide, thus giving the company using the tags supply chain visibility. The downside of this tag is that it is relatively expensive. This is relative when compared to the cost of losing a shipment or a customer due to a lost or misrouted shipment.

The tags getting the most attention over the past decade is the passive tag. Wal-Mart, with great fanfare, announced that as of January 1, 2005 every supplier would have to start using RFID tags down to the item level. The Department of Defense made a similar announcement about the same time. Wal-Mart quietly backed off their demand to only include the top 100 suppliers to two distribution centers and in 2009 announced that they would apply tags to shipments that suppliers did not tag and charge the companies for the tags. This worked out to the advantage of the companies. In 2013, Wal-Mart did not admit defeat with their initiative but did announce that they would charge suppliers per pallet that was not tagged. The cost of this charge was much smaller than the cost for smaller suppliers to buy the tags and the infrastructure to write the tags.

In July 2010 Wal-Mart announced a program to place RFID tags in jeans and other clothes to “improve inventory accuracy.” This same concept was attempted in 2006 by United Colors of Benetton with a great outcry of invasion of privacy by their customers in England. This outcry led to abandonment of the program.

The concerns about invasion of privacy is not a new concern with RFID tags although passive tags need to be activated by a reader and can only be read from about a foot away. California has considered several laws to let customers know if the product that they are buying has an RFID tag and if so, give the customer the option of having it disabled. The concern is: if I can read the tag, who else can read it? Figure 13.5 is a picture of a tag developed by Michelin to track and inventory tires. Another use of this tag was to let customers know if there was a recall or if they needed to rotate their tires. Again, the concern is that if they can read the tags who else can read it and can someone track my vehicle to see where I am going and where I have been. In 2018 several companies started working on an encrypted tag. This development will allow companies to keep others from reading their RFID tags and should alleviate some privacy concerns.

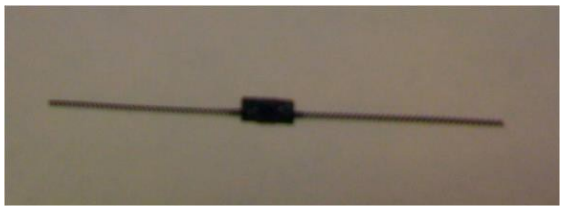

Figure 13.5: Michelin RFID Tag for Tires

Comparing Two Processes

What if there are options for the production processes? There is a rather simple calculation for choosing the best process based on cost analysis. This calculation compares the two processes to determine which process will provide the lowest total costs based on the forecasted production levels. Equation 13.1 shows the calculation for the Point of Indifference. The Point of Indifference is that production point where the total costs for either process are equal.

Point of Indifference = the point where:

$$\text{Fixed Costs}_A + \text{Variable Costs}_A\,(x) = \text{Fixed Costs}_B + \text{Variable Costs}_B\,(x)$$

Where x = demand quantity or forecasted production level

Equation 13.1: Point of Indifference

Example 13.1 Using Equation 13.1

Process A:	Process B:
Fixed Costs = $250,000	Fixed Costs = $350,000
Variable Costs = $50/item	Variable Costs = $35/item

Step 1: Set up the Equation 1 equations to set Process A and Process B equal to each other to solve for x (forecast production quantity and Point of Indifference)

$$\text{Fixed Costs}_A + \text{Variable Costs}_A(x) + \text{Fixed Costs}_B + \text{Variable Costs}_B\,(x)$$

$$\$250{,}000 + (\$50)(x) = \$350{,}000 + (\$35)(x)$$

$$(\$15)(x) = \$100{,}000$$

$$x = 6{,}666.6667 = 6{,}667$$

Items must be rounded up to a whole number as a partial product is not feasible or possible,

Therefore the Point of Indifference is at a production level of 4,000

Step 2: Insert the Point of Indifference into the Equations to determine the best process: If the forecasted production level is 6,000, the lowest total costs are calculated:

Process A:

= $250,000 + ($50)(x)

= $250,000 + ($50)(6,000)

= $550,000

Process B:

= $350,000 + ($35)(x)

= $350,000 + ($35)(6,000)
= $560,000

Step 3: Select the process with the lowest total costs. In this example, the company should select Process A. Based on this calculation, if the forecasted production had been 7,000, Process B would be chosen.

Process A:
= $250,000 + ($50)(x)
= $250,000 + ($50)(7,000)
= $600,000
Process B:
= $350,000 + ($35)(x)
= $350,000 + ($35)(7,000)
= $595,000

Summary

The selection of a process for production of the product designed in Chapter 7 may impact expansion decisions, may impact investment expenses, or may very well drive the make or buy decision process.

The selection of processes and equipment for the production of a product must be conducted concurrently with the design of the product if the goal of getting a quality product to the market as quickly as possible is to be met by the company.

Thinking Questions and Problems

1. Why is the process development process important to the Operations Management Chain?
2. What is the goal of process design?
3. What is the importance of the Point of Indifference?
4. If a company has the option of choosing between two processes for the production of their product, calculate the Point of Indifference with the following data:

   Product A: Fixed Costs = $500,000; Variable Costs = $125 per item produced

   Product B: Fixed Costs = $750,000; Variable Costs = $75 per item produced
5. If the forecasted production for the above data is 9,000 units, what process should the company select?
6. Research RFID tags and explain the size and capability differences between active and passive tags.
7. What aspects should a company consider if making a make or buy decision?
8. What is ERP and why is it important?
9. What documents comprise the recipe card for a product?
10. Create a process map of any process that you are familiar with.
11. What is the purpose of a process map?

12. Why is it important to relook the Break Even Point calculation as part of the process design steps?

Chapter 14

Productivity

What is productivity? Productivity is a ratio of the outputs from the operations management transformation process to the inputs to the transformation process as shown in Equation 14.1.

$$Productivity = (\frac{outputs}{inputs})$$

Equation 14.1: Basic Productivity Formula

Haven't we already discussed this once when we talked about measures of competitiveness? Yes, we discussed this briefing in Chapter 1 when we introduced the concept of Operations Management. However, we need to discuss it in greater detail to look at the uses of productivity calculations and how the calculations are made.

The Association for Supply Chain Management defines productivity as: "An overall measure of the ability to produce a good or a service. It is the actual output of production compared to the actual input of resources. Productivity is a relative measure across time or against common entities (labor, capital, etc.). In the production literature, attempts have been made to define total productivity where the effects of labor and capital are combined and divided into the output."[81]

Productivity is impacted by many factors. Consider the impacts to productivity from the March Madness every year when employees are more concerned about busted brackets than

[81] ASCM dictionary app, "productivity."

customer support. Or the impacts to productivity every time Louisiana has to button down for impending hurricanes rather than process customer orders. Think about the impacts in 2020 to productivity as employees were forced to work from home. How many did not have reliable internet connectivity or the same resources available in the office and who was checking on the employees to make sure that they were actually working?

Why Should I Care About Productivity?

As was mentioned in Chapter 1, productivity is a commonly used measure of competitiveness between companies, individuals, and plants within a company. Productivity can also be used a measure of efficiency for a company. It also ties to quality – if we have to rework products, then we are not being productive. It is also tied to profitability. The more productive a company is, the more profitable it will be. It may also be used as measure of the engineering efficiency of a process or transformation activity.

Productivity is usually expressed in units of output per unit of inputs. For example, it may be displayed or expressed as labor productivity and shown as dollars or units produced for every labor hour or labor dollar invested.

Productivity is simply the ability to produce goods or services compared to the resources to produce them. So, obviously the higher the costs to produce a product or service, the lower the productivity rate will be. It is incumbent on all managers at every level to control these rates of investment while trying to maximize the outputs. This does not mean working at levels that burn out the employees or wear out the machines just to hit productivity targets. Decisions on productivity need to be long term decisions and not short term/short sighted decisions.

Productivity and Specialization

Does specialization increase or decrease productivity? I think the answer to this question is, "it depends." Too much specialization leads to idle time for employees in some specializations thus decreases overall productivity. But the flip side to this argument is that if an employee is a specialist in a particular area, they should be very productive at what they do with little to no rework of their production.

The other argument is that specialization may lead to boredom. If an employee only does one thing all the time, they may in fact get bored and start making boredom mistakes or taking short cuts in the production cycle or they may develop repetitive motion injuries which may lead to decreased productivity. Harley-Davidson tries to prevent the repetitive motion injuries and boredom by assigning workers to a team that frequently changes activities in the assembly plant. The collateral benefit of this type of job rotation is that the workers get to see the impacts of different functions on the overall product quality.

Productivity and Technology

What about technology? Does it always increase productivity? Personally, I don't think so. It should, after all that is the goal of technology. However, how productive are you when your internet connectivity goes down? How productive are you when you are constantly bombarded with e-mails?

While technology should increase productivity, some workers are intimidated by technology advances or abuse the technology available. How much time in any given workday is devoted to surfing the web or sending personal e-mails? Or how much productivity is lost when someone sends you a document with corrections that need to be made and you realize that the time it took to write the e-mail and make the annotations on the document took longer than it did

to actually change the document and simply ask for comments? How much time is lost trying to make PowerPoint slides perfect with animations and graphics flying in and flying out? This is why a previous Chief of Staff for the Army dictated that slides would be plain, to the point and no graphics or animation.

Factors that may Affect Productivity

Technology innovations may impact productivity. In the short run, these innovations have to be mastered and may decrease productivity. Once mastered, these innovations should increase productivity.

Economies of scale can impact productivity. The more items that a company produces from the operations management transformation process, the more productive they should be.

Employee training/motivation/engagement can impact productivity. If employees feel that they are appreciated they will work better and be more productive. When employees feel unappreciated, their productivity usually decreases, or they leave the company. Employee retention or turnover rates can severely impact productivity. There was a facility in West Memphis, Arkansas a few years back that was experiencing a 95% turnover rate in employees. They were constantly hiring and training workers and could not reach respectable productivity rates with the constant inflow of new employees. One company that I worked with in Southern California experienced a 50% turnover rate for their employees. The result was a continual hiring action and training of new employees and the necessary certification of the employees only to lose them after the certification. The reason most of the employees left was that there was a distribution center less than a half mile away that was paying almost double for a certified/licensed forklift operator. The reason they could afford this was because the other company was paying for the training and certification but not recognizing the new skills of their

employees with a pay raise. They could not afford the pay raise because they were constantly spending their money on training of new employees.

Calculating and Using Productivity to Assist in Decision Making

Productivity calculations allow managers to compare how their company is doing in relation to the competition, how their company is doing in the international markets, compare different processes within the company, or compare different plants/facilities within the company. For example, a company may want to see how its West Coast facility is doing compared to its East Coast facility. Then the company can delve into why the facilities are not at the same productivity levels. This could be tied to management, facility constraints, labor issues or different machines. It also allows countries to compare their productivity to other countries.

Partial Productivity

Partial productivity is usually relatively easy to calculate because it is based on one particular aspect of inputs. The problem with partial productivity is that is may give a false picture of the true productivity. Since companies are tempted to use that statistic or metric that makes them look better, they may use a partial productivity measure that is better than the overall productivity. Partial productivity is calculated using only one factor as shown in Equation 14.2 and Example 14.1.

Partial productivity = outputs/single factor inputs

Equation 14.2: partial productivity

Outputs = 500 items per hour

Inputs = 40 labor hours

Partial Productivity = 500/40 = 12.5 items per labor hour

Example 14.1 Partial Productivity

Multi-factor Productivity

This calculation uses more than one factor for the productivity calculation. If we add in labor costs and material costs to Example 14.1, we will see the multifactor productivity calculation as shown in Example 14.2

Outputs = 500 items per hour

Inputs = 40 labor hours

Labor costs = $25/hour

Material Costs = $1500/hour of operations

Multi-factor Productivity = 500 items/(((40hours)($25/hour))+($1500/hour)

500 items/($1000+$1500)

= .2 items/dollar invested

Example 14.1 Partial Productivity

Total Productivity

Total productivity takes into account every input into the transformation process. Total productivity is a better metric for managing productivity and profitability than single factor or partial productivity.

Changes in Productivity

Hopefully, we are measuring productivity growth, but it may be productivity decline as well. The change in productivity calculation is shown in Equation 14.3 and Example 14.3. This calculation is usually shown in a percentage of growth or decline.

Change in Productivity = (Current Productivity – Baseline Productivity)/Baseline Productivity

Equation 14.3 Change in Productivity Calculation/Equation

Base year productivity = 16,000 produced per hour

Current year productivity = 22,000 produced per hour

Change = (22,000-16,000)/16,000 = 37.5% increase in productivity

Example 14.3 Change in Productivity

Productivity Assumptions

There are at least two assumptions that I believe should be factored into every productivity calculation. The first is that the outputs are quality outputs – if not, then we are not being productive, I don't care how many we are making. The second assumption is that someone is buying what we are making. If everything we make or any of what we make goes on the shelf and no one buys it, then we are not being productive because we are adding value.

Summary

Productivity is critical to success in business and operations. It is important to know what it is, how it is calculated, how it is used, and the two basic assumptions built into every productivity calculation.

Chapter 15

Warehousing/Distribution Management

Chapter 2 set the foundation for detailed discussion of the supply chain functions of Logistics, Warehousing, and Distribution Center Management. Each of these critical functions are important to the success of any supply chain and any operations management chain.

The 14th edition of the APICS Dictionary defines distribution as: "The activities associated with the movement of material, usually finished goods or service parts, from the manufacturer to the customer. These activities encompass the functions of transportation, warehousing, inventory control, material handling, order administration, site and location analysis, industrial packaging, data processing, and the communications network necessary for effective management."[82]

According to the Warehousing Education and Research Council's (WERC) WERCipedia (WERC's online dictionary) a warehouse is a "Place for receiving, storing and shipping material and merchandise and making changes to their packaging or configuration."[83] A Distribution Center is defined as: "a building, structure or group of units used to store goods and merchandise that are to be delivered to various places on an as-needed basis."[84]

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[82] "Distribution," APICS Dictionary, 14th edition, APICS, Chicago, IL, 2013, p. 40.

[83] "Warehouse," WERCipedia, Warehousing Education and Research Council, www.werc.org, accessed, August 30, 2010.

[84] "Distribution Center," http://www.wisegeek.com/what-is-a-distribution-center.htm, accessed April 21, 2010.

WERC also provides a definition of logistics as: "Logistics plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers" requirements."[85] Logistics is the historical term for what most companies call distribution today—getting products or people from one location to another. Distribution Centers and Warehouses are part of this logistics network.

Warehouse and Distribution Center are commonly used interchangeably. This is erroneous. Although both facilities have the same basic functions as we will discuss in this chapter, a Distribution Center focuses on getting products in and out quickly, whereas a Warehouse may store products for an extended period of time. For this reason, when we discuss inventory turns later in the inventory management chapter, remember that because of the length of storage, a Distribution Center should have much higher inventory turns numbers than a Warehouse. The changing face of supply chain management and the increase in smaller/individual orders and the processing of returns have also had an impact on the size and layout of Distribution Centers.

Warehousing

The introduction to the US Navy's publication on warehousing design lays out the reason for warehousing and distribution channels. "Because of the pattern of logistics management and the technical nature of many supply functions, consolidation of operations on the basis of material handling configuration is inhibited. Although a carton of wrenches,

[85] "Logistics," WERCipedia, Warehousing Education and Research Council, www.werc.org, accessed August 30, 2010.

hammers, or pliers might have the same handling characteristics as a unit of avionics or a pilot's crash helmet, these items generally flow through different distribution paths in their paths in their movement between the supplier and the ultimate user."[86]

Because of the differences between the various forms of materials and goods moving through the supply chain, warehouses are a necessary part of the supply chain. Warehouses exist to provide storage of the items moving through the supply chain and provide this storage at a location that is in close proximity to the customer. In general, the design of a general supply warehouse must be based on the characteristics of the material being handled and stored (shape, environment, stackability, etc.), the volume and flow pattern through the facility (transaction and cube movement rate profile), and the inventory pattern (item count, item cube, quantity mix, and inventory turnover patterns).

Types of warehouses

- **Cold Storage**. Cold storage warehouses are used for the storage of food items that require temperature-controlled storage. Cold storage warehouses can be a standalone facility that is capable of storing either climate-controlled storage (i.e., fresh fruits, meats, or vegetables) or frozen storage. One of the critical considerations for operating a Cold Storage Facility is the compatibility of the material handling equipment used with the items being stored and the lower temperatures associated with cold storage facilities. A cold storage facility may be collocated with a Dry Food Storage facility.

[86] Warehouse Modernization and Layout Planning Guide, Department of the Navy, Naval Supply Systems Command, NAVSUP Publication 590, March, 1985, p. 1-1.

- **Dry Food Storage Warehouse**. A Dry Food Storage Warehouse stores staple items such as canned goods and other food items that do not require a "cold" temperature for long term storage. Just as there are considerations for the equipment to facilitate the operation of a cold storage facility, the equipment used to move dry storage food items require compatibility with the food items being stored. For example, electric or propane forklifts are better for a dry food facility than gas-powered forklifts.

- **General Supplies Warehouse**. A General Supplies Warehouse is a facility that can handle almost any type of supply or material. The limit to what can be stored in a General Supply Warehouse is the square footage of the facility, the material handling equipment available, the size of the materials being stored, and the compatibility of the items being stored.

- **Warehouse in a Warehouse**. A "warehouse in a warehouse" is a concept for organizing warehouses to be more efficient. This concept involves organizing the products being stored in a facility. A typical Menard's store is a good example of a warehouse in a warehouse. A Menard's store is organized to place like items in zones or "warehouses" within the overall warehouse. Look at the paint department or the flooring department. Each of these departments is a mini warehouse in the Menard's Warehouse. Think about the lawn and garden section in your local Menard's or Home Depot. The lawn and garden section is like a warehouse in a warehouse. In a repair parts warehouse, items may be stored together by vehicle type or vehicle model to enable ease of finding the right product.

- **Climate Controlled Facility**. This type of facility differs from a Cold Storage Facility in that it is not designed or certified to store food items. In the Kansas City, Missouri area, there are a number of caves used for climate-controlled storage of items as diverse as old Hollywood movie props to old vintage films and film canisters. The purpose of this type of facility is to provide protection for the items in the warehouse that may deteriorate if stored at "room temperature" or in changing climatic conditions.
    - These caves are the brainchild of Kansas City Chiefs founder Lamar Hunt. The caves maintain the same temperature year-round. It is this year-round temperature that makes the underground storage a popular location for long term storage.
    - One of the newer additions to public storage facilities is climate controlled storage units to provide individuals with a way of storing household goods in a controlled environment.

- **Other miscellaneous warehouses and distribution facilities**:
    - **Local warehouse**—the purpose of a local warehouse is to provision the stocks and materials closer to the customer thus reducing the transit time for resupply of retailers or shorter transit time to the customer.
    - **Fulfillment center**—a fulfillment center is designed to receive/pick/pack/ship smaller orders. A fulfillment center may be part of a larger Distribution Center or may be a standalone operation.
    - **Value added/service center**—the purpose of a value-added services center is to provide services not normally associated with the warehouse or distribution center.

These services may be the type discussed in Chapter 5 as part of the distribution center. The value-added center may be collocated with the distribution center or warehouse in order to provide overnight shipping coordination. In this case, the shipping company such as UPS or FEDEX may collocate in the shipping area of the facility to speed the shipment of overnight deliveries or parcel shipping.

Warehousing History

Warehousing is one of the oldest professions known to man. Once early man discovered fire, it became a mission to "store" the fire to keep it burning. Hunters throughout history have stored meat during the winter to ensure food throughout the winter season.

In Biblical times, Joseph, after being sold into slavery by his brothers, made history in Egypt running the grain warehouses for the Pharaoh. This led to the migration of the Israelites to Egypt during the famines and the eventual exodus of the Israelites from Egypt. The mass migration led to eventual problems that seem to be continuing today between Egypt and Israel.

Alexander the Great learned the importance of warehousing to supply his Macedonian Army as the army moved across the Asian Continent. He also learned the expense of warehousing and was one of the first operations leaders to decide that warehousing was not a core competency of his army and "outsourced" his warehousing by foraging from the local countryside to support his army.

Venice, Italy became the crossroads and warehouse location for all of the East-West trade. The growth of trade between the silk road and Europe created a need for

storage along the trade route. The warehousing industry helped to support the goods coming to and going to China and the rest of Europe.

In the United States, the military outposts west of the Mississippi served as warehouses of supplies, ammunition, and other goods to support the movement of settlers and civilization across the country. A study of the expansion of the United States is not complete without considering the purpose of these storage outposts and the contribution of these warehouse outposts to the success of the country's expansion. A quick look at Kansas shows Fort Leavenworth, Fort Riley, Fort Hays, Fort Dodge, and Fort Scott.

The forklift first appeared in the 1940s and changed the face of warehousing and distribution forever. Prior to the arrival of the forklift, all materials in warehouses were hand loaded and unloaded.

Warehousing/Distribution Challenges

- **Proliferation of Stock Keeping Units (SKUs).** According to AMR Research released in early 2010, the number of SKUs in the commercial supply chains has increased by 15% over the past three years. Each of these items must pass through a warehouse or distribution center enroute to the ultimate customer. This is akin to the Apple Effect – the more new phones Apple introduces, the more new accessories there are and the distribution center has more items to stock.

- **Instant Customer Service Requirements.** As a result of the ability to order on the Internet, more direct to customer shipments are occurring each day from warehouses and distribution centers. This has several impacts on the facilities. The first is that the distribution center that used to have pallet storage, case storage, and bulk storage areas in the facility now have to also have an individual item picking and storage area in the

facility. This also impacts packing and shipping requirements and in many facility creates the need for a cross-docking area.[87]

- **Pressures to make inventories smaller yet more responsive.** Financial pressures to lower inventory levels puts pressure on the warehouse manager/distribution center manager. The typical act is to cut inventory levels across the board. The problem with this approach is that reducing inventory levels for nonproductive inventory or inactive inventory will not produce cost savings. The typical method for reducing the stockage levels is to reduce the level through attrition of the product and not replenishing to the previous levels. However, if the inventory is not moving, the opportunity to reduce the stocks through attrition is not available. The result from this technique is usually frustration and no visible improvements in the inventory values. The move to smaller inventories may be relooked by many companies after the panic buying of 2020 and the coronavirus pandemic. Perhaps some just in case inventory really is needed.

  The more productive technique to improve the responsiveness of the inventory while reducing the inventory value is to do an analysis of the inventory activity. If an item is no longer moving, it may be time to completely eliminate the product from the stocks. Then after the nonproductive inventory is removed, the active stocks can be

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[87] Cross Docking according to the APICS Operations Management Body of Knowledge is "a distribution technique in which items are brought into a distribution center for immediate dispatch. Instead of being received and stored away, these items are loaded into the distribution center's sorting system or are taken directly to shipping for sorting and dispatch." *APICS Operations Body of Knowledge*, 2010, p. 22.

reduced to improve the inventory turns and responsiveness to the needs of the customers.[88]

- **Pull Philosophy.** The pull philosophy is an outgrowth of Just-in-Time. The details of Just-in-Time and the pull philosophy or pull methodology are discussed in Chapter 11. The fundamentals of pull state that an item will not be moved or shipped until someone has ordered or requested the item. The impact on the warehouse or distribution center is that the product has to be on hand in order to be available when the customer asks for it. This concept is counter to the previously discussed pressure to reduce inventory levels.

- **Smaller transactions.** This has already been discussed in other areas. The number of smaller transactions requires more space in the facility to handle the individual item picking and packing. This also requires additional personnel in the facility.

- **Value added services.** We have already discussed the use of value-added services in the distribution centers. The pressure to add these services impacts the space utilization in the facility and the number of personnel required to add these services to the offerings of the facility to improve customer satisfaction. When Polo added embroidery services, they had to carve out space from the existing distribution center rather than add on to the facility.

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[88] One particular distribution center called their inactive stocks as "dormant" stocks to avoid calling the stock nonproductive. This particular facility had over $63 billion dollars in "dormant" stocks. Their definition of dormant was no orders for the item in the past two years and no replenishment actions in the past year.

- **English as a second language.** The biggest complaint in the distribution business today is that the number of workers that do not speak English or speak English as a second language. This is primarily because there are certain jobs that some Americans will not do anymore. Driving a forklift eight hours a day fits into this category.

  However, this is not a new complaint. In 1945, the biggest complaint in the warehousing industry was that the workers did not speak English. This was a result of so many men deployed to Europe or the Pacific Theater to fight in World War II. This problem is not going to go away. The solution is that management has to learn another language. One facility that I worked with in Southern California had a predominant number of Spanish speaking workers and very few Spanish speaking managers. This facility complained that productivity was not good and even bragged about being "the worst distribution center in the country." Their issue was a language problem. Only one manager spoke Spanish and only a few of the workers spoke English. The answer was to enroll managers in Spanish classes and workers in English as a Second Language classes.
- **Complicated WMS and proliferation of systems.** Every week a new advertisement hits my e-mail box about a new Warehouse Management System or new/updated Enterprise Resource Planning program. Not only do these systems continue to expand and change, but they continue to become more and more complicated. These systems require additional training and systems analysts to keep the chains strong.
- **Integration of online and bricks and mortar operations.** Traditional operations were always bricks and mortar operations. The traditional stores had a traditional way of doing business. These stores received shipments from the distribution center or warehouse and sold the products to customers in the bricks and mortar stores. With the advent of the

Internet, stores had to change their strategies and were forced to incorporate sales through the Internet to customers that may never walk through the door of the bricks and mortar store. This change in customer support strategy also impacted the way items were stored in distribution centers and warehouses.

The purchase of Whole Foods by Amazon caused a reverse of this. Amazon had to learn how to apply their years of online experience and apply it to a brick and mortar operation.

- **Smaller orders.** The trickledown effect from the change in customer support requirements was the realization that customers ordering over the Internet were ordering smaller quantities of products. These smaller quantities required new picking techniques and new picking areas to support individual item orders vice rather than the traditional case lot or pallet load shipments from the warehouse or distribution center to the stores.

- **Returns.** In Chapter 17 we will discuss the returns and reverse logistics problems and processes in great detail. The reverse logistics problem is nothing new but the increase in the number of items coming backward from the intended customer has created a whole new industry. In addition, the increase in returns and the focus on returns as a way to capture costs from the system has created a requirement for distribution centers and warehouses to have an area for returns processing and the need to store the returned products until the products are back on a store shelf or disposed of properly.

- **The appearance of 3PL providers.** A 3PL provider is a third-party logistics support provider. Once companies realized that doing logistics and distribution was not a core competency, 3PL companies started appearing around the world. These companies

provide the services, warehousing, logistics, and transportation that have been outsourced by companies. There are now over 1,400 companies in the United States alone that perform these functions as a core competency that other companies have determined are not core competencies but are still critical to the success of the company.

Warehousing Management

Warehousing focuses on the storage of products whereas distribution centers focus on the short-term storage and rapid movement of products through the distribution center and out to the customer. Warehouses are concerned about storage times and holding times while distribution centers are concerned about throughput rates. The throughput is the amount of products flowing in the receiving door and out the shipping door. The use of cross-docking helps to improve throughput rates. Cross-docking is a methodology for managing the flow of products by managing the inbound products and synching these products with the outbound flow of products. This method increases the throughput through the facility because the items being cross-docked never go into a storage facility. These products come in one day and are out of the facility within 48 hours or less. Most major distribution centers have created a cross-docking area to hold products until the products are loaded on an outbound truck. This concept not only increases throughput and reduces inventory investment levels, it also increases the speed of the product to the customer.

Warehousing/Distribution Center Functions

- **Receive:** This is the function of unloading the inbound freight. The accuracy of the performance of this function sets the stage for the success of the overall operations. If the receiving function is not properly performed, the product and product quantities will not

match what should be on the shelves and the ability to properly support the customer will be impacted.

- **Putaway:** Once the products have been received at the warehouse or distribution center, they have to be put on a shelf if the products are going into storage locations or moved to the cross-docking area if the products are identified for cross-docking. The importance of accurate and proper putaway is critical to the overall success of the facility. If the items coming into the facility are properly identified at the receiving docks and put in the proper location then the right item will be in the right location in the right quantity when a customer orders that item.

  Putaway also involves housekeeping in the facility. When items are placed on the shelves or in a storage location, the items must be placed neatly in the location. This helps to make sure the warehouse/distribution center worker can properly identify the items when performing the picking function discussed below.

- **Store:** This function is relatively self-explanatory. This is the warehouse/distribution center function of keeping items on the shelf or in the facility. This is the focus of warehouses.

- **Pre-packaging – kitting:** This function of distribution centers is the concept of putting items of like use together to create a "kit" that can be shipped as one item. A prepackaged oil change kit is an example of this. The distribution center may kit the oil, filter, and filter wrench into one kit with a new stock number that will be sold as one item rather than three separate items. Some repair parts facilities not only kit the items together but

by storing items by vehicle type in the distribution center create a warehouse in a warehouse similar to the concept discussed earlier.

- **Order entry:** Order entry may be automated and linked to the warehouse management system or could be a manual entry "fat-fingered" in by someone in the warehouse or distribution center. This is another critical function to the success of customer service operations. If the wrong stock number or SKU is entered into the system, the wrong item will be picked by the warehouse/distribution center worker and if an audit of the shipment does not catch this error, the customer will get the wrong product or the wrong quantity of the right product.

- **Picking:** This is the physical function of getting the items off the shelf and ready for shipping. Picking may be accomplished by sending workers to various zones or sections of the warehouse/distribution center and then consolidating the items into one shipment or the picking may be accomplished as an order where one worker travels through the facility picking all the items for the order before moving to another order.

  Picking may be done from a printed pick list with SKUs, storage locations, and quantities. Picking may be accomplished with a manual pick list. More modern distribution centers are using either "pick to light" where the worker stops at the next location with a light and either uses an accompanying pick list or the location will have an LED with the number to be picked; or the picking may be performed using voice picking which is relatively new compared to the other picking techniques.

  With voice picking the worker has a headset linked to the warehouse management system that directs the worker to the next location and tells the worker how

many to pick from that location. Before the voice picking system will allow the worker to move to another location, the worker must confirm the location and the quantity picked. This system frees up both hands to pick the items and move the tote or cart to the next location and is a more accurate system for picking items in the facility.

The more accurate the picking process runs, the more accurate the items and quantities in the shipment to the customer will be and the more satisfied the customer will be. This has two benefits. The first benefit is that the customer will most likely buy again if satisfied and the second benefit is that the proper shipments help reduce returns thereby saving money for the company.

- **Packing—includes checking for completeness; labeling; weighing; loading:** This is the function of preparing the items for safe shipping. If the items are properly packed, they should arrive undamaged when delivered to the customer. Packing the item is more than just putting it in a box or envelop. The packing department has to know what size package to use, if additional packaging is needed to protect the item. Packing also includes ensuring the address is correct, that the item is properly labeled, weighed, and prepared for loading to the outbound movement. The checks of the packing department help to ensure that the packages are delivered to the right customer.

An example of the checks at the packing department comes from a distribution center in Kentucky that was experiencing a large number of discrepant shipments. The packing department was not checking the accuracy of Zip Codes and Addresses. For example, shipments to Missouri had Zip Codes for Massachusetts. The result was delays in shipping to the customer and a decrease in customer satisfaction. A simple matching of

addresses and Zip Codes in the packing department significantly reduced the number of delayed shipments.

- **Shipping:** This is the last function under the control of the distribution center or warehouse. Accurate shipping is critical to customer satisfaction. As discussed earlier, some of the shipments via FedEx and UPS may be managed by the shipping company at the distribution center to facilitate accuracy and speed. Some shipping companies will actually plan the shipping manifest and loading to facilitate more efficient shipping from distribution centers to customers or transshipment sites.

All of these functions feed:

- **Perfect order fulfillment.** Perfect order fulfillment is a metric of distribution center effectiveness and efficiency, as part of the overall supply chain. Perfect order fulfillment is a measure of how well you are meeting the needs of the customer. This metric looks at the ability of getting the right item to the right place, at the right time, in the right quantity, in the proper condition, and with the proper billing. The calculation for perfect order fulfillment is shown in Equation 15-1.

Right Item % x Right Quantity % x Right Place % x Right Condition % x On Time Delivery % x Correct Billing %

Example:

Right Item % = 99%

Right Quantity % = 99%

Right Place % = 99%

Right Condition = 100%

On Time Delivery % = 99%

Correct Billing/Invoicing % = 99%

Perfect Order Fulfillment = .99 x .99 x .99 x 1.00 x .99 x .99 = 95.09%

Equation 15-1: Perfect Order Fulfillment

- **Carrying costs.** As we had seen when we discussed inventory management and the Economic Order Quantity in Chapter 11, the carrying costs for a distribution center's inventory includes the opportunity cost of the money used for the inventory, the insurance for the inventory, the overhead allocated to the inventory items, the cost of the labor to count, pick, pack and ship the items, and the costs of loss or obsolescence. A

properly managed distribution center or warehouse will have lower than the industry average for carrying costs.

- **Loss.** This could be loss of inventory as a result of mi-shipment, theft inside the supply chain, or employee theft. The distribution center management must be involved in the security of the inventory to prevent pilferage by the employees and theft from outside the distribution center. The distribution center management must also be engaged and constantly monitoring the housekeeping of the center. Proper housekeeping will prevent the internal mis-shipment and items placed in the wrong locations that give the illusion of losses.

- **Damage.** Damage in the warehouse or distribution center is inevitable. When things are moved or sit for long periods of time as they do in warehouses, things get damaged. The goal of the distribution center management or the warehouse management team is to minimize this damage. Some of the damage can be eliminated by changing the metrics for productivity in the facility. In one facility that I had the opportunity to do some work with, this was the case. The metric for productivity in most facilities is items or orders picked per hour—a measure of how many different items are taken off the shelf to prepare for shipment to the customers each hour. In this particular facility, no attention was given to the condition of the items or the techniques used to pick the items. What was happening in this facility was that the workers had "cracked the code" for productivity. They realized that the key to higher productivity was not to take the time to take the items off the top pallet in a stack of three high but to simply pull a can or two out of the middle pallet. This saved time and improved their items per hour metric. However, what it created was a lot of pallet stacks that were leaning like the Tower of Pisa by the

end of the day. The other result was that cans in the middle pallet were bent and damaged from the shift in weight placed on them. This problem was preventable with management oversight and training.

- **Mis-shipment.** This is the problem of items going to the wrong customer. This problem is fixable and preventable with proper supervision and training. I am not an advocate of 100% inspection of every shipment to prevent this, but regular spot check sampling and proper training coupled with good housekeeping in the facility helps to ensure that the right product goes to the right customer.

- **Frustrated Cargo.** This is really a misnomer. The cargo is not frustrated. The one that is frustrated is the warehouse manager. Frustrated cargo is a distribution term that describes cargo or shipments that are either not deliverable or the customer cannot be located. Frustrated cargo can be a huge problem for distribution centers and warehouses. Frustrated cargo represents materials that have been prepped for shipment, represents money tied up in products that are not available to other customers, and may end up as "lost" products. In one distribution center a couple of years ago there was a pallet of frustrated cargo that sat in the same place for so long that it became invisible to the workers and became lost even though every worker had to pass the pallet almost every day and some of them multiple times a day.

In Kuwait in 2003, we had an area we called the miscellaneous line. The miscellaneous line was two pallet positions wide and about one hundred yards long. These pallets were technically frustrated cargo, but we renamed it miscellaneous cargo. The miscellaneous cargo was cargo that the customer unit could not be identified because

of the loss of shipping labels or unknown customers such as the Defense Intelligence Agency and the Embassy.

Frustrated cargo is not necessarily an indicator of poor facility management. But the handling of the frustrated cargo may be an indicator of poor management. A good facility manager will dedicate resources to research the frustrated cargo and the causes of the frustrated cargo in order to better serve the customers.

Factors Influencing Distribution Operations

Time is critical in today's distribution operations. The most successful distribution and warehousing operations are those that focus on reducing every aspect of the distribution operations. This is accomplished by walking the process and identifying areas that can be improved and getting rid of the non-value-adding, time-consuming processes that are impacting customer responsiveness of the facility.

Just as time is critical to the customers of the distribution systems, quality is also important to the customers. This is not just the quality of the product; it is also the quality of the distribution system from the suppliers' suppliers to the customers' customers. This includes error-free delivery. If you buy a new washer and dryer from a store, you expect the delivered products to match what you picked out in the store. If the delivery workers drop the dryer off the back of the truck the quality of the system is jeopardized. If a company outsources the delivery this should not change the expectations for quality in the distribution system.

The workforce mix is a challenge as distribution systems continue to try to provide quality support to their customers. This workforce mix is a combination of cultures and generations. The challenge for leaders of distribution centers is to get the most out of their employees. The challenge is to first understand what motivates each individual employee and to

understand the language and culture of the employees. The leader must motivate the workers to want to provide quality support to the customers. Without an understanding of the language and/or the background or culture of an employee, a leader cannot motivate the worker.

Safety is another aspect that impacts operations in the Warehouse or Distribution Center. The Occupational Safety and Health Administration (OSHA) provides very strict safety guidelines for facilities in the United States. These guidelines sometimes appear to be hand-cuffing the management of the facility to improve operations but are provided to prevent worker injuries. In the Warehouse forklifts pose a great threat to safety if these OSHA guidelines are not adhered to. Here is an example of an unsafe practice in a facility outside the United States. Figure 15.1 is an example of unsafe facility practices.

Figure 35.1: Unsafe Pallet Storage in Panama

Types of Facilities— Private versus Public

Most facilities fall into either categorization of a Private Warehouse/Distribution Center or a Public facility.

Private. A Private Warehouse/Distribution Center is wholly owned or wholly leased by one company and stores only the products of that one company. This form of storage provides control to the owner or lessee of the facility. This control comes in the form of what products are stored and control of the management of the facility. If the facility is occupied by the owner, there may be tax advantages for owning the facility and the possible advantage of an increase in value for the facility and the land that it sits on. The downside of private facilities is the fixed costs and overhead for owning the facility. There is also an assumption that there will be enough sales and stocks to make the ownership of the facility profitable. At the same time, there is an intangible benefit of having your own facility.

Public. A Public Warehouse/Distribution Center can store products for multiple companies in the same facility. The advantage for the companies using this facility is that they do not have to own the facility to use it and only pay for the area that is used. This may be to meet peak requirements or abnormal demand requirements. Another advantage of using a public facility is the ability to store products in a facility operated by a company whose core competency is running a distribution facility. Because the company running the public facility has this as a core competency the exact costs of the storage and distribution operation will be known by the companies using the facility.

One downside of the public facility is that the needed space may not be available for peak periods when the space is needed. Another potential downside is that if a company has a

specialized storage requirement the expertise may not be available in a public facility that would be available in a privately owned facility. One more major drawback of the public facility is the compatibility of warehouse management systems. Not all warehouse management systems are the same and may require either manual intervention or middle ware to translate information from a company's system to the public facility's automated systems.

Warehouse/Distribution Center Layout and Design

The design of the facility will enhance the profitability of the warehouse or distribution center. The primary goals of the distribution center or warehouse design is the maximization of space utilization (both square footage and cube footage) while minimizing the movement of products in the facility. These goals may be accomplished by using cross-docking or by analyzing the velocity of the products. The other goals discussed in the discussion of facility layout and design also are applicable for warehouse and distribution centers.

Figure 15.2 shows a layout option for consolidating shipments at a transshipment facility to produce full truckloads to customers. This diagram from the US Navy Supply Publication 590 shows the flow of products in a transshipment distribution center.

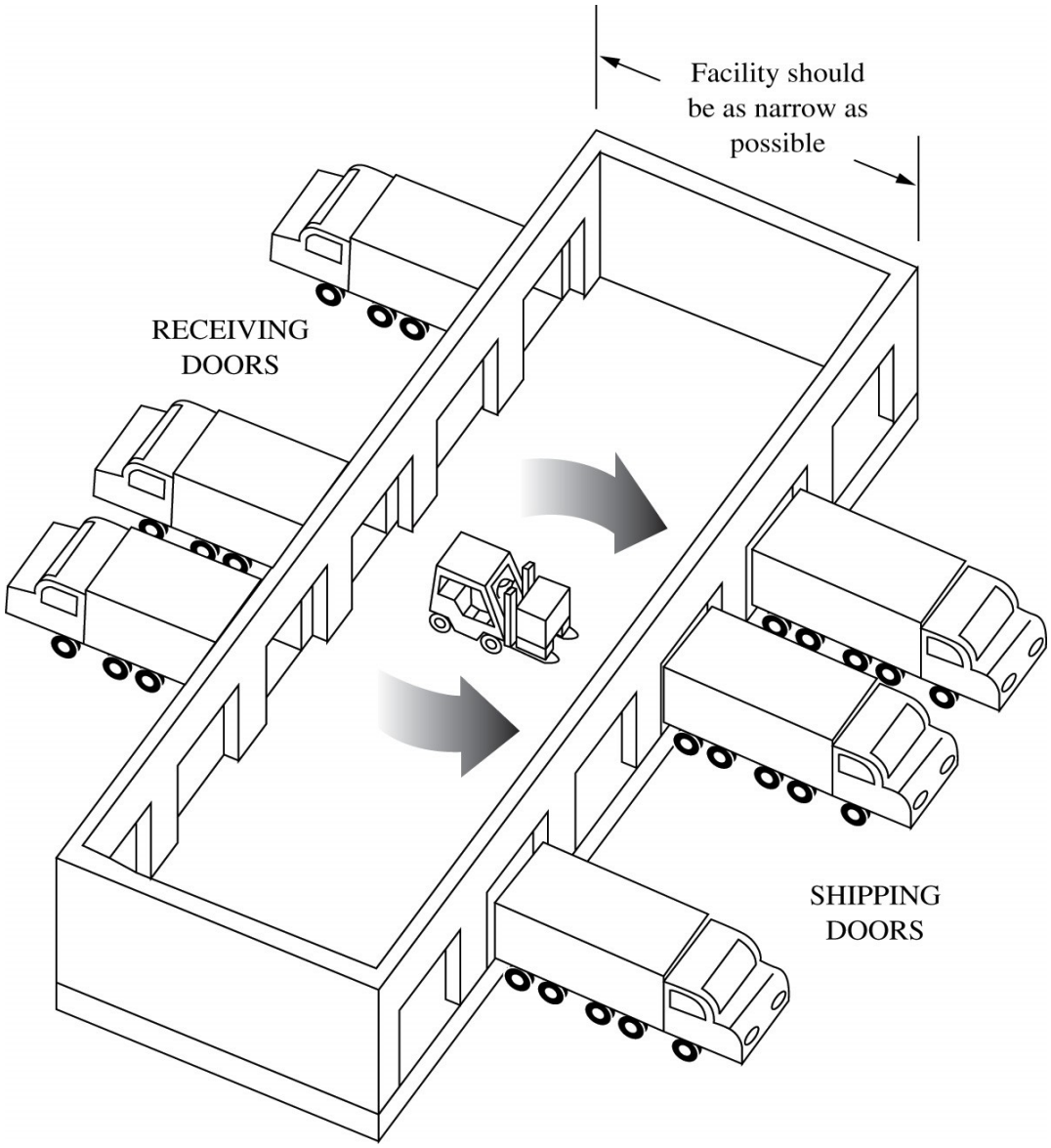

Figure 15.2: Ideal Facility for Pure Supplier Consolidation (Full Pallet Movement)

Figure 15.3 shows a typical flow pattern for distribution centers. This flow shows a logical flow of products through a facility to minimize movement and maximize space utilization in the facility.

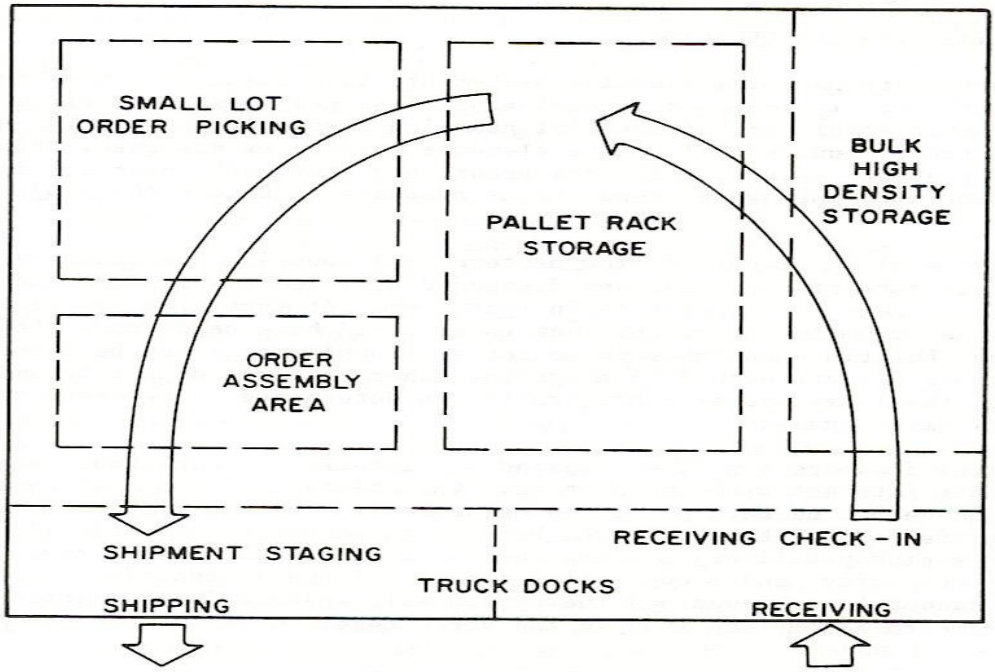

Figure 15.3: Logical Flow Pattern in a Distribution Center

Cross-Docking

As discussed in previous chapters, cross docking is a methodology to reduce inventory value (thus increasing turns) while decreasing the time that the product is in the distribution center (also impacting turns). Cross-docking is nothing new. It is a methodology of knowing what is coming in and synchronizing the inbound shipments with the outbound shipments. For example, in Figure 15.3 the product would go from the receiving area to a holding area to the

shipping area. The goal of cross-docking is to have the product in and out of the facility in less than 48 hours. This is not that different from the operations of the Pony Express that ran from St. Joseph, Missouri to points west. The packages came in and went out in the same day. Wal-Mart executives have claimed that they invented cross-docking. They did not invent it but Wal-Mart has worked hard to perfect cross-docking. Cross-docking is not easy to accomplish but once implemented can reduce costs and improve distribution metrics to include inventory turns and customer responsiveness.

Cross-docking success depends on several key factors. The primary factor is world class communications. Communications is necessary to ensure that the facility knows what is coming in so the outbound shipments can be planned. Communications is also critical to achieve synchronization between the facility's inbound and outbound transportation partners. This synchronization is also a product of good transportation planning and reliable forecasts of product demands.

Attributes of World Class Warehouses and Distribution Centers

- **100% Inventory Accuracy.** This is a must. A facility has to have 100% accuracy in their inventory counts and inventory accountability. Proper storage techniques, proper employee training, and good housekeeping will contribute to this metric. Anything less than 100% is not acceptable. This means that something is not being done right in the facility and the automated system does not match the physical count of the products. Anything less than 100% means lost profits and lost time researching why the inventory levels do not match the automated books.

- **Perfect Order Fulfillment.** Although we have already discussed this in detail, it is important to mention it again as a measure of world class warehousing/distribution.

Customers have access to inventory and shipment data online and expect delivery when promised.

- **Value added services.** Although there is no metric for this attribute, providing these value-added services or postponement services is important to attract and keep customers who have a choice of service providers.

- **Cleanliness.** There is no metric for this attribute either; however, the cleanliness and housekeeping of the facility will contribute to the perfect order fulfillment, inventory accuracy, and on-time deliveries by being able to find the right product when needed.

- **Time Definite Delivery.** This attribute is tied to transportation planning and synchronization. Time Definite Delivery tells the customer exactly when the vehicle will be at their facility. The opposite of Time Definite Delivery (TDD) is the cable companies that tell you they will be there sometime between 8:00 and 12:00 forcing the customer to sit around and wait. With TDD, the customer can plan his/her workforce around the time that the truck will arrive in order to quickly off load the vehicle.

- **On-time deliveries.** This attribute is related to TDD. This metric is measured from the perspective of the customer. How often does the shipment arrive when promised? One company was allowing their contracted trucking company to measure this for them. Amazingly, every month the company was very close to perfection. But when measured by polling customers, the on-time delivery percentage was much lower. To be world class a company has to be as close to 100% on-time delivery as possible.

- **Employee Education Programs.** The Toyota North American Parts Distribution Center has a requirement for over 80 hours a year in mandatory training programs for every

employee. Keeping employees up to date on new technologies or old methods for standardization is important to get distribution centers or warehouses to world class or to maintain world class levels of performance.

- **Safety.** This is important for any operation but for warehouses and distribution centers this must be considered and enforced. No matter how good a distribution center thinks they are, a safety problem will negate any other activity.

- **Obsolete Stocks.** A well-run facility will have the right items on the shelves in the right quantities to support their customers. The amount of stocks that are obsolete drive up costs and reduce the value of the inventory. In addition, if stocks become obsolete these stocks must be disposed of. This adds more costs to the operation.

- **Turns.** Inventory turns is a measure of how fast the inventory on the shelves is replenished. As mentioned earlier, this is a very misunderstood metric. Not because of the calculation of Cost of Goods Sold divided by the Average Value of the Inventory, but because of the interpretation that what is good for one facility is the right number for another facility. To compare turns the benchmarking must be between like facilities or industries. There is no one size turns metric.

- **Processing Times.** A world class facility is measuring their processing times in minutes. How many minutes does it take to clear the floor, pick an order or load a truck?

- **Cross-Docking.** A world class facility employs the concept of cross-docking discussed earlier. This not only improves inventory turns but reduces the average processing times by not having to place the items that are cross-docked on the shelves and later having to pick these items.

Summary

Distribution Centers and Warehouses are different in nature in that warehouses focus on longer storage times. However, the metrics and tools to improve facility operations are similar. The goal of every facility manager is to ensure that his/her facility is not the weakest link in the supply chain.

Discussion/Review Questions

1. Why is perfect order fulfillment so critical to successful operations?
2. What are the attributes of world class distribution systems?
3. Why is cross-docking important to reducing customer response times?
4. A company has calculated their inventory turns at 12. Is this good or bad? Explain your answer.
5. A company has calculated their Cost of Goods Sold at $25,000,000 and their Average Inventory as $12,500,000. What is their inventory turns rate? Is this good or bad?
6. A company has 14 inventory turns a year. The average turns calculation for their industry is 28. What should the company do to improve their turns?
7. Why is a flow important to the success of a facility?
8. What is Time Definite Delivery? Why is it important from the customer perspective?
9. From what perspective should on-time delivery be measured?
10. Think about the historical development of logistics, why is it necessary to understand the history of logistics and warehousing?
11. What is the difference between a public and a private facility?
12. How do warehouses and distribution centers differ?
13. What is the advantage of a fulfillment center?

Chapter 16

Inventory Management

Empty Shelves (as shown in Figure 16.1)– are they empty because of poor inventory management or poor forecasting? A good case could be made for either. Obviously with the panic buying of 2020, no one could have forecasted the rush to hoard products or stock enough products in a store to accommodate the rapid demand for inventory. However, contingency planning for inventory could have partially alleviated some of the stockouts.

Figure 16.1: Empty Shelves in Florida in 2020

Proper and accurate inventory management is critical to the overall success of the supply chain and the operations management chain. This is one of the strongest links between operations management and accounting. Inventory management is an accounting activity. Some of the banks in Brazil are starting to see the link between finance and inventory management. These banks are starting to view ATMs as retail outlets, the banks as mini-distribution centers,

the central bank as the long term storage warehouse, and the inventory is the cash in the ATM. They have to determine the inventory levels for the retail outlets (ATMs) and the reorder points to keep these retail facilities stocked.

The inventory manager must answer four basic questions and work closely with the forecasting to ensure that the right amount of inventory is available. Most texts only list the first three questions, however, in 21st Century Supply Chains, the fourth question is just as important. The four questions that must be answered by the inventory manager are:

1. What should be ordered?
2. When should it be ordered?
3. How much should be ordered?
4. Where should it be stocked?

The goal of this chapter is to help the operations manager and the inventory manager answer the first three of these questions. Question number 4 is linked to location analysis and an understanding of the customer base and customer clusters. Answering these questions creates a balancing act for the inventory manager. How much is enough and how much is too much?

What Is Inventory?

Inventory is an insurance policy against stocking out and against not having what the customer wants at the time that the customer wants it. The APICS/ASCM Dictionary defines inventory as:

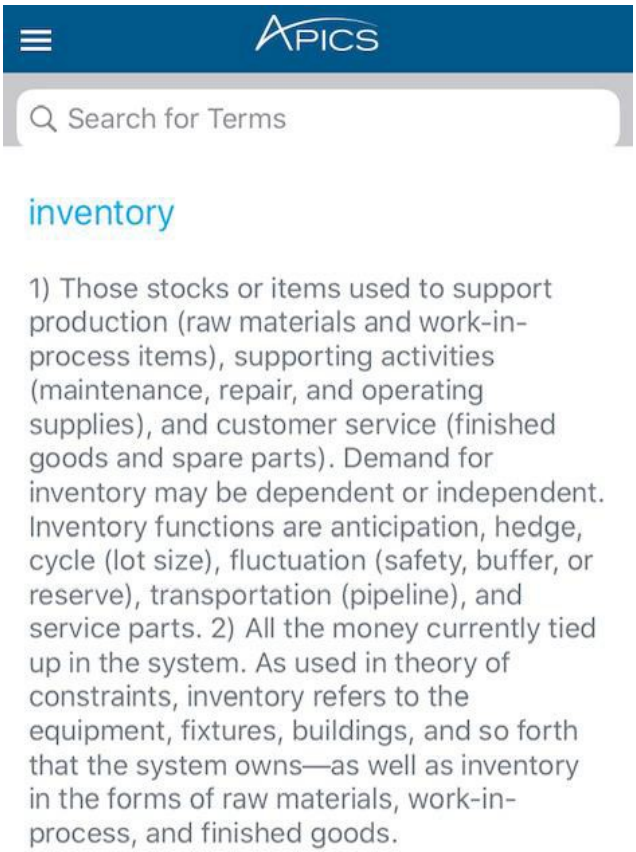

Figure 16.2: Screenshot of APICS Dictionary App definition for Inventory[89]

Unlike automobile insurance or homeowner's insurance, for this form of insurance you want just the right amount and you want to use your insurance. Most people that pay for insurance buy the insurance with the hope that it will never be used. The insurance known as inventory is one type of insurance that you want to use every day in meeting the customers' needs because the reason for the insurance level is based on your desired customer service levels. You want your insurance to be there to prevent the customer from going to the competition. This is where the balancing act comes in. You want enough inventory to meet the needs of the

[89] The APICS Dictionary app is available for free from the Apple Store and provides a readily available resource for supply chain and operations management terms.

customer without having so much inventory that it goes bad, becomes obsolete, or costs the company large amounts of money to store the product while waiting for the customer to want the product. Inventory that does not sell is a liability to the company and consumes resources that could be used for other activities or for more of the right inventory.

There is another balancing act in inventory management. This balancing act is between the financial managers, the inventory managers, and the procurement/acquisition managers. Financial managers see inventory as a liability because the only good inventory to the finance managers is cash. Therefore, finance managers want lower inventory levels and higher levels of cash. Inventory managers want high stockpiles of the right raw materials. Marketing managers want the proper levels of finished goods to meet customer needs. The procurement/acquisition managers have to purchase the right amounts of inventories to meet the production requirements and finished goods requirements while trying to keep the financial managers happy at the same time. This is one reason why procurement folks usually do not smile much.

Inventory is simply the stocks maintained by a company to meet normal demand patterns. Safety stock is maintained to cover the variability in demand. The decisions made concerning inventory levels and the types of inventories maintained have impacts other areas of operations management and may impact positively or negatively the profitability of the company.

Types of Inventory

There are many different types of inventory that a company may have to meet the customers' needs. This list is not an exhaustive list, but it does show the primary forms of inventory.

- **Raw materials:** In any manufacturing operation, somewhere in the manufacturing chain raw materials are needed to produce products. The operations manager has to manage the inventory levels of raw materials, especially if there is a shelf life for the raw material. In other words, will the materials spoil/rot/deteriorate over time if more than the required amount is stocked or if the amount stocked exceeds the needs of the company?

- **Purchased parts:** If the company does not make the product from raw materials then it will most likely stock the assemblies that will be used to assemble the product. Raw materials and purchased parts are not an either/or stockage. A company may use some raw materials for certain parts of the product and assemblies for the rest of the product.

- **Labor:** Most textbooks will tell you that this is a form of inventory. It is included in this list to show that in the real world this should never be considered a form of inventory. The reason for this is that with the exception of professional sports, labor is not bought and sold or stored waiting for consumption like inventory. During the eighteenth and nineteenth centuries, in the United States (and continuing into this century in some countries)[90], the use of people as a commodity that was bought, sold, and traded was practiced. This practice almost destroyed the United States and is still impacting the country over 150 years after the practice was abolished. The picture in Figure 16.3 is the Old Slave Mart in Charleston, South Carolina. This Mart was the largest in the United

[90] One of the biggest concerns and areas of interests in 21st Century Supply Chain is who is making the product and is the worker being forced to work in the factory or serving some form of indentured servitude or slavery while working on the products. Concerns center around knowing what is going on in a supply chain and what suppliers are doing to produce the goods at the low prices.

States and continued to operate long after the sale of slaves was outlawed in the country. **The key with people is: you manage things and you lead people! In other words you manage inventory and since you do not manage people, they should not be considered a category of inventory. Companies do not own their employees and although employees are the greatest asset of a company, they are led not managed.**

Figure 16.3: The Slave Mart in Charleston, South Carolina

If you are ever in Charleston, SC, I highly recommend that you visit this museum to remind you of what this type of activity can do to a person and a country. The effects of this activity linger today and can be seen from a historical perspective in Kansas City, MO, at the Negro Leagues Baseball Museum. [91]

[91] The Negro Leagues Baseball Museum (www.nlbm.com) was established to memorialize the time period when baseball was segregated and people of color were not allowed to play in the Major Leagues of Baseball. Like the Old Slave Mart Museum in Charleston, SC, this museum is a great place to get an historical perspective of what life used to be like in the USA.

- **Work-in-Process (WIP):** Work-In-Process inventory is simply items that are somewhere between raw materials and finished goods. WIP is partially completed products and is the only form of inventory that everyone in the company agrees is a liability. WIP has no value to anyone. It cannot be sold as a finished product and cannot be put back on the shelf for later use. Figure 16.4 shows work-in-process at Krispy Kreme Doughnuts. The process for producing a doughnut involves a "rising" process for the formed doughnuts and then the raw doughnut is placed in the hot oil to cook the doughnut. The doughnut is then flipped so that both sides of the doughnut get evenly cooked. Even a lover of hot Krispy Kreme doughnuts would not want a half-cooked doughnut. Sometimes the doughnut does not flip. In this case the WIP doughnut is thrown away before the product reaches the frosting waterfall.

Figure 16.4: Doughnuts as Work-In-Process at Krispy Kreme

In a manufacturing environment WIP builds up behind unbalanced workstations (refer back to the discussion on process design) and may show an inventory manager where the constraints are in the process. Like the half-cooked Krispy Kreme doughnuts, the WIP in the manufacturing environment is of no value to the company or the customer.

Work in Process inventory is considered a liability by everyone in the supply chain, efforts to reduce WIP will help contribute to adding value to the operation.

- **Component parts:** This inventory category includes the nuts, bolts, screws, washers, and fasteners used to assemble a product. This type of inventory is not usually the high dollar inventory items but is just as critical to the success of the manufacturing operations and should not be neglected. A $2 dollar component may be just as important to the assembly of a product as the $2000 component.

- **Maintenance, Repair, and Operations (MRO):** This is an aspect of inventory that is often overlooked by most academic textbooks. According to the *APICS Operations Management Body of Knowledge*, MRO inventory is defined as: "items used to support general operations and maintenance, such as spare parts, and consumables used in the manufacturing process and supporting operations."[92] Although these parts are critical to the successful operations of a facility or manufacturing process and not the glamorous inventory items like raw materials and finished goods inventory, MRO inventory should be managed as carefully as other forms of inventory. A spare part for any of the machines or material handling equipment will bring an operation to as quick a stop as the shortage of the component parts. While managing MRO inventory it is important to remember that a $6.00 fan belt can cripple a machine as quickly as a $3000 engine. This makes it critical to understand each item that is or may be stocked in MRO inventories.

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[92] MRO, *APICS Operations Management Body of Knowledge*, 2nd edition, APICS, Chicago, IL, 2010, p. 45.

MRO inventory is not limited to manufacturing operations. In an office setting MRO inventory is found in the supply room as office supplies. Work in an office can come to a halt without the necessary office supplies. Can you put together a professional presentation without printer cartridges or printer paper? Of course, you cannot.

MRO supplies are also necessary in an academic environment. Imagine trying to take an exam in a large classroom without the printed exams or the scantron sheets or the "blue" essay books, or pencils?

- **Working capital:** This is the finance manager's favorite form of inventory. This form of inventory is necessary for the success of the any operation. A lack of cash flow or available cash will cripple any operation regardless of the size of the company.

- **Tools, machinery, and equipment:** In a manufacturing environment or in a distribution operation, the tools, machines, and equipment used to make the products or move the products are part of the inventory. If the proper levels of this category of inventory are not maintained, the capacity and production capabilities of the company could be significantly reduced.

  In the distribution center a shortage of pallet jacks, pallet racks, or forklifts can impact the ability to provide rapid response to the customers. In the classroom the shortage of desks or chairs impacts the capacity of the school to provide quality education if it means students are sitting in folding chairs or on the floor.

- **Safety stock:** Safety stock is an insurance policy on the insurance policy of inventory or maybe an insurance rider. Safety stock is stockage above normal stock levels to help prevent a stockout due to increased demands for the product, longer than normal lead times for replenishment, or variability in the levels of the demand for the product.

The US Army's manual for warehousing operations refers to safety stock as a safety level and describes the safety stock as the "quantity of stock on hand to sustain operations in the event the demand rate changes unusually or the replenishment time becomes longer than expected. It is a safety factor intended to be used while replenishment requisitions are still due in." [93]

Safety stock does not need to be carried for every item. A company may decide to take acceptable risk with certain high dollar items in order to have safety stock for more less expensive items. After all, a smaller, less expensive repair part such as a fan belt can cripple a car just as quickly as a blown engine and probably a fan belt needs to be replaced more often than a complete engine. Therefore, a repair parts company will more likely have safety stock for fan belts and windshield wipers than automobile engines.

Nor does the safety stock need to be kept at each location. It may be more economical for the company to maintain safety stock at a central location rather than at every distribution center or at every store. A centrally located safety stock for a retail operation with 100 stores would mean one set of safety stock rather than 100 sets of safety stock. This concept only works if the centrally located safety stock can be delivered to the needed location quickly. This may be the justification for a safety stock distribution center located near the FedEx or UPS major sorting facilities. Otherwise, the savings from the centralized stock may be negated by premium shipping charges or lost sales due to stockouts.

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[93] Department of the Army Pamphlet 710-2-2, Supply Support Activity Supply System: Manual Procedures, Headquarters, Department of the Army, Washington, DC, 1998, p. 19.

- **Just-in-case:** Just-in-case inventory is the opposite of just-in-time inventory. Just-in-case stocks are kept in the inventory just in case a customer may want it. Just-in-case inventory is not supported by any calculation or inventory model. This form of inventory may or may not be demand supported or even productive inventory. In many cases, the just-in-case inventory may be reducing the inventory turns calculations because the inventory is not moving as it is there just in case someone orders it or asks for it.

  Sometimes just-in-case inventory is a good thing. Some items in inventory need just-in-case stocks to prevent stocking out of the items. Toilet paper is a good example of stocks that should be kept as just-in-case, because stocking out of toilet paper is not a good thing. Beer at a party is another example of the need for just-in-case stocks. Why? Because if you run out in the middle of the party there is a chance that the person going to get more beer will not come back to the party (especially when a flawed decision process allows a driver who has already had too much beer to pick up the beer).

  However, in the real world just-in-case stocks manifest themselves as stock on the shelves of the stores just in case a customer may need that product again in the future. The key here is to determine that point in the life cycle of a product that the repair part should no longer be stocked or how long a product should be kept on the shelf before it is removed from the inventory.

- **Vendor Managed Inventory (VMI):** This concept was discussed in the supply chain chapter but needs to be discussed here to complete the discussion of inventory. VMI is inventory on the shelf but does not count against the inventory value of the facility. The inventory on the shelf belongs to the vendor until it is sold by the store. An example of this is the tool department at The Home Depot. The tools belong to the vendors until the

product is sold. The bottom line of the VMI program is that the onus is on the vendor to keep the products stocked on the shelf.

Wal-Mart and Proctor and Gamble have perfected the partnership on VMI. The benefit to Proctor and Gamble is information on what is being sold in order to better schedule deliveries and production. The benefit to Wal-Mart is a savings of eight-man years per store per year by not having to count the products on the shelves, place orders for the items, receive the items, and place the items on the shelves. With "8,613 retail units under 55 different banners in 15 countries"[94] this amounts to approximately 69,000-man years for Wal-Mart. At an average wage of $12 an hour, this means that the VMI partnership with Proctor and Gamble saves Walmart approximately $1.7 billion annually.

- **Finished goods**: Upon completion of the manufacturing process, inventory may take the form of finished products awaiting shipment or waiting for customer orders in the case of make-to-stock items. If the forecasts are relatively accurate for the make-to-stock items, the amount of finished product held for sale will not become obsolete inventory. These finished goods may be in warehouses/distribution centers or may be in-transit inventory.

- **In-transit inventory:** This form of inventory is finished goods that have departed the manufacturing facility enroute to a distribution center or from a distribution center to a customer or retailer. The problem with in-transit inventory is that this inventory, if not enroute to a customer, is not available to for sale to a customer or available for use in a manufacturing facility. The goal of all companies is to minimize in-transit inventory. In

[9494] http://walmartstores.com/AboutUs/, accessed September 27, 2010.

2009, Maersk Lines announced that they would save over $1 billion (USD) by reducing shipping speeds by half. For Maersk Lines this move produced savings from reduced fuel costs. For customers of Maersk Lines this move doubled the in-transit times for product in-transit—more dollars tied up in inventory that is not available for sale to customers.

Addiction to Inventory. Unfortunately, the bottom line is that sometimes inventory is held in all of the above forms as an addiction. Some managers become addicted to inventory – the more one has, the more value that they perceive they are to the company (akin to the idea of he who dies with the most toys…). Inventory is used to cure ills and inefficiencies in a company's processes or supply chains. When I was at the US Army's National Training Center the first time, I had over 120 days of inventory on hand. The average lead time/replenishment cycle was over 58 days if I did not have it on the shelf.

My customer base changed every 28–35 days. Simple math shows that any item ordered by a customer that was not on my shelves probably would not during their training cycle of 28-35 days. But because I had so much inventory on the shelves, I was not worried about any shortfalls or possible inefficiency or inefficiencies in the supply chain. All of my supply chain ills were cured by the huge pile of inventory on my shelves. This pile of inventory is sometimes referred to as mountains of inventory.

No good discussion of inventory management is complete without some form of a "water" diagram. In Figure 16.5, the water level represents inventory levels and the boulders under the water represent the problems or ills cured by the inventory. As long as the water level remains high the inefficiencies or boulders are not a problem.

Here is where this text and other texts disagree. Most texts recommend lowering the inventory levels to reveal the inefficiencies—or in line with the water analogy, lower the water level to reveal the boulders. The problem with this is if the water is lowered, the boat will hit the rocks, or the waterway will be impassable. This technique also assumes that all inventory is productive inventory. Reducing nonproductive inventory has no impact on the operations and will not produce savings or reduce inefficiencies.

The best way to improve inventory efficiencies while reducing the inventory levels is to start by walking the process and identifying the inefficiencies protected by the excess inventory levels. Then and only then should the inventory levels be reduced.

The solution to the high levels of inventory at the National Training Center was to walk the process and identify the inefficiencies that drove the high levels of inventory. While walking the process it was discovered that the shipping time from the supporting wholesale distribution center was taking ten days on average. However, the driving time from the distribution center was eight hours in a small Ford Escort.

When asking questions as to why it was taking so long for the delivery, it was discovered that the company point of view was: “We’ve been delivering here for almost twenty years. The first time we delivered there we had a mechanical problem and it took ten days. No one complained, so we assumed ten days was the standard.”

Further questioning produced a new solution. The transportation manager said, “We can close the door on the truck at 8:00 p.m. tonight and deliver to your door by 8:00 a.m. tomorrow morning.” By walking the process almost ten days was removed from the in-transit time. This improvement allowed us to reduce the inventory levels accordingly.

Each subsequent process walk revealed more inefficiency in the system. Each time any inefficiency was identified and fixed the inventory levels were further reduced again.

Walking the process, identifying inefficiencies and fixing them enabled us to reduce the inventory level from approximately $200 million (USD) to approximately $20 million while reducing the replenishment times from 58 days to 4.6 days over a couple of years.

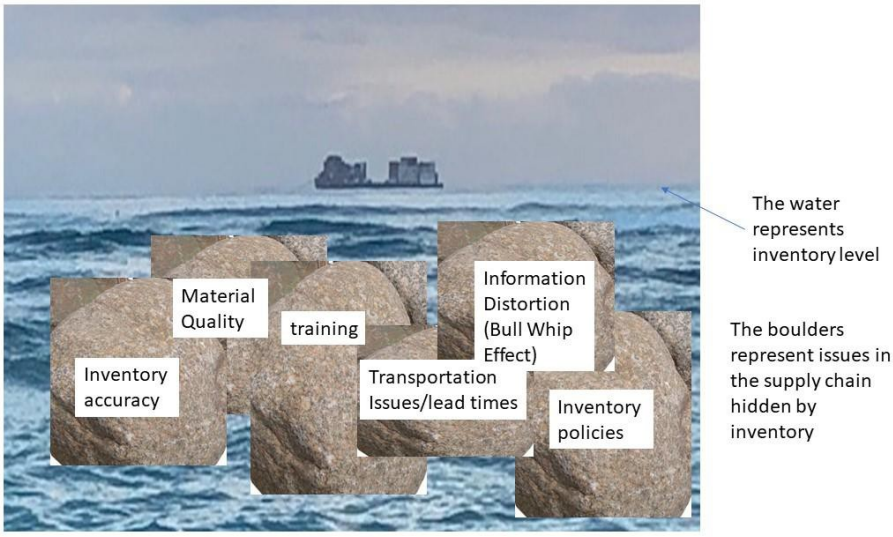


Figure 16.5: Water levels and Inventory Management

Why Have Inventory?

Now that we have discussed the types of inventory, it is important to discuss why companies have inventory. As we saw in the previous section, companies may have inventory to cover up the inefficiencies in their supply chains—even if they do not realize that this is the reason for their high levels of inventory. Other reasons for maintaining inventory on hand include:

- The primary reason to have inventory in the supply chain is to ensure that the company covers any variations in the demand of the customers. As mentioned earlier, this form of inventory is an insurance policy against a stockout. When the company maintains inventory for this purpose, the goal is to have what the customer wants in the quantities the customer wants to improve customer service.

- Inventory may serve as a buffer to prevent stockouts in the manufacturing chain. If all of the facility is not balanced or if the demand for the products being produced varies, insurance can provide a buffer to keep the operation flowing.

- Inventory may serve as an insurance policy against price increases or to take advantage of price breaks for purchasing large quantities. There is a downside to this type of inventory management practice. A company has to conduct a good analysis of the carrying costs of having the inventory on the shelf. A price break for a large quantity of inventory that is excess to the needs of the company is not a savings. A purchase that provides the company a hedge against inflation or against a price increase that results in so much inventory that the inventory becomes obsolete is not deal for the company; or if the cost to keep the inventory on the shelf exceeds the "savings" from the price break or anticipated price increase, there is no benefit to the company.

- Inventory may provide a buffer for contingencies such as hurricanes, fires, or any bad weather. Rapid response supply chains should maintain certain levels of stocks to support operations during such occasions. For example, an agency or company may stockpile generators, bottled water, and staple food items to posture the supply chain to support any disaster relief operations—manmade or natural. Contingency stocks may very well

include a backup stock of wine and other important items to carry one through an emergency.

Reasons against Having Inventory

Just as there are valid reasons to have inventory in the supply chain, there are also reasons against having inventory. Keeping in mind the need for customer service to remain a viable entity, these reasons may not be as valid from a holistic supply chain perspective.

The first reason against having inventory has been touched on already—using the inventory to mask inefficiencies in the supply chain. As long as large piles of inventory (sometimes called mountains of inventory) exist companies may not become concerned with non-value-added processes and non-value-added inventory. So, the argument becomes get rid of the inventory and improve the system. As we discussed earlier, this may not fix the problems.

One company that I worked with reduced inventory by 20% across the board based on this philosophy of getting rid of inventory to improve operations. Costs did not decrease as rapidly, but the customer service levels did decrease as a result of the decreased inventory levels. Why? These reductions also included reducing the authorized levels of the nonproductive inventory. As the nonproductive inventory items were not selling, the value of those Stock Keeping Units (SKUs) did not decrease and the impact on inventory turns remained the same. An item that is not selling will not turn over and will lower the inventory turns for the facility or the company. In addition, the 20% reduction to the fast-moving items resulted in sales that exceeded the ability to replenish, thus producing stockouts, also known as zero balance lines.

Other reasons for not maintaining include not tying up precious financial resources with inventory—especially if the inventory is not moving. Large levels of inventory

(especially non-selling inventory) divert management attention from other strategic issues. More companies are discovering the value of strategic and aggregate inventory management as a cost savings and to improve efficiency and customer service.

Aggregate Inventory Management

"Every management mistake ends up in inventory."

—Michael C. Bergerac, Former CEO, Revlon, Inc.

Aggregate inventory management seeks to answer the questions of inventory management by answering the following questions:

1. How much do we have now? What is our on-hand inventory? Knowing how much we have on hand is important before any inventory decisions are made. If a company does not have a good idea of how much inventory is on the shelf, they may order more or find themselves unable to fill customer orders. Not knowing the amount of an item on the shelf is an indicator of poor inventory management and poor warehouse/distribution center management.

2. How much do we want? The answer to this question is based on the forecast of what the company needs to make or needs to ship to customers. In order to know how much inventory a company wants depends on knowing the answer to the first question.

3. What will be the output? How much product does the company need to make? This is based on the manufacturing forecast or hopefully from the Master Production Schedule. How many products the company is going to make from the items in the inventory drives the previous questions. How many end items the company will make drives the total number of the component items the company must have in the inventory at the start of production.

4. What input must we get? In order to know how many items the company needs to order, the company needs to know how many end items need to be produced less the on-hand balance. This produces the amount of each component or raw material that needs to be ordered to meet the production numbers.

5. When do we need to order the items? This is the final aggregate inventory question necessary to be successful in operations management. The answer to this question may be more important than knowing how much to order. Why? Because if a company knows how much to order but does not know when the item should be ordered, the product may not arrive in time to meet the production requirements. However, if the company knows when the product should be ordered but does not have an exact number that needs to be ordered because of other warehouse problems, at least some of the finished product can be made to meet part of the customer orders.

Good aggregate inventory management leads to customer satisfaction and meeting the needs of the customers. Poor inventory management decisions can be identified by looking for the following symptoms:

- A large number of backorders. This is a good indicator of not having the right items on the shelves at the retail facility or distribution center to fill the orders of the customers. A similar symptom may be filling the customer orders from another distribution center in the supply chain. Backorders or passing of orders to another distribution center is a red flag that should indicate to management that the inventory on the shelves is either too little or consists of wrong items.

- The first symptom may lead to another symptom. This symptom is customer turnover or customer churn. The inventory management problem in the previous symptom leads to this problem. If an activity does not have what the customer wants and passes the action or backorders the action, customers will leave and "shop" elsewhere. This may be evident by the number or orders that are cancelled by the customers as a result of the backorders. Customers usually only order something when they need it and they want it now!

- Poor inventory may manifest itself in an increasing investment in more and more inventory with no change in backorder levels. How can this happen? If we add more to the inventory and spend more money won't that fix any problem? This attitude leads to compounded problems. The goal is to have the right stuff on the shelf in the right quantities to meet customers' requirements. If the company adds more of the wrong inventory or adds more wrong items, the number of backorders will not decrease. A careful analysis of the inventory is necessary to know what to add and how much to add to meet the customers' needs.

- Not enough inventory and/or the wrong items in the inventory produced the previous problems; having too much inventory produces different symptoms. Having too much stuff not only leads to higher inventory costs as discussed below, but also produces a shortage of storage space and the requirement to store items outside in trailers (a very expensive form of storage) or leasing additional or contract warehouse space.

Inventory Management Methodologies

Once a company determines the answers to the four questions above, the company must decide on three basic inventory management methodologies. These three methodologies are Just-in-Time, Pull, and Push. Almost every inventory management method falls under one of these three methodologies.

- **Just-in-Time (JIT).** Although we will discuss this in detail in the next chapter, it is important to mention it here as part of inventory management. As you will see in Chapter 14, there is much more to JIT than inventory management, but many companies only see JIT as an inventory methodology. As an inventory management methodology, JIT seeks to have as little on the shelf as possible. This leaves no buffer against demand variations or lead time deviations. As the total demand for a product does not change rapidly in most cases, a company that goes to JIT as an inventory management methodology is simply passing the requirement for stockage to the next level of supply support. We will discuss this concept in detail in Chapter 14.

  This is just my philosophy, but the move to just in time inventories over the past decade may have impacted the inability of the supply chain to support the panic buying of 2020. For JIT to work as an inventory methodology, someone in the supply chain has to have the inventory. The US Military saw this same phenomenon during the initial stages of Operation Iraqi Freedom in 2003, the logistical system for the Army Materiel Command and the Defense Logistics Agency moved to a JIT concept in the late 1990s – the result was the same thing we are seeing in 2020, a lack of product in the supply chain to support all customer needs.

- **Push.** The Push Methodology is based on the assumption that the folks at corporate headquarters know more about what an activity needs than the folks managing that activity. Most textbooks will tell you that the Push Methodology is not efficient in the long run. The fact is **Push** is not efficient in the long run or the short run. Look at the mess in Kuwait in March 2003 as a result of the Push mindset, as shown in Figure 16.6. This same mindset provided the mountains of inventory that provided the background for LTG Gus Pagonis' book, *Moving Mountains,* from the first Gulf War.[95] The Push mindset is the reason for so many "Sales" at the end of a season—this coupled with poor forecasting. The Push formula is to send items forward in the supply chain based on what the higher corporate headquarters thinks should be in the stock mix.

Figure 16.6: Inventory as a Result of the Push Method of Inventory Management

[95] Also known as Operation Desert Shield/Desert Storm

- **Pull.** This methodology is similar in nature to JIT. Both methods seek to minimize unneeded inventory. Pull means that nothing is shipped to a company or location for their inventory needs until the items are asked for. This methodology is based on the premise that the retailer, customer, or facility knows better what they need than the next level up in the supply chain.

Inventory Costs

The decision on what methodology is used may very well impact the costs associated with inventory (remember, the costs of the inventory is one reason for arguments again having inventory at all). Inventory costs are driven up by poor inventory management decisions and poor inventory forecasting methodologies. An inventory cost above the value of the inventory itself includes the inventory carrying costs. Inventory carrying costs are the costs to the company to keep items on the shelf over time. The biggest percentage of inventory carrying costs is the cost of the capital tied up in inventory that could be used for other purposes in the company. This cost includes the cost of the interest that could be made if the capital is simply put in an interest-bearing account.

Other costs associated with inventory carrying costs include:

- Taxes. This is one of the reasons why companies have sales at the beginning of the year. If items can be sold before the annual inventory, two benefits occur. First there will be fewer items on the shelf to count during the inventory and the value of the total inventory is less, so taxes on the inventory value will be less. Also included in the taxes part of the carrying costs may be an allocated portion of the property taxes on the facility. Because of the difficulty in allocating property taxes on a facility to inventory, this is not a common practice.

- The cost of inventorying the products. This is not cheap. Someone must be paid to conduct the physical count of the items on the shelf. Then someone must reconcile the inventory count and conduct recounts, if necessary. All this costs time and money.

- There is a cost associated with obsolescence. Obsolete, excess, dormant, or aged inventory are the same thing. Regardless of what a company calls this inventory it is a liability on the books and costs the company money to continue holding these items or to dispose of the items. The better the inventory management decisions, the lower the obsolescence costs.

- Another aspect of inventory carrying costs is the insurance to cover any natural or manmade disaster. My first warehouse was destroyed by a hurricane force wind. A recent storm in the Memphis, Tennessee area did similar damage to a much larger distribution center. Without insurance on the inventory items the company would face large losses.

- Theft and pilferage. This is also known as shrinkage costs. We will discuss this in Chapter 18 when we discuss supply chain security and supply chain preparedness. Losses to distribution centers and warehouses from theft and pilferage cost supply chains, depending on the source, between $50-$60 billion (USD) annually in the United States alone. These costs add to the inventory carrying costs.

All of these costs added together create a cost that is usually measured as a percentage of the inventory value. The biggest problem with inventory carrying costs is that many companies have no idea what their inventory carrying costs really are. These companies use the industry average as the figure for their carrying costs. As we will see when we discuss the Economic Order Quantity as an ordering technique, not knowing what the real inventory carrying costs are

can have a major impact on funding and ordering quantities. This creates a continual problem with more carrying costs. Benchmarking studies show that inventory carrying costs may reach as high as 40% of the value of the inventory. Remember there is a flaw to managing to averages. Someone is above the average and someone is below the average. If a company does not know what their true inventory carrying costs are there are problems, but this may also be another symptom of inventory management problems. The other side of inventory related costs comes from not having enough inventory on the shelf. This leads to stockout or shortage costs. The inventory manager must find the right balance between carrying costs and shortage costs.

When to Order

Now that we have established the costs of having too little or too much inventory on the shelves, it is important to determine when to order the items—remember it may be more important depending on the product to know when to order that how much.

If a company does not have a fixed interval for ordering, a reorder point is necessary to determine when to order. A fixed ordering interval simply states that at certain intervals the company will order enough to raise the inventory levels back to a pre-established maximum authorized stockage level—usually referred to as the stockage objective or maximum inventory level.

If a reorder point (ROP) is used the calculation can be a very simple calculation as shown in Formula 16-1. This calculation will work if the Lead Time is in days, weeks, or hours.

ROP = D x LT

ROP = (D x LT) + SS (if safety stock is used)

D = Demand during Lead Time

LT = Lead Time to replenish

SS = safety stock

Formula 16-1: Reorder Point Calculation

There are at least seven commonly used Reorder Points. Some of these reorder points are more common than the others and one is the precursor of a commonly used Just-in-Time technique. These reorder points are used for independent demand items—those items that are not dictated by the demand for another product. The opposite of independent demand is dependent demand—the inventory level of a dependent demand item is dictated by the Master Production Schedule.

- **Fixed Reorder Point.** This is also known as a periodic demand. A fixed reorder point dictates that at a set time or period a replenishment order is placed. At this predetermined period the inventory is counted and the on-hand balance is subtracted from the maximum desired inventory level. The difference between the on-hand and maximum-desired levels is ordered.

- **Variable Reorder Point.** Rather than ordering at a fixed time interval, an order is placed whenever the on-hand inventory reaches a set inventory level. At this point, the quantity ordered will take the on-hand inventory to the maximum stockage requirement.

- **Two Bin.** The Two Bin Reorder Point is the precursor to the Kanban system (see Chapter 14 for more details on the Kanban system). The Two Bin System is used for smaller parts such as nuts, bolts, screws, or washers. This system of reordering uses two bins for storage of the items. The reorder point occurs when the first bin is emptied. The quantity of each bin equals the demand during the replenishment lead time times the lead time (ROP = Demand during lead time x lead time). When the first bin is emptied, the necessary replenishment quantity is ordered. The theory is as long as the lead time is constant the second bin will become empty at the same time that the first bin is replenished. A variation of the Two Bin System is one bin with a line placed inside the bin. When the line is visible, it is time to reorder.

- **Card.** The Card Reorder Point is a visible card to tell the company or store that it is time to reorder. Bookstores use the Card System for books and the small carousels of book markers at the checkout line. When a bookmark is removed from the carousel, the card is visible to the clerk and a reorder or restock is made. In the books on the shelves, a card signals the checkout clerk to key in the reorder. Figure 16.7 is an example of a card reorder point.

Figure 42.7: Card Reorder System

- **Judgmental.** This form of reorder point is based on someone's judgment or experience. This form of reorder point is not common except in smaller operations. For this form of reordering to be successful, there has to be a good level of experience and knowledge of the products and the sales of those products. At the US Army's National Training Center different units would use repair parts at different levels depending on their equipment mix. The repair parts distribution center used a variable reorder point. However, when certain units were scheduled to train, judgmental increases to the stockage levels helped to prevent stockouts.

- **Projected shortfall.** Like the judgmental reorder, this form of reorder is dependent on someone's experience and knowledge of the products. If forecasts show a projected shortfall using the normal reorder point, an additional replenishment order may be placed.

- **Min-Max.** This is the newest reorder point methodology. However, like many "new" ideas, Min-Max is just a variation of the traditional reorder point. When on-hand

inventory hits the acceptable minimum level, an order is placed to take the inventory back to the maximum desired inventory level.

Economic Order Quantity

Just as the reorder point and reorder quantity may tell a company how much to order, the real purpose of the ROP is to tell the company when to order. The Economic Order Quantity calculation helps the company determine how much to order. The goal of the Economic Order Quantity is to balance ordering costs and inventory carrying costs.

$$EOQ = \sqrt{2AC_o / I}$$

A = Annual Demand

C_o = Cost of Ordering

I = Inventory Carrying Costs

Formula 16-2: Economic Order Quantity Calculation

The Economic Order Quantity (EOQ) calculation depends on five basic assumptions in order to be useful as a tool for determining how much to order. Not all of these assumptions may be valid in today's business environment. These assumptions are:

1. The demand rate is constant and known. Demand is not always constant in today's businesses. Customers have the option of buying via the Internet and buy when they need a product. When the EOQ formula was developed the majority of

orders were placed by stores at set quantities. If demand is not constant, this assumption is not valid and therefore the EOQ calculation may not be the best methodology for a company to use.

2. There are no quantity discounts for products. Any good corporate buyer is going to try to get a discount for quantity buys. If the buyer gets the discount, this EOQ assumption is not valid and again the calculation may be flawed.

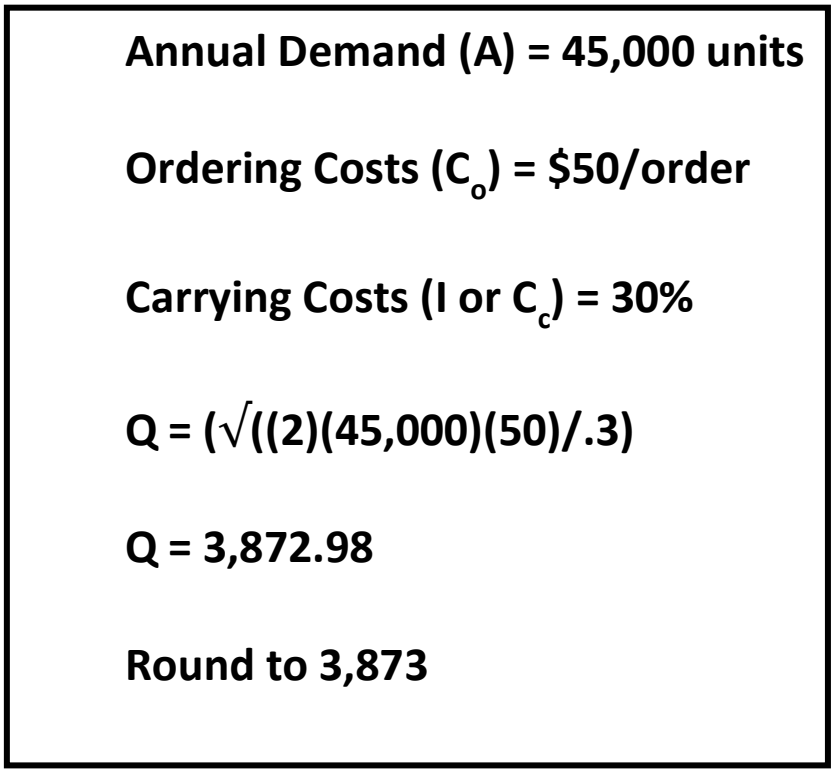
3. The entire order is delivered complete. This means no split shipments, no substitutions, and no backorders. Is this valid in today's environment? Substitutions and split shipments are commonplace in today's business. Sometimes the split shipment is by design because the company only needs part of the product now and part of the order later. Split shipments and backorders also occur when demand is not constant, and the supplier has a stockout. This is reality.

4. The ordering costs and the carrying costs are known. Every company should know these costs. If the company knows these costs this is a valid assumption.

5. Stockouts are not allowed as demand is constant. Look at assumption number 1; if that assumption is not valid due to variable demand patterns, then this assumption may not be valid either.

Even when all five assumptions are valid, there are sometimes when the EOQ is not needed as a replenishment calculation. If a company receives a fixed order quantity from a customer for a product and the EOQ quantity is different from the customer order quantity, then the customer order quantity should drive the company's order. If there is a limit on the size of an

order such as a fixed lot size, then the lot size or multiples of the lot size should be ordered. A third exception to the EOQ is when there is a limitation on the tool/machinery life or the shelf life of the raw materials. For example, if the EOQ calculation determines that 4,000 pounds of a raw material should be the order quantity, but the material has a limited shelf life that is shorter than the forecasted usage period, then the order quantity may be less than the EOQ.



Example 16-1: EOQ Calculation

With the EOQ a company can forecast the number of orders that it will make each year. Example 16-2 shows the calculation to estimate the number of orders. Knowing the forecasted number of orders for a year enables a company to more accurately forecast ordering expenses for the year and when all orders are summed up, it may allow the company to forecast how many purchasing employees should be employed for the next year.

 # ORDERS/YEAR = A/Q

= 45,000/3873

= 11.6 orders a year

Example 16-2: Calculating the Number of Orders Per Year

Safety Stock

Safety stock is an additional insurance policy to back up the primary insurance policy known as inventory. This is simply a level of stockage above the normally calculated inventory levels to prevent against increased demands or lead times, longer than normal replenishment times or variability in demands for a product. Normal inventory levels are set to meet customer demands while safety stock insures against stockouts from variations in demand or lead times. Safety stock is also maintained in some companies as a buffer to protect the manufacturing company against forecasting errors.

Safety stock may as well be called sacred stock in most organizations. The reason for this is that many companies do not want to touch their safety stocks. One particular company actually preferred to backorder customer requests than use their safety stock and go to a stockout position to meet the customers' orders. Their rationale was that they reported SKUs that were stocked out to their Vice President and CEO, but their reports did not include backorders.

Safety stock adds costs to every location that maintains a safety stock without necessarily adding value to the ability of the inventory to support the customers. A company may better serve the customers by consolidating the safety stock for the entire distribution network at one central location. Safety stock is usually set as either a set number of days of supply above the normal stockage level or a percentage of the lead time demand.

Inventory Turns

The most misunderstood metric for distribution centers is the measure of inventory turns. Inventory turns is a simple calculation as shown in Formula 16-3. Inventory turns provides a benchmark for companies within their industries. Comparing inventory turns calculations between different industries only creates confusion and frustration. Comparing the turns for a dairy product with a hardware store will not produce a good benchmark. For years everyone wanted to benchmark against Dell Computers even if they were not in the computer industry.

$$\text{Inventory Turnover} = \frac{\text{Annual cost of good sold}}{\text{verage Inventory Investment}}$$

Formula 16-3: Inventory Turnover Rate Calculation

Theoretically, the following issues are associated with inventory turns. Remember, all things change when you go from the abstract to the concrete.

- Low inventory turns equates to high carrying costs and very low stockout costs. In actuality, low turns may show that there is too much inventory on the shelf which would indeed equal low or no stockout costs. However, it could also mean that there are too many of the wrong items on the shelf. If a company is stocking the wrong items on the shelf, the turns will be low but the stockouts or backorders will still be high. One company with multiple distribution centers was experiencing very low turns (less than four a year) but was also backordering a very large percentage of customer orders because the items the customers wanted were not stocked in the right distribution center.

- High inventory turns should mean lower inventory carrying costs but high stockout costs. However, if the inventory is the right size, replenishment times are stable, and the forecasts for sales are relatively accurate, a high level of turns can be achieved while keeping stockout costs to a minimum.

Other Performance Measures

- Average Inventory Investment: The average inventory investment is calculated for the year in most cases. Comparing average inventory levels is not an effective method to benchmark between companies. This is a necessary financial metric to help companies determine how they are doing compared to previous years.

- Days of Inventory (Days of Sales): This metric is related to inventory turns. This measure looks at how many days of sales can be supported from the on hand inventory. In theory, the lower the Days of Inventory, the more efficient the inventory is performing.

$$\text{Days of Inventory} = \frac{\text{Average inventory Investment}}{\text{Annual Cost of goods sold}}$$

Formula 16-4: Days of Inventory Calculation

Inventory Analysis Using ABC Stratification

ABC analysis has nothing to do with Activity Based Costing. ABC analysis is based on Pareto's Law—also known as the 80/20 rule. Pareto postulated that 80% of the wealth was in the hands of 20% of the population. This rule also applies to distribution centers and inventories.

The application of this principle to inventories states that 80% of the inventory value is tied up in 20% of the inventory items. By applying the 80/20 rule, inventory items can be stratified into A items (20% by value and volume), B items (25–30% of the items), and C items (50%).

ABC analysis using this methodology can dictate inventory management and inventory control measures. A items are those high value items that should be more stringently controlled and inventoried as often as once a week or once a month. B items can be inventoried a little less frequently—perhaps quarterly. C items include the small dollar items that fill up distribution centers. These items can be inventoried once a year.

There is another application of ABC—the organization of the distribution center by volume. The A items in this application are the very fast-moving items and should be placed closest to the shipping area to reduce movement and improve picking times for the fastest moving items. Further analysis may determine that in lieu of placing these items close to the shipping area, the items may be candidates for cross-docking. The C items are the slow-moving items. These items may be candidates for elimination from the stocks altogether or placed in the farthest locations from the shipping docks.

ABC analysis also applies to customers. Just as the inventory is stratified to better manage the distribution center, customers can be stratified to make sure the better customers or largest customers get better service or have priority for low volume or constrained stocks.

Inventory Controls

Inventory control is the physical counting of the items and the security of the items in the distribution center. Inventory control sounds easy on paper—what comes in should be counted and what is in the center should be accounted for, and what goes out should be carefully counted and checked. Remember Clausewitz? This is another way that things change when moving from

the abstract to the concrete. If inventory control was as easy as it sounds, everyone would have perfect inventory control. And, no one would have a shrinkage problem with their inventory.

Proper inventory control starts at the receiving dock. A proper count is necessary when the items come into the distribution center, warehouse, or store. After counting the items, they must be put in the proper location. While in the location the items must be counted and when the items are picked for shipping, the items need to be counted again. If an item is stored in more than one location, this information should not be a secret. Every location has to be recorded to make sure an accurate count is possible.

There are four basic inventory counting techniques in use today. Most companies use an annual wall-to-wall inventory count, a cyclic count, a periodic count, and may also use a sensitive item inventory count. Usually a tolerance is set for the count. As long as the physical count is within the set tolerance, the count is accepted. If the count does not match the inventory record or is out of tolerance, research is necessary to determine why there is a discrepancy and when the discrepancy may have occurred.

The wall-to-wall count is the preferred method of the finance officials. This count happens once a year and every item in the facility is counted and matched against the inventory record system within the Warehouse Management System. The problem with an annual wall-to-wall inventory is that the facility is usually closed down for the duration of the count. If the counts do not match, this closure could last for up to a week. This impacts customer service if orders are not being picked during the count. One facility in South Los Angeles has a 50% employee turnover rate each year. This means that half of the employees that may have made an inventory mistake or picking error in February will not be there to help solve the problems next

January when the wall-to-wall inventory is conducted. This may impact the ability to solve the problems.

The best alternative to annual wall-to-wall counts is the cyclic inventory. Cycle counting counts each of the items at least annually but does not require shutting down a facility to do the count. A cycle count may be conducted in conjunction with routine order picking. A worker may be told to go to a location to pick an item and then count what is left and record it. Like the wall-to-wall count, this count will be matched against the inventory record for accountability. If a cycle count is properly organized, each item in the inventory will be counted at least once a year and some items may be counted more often. Cycle counting does not require closing the facility to do the count and as it is done more frequently, finding the cause of problems may be faster and much easier to identify. To prevent any complications with cycle counts, in one facility we established a third shift that did nothing but cycle counts. This facility went from 84% inventory accuracy to 99% accuracy within three months of adding this new counting shift.

A periodic inventory is an adaptation of the cycle count concept. This methodology states that a certain percentage of the items are counted each period—week, month, or quarter. The goal of this program is to count every item at least once every year.

A sensitive item inventory is another adaptation of the cycle count concept. A company that normally does annual inventory counts may choose to conduct more frequent counts of high dollar or highly pilferable items to ensure that these items do not walk out of the facility. This type of inventory count makes the insurance folks happy and helps to keep facility managers feel more comfortable about the safety of the inventory.

The ABC analysis can be applied to the inventory count methodology. The A items, those expensive or fast-moving items, may be counted monthly. The B items may be counted semi-

annually, and those low cost and/or slow-moving items may only be counted annually or when a stockout occurs.

Special Concerns in Inventory Management

Inventory management is critical to the operational success and financial success of a company. There are some very real concerns that impact the quality of a company's inventory management efforts.

The first major concern is the proliferation of Stock Keeping Units in the inventory. This is a two-part problem. The first part of the problem is how a Stock Keeping Unit (SKU) number is assigned. Some companies assign a different SKU for the same item stocked in a different store or warehouse. This causes confusion. An SKU should be a unique item identifier for an item throughout a supply chain. The second part of this problem is the increase in SKUs across supply chains. AMR research recently revealed a 15% increase in the amount of products in supply chains over the past several years. Consumer pressure to produce new products contributes to this problem. The more items that a supply chain can stock contribute to the accuracy problems and the pilferage problems.

Dead/obsolete inventory is a concern for inventory managers. This is inventory that is of no value. This inventory is driven partially by the pressure to increase the number of products and the shelf life of those products. This inventory is also partially driven by forecasting inaccuracies. Dead or obsolete inventory not only takes up space and contributes to higher inventory carrying costs, but it also contributes to higher inventory turns rates while reducing profitability for companies.

Substitute and complementary items cause inventory problems. When the primary item is an out of stock item, does the company have another item that can be substituted that is

acceptable to the customer? The Department of Defense Logistics Agency maintains and publishes a listing of interchangeable and substitution items. Complementary items also create a problem if the forecasting effort does not link the items together. These items may be used at the same time such as oil and oil filters that can be placed in a kit or may be like the shirts stocked by L.L. Bean that are usually ordered together. In the fashion world complementary items may be the matching shoes and bag or suits and ties. Keeping complementary items in stock together may create challenges for inventory managers.

Repair parts and replacement parts create problems for inventory managers. Why? If everybody has repair parts how can this be a problem? Remember the discussion of independent versus dependent demand items under the forecasting discussions? Repair parts are independent demand items and therefore are much harder to forecast since end items breakdown at different rates. These items reinforce the need to have good forecasting techniques for repair parts and replacement parts in the supply chain.

Items going backward create issues and problems for inventory managers. Reverse logistics is discussed in detail in a later chapter but is important enough to mention here as one of the areas of concern in inventory management. Any resaleable item that comes backward adds to the on-hand inventory and adds to the inventory value, inventory carrying costs, and inventory turns calculations.

Summary

In this chapter we have looked at why have inventory. Inventory is needed to cover the normal customer demands for products. Inventory is an insurance policy to prevent against stockouts from normal demand. On top of the inventory is another level of inventory called safety stock that prevents stockouts from variations in demand or variations in replenishment

lead times. The long running argument between operations managers and finance managers centers on the utility of inventory. Operations managers believe that much of the inventory is an asset while finance managers believe any inventory that is not cash is a liability. Both camps do agree that work-in-process inventory and obsolete inventory are indeed liabilities.

Inventory management seeks to answer four questions. We looked at three of these questions in detail in this chapter. The first question is what to order. This is driven by the Master Production Plan in a manufacturing facility. The second question is how much to order which is driven by the Economic Order Quantity which seeks to balance ordering costs and carrying costs. The third question may be the most important question of all—when to order. This is driven by the reorder point calculation. The reorder point uses demand during the replenishment time and the length of the replenishment time to prevent stockouts and determine when to order. The fourth question ties to supply chain management and location analysis: where should the product be stocked to meet the needs of the customer?

Having the right inventory on the shelf in the right quantities drives the calculation for inventory turns. Although this calculation is widely misunderstood, it is a good metric for the inventory levels necessary to support customers.

Inventory management is critical to successful operations and is important to meeting the needs of customers. Poor inventory management produces lost sales, excess stocks on the shelves, and higher inventory carrying costs. Good inventory management is important for customer service and profitability.

Discussion Questions and Problems

1. Why do companies have inventory?

2. Is inventory an asset or a liability? Can it be both? Explain your answer.

3. Can an inventory item that is an asset become a liability? Give an example.

4. A company has an average inventory value of $550,000,000 and their Cost of Goods Sold for the year is $41,500,000,000. What is their inventory turn? Is this good or bad?

5. A company decides to add safety stock to its distribution centers. The company has 15 distribution centers throughout the United States. Would the company be better served to have safety stock at each location or should they consolidate the safety stock at one location? Justify your answer.

6. If JW, Inc. has a fixed lead time for replenishment of its Widget B of 10 days and an average demand of 12 Widget Bs per day, (assuming no safety stock) where should JW Inc. set their reorder point? How would this change if they set safety stock to 2 days of demand?

7. KW Industries has analyzed their inventory and come up with the following data:

   Inventory Carrying Costs = 12%

   The cost of placing an order = $55/order

   Annual sales of Product X = 6,000,000

   Calculate KW's EOQ for Product X

8. Using the information from Question 7, how many orders will KW place in the next year?

9. Using the data from Question 7, what happens to the EOQ if the ordering costs increase to $65/order?

10. What are the types of inventory a company may have?

11. What is safety stock and why would a company have safety stock?

12. When is the EOQ not necessary?

13. Is the EOQ calculation still valid in today's business environment when applying the assumptions of the EOQ? Explain your answer.

Chapter 17

Reverse Logistics

"In an ideal world, reverse logistics would not exist."[96]

"1.9 million Dishwashers recalled."

"Chrysler issues recall."

"Cadmium prompts new recall. 12 million of the McDonald's collectibles affected."[97]

"***Netherlands recalls 600,000 face masks from China due to low quality"***[98]

"Toyota recalls 3.2 million vehicles worldwide over fuel pump problem"[99]

These are just a few of the recent headlines that have impacts on reverse logistics operations. As Jim Whelan stated in his article, "In Through the Out Door," in March 2001, if we lived in a perfect world, we would not have to worry about the reverse logistics operations. Obviously as the above recent headlines show, we do not live in an ideal world. Because we do not live in an ideal world, as operations managers and supply chain leaders, we need to be concerned about stuff in the supply chain going backward. This chapter looks at reverse logistics and its impacts on operations management and supply chain management.

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[96] Jim Whalen, "In Through the Out Door," *Warehousing Management*, March 2001.

[97] *The Kansas City Star*, Justin Pritchard, The Associated Press, June 5, 2010, p. 2.

[98] Stuart Lau, https://www.scmp.com/news/china/diplomacy/article/3077428/netherlands-recalls-600000-face-masks-china-due-low-quality, 29 March 2020

[99] David Shepardson, https://www.cnbc.com/2020/03/04/reuters-america-update-1-toyota-recalls-3-point-2-million-vehicles-worldwide-over-fuel-pump-problem.html, 4 March 2020

The Chrysler recall noted above involved over 35,000 cars. This is small in comparison to the early 2020 recall for Toyota which involved an estimated 3.2 million vehicles worldwide in 2020 or the 1.5 million General Motors vehicles recalled in 2014. The above referenced McDonald's recall of Shrek collectible glasses involved over "12 million" glasses that contained cadmium, a toxic metal known to cause cancer. "In all, the Wall Street Journal reports, 51.26 million vehicles were recalled in 2015, just slightly more than the 50.99 million officially recalled in 2014." [100]

Each of these recalls requires collecting the recalled items and shipping them backward through the reverse logistics pipeline and possibly impacting the forward flow of materials and supplies through the forward supply chain as we will see in this chapter. In this chapter we will look at reverse logistics and attempt to answer the following question: Is Reverse Logistics a Problem, an Irritant, or an Opportunity?

What is Reverse Logistics?

The APICS Dictionary defines reverse logistics as: "A complete supply chain dedicated to the reverse flow of products and materials for the purpose of returns, repair, remanufacture, and/or recycling."[101] Another commonly used commercial definition of reverse logistics is: the process of moving products from their typical final destination to another point, for the purpose of capturing value otherwise unavailable, or for the proper disposal of the products.

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[100] https://consumerist.com/2016/01/22/2015-was-another-record-year-for-vehicle-recalls/ , accessed September 12, 2016.

[101] Reverse Logistics, APICS Dictionary, 14th Edition, 2013, APICS—The Association for Operations Management.

The Reverse Logistics Association defines reverse logistics as: "as all activity associated with a product/service *after* the point of sale, the ultimate goal to optimize or make more efficient aftermarket activity, thus saving money and environmental resources."[102] According to Gailen Vick, Founder and Past-President of the Reverse Logistics Association, "In other words, anytime money is taken from a company's Warranty Reserve or Service Logistics budget that is a Reverse Logistics operation."

"*Over the past dozen years or so, and increasing number of businesses have recognized the need to ramp up their reverse logistics operations to a global capability…*

The areas of Logistics and Reverse Logistics probably represent the greatest opportunities for cost savings and are, therefore, among any organization's most important functions."[103]

The attention to reverse logistics is relatively new in the history of logistics and supply chain management. The US Army did their first study of reverse logistics operations in 1998.[104] The first commercial study of reverse logistics was conducted the same year by Dr. Dale Rogers

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[102] Reverse Logistics, Reverse Logistics Association, http://www.reverselogisticstrends.com/reverse-logistics.php, accessed June 5, 2010.

[103] Pollock, William K., "The Globalization of Reverse Logistics Operations," *Reverse Logistics* Magazine, May/June 2008, pp. 16–19.

[104] The US Army defined reverse logistics as: "The return of serviceable supplies that are surplus to the needs of the unit or are unserviceable and in need of rebuild or remanufacturing to return the item to a serviceable status." The study by the US Army revealed that over 50% of every item ordered and 50% of the dollar value of all orders were being returned for whatever reason.

and Dr. Ron Lembke. This study by the Reverse Logistics Executive Council was published as *Going Backwards: Reverse Logistics Trends and Practices.*[105] This study is still the most comprehensive commercial study on reverse logistics.

Prior to the Army's study and the study by Drs. Rogers and Lembke many companies did not want to even admit that they had reverse logistics problems or processes. For many years, reverse logistics and returns was a lot like many families' crazy uncle or aunt. Everyone knew that returns and reverse logistics were taking place but no one wanted to admit it. In fact, some companies viewed returns and the resultant reverse logistics as the seedy side of the company and refused to discuss it. The study by Rogers and Lembke put a new light on returns and reverse logistics and opened the door for others to start looking at the processes. The authors of *Going Backwards* wrote, "Reverse logistics is a new and emerging area, and as such, only a limited amount of information has been published to date."[106]

In 2003, The Reverse Logistics Association was formed as an industry association to focus on returns, recycling of materials, and ways to turn the reverse logistics processes from money pit to profit center. The first annual conference for the Reverse Logistics Association was held in Las Vegas in February 2004. This conference had about 100 attendees and about 20 vendors that focused on reverse operations. The 2020 conference had over 1000 companies represented, and a convention center ballroom filled with vendors that focus on returns and

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[105] The book *Going Backwards: Reverse Logistics Trends and Practices* is available as a free download at http://rlec.org/reverse.pdf

[106] Rogers, Dale, and Tibben-Lembke, Ron, *Going Backwards: Reverse Logistics Trends and Practices*, Reverse Logistics Executive Council, 1998, University of Nevada-Reno, p. xix.

reverse logistics activities. An example that more companies are becoming aware of the need to focus on reverse logistics.

In 2006, reverse logistics was reported as a $100 billion industry in the United States alone. This was up from the $35 billion estimated in *Going Backwards* just eight years earlier. The problem of returns and reverse logistics is becoming an international problem but is a problem created in the United States and the liberal returns policy of most retailers and suppliers have created a "try it before you buy it" mindset. This mindset is partially what drives the reverse logistics processes. The other driver is overproduction and excess. By 2020, reverse logistics has grown to a multi-trillion dollar business worldwide.

If liberal returns policies help drive the reverse logistics problems, why do companies continue to offer these liberal returns policies? The biggest reasons for these policies are customer service and to provide a competitive advantage or at least provide the company with an order qualifier to keep them in the game. If all of the competition is offering liberal returns programs, a company has to do the same to remain competitive.

Reverse Logistics in History

Although it would appear that the problem of reverse logistics is a late twentieth century/early twenty-first century problem, it is far from a new problem. Let's take a look at some of the earlier examples of reverse logistics:

- After the end of the American Civil War in 1865, North Carolina lore has it that as General William Sherman was heading north to link up with General Ulysses Grant after the surrender of General Joseph E. Johnston in North Carolina he encountered a problem. This problem was that the spring rains in North Carolina caused the Neuse River to rise well above normal levels. Rather than take all of the now unnecessary supplies north over the

swollen river, General Sherman's logisticians decided to dump the supplies on the south side of the Neuse River north of Raleigh. The idea of dumping excess/obsolete items carried well into the twentieth century as a method of "dealing" with unwanted stuff.

- In 1894, Montgomery Ward's started what is now a major driver of the reverse logistics operations. Montgomery Ward's was the first retailer to offer a 100% guarantee with the promise of a full refund if you were not satisfied with the product. This is somewhat ironic that the company that started the returns problem is no longer in business.

- As a result of the critical shortages of materials such as metals and rubber during the 1940s as a consequence of the need to support the war efforts for World War II, the recycling of materials and the advent of remanufacturing was born. This new business practice continues today. A large proportion of the starters, alternators, and generators in the automobile repair parts industry today are remanufactured or rebuilt.

- At the end World War II in Europe there was over 77,000,000 square feet of storage locations holding materials and supplies that were excess to the needs of the United States Army. As the United States moved from a combat force to an occupation Army, items shipped to Europe for combat were no longer needed. The value of these items scattered across the European continent was approximate6ly $6.3 billion in 1945 dollars. All of these items had to be disposed of, donated, or returned to the United States. This is about $90.5 billion in 2020 dollars.

- On the other side of the war in the Pacific Theater, reuse and recycling had a different theme. Because of the extremely long order cycle times to get resupplied in the South Pacific, Armed Forces units started "recycling" and salvaging clothes and shoes of Soldiers and

Marines being shipped home. The shoes were resoled and the clothes were repaired and reissued to counter the long replenishment lead times.

- In September 1982, McNeil Labs and Johnson and Johnson had an incident that provides us with a more modern example of a need to conduct reverse logistics. In Chicago, Tylenol® laced with cyanide was discovered. All of the Tylenol® across the United States was pulled off the shelves and returned to McNeil Labs facilities. The result of the reverse operations produced tamper resistant containers and was handled in such a manner that customer confidence was not shaken. This also provided Johnson and Johnson and McNeil Labs with a blueprint for similar recalls in 2010 as a result of contaminated raw materials used to produce Tylenol®. The problem in 2010 and 2011 was that instead of following the blueprint for success, they denied the problem was theirs and the result was another issue with Tylenol® a year later. In 2010, Johnson and Johnson tried to blame the wood pallets for a "musty" smell that was making customers sick. When analyzing this position, it would be quickly apparent that this was not a well thought out answer. Look at the example in Figure 17.1. It was later discovered that one manufacturing plant had some bad materials and this was the cause, not the pallets.

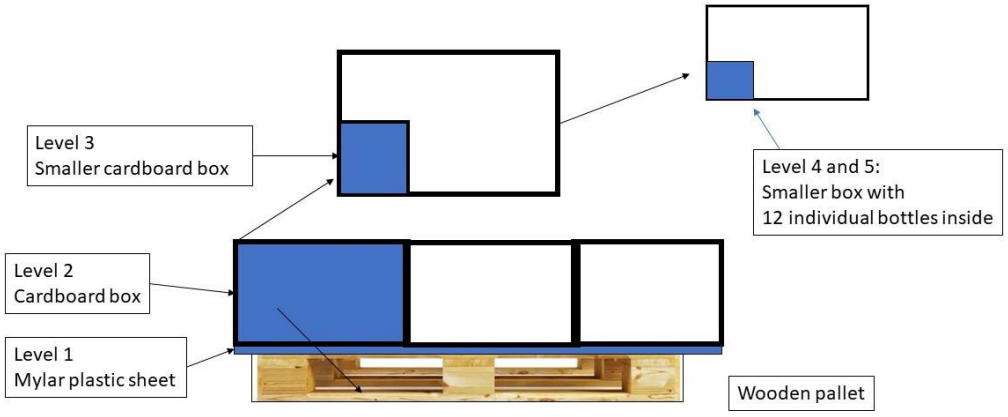

Figure 17.1: The number of layers between the Tylenol and the Wooden Pallet

- European concerns about the environment led to recycling initiatives and packaging concerns that have spread across the ocean to the United States. The Europeans as a whole have been concerned about the environment long before it became a Nobel Prize winning concern in the United States. Items that were being recycled in Germany in 1995 that still are not recycled in the United States. In Wiesbaden, Germany, there was a city official who had the sole responsibility of going through the trash dumpsters in the US Military housing areas to make sure the Americans were not throwing away items that should be recycled. Why is this important in a discussion of reverse logistics? Because, items that are recycled have to go backward in the supply chain. A 1991 Ordinance in Germany put teeth into recycling, thus impacting the reverse pipeline.

- Legislation in the United Kingdom in 1996 concerning the size and waste in packaging and shipping was followed by legislation by the European Union in 2001 that added goals for the reduction of packaging materials. The size of packages and the requirement to recycle or

return packaging materials impacts the reverse logistics pipeline. These legislations put the onus on the shippers and producers to minimize package sizes and forces the shippers to bring back the packing materials. Reducing the package size also contributes to a reduction in the energy and natural resources necessary to produce the packages.

Military and Commercial Perspectives of Reverse Logistics

As we mentioned earlier, the first real study of reverse logistics in the commercial sector was published in 1998 by the Reverse Logistics Executive Council about the same time that the US Army was analyzing their reverse logistics operations. So, let's take a look at the operations from both perspectives.

Reverse Logistics from the Military Perspective

"The Army's reverse logistics pipeline processes are relatively slow and variable… for reference, we define improving the flow in the reverse logistics pipeline to mean timely movement to minimize the amount of inventory investment. In other words, the objective is to make the most cost-effective use of existing inventories."[107]

When the US Army conducted research in 1999 on reverse logistics, they found out that at one point in 1999 the value of the items going backward actually exceeded the value of the items going forward. This is no way to run a business.

In 2002-2003, the US Army moved the equivalent of 150 Wal-Mart SuperCenters from the United States and Europe into Kuwait in anticipation and preparation for the eventual invasion of Iraq to topple the Saddam Hussein Regime. Any time that much stuff is moved there

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[107]Diener, David, et. al., "Getting Value from the Reverse Logistics Pipeline," Rand Arroyo Center, 2000, p. xiii.

is bound to be excess or the wrong stuff sent. In 1997, the US Army went into Bosnia to provide humanitarian support. Within 48 hours excess items started coming backward in the supply chain. The same situation was seen when in 1992 when the Army went into Somalia to provide humanitarian assistance. Within a few days of US forces arriving in Somalia, items started going backward in the supply chain.

The movement of supplies and equipment in 2002-2003 created excess and the steady flow of personnel, supplies, and equipment into and out of the country complicated the situation by adding some fog and complexity to the supply chains. In August of 2003, the US General Accounting Office did an audit of supplies in Kuwait and Iraq. The result was a renewed focus on reverse logistics. The initial draw down of forces and the accompanying evacuation of American Soldiers and Marines from Iraq at the conclusion of the major hostilities created a huge reverse logistics operation that involved over 30,000 vehicles alone that had to be processed and returned to the United States.

Part of the problem with the excess supplies was that soldiers were sent to their staging areas prior to entry into Iraq from Kuwait. Prior to moving to the staging areas, the soldiers had recreation activities and fitness centers in Kuwait; however, while awaiting the invasion these soldiers had nothing to do in their free time. When the soldiers got bored, they ordered stuff to see if it would really come in. General George S. Patton, Jr. stated, “In battle, troops get temperamental and ask for things which they really do not need. However, where humanly possible, their requests, no matter how unreasonable, should be answered.” Based on that attitude, whatever was ordered was shipped. The result according to *Jane’s Defence Weekly* was an area approximately 100 acres (*Jane’s Defence Weekly* stated it was an area about 40 hectares)

filled with stuff waiting to be returned to the United States. Some of this can be seen in Figures 17.2 and 17.3 from the GAO report.

Figure 17.2: Items Waiting Return from Kuwait According to the General Accounting Office

Figure 17.3: Items Waiting Return from Kuwait According to the General Accounting Office[108]

For every item ordered that was not really needed or that for whatever reason did not reach its intended customer, the reverse logistics problem grew. As the US Armed Forces started the withdrawal from Iraq and Kuwait, perhaps the largest reverse logistics operation in history occurred.

The Commercial Perspective

"Life is like a box of chocolates, you never know what you are going to get."[109]

Reverse Logistics is very similar. Even when a company knows what should be coming back based on the Returns Merchandise Authorizations, there is no guarantee that that is all that will show up at the distribution center. Experience shows that when you open the door to the truck, you never know what may be in the boxes of stuff coming backward.

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[108] "*Defense Logistics: Preliminary Observations on the Effectiveness of Logistics Activities during Operation Iraqi Freedom,"* General Accounting Office, 2003.

[109] *Forrest Gump*, Paramount Pictures, Robert Zemickis, 1994.

Work with large and small companies has revealed that many companies still do not know the rate of their returns. Companies often quote "industry averages." The problem with averages is that half of the companies are above the average rate and half of the companies are below the average rate. If a company does not know its true rate of returns there is no way the company can get a handle on the problem—profit from the opportunity that the returns offer. In addition, companies do not seem to know what it costs to process a return. Again, this can create a problem for companies. A third problem for many companies is that they do not know how long it takes to get the resalable/serviceable product back on the shelf and ready for resale.

Regardless of the situation, rates of returns and time to get back on the shelf, there are costs to reverse logistics above and beyond the cost of the item itself. Figure 17.4 shows some of these costs.

- Merchandise credits to the customers.
- The transportation costs of moving the items from the retail stores to the central returns distribution center.
- The repackaging of the serviceable items for resale.
- The cost of warehousing the items awaiting disposition.
- The cost of disposing of items that are unserviceable, damaged, or obsolete.

Figure 17.4 Typical Costs of Reverse Logistics above the Cost of the Item

When an item comes back from the customer—for whatever reason, whether that customer is another distribution center, a retail activity or the ultimate end user—the cost of the item being returned is only a part of the reverse logistics equation. Someone in the reverse supply chain has to process the merchandise credits or payment to the returning party. Even if this is an automated process, someone has to process the request for reimbursement and the Returns Merchandise Authorization.

Once the item has been returned to the store by the customer, the item has to be transported to a distribution center—either corporate owned or a Third Party Logistics Provider such as GENCO.[110] Either way, there will be transportation costs to get the returned item back to determine if the item can be resold as is, repackaged, repaired, rebuilt, remanufactured, or disposed of. Until their purchase of ATC a few years ago, GENCO focused solely on reverse logistics activities.

If the item is still serviceable or complete without damage—which means it can still be resold as new, it may need to be repackaged. As all parents know, children do not always carefully take products out of the package when opening gifts. Too often, children will receive more than one of the same gifts thus creating a need to take one of the gifts back to the store for exchange. If the package has been destroyed in the process of opening the gift, this item will require repackaging before it can go back on the shelf.

Once the item has been repackaged, rebuilt, repaired, or remanufactured for resale, it is usually stored somewhere in the supply chain awaiting return to a store or shipping after an online purchase. This storage, even if only for a short time, is still a part of the company's carrying costs and can therefore detract from the bottom line for the company. In addition, there is another unplanned transportation expense to get the item back to a store or shipped to a customer if purchased online.

If the returned item is not able to be resold, rebuilt, or remanufactured, then the item must be disposed of. If hazardous materials are involved in the operation of the product or the manufacturing of the product, additional disposal costs are involved. Disposal costs are incurred

[110] For more on GENCO go to: http://www.genco.com/Reverse-Logistics/reverse-logistics.php

for items that may still be in a resalable condition but for whatever reason are now obsolete due to changes in trends or having been replaced by an updated product while the original product was moving backward in the system.

There is another cost of processing returns that sometimes gets lost in the system. This is the cost of lost sales because an item is bought bringing the inventory to a stockout situation or as the Army calls it a "zero balance" situation. If a customer buys a product with the intent of using it for a day or two and taking it back a lost sale may ensue when another customer really wants that product that is not on the shelf. This may sound farfetched but let me give you an example. When I was in college, a fraternity brother in charge of "Pledge Recruitment" bought a film projector to show films of the fraternity in action the previous year.[111] This fraternity brother did not own a projector so he "bought" one and took it back the next day for a full refund. Assuming this was the last projector on the shelf, if a customer that really wanted to buy and keep a projector came in after the fraternity brother and found an empty shelf, a sale would be lost and possibly a true customer would be lost for good. The majority of these items returned show no defects or no faults noted. This means that any given day there is a large number of salable items going backward and not available for sales to customers.

Another example of lost sales during the Christmas sales and post-Christmas sales is Wal-Mart. The returns after the Christmas season across Wal-Mart in represents approximately 4

[111] This was a Military Fraternity with a competitive drill team that competed in National Championships and also performed in local and national parades and had a Bicentennial Drill Team that served as the official representative for the Governor of North Carolina at official Bicentennial activities.

days of sales for Wal-Mart according to Wal-Mart officials.[112] To give you feel for the size of 4 days of sales for Wal-Mart, Wal-Mart makes approximately $57 million an hour every hour of the day. By comparison, the sales of Wal-Mart for the three days after Thanksgiving in the United States (Black Friday, Saturday, and Sunday) exceeds the Gross Domestic Product for South Africa for an entire year.

Other examples from commercial industry that demonstrate the costs of returns to the companies include:

- One major home appliance company disposes of over $40 million annually of their returned products rather than refurbish the items because the company is concerned about degrading the value of their new items. This is money lost to the system completely.
- Many companies do not really know the cost of processing a return and continue to process and refurbish items that are really cost prohibitive. A manufacturer of video recorders was spending approximately $85 to process and repair a device that only sold for $50. After discovering this problem, the company started shipping a new device to customers under warranty and having the customer dispose of the old product. Sure, this opened them up for some customer fraud but was still cheaper than the original system.

[112] According to one Wal-Mart representative the returns after the 2003 Christmas season equated to approximately two thousand (2,000) Twenty Foot Equivalent Units (TEUs) (a TEU is a standard 8x8x20 foot shipping container).

- In 2001, Corporate America processed over $60 billion in returns. Of this it cost approximately $40 billion to process these returns and once processed, they discovered that almost $52 billion worth of products were excess to the systems that accepted the returns and therefore provided little value to the company. This is why reverse logistics and the returns process started getting corporate attention.
- One major distribution company conducted an auction for items that were excess to their operations and sold most of the items at about half price.
- A major West Coast discount company was in the practice of returning seasonal items to a central distribution center. In fact, this company leased a 300,000 square foot distribution center for the sole purpose of storing seasonal items that were returned by its stores. The problem was that a large percentage of the seasonal items for the Christmas season arrived back at the distribution center slightly damaged or were damaged during the year before they could be sold or shipped to the stores for possible sale. The consulting company working with this company recommended donating the seasonal products to local schools for arts and crafts and taking a write off rather than experience multiple handling and damage during the returns and storage processes. This brought the company reduced costs and more "good will" in the local communities.

Reverse Logistics and Uncertainty

Because of the uncertainty in the reverse logistics system, the time to process returns is considerably longer than the time to process items in the forward supply chain. One particular

major distribution center took an average of 1.1 days to completely process the expected and known inbound shipments. However, it took this distribution center approximately 8.5 days to process returns to the distribution center. This additional processing time included identifying the item, identifying the condition, and serviceability of the item (which included testing for electronic items) and then disposing of the item, repackaging it for restock, or sending the item out for refurbishment or rebuild for future sales.

Another distribution center had non-value-adding operations in its returns process for items that had been rebuilt or refurbished. These items coming back into the distribution center for the third time (the first time was as a brand new item; the second time as returned item; and the third time as a rebuilt or refurbished item) were unpacked, inspected, and then the batteries for the items were taken out and separated from the end item. When a refurbished or rebuilt item was ordered on the company's Web site, the end item and the battery were reconnected at another station before shipping to the customer. This appeared a bit strange and the only explanation I could get was that the company had "always done it this way."

My original thought was maybe there was some OSHA regulation prompting this action. There was no OSHA requirement, but it was only an outdated way of doing business adding additional costs and handling requirements to the returns process. When asked why again, I was told that sometimes customers ordered just the battery or just the end item. How often? This revealed that it was very rare when the battery or end item was ordered separately.

Other examples of waste in the reverse logistics chain include:

- Estimates show that returns immediately following the holiday seasons in 2004 and 2005 were approximately $16.2 billion (USD) each year or about 25% of everything sold during the holiday season came back for whatever reason. It could

be that a child received more than one of the same gift item; you bought your aunt a new sweater size 16 but she insists that she is still a size 8; the sweater was the wrong color; or you just did not like the gift. This is one of the reasons that retailers like gift cards. Not only do gift cards not come back as returns, but the other reason that retailers like gift cards is that they are hoping that the recipient does not use the entire value of the card or even loses the card.

If this same percentage of items bought during the holiday season continues, when the data for 2019 is released, the value of returns for the most recent holiday season will exceed the 2001 value of all returns— or approximately $250 billion. Although it appears that returns are slowing in the brick and mortar retail sector, since many reports only look at brick and mortar retail sales and not e-commerce. As e-commerce continues to grow, the value of products returned from online sales will continue to grow. The returns for online sales is habitually higher than for brick and mortar sales.

- Wal-Mart has reported at professional conferences that they value of returns for the company exceeds $6 billion annually. There are companies that would love to have $6 billion in annual sales going forward. The returns for Wal-Mart equate to approximately 17,000 trucks a year going backward with items returned by customers and stores. Simple math shows that this equates to about 46 trucks a day 365 days a year going backward for one company.
- One major cosmetics manufacturer was experiencing over $60 million a year in returned products. Unlike other manufacturers there is no real after market for used cosmetics. How could there be such a large volume of returned cosmetics?

One simple explanation could be allergies to the products; another explanation is tied to formal events. Every format event requires a new dress, shoes, hand bag, and matching make up. When the formal event is over there is no more need for the matching make up as formal event etiquette dictates that the outfit cannot be worn again. This helps to drive the cosmetic returns.

- In 1998, the year before they went into bankruptcy, K-Mart established a Vice President of Reverse Logistics. This corporate level position was necessary because of the company's $980 million in returns the previous year. A conversation with this official revealed reverse logistics nightmares for retailers. In the early days of MP3 players, young folks discovered that the value of the players was in the memory chips used to store the songs. As these chips were easily removed, a large number of MP3 players were returned as defective. When the players finally arrived at the returns processing center it was discovered that the defect was the missing chips. Another reverse nightmare was lawnmowers purchased in the spring and then returned in late summer or early fall as defective as they were still under warranty. When the lawnmowers reached the returns processing center, it was discovered that the reason that the lawnmowers were "defective" was that the lawnmowers had no gas or oil. Thus, the owners got free use of the lawnmowers for the season.

Six Sigma and Reverse Logistics

Can you apply Six Sigma methodologies to reverse logistics? Is it possible to apply the methodology of Six Sigma to managing returns? Would that help prevent such wastes in the system? Absolutely!

- Define – What is our reverse logistics policy and what are the impacts to our operations from the current policies on returns? What is our reverse logistics chain and how many links are there in this chain?
- Measure – What is our actual rate of returns? What are our reverse logistics chain costs?
- Analyze – What are the average industry rates of returns and how do we compare to our industry? What are the average industry costs for processing items through the reverse logistics chain? How do our costs measure up against our competition? Do we have non-value-added processes in our reverse chain that add to the costs of processing returns?
- Improve – What best in class processes should we add to our reverse chain to make it more profitable and improve the bottom line of the company while improving customer support? This is becoming easier to identify as the interest in reverse logistics continues to grow.
- Control – Once we have identified the new processes and put them in place, how do we institutionalize these processes? That is the real challenge of applying Six Sigma to the reverse logistics processes.

Home Depot has applied similar logic to its returns processes. Although The Home Depot is the fastest company in the United States to reach in excess of $100 billion in sales, its returns are only about $10 million a year. When compared to other comparable size companies this is very small. The first step was to establish a data base of customers bringing products back to the company on a habitual basis—this was actually done to identify potential theft of products and initially was only for

customers returning items without a receipt. The next step to reduce returns to identify which product lines had the highest return rates.

The result of this analysis revealed that the largest volume of returns was for tools. Further analysis into the why of this discovery revealed that once a job was finished tools were no longer necessary so the "home improver" brought the tool back. Think about it, if you are putting in new tile you need a wet saw to cut the tile. Once the tile is in place, what is the need for the wet saw?

The Improve and Control steps of Six Sigma resulted in the "Tool Rental Centers" being established in larger Home Depot stores. This proved to be not only a method to reduce returns but after a few rentals the tools paid for themselves.

Other Consequences of Reverse Logistics on Companies

"Approximately 8% of all merchandise is returned, surging to 10% over the holidays to match increased sales. Because the products returned can rarely be resold at full price, that equates to a matching loss of 10%, a significant portion of profits. Online return numbers are even higher, clocking in at 30% overall, or 40% for clothing."[113]

As was mentioned earlier, for every item that is going backward and is in a serviceable or resalable condition there is the potential for a lost sale. Another aspect of the processing of returns was mentioned earlier in the processing times for reverse logistics items. An increase in the volume of items going backward coupled with the increased processing times creates impacts on customer order processing times and the flow of products forward. In some supply chains this

[113] Jennifer McKevitt, Supply Chain Dive, https://www.supplychaindive.com/news/reverse-logistics-returns-supply-management/432665/, December 20, 2016.

creates a constipated supply chain where everything is moving very slow or not at all. This also contributes to customer confidence that leads to inflated orders which leads to more products going forward and then more products going backward, which constipates the system even more. This also leads to the requirement for larger logistics and supply chain footprints. The increased volume going forward dictates larger distribution centers to include more storage area, more inbound doors, and more outbound doors. This is coupled with the need to have a larger area in the distribution center to process returns.

Electronics and Reverse Logistics

Because of the rapid obsolescence of electronic products, a fear is the growth of electronic waste from the improper disposal of the old electronic products rather than properly recycling them. Worldwide, electronic waste accounts for approximately 20–50 million metric tons placed into landfills.

Electronic waste accounts for approximately 3–5% of items placed on municipal landfills but these products account for 70% of the toxins found around landfills in the air, water, and soils. Think about computers and monitors. Annually over four billion pounds of plastic and approximately four million pounds of lead are put in landfills annually. Both of these items are recyclable and there are known dangers from lead in the environment. Also remember that lead is a finite metal. Why throw away what can be reused. It is the responsibility of supply chain managers and operations managers to ensure that these products are properly handled in the reverse logistics pipeline.

One company that specializes in processing returned cellular telephones was able to mine 75 pounds of gold from approximately 6.5 million handsets in 2012. Another company used the recycled printer cartridges to make sustainable road signs and park benches. The proper handling

of electronics and the capturing of value from items going backward is a critical aspect of success in the realm of reverse logistics. Figure 17.5 shows an example of road signs being produced from recycled printer cartridges. These signs are more durable than aluminum signs, cheaper than aluminum signs, and because they are not made of aluminum, they are not stolen as often.

Figure 17.5: Example of Stop Sign made from recycled printer cartridges

Summary

"The truth is, for one reason or another, materials do come back and it is up to those involved in the warehouse to effectively recover as much of the cost for these items as possible."

—Jim Whalen, "In Through the Out Door," *Warehouse Management* Magazine

The Reverse Logistics Executive Council has estimated that the cost to process returned items can exceed 200–300% of the actual cost of the item and takes up to eight to twelve more steps to process the returns.

The reverse logistics operations have become a source of revenue for companies that are intensively managing the reverse logistics chain and continue to be a sore subject for companies

that have not yet got a handle on their returns processes. The continued growth worldwide of the Reverse Logistics Association is proof that this not a US-only problem and that more companies are becoming concerned about getting control of these operations.

Reverse logistics impacts other areas of the operations management chain while consuming precious resources and dollars in the company. Reverse logistics operations and activities impact:

- The accuracy of forecasting because of the counting of "sales" that may not actually be sales after all when the product gets returned.
- Carrying costs of inventory by impacting the number of personnel needed to inventory the items, process the items, and the needed space to "house" the items coming backward.
- Transportation costs for the move back from the retail store or customer to the distribution center or central returns processing center. In addition, it impacts the costs of transportation by having to ship the same items to a store or customer more than once.
- Marketing costs—this is a result of having to market refurbished or remanufactured items.
- Personnel costs for the employees that have to process the returns.
- Space costs – one of the reasons for the growth in the size of distribution centers is the requirement for space to receive and temporarily store returned items.

Reverse logistics as a topic of discussion and concern is relatively new in the study of operations management and may very well be the last great frontier for reaping profits and savings from the total supply chain.

Discussion Questions and Activities

1. Check with a local store in your area and ask what their returns policy is and what rate of returns they get as a percentage of sales.
2. What experience do you have with returning an item? Was it a pleasant experience or was the process a hassle? Was the time it took to process the return worth the effort?
3. Visit your local Cabela's (if there is one close to you) and look at the items in their "Bargain Cave." Look carefully at the items that were bought, used, and then returned.
4. Think about the impacts of the reverse logistics operations on your company's operations.

Chapter 18

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

Just-in-Time is credited to the Japanese quality movement and the Toyota Production System. However, most of what is credited to Taiichi Ohno and others are derivatives of the teachings of W. Edwards Deming. The Theory of Constraints came to us from Israel (Dr. Eli Goldratt) about the same time that Six Sigma was arriving from Motorola. Lean is the "newest" continuous process methodology to come along but a deep dive into its origins show that when Ohno and crew originally wrote about what we call Just-in-Time, they called it lean.

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 out of books and consulting fees. Although the four programs have similarities in their results, the approaches of these programs, except for 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**, map the process or document the process in order to establish what is being done and why. Then the process map or flow chart can be used to identify the non-value-

added activities or subprocesses as well as 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. Another key observation at this point in the discussion of continuous process improvement programs is that all improvements are changes but not all changes are improvements. Think about the times you have seen change for the sake of change rather than change for the sake of improvement. A promise of "change you can believe in" should really be "improvements you can believe in." The programs in this chapter will help the operations management student (and the future operations managers) identify those non-value-adding processes as candidates for improvement or elimination.

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 and Shigeo Shingo get 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 who went to Japan after the war to help the Japanese businesses recover. The teachings of Deming trace their roots to Walter Shewhart, the father of statistical quality control and the designer of the Plan, Do, Check, Act Cycle that is the foundation for almost every continuous process improvement program.

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 1950s and 1960s, the words "Made in Japan" on a product almost assured the

buyer that the quality was suspect at best. While everyone was making fun of Japanese quality, engineers in Japan were reverse engineering products to determine how to make them better and less costly. 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 (APICS). In 2018 APICS was renamed the Association for Supply Chain Management (ASCM). Just as the organization has evolved, so did their view of JIT. Now APICS/ASCM defines Just-in-Time as: "A philosophy of manufacturing based on planned elimination of all wastes and on continuous improvement of productivity" (John Blackstone, 2014). The concept of "zero inventories" was a narrow-minded focus on the JIT waste of stocks (we will discuss this shortly).

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. You may recall the discussions on positioning the firm when we stated that to be successful when competing on cost, the company must eliminate all waste. From a JIT perspective, waste is anything that does not add value.

As an inventory management philosophy, waste is defined as anything above what you need right now. 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. This places a greater onus on the suppliers to quickly resupply. The APICS/ASCM dictionary app defines the JIT supplier environment as "a company must supply components and subassemblies in exact quantities, delivery times, and quality. Shipments are made within narrow time windows that are rigidly enforced. Virtually every component must be delivered on time and be within specifications."[114]

he drawback of JIT as an inventory methodology is that it means someone must have the inventory in the supply chain or the ability to quickly produce the inventory to meet downstream needs in the supply chain. The pandemic panic buying of 2020 revealed some of these flaws in the JIT supply chain. When no one has the product, it will run out.

The US Military discovered this same issue at the start of the Second Gulf War (Operation Iraqi Freedom). The Military, in a cost cutting measure, went to a JIT-like supply system. The problem was that the flawed logic reduced inventory levels in the entire supply chain and the ramp up for deployments and combat operations left the units with severe shortages for some items and in 2003 revealed the same flaw that was relearned by the civilian world in 2020 – some one has to have the inventory somewhere in the supply chain.

Another example of this flaw in the JIT inventory methodology can be seen 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

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[114] The APICS/ASCM dictionary app is available through the Apple Store and provides definitions of all major operations and supply chain terms. The APICS Dictionary is available for sale through the APICS/ASCM website at www.apics.org. The app is free and provides all the same information as the dictionary – go for the free app.

transportation started moving again. Hewlett-Packard missed deliveries as a result of going to a true JIT inventory methodology, while Dell was able to meet almost all of their deliveries.[115] 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 (refer back to the discussions of just in case inventory in the Inventory Management chapter).

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 the goals of JIT. The primary 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.

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[115] 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? It could also be viewed as a form of Vendor Managed Inventory and therefore not on the books of Dell until delivered into their assembly plant. The Opal Plant in Russelsheim, Germany also bills themselves as a JIT facility, but outside the back door of the plant is a yard full of inventory that belongs to the vendors that is stored in semi-trailers (an expensive form of storage) to ensure that the products are there when Opal needs them.

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.[116] JIT mandates only producing what is needed and nothing more.

- **Waiting:** There is no value in waiting. Remember our apple sauce example from our discussions of process design. Or think back to your last visit to an amusement park – what was the value in waiting for an hour for a 3-minute ride? That is the very reason that Disney went to the fast pass concept to reduce waiting times and allow you to spend more time doing other things in the parks. This is also the reason that Disney has revamped the queueing process at many rides to provide interactive games and videos to help reduce the feeling of wasted time while standing in line.

In manufacturing, 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 ties back to our facility layout discussion and balancing the production line to prevent work in process building up.

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[116][116] Think back to the discussions of utilization when we discussed capacity planning. In that discussion we stated that utilization rate should match sales rate – this is a direct link between JIT implementation and capacity planning. Hopefully, through the course of this instruction you will start to see that many of the operations management terms and concepts are linked and dependent on each other for success.

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. The old American Tobacco Company used to have a person standing in front of every machine to fix it in case it broke down, however, according to one worker there the machines never broke down.[117]

- **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.

  Non-value-added processing also includes preforming processes that do not need to be done. This waste is a contributor to work in process by tying up resources that may not need to be used.

- **Inventory in excess of immediate needs:** This waste is very close in nature to the first waste of overproduction. This is also the waste that led to the original focus on "zero

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[117] The American Tobacco Company had a preventive maintenance shift on the weekends to work on the machines in the cigarette manufacturing facility to ensure that they were operational. They also had mechanics on each shift to fix the machines if the person watching the machine ever reported that they had stopped working.

inventories." Careful and accurate forecasting coupled with knowing what the customers need and want will help the company eliminate this waste. Managing this waste does not mean zero inventories, but it does mean reducing nonproductive inventory. As you recall from our discussions of inventory management, non-productive inventory is stuff that no one is buying. If no one is buying it, then why is it being held in 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. Sometimes the use of RFID tags helps to identify this unnecessary or wasted movements.

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.

In Just-in-Time, the movement of one inch is still considered a movement. If it does not need to be moved, why move it? This ties to our discussion of facility layout and the goal to minimize moving or touching an item.

- **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 16 will look at some of the additional costs companies incur from the waste of reworking defects. The bottom line is design a quality product, design the process to build a quality product, then train the employees to build a quality product.

- 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? Only have meetings when it is necessary. The goal of software like Microsoft Office is to improve productivity by being able to share information electronically rather than have to sit in a meeting to have someone read slides to you. If a face to face meeting is not needed, why have it? How much money is spent annually in companies on meetings that are not necessary.

JIT Elements

In addition to 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." The key with flexible resources from my perspective is: if I give you additional training and additional skills, I should also give you additional pay for those skills.

- 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 18-1, 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 18-1).

$$\text{\# of Kanbans} = \frac{\text{average demand during lead time + safety stock}}{\text{container size}}$$

Formula 18-1: Kanban Calculation

a. demand = 300 widgets per hour
b. lead time= 1 hour
c. safety stock is set at 10% of the demand during the lead time
d. container size = 75 widgets

$$K = \frac{(300)(1) + 30}{75}$$

$$= 4.4 \text{ Containers}$$

Example 18-1: Kanban Calculation

In Example 18-1, 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. This is the only calculation that we look at in this course that we have an option of rounding up or rounding down. Being a strong believer in never running out of product, I always recommended to my clients to round up.

- 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 18.1 and 18.2. Figure 18.3 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 18.1: Tire Jack Mark for NASCAR Pit Crews for Quicker Set Up Times

Figure 18.2: Another View of the Jack Set Up Mark on the US Army NASCAR Car

Figure 18.3: Tires Readied for Use on a NASCAR Cup Series Car

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 in Figure 18.3. 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. This was time consuming and distracting to the driver.

- 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. When the Harley-Davidson Plant was operational in Kansas City, Missouri, although each of the three main lines was dedicated to a particular line of motorcycles, each line is in fact a mixed model assembly line. On the same line the company makes V-Rods for the United States, Japan, Australia, and Europe. 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. However, they could not make a Sportster on the Dyna line thus reducing some flexibility in the plant.

- 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 practice 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 14th 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" (John Blackstone, 2014). 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[118]

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[118] *The Theory of Constraints Handbook*, edited by James Cox, III, and John G. Schleier, Jr., McGraw-Hill, New York, 2010, p. 3.

The Theory of Constraints (TOC) grew from the business novel, *The Goal*,[119] 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."[120] 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 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

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[119] *The Goal* was released in 1984; the term theory of constraints did not appear until 1987.

[120] APICS Dictionary, 14th edition, 2010, p. 142.

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 drumbeat 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. Define the process – what are we doing? In order to define the process, you have to physically walk the process. This is akin to the concept put forth in the Harvard Business Review called "Staple yourself to an order."
- **Measure –** in this step the process as the process is walked and documented, a detailed process map with every activity, the time allocated to the activity and how long each activity takes 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 and test it to make sure it works.

- **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.

Lean

When Ohno and Shingo wrote about the Toyota Production System, they actually called what we now call Just-in-Time "lean." Something got lost in translation for many years. In 1995, James Womack wrote *Lean Thinking*. It was a follow on to his book, *The Machine that Changed the World.* His first book was about the Toyota Production System not really a machine itself. While researching the for the book, Womack became very interested in the foundations of the Toyota Production System. His follow-on book, *Lean Thinking,* turned out to be a literal translation of Ohno and Shingo.

This literal translation became the foundation of the lean movement. This foundation of lean includes the following similarities with JIT:

- The mandate of lean is to eliminate waste, improve quality and reduce costs. The same mandate and goals of JIT.
- There are seven wastes in lean – in fact they are the same seven wastes of JIT since it is simply a literal translation from Japanese into English of Ohno/Shingo.

Lean has taken on a life of its own since the release of Womack's book. In the quality world, half of the "experts" believe that lean is a tool of JIT and half of the "experts" believe that JIT is a tool of lean. In actuality, they are the same thing. They have the same wastes, the same goals and the same mandate. And they both come from the original works of Ohno and Shingo.

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 is 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 non-constraint 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 14?
15. How can quick set ups improve operations?

Chapter 19

Supply Chain Preparedness

Supply chain security has long been a problem for practitioners. As you will see in this chapter, this is not a new problem. The events of September 11, 2001and the events of the rest of that week, emphasized the importance of security and the potential impacts of interruptions to the supply chain. This is not a United States-only problem—Supply Chain Security is an international problem with large implications for everyone involved in supply chain management and operations management. But the time has come to look at other impacts to supply chains that may disrupt the continuous flow of goods and services to the customers.

Why should you care about supply chain security? As long as the items that you order arrive, are you really concerned with how they get there and whether or not the items are secure while in transit? This goes back to "supply chain done well is all but invisible." Supply chain risks come in the form of panic buying during the pandemic, supplier failures, natural disasters as we saw at the Port of New Orleans during and after Katrina in 2005 or the problems at Port-Au-Prince after the earthquake in 2010, Puerto Rico impacts from the 2018 hurricanes, terrorist attacks, employee theft, or risks from regulatory requirements. The 2016 earthquakes in Japan impacted supply chains as far away as Kansas City, KS.

What is supply chain security and if it is so important how come it is not discussed in most operations management textbooks? The goal of this chapter is to not only familiarize the student of operations management with the topic of supply chain security but to also demonstrate to the student the importance of end-to-end supply chain security throughout the entire supply chain and the costs associated with supply chain security. At the same time, the goal is to show the importance of supply chain preparedness in operations management and in business in general.

There is not much more in the form of strategy for supply chain security today than there was in the Wu Province of China in 512 B.C. Sun Tzu lived in the Wu Province and wrote in the

first chapter of his book *The Art of War* that protecting supply lines was important. In fact, he went so far as to say that to be successful in any operation, you must protect your supply lines. The United States published a *National Strategy for Homeland Security* in 2007 that mentions no more about supply chain security than Sun Tzu's work 2500 years earlier. The National Supply Chain Security Strategy from 2012 (see Figure 19.1) has a longer executive summary than the strategy document itself. A lot of energy is going into writing about supply chain security but not a lot of energy is going into actually preparing for interruptions in the supply chain.

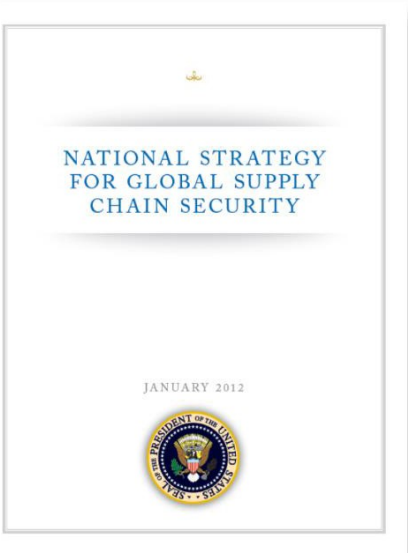

Figure 19.1: National Strategy for Global Supply Chain Security Cover

Supply chain security is all the actions taken to ensure the security of items passing through the supply chain. Supply chain security has major impacts on the actions of key players throughout the supply chain and can impact customer responsiveness and supply chain costs. According to several accounts, the impact of an attack on a major port within the United States could cost as much as $20 billion daily to the US economy. According to *FORTUNE* magazine, the costs to the US economy as a result of the terrorist attacks of September 11, 2001, is approximately $50–80 billion a year as a result of increased inventory levels, increased security measures, and higher transportation costs.

Counterfeit products are the latest threat to supply chains. Amazon announced in their 2018 that they had a major issue with counterfeit products. This was followed by a claim from Apple that as much as 90% of the Apple products sold through Amazon were fake. In 2020, the growth of e-commerce as a direct reaction to coronavirus fears led to a growth in fraudulent products being offered to consumers.

The fact that supply chains continue to lengthen and become more globalized contributes to the complexity and security implications of supply chains. Although the terrorist activities around the world have put the focus of supply chain security on attacks to the supply chain from terrorists, the fact is that the risks to supply chains requiring attention and impacting security are greater than just terrorist attacks as we will see in this discussion of supply chain security. The threats to supply chains can come internally or externally to the supply chain.

Is supply chain security really a problem? Here (Figure 19.2) are some of the threats to twenty-first century Supply Chains:

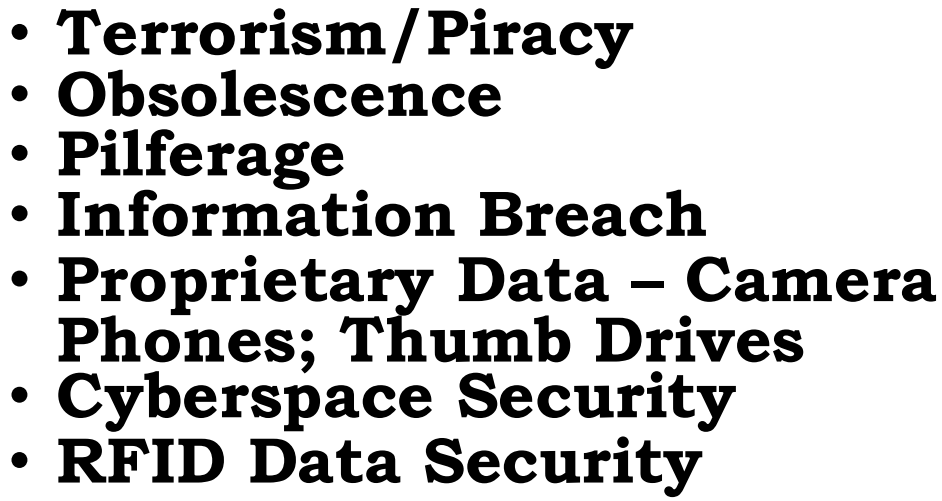

Figure 59.2: Threats to Supply Chains

Let's take a look at each of these threats to supply chains. The most commonly associated threat to supply chains is terrorism. Another form of terrorism that has received more than cursory attention lately is the threat of piracy. Terrorism threats receive more attention than other potential threats to supply chains.

Obsolescence of materials and products is a threat to supply chains as was discussed in previous chapters. Although this threat to supply chain operations and operations management success is critical, it is not a threat in the sense of supply chain security. But proper planning and careful inventory management can prevent this from being an issue.

Pilferage and theft within supply chains is a growing problem. This comes in the form of employee pilferage and theft along the entire supply chain. Theft by employees in distribution centers in the United States alone is reported as high as $60 billion annually (two studies were

released in 2019 that placed this issue at between $10 and $60 billion depending on which study you believe). According to one investigator specializing in distribution center theft this figure may be only 10 percent of the actual losses since some companies do not want to report employee theft.

As we will see in the next section when we look at some recent headlines about security, information breaches are becoming a larger and larger problem as more business is completed on the Internet. A recent article in the *Kansas City Star* newspaper looked at the proliferation of information on the Internet as a result of e-commerce and social networking sites. Everyone read about the 2013 security breach at Target and the trickle-down effects from that debacle—this all started with a supplier's computer system and allowed a backdoor into Target's system.

Tied to information breaches and loss of data is the theft of proprietary information by disgruntled employees. Several years ago, a secretary at Coke was arrested by Federal Agents for trying to sell the proprietary formula for Coca Cola to Pepsi. Twenty-five years ago, a good computer had a 100 MB hard drive (yes, you read that right, 100MB – about the size of this textbook with pictures). Today you can buy a 256 GB thumb drive that can hold thousands of pages of proprietary data and information if a disgruntled employee wanted to steal information and sell it to competitors. Cell phones with cameras used to be a science fiction story; today any employee can capture data from work on the phone and pass it to others easily or with a camera pen for that matter. Some companies do not allow cell phones on tours of the factory—the reason given is to prevent distractions; however, when questioned privately several admit that the ability to take pictures of proprietary operations with the phones is the reason for the rules. The 3M plant in Panama makes sanding disks and buffing pads using robotics, they do not allow cameras as they don't want their competition to see what they are doing.

RFID security is a grave concern as discussed earlier. If you can read your tag's information, who else can read the information thus making your data available to many and allowing potential thieves to target shipments? It was not until 2013 that developers started working on an encrypted RFID tag. This after over 20 years of commercial use for RFID tags. This is from a 2016 article on encrypted RFID tags:

"Radio frequency identification (RFID) chips have made cashless payments commonplace and opened the way to automatic inventory control. However, they've also made it possible for credit card details and other private information to be stolen wirelessly. To make

things a bit more secure, MIT and Texas Instruments are developing an "unhackable" RFID chip that's designed to fend off information-stealing attacks."[121]

There are other potential problem areas for supply chains that need to be discussed before we move on. As much as 66% of all sealift containers coming into the United States arrive through 20 major ports. Although this sounds significant from a security perspective, it becomes even more significant when drilling down a bit and realizing that more than 58% of the inbound containers to the United States come in through the Ports of New York/New Jersey, Los Angeles, and Long Beach. And this becomes even more significant from a supply chain security perspective when one realizes that approximately 44% of the inbound cargo containers arriving in the United States come to the West Coast Ports of Los Angeles and Long Beach. From a security perspective, these threats or potential problem areas are a result of the lengthening of supply chains as a result of globalization of supply chains and the continued trend to off-shore manufacturing operations to emerging countries. Perhaps the lessons being learned during the 2020 pandemic will result in more operations being near-shored (Mexico, Latin America) or even brought back to the US which would shorten supply chains and possibly reduce some risks associated with longer supply chains.

A Sampling of Supply Chain Security Related Headlines:

- Kids hospitalized after eating counterfeit Nerds laced with THC
- Natural Disasters – follow up report on Puerto Rico
- Floods
- Factory Fires
- Cyber attacks –
- Panic Buying
- Citrus Australia trials blockchain traceability system
- Coronavirus increases online shopping, but buyers fear fakes

As more companies start to experience supply chain interruptions, headlines such as the ones listed above continue to increase. As more companies discover the risks to their supply chains, more executives are becoming interested in preventing, mitigating, or eliminating supply

[121] https://newatlas.com/unhackable-rfid-team-credit-cards/41707/, accessed 20 April 2020.

chain risks. Even though the focus remains on terrorist threats, supply chain security includes supply chain preparedness which also includes the risks from natural disasters as has been seen from Hurricane Katrina in 2005 and the impacts to the shipping into and out of New Orleans; the impacts to the food supply chain as a result of the British Petroleum oil catastrophe in the Gulf of Mexico; the impacts from the earthquakes in Japan in 2012 and 2016; the impacts to the medical supply chain after the hurricanes ravaged Puerto Rico in 2018; and the impacts in shipping from Hurricane Harvey's deluge in Houston in 2018.

"We have proved to our management that good security is good business."

—Ann Lister of Texas Instruments

Examples of supply chain security problems, not making headlines:

- Distribution Center, 2014: "A big problem that we are facing now is the printing of shipping labels at home and employees picking shipments for themselves and putting on official looking shipping labels."
- Major Distributor, Dec 2006: A company I was working with during this time had a security problem. This particular company used RFID tags and an Automated Manifesting System to track and process electronics shipments. As a result of this technology and partnerships with certified suppliers, this particular company was in the habit of accepting shipments based on the RFID tags and the Automated Manifesting System.

  This particular truck arrived at the dock of the Third Party Logistics Provider (3PL) providing distribution center management for the company. This truck backed up to the dock at the distribution center to the dock door designated at the entry gate. The driver dropped the trailer at the dock door and left. Thirty minutes later another tractor hooked up to the trailer and departed the yard. No one at the security gate suspected anything as the average time to offload a truck was about 30 minutes.

  Six months later the company, their insurance company, the trucking company, and their insurance company were still in discussions on who was liable for the disappearance of over $3 million (USD) in electronics.
- Locks on trucks: Apparently thieves in the New York area have discovered that getting access to cargo in the back of a semi-trailer is not that difficult. All that is needed is a Bic lighter. Holding the lighter under the large locks on the back of the trailer for a set period

of time allows the thieves to then hit the lock with a hammer and the lock will split wide open giving access to the thieves to all that is in the trailer. This is why you will see trailers parked back to back in trailer yards when not on the road.

- SAFE Port Act: The full title of this law is the SECURITY AND ACCOUNTABILITY FOR EVERY PORT ACT OF 2006. The act was signed into law on October 13, 2006. This law defines the supply chain as: *"INTERNATIONAL SUPPLY CHAIN. —The term ''international supply chain'' means the end-to-end process for shipping goods to or from the United States beginning at the point of origin (including manufacturer, supplier, or vendor) through a point of distribution to the destination."*[122]

  This law provided for unannounced inspections of cargo containers and added more legitimacy to the Customs-Trade Partnership Against Terrorism (C-T PAT). The law also set forth for the scanning of containers at ports of entry. "*SCANNING CONTAINERS.—Subject to section 1318 of title19, United States Code, not later than December 31, 2007, all containers entering the United States through the 22 ports through which the greatest volume of containers enter the United States by vessel shall be scanned for radiation. To the extent practicable, the Secretary shall deploy next generation radiation detection technology."*[123]

The law also established the requirement for a strategy for improving the "International Supply Chain." Part of this strategy resulted in 2010 of what has become known as the 10+2 Reporting Requirements. According to the Customs and Border Patrol, "The Security Filing, commonly known as the '10+2' initiative, is a Customs and Border Protection (CBP) regulation that requires importers and vessel operating carriers to provide additional advance trade data to CBP pursuant to Section 203 of the SAFE Port Act of 2006 and section 343(a) of the Trade Act of 2002, as amended by the Maritime Transportation Security Act of 2002, for non-bulk cargo shipments arriving into the United States by vessel." These reporting requirements must be done electronically via an Automated Manifesting System or an Automated Broker Interface. This

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[122] The SAFE Port Act is Public Law 109-347.

[123] PUBLIC LAW 109–347—OCT. 13, 2006, **Subtitle C—Port Operations SEC. 121. DOMESTIC RADIATION DETECTION AND IMAGING.**

reporting is commonly called the 10+2 Reporting Requirements. Figure 19.3 shows the "10" reporting items for shippers/importers:

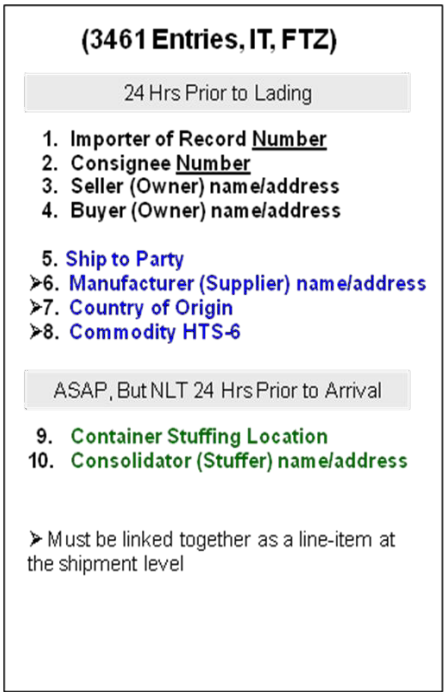

Figure 19.3: Reporting Requirements[124]

In addition to the "10" reporting requirements for shippers, the carriers are required to report their vessel stow plan and any container status messages.

- Scanning of Containers: The goal of the scanning of all containers coming into the United States is to identify any potential dirty bomb coming into the United States in any one of the approximately 12 million containers coming into the country. The use of X-ray machines and radiation detectors is the plan for this scanning. The concern of the workers at ports is the effect to the workers from the exposure to large X-ray machines. Included in this effort are the Container Security Initiative, the Megaports Initiative, and the

[124] http://www.cbp.gov/xp/cgov/trade/cargo_security/carriers/security_filing/, accessed May 30, 2010.

Secure Freight Initiative. The National Strategy for Homeland Security explains the process as[125]:

*"The **Container Security Initiative** (CSI) creates a security regime to prescreen and evaluate maritime containers—before they are shipped from foreign ports—through automated targeting tools, ensuring that high-risk cargo is examined or scanned. The **Megaports Initiative** is a Department of Energy program in which the United States collaborates with foreign trade partners to enhance their ability to scan cargo for nuclear and other radiological materials at major international seaports.*

*The **Secure Freight Initiative** is a comprehensive model for securing the global supply chain that seeks to enhance security while keeping legitimate trade flowing. It leverages shipper information, host country government partnerships, and trade partnerships to scan cargo containers bound for the United States."*

The Department of Homeland Security (DHS) initiated the first phase of the Secure Freight Initiative in 2007. This phase included the use of "existing technology and proven nuclear detection devices" at six major ports of embarkation shipping to the United States. According to the DHS, "Containers from the ports will be scanned for radiation and information risk factors before being allowed to depart for the United States." The first six ports in this program are: Port Qasim (Pakistan), Port Cortes (Honduras), Southampton (United Kingdom), Port Salalah (Oman), the Port of Singapore, and Port Busan (South Korea).

There is a link between homeland security for the United States and any country and supply chain security as discussed in ***The National Strategy for Homeland Security***. This document was published in October 2007. The strategy starts with:

"America is at war with terrorist enemies who are intent on attacking our Homeland and destroying our way of life…… The purpose of our strategy is to guide, organize, and unify our Nation's homeland security efforts. It provides a common framework by which our entire Nation should focus its efforts….

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[125] For more on the National Strategy for Homeland Security go to http://www.dhs.gov/xlibrary/assets/nat_strat_homelandsecurity_2007.pdf

The private and non-profit sectors also must be full partners in homeland security. As the country's principle providers of goods and services, and the owners or operators of approximately 85% of the Nation's critical infrastructure, businesses have both an interest in and a responsibility for ensuring their own security. The private sector plays key roles in areas as diverse as supply chain security….

Our vast land and maritime borders make it difficult to completely deny terrorists and their weapons access to the Homeland."[126]

- Containers in Pakistan: During Operation Enduring Freedom, all cargo that could not be brought in by air arrived via ground shipment through Pakistan. The thieves in Pakistan figured out that the military containers were weighed when they leave the port of entry and are then weighed again upon entry into Afghanistan. The solution of the thieves was to cut the back of the container off, empty the supplies and materials in the container, and fill it back with filled sand bags until the proper weight was achieved and then weld the back onto the container. This left the security seals intact and gave the illusion of a container that had not been tampered with as it crosses the border.
- C-T PAT: This started after September 11, 2001 as a voluntary partnership between the Customs and Border Patrol and Commercial companies. By the time the SAFE Port Act, became law, this voluntary organization had over 9000 participants. The participating companies go through an audit and certification process to demonstrate that they have control of their containers and products from the time the products are loaded into the containers. This then provides the participants a "fast-pass" through the inspection processes established by the SAFE Port Act. "Partners in protection" is the Canadian equivalent of C-T PAT.

- ISO Standards for Supply Chain Security: According to the International Standards Organization, "The **ISO 28000 series of standards** on supply chain security management systems, which have just been upgraded from their status of Publicly Available Specifications to that of fully fledged International Standards, will help to reduce risks to people and cargo within the supply chain. The standards address

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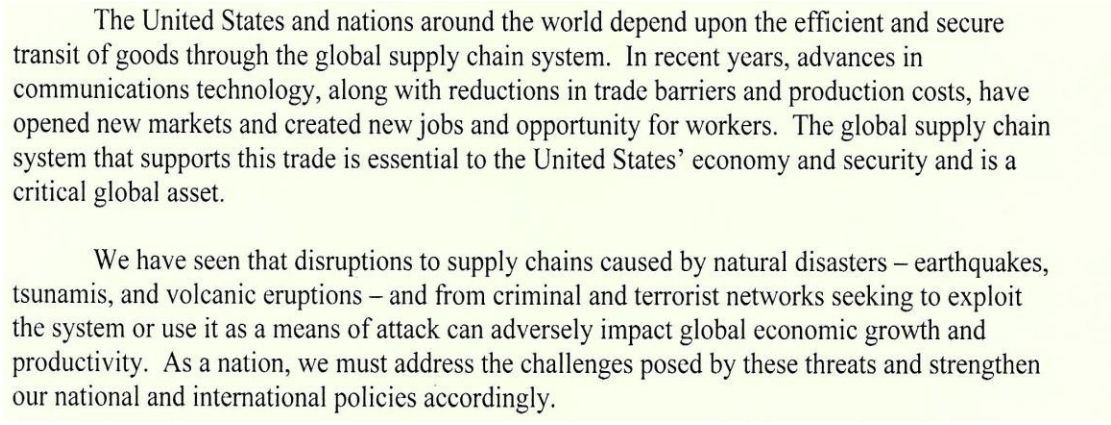
[126] National Strategy for Homeland Security, Homeland Security Council, October 2007, pp. 1–6.

potential security issues at all stages of the supply process, thus targeting threats such as terrorism, fraud and piracy."

- Terrorism Risk Insurance: The US Terrorism Risk Insurance Act was signed into law by former President George W. Bush in 2002 and renewed in 2007 with an expiration date of 2018. The goal of this law is to supplement commercial insurance companies in the event of terrorist attacks such as 9/11. On December 20, 2019, the President signed into law the Terrorism Risk Insurance Program Reauthorization Act of 2019 (Pub. L. 116-94, 133 Stat. 2534) [2019 Reauthorization Act], which extended TRIP through December 31, 2027.
- The National Strategy for Global Supply Chain Security was published in 2012.[127] The opening paragraphs for the strategy are shown in Figure 19.4.



The United States and nations around the world depend upon the efficient and secure transit of goods through the global supply chain system. In recent years, advances in communications technology, along with reductions in trade barriers and production costs, have opened new markets and created new jobs and opportunity for workers. The global supply chain system that supports this trade is essential to the United States' economy and security and is a critical global asset.

We have seen that disruptions to supply chains caused by natural disasters – earthquakes, tsunamis, and volcanic eruptions – and from criminal and terrorist networks seeking to exploit the system or use it as a means of attack can adversely impact global economic growth and productivity. As a nation, we must address the challenges posed by these threats and strengthen our national and international policies accordingly.

Figure 19.4: Supply Chain Security Strategy (Government, 2012)

Risk Analysis and Supply Chain Security

"If you do things the way you've always done them, you'll get the same things you've always got."

—Darrell Waltrip (Three-time NASCAR Winston Cup Champion)

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[127] Go to:

http://www.whitehouse.gov/sites/default/files/national_strategy_for_global_supply_chain_security.pdf for more information on this strategy.

The goal of supply chain risk analysis is twofold. The first goal is to ensure that you do not do things the way they have always been done in the past. The second goal of risk analysis is to identify the risks to the supply chain and the severity of the impacts if the risks become reality. Supply Chains are inherently complex, dynamic, and fluid, characterized by uncertainty, ambiguity, and friction. These characteristics cloud the operating environment. These supply chain characteristics also create risks to the supply chain. The best way to identify risks to your supply chain is to walk the process to completely understand the potential risks to the supply chain.

Once the risks have been identified the next step is to implement a risk management program. The goal of the risk management program is to implement processes that will eliminate, minimize, or mitigate the occurrence and/or impact of any potential risk. The goal is to prevent any catastrophic risk to the supply chain. Just what is a catastrophic risk? Anything that can slow or stop the flow of supplies through the supply chain is potentially a catastrophic risk. It could be a recalled product as Mattel learned in 2008, it could be the inability to meet shipments as Hershey learned in 1999, or as Toys-R-Us learned in the same year. The goal of a good risk management program is to ensure that the problems do not become catastrophic by hitting the front page of *USA Today* or the headlines of CNN.

Historical perspective of Supply Chain Security

Risks to supply chains are not a twenty-first century invention. This has been a problem for at least 2500 years. In *The Art of War,* Sun Tzu wrote that the key to success in any operation depended on protecting and securing supply lines. The Japanese Imperial Navy clearly understood supply chain security as they moved across the northern Pacific Ocean enroute to Pearl Harbor.

In his book, *Vietnam Logistics,* General Joseph Heiser wrote, “There were no secure rear areas.” He went on to explain that the fuel lost from the pipelines from theft was almost as great as the amount of fuel delivered to the intended recipients.

The pirates of the Caribbean were real and made their fame by interdicting supply lines to the “New World” long before they became part of a ride at Disney World and later a series of movies. Blackbeard based his crew out of the Ocracoke, North Carolina and made his fortune doing the same off the East Coast of the United States. The goal of the pirates in the 1700s was

to stop shipments moving from the Old World to the New World and take what they wanted from the ships heading west.

In the United States, the Native Americans realized very early that the best way to slow the expansion of the settlers moving west was to attack the wagon trains. Their goal was to stop the supply and resupply of the settlers. The reaction to counter these attacks was the establishment of outposts or military forts throughout the western United States to protect the supply lines.

The German Navy understood the same concept during World War II and did their best to slow the resupply of Allied Forces by attacking the ships at sea in the Atlantic Ocean and as close as just off the coast of North Carolina. They understood that if the supply lines were severed, the ability to sustain combat operations was severely diminished. The Germans even contemplated destroying the Panama Canal to interrupt the flow of supplies.

During the American Civil War, the goal to interdict the supply chains led to the actions that produced the first Congressional Medal of Honor recipients. It also led to a Disney movie, *The Great Locomotive Chase*, in 1956. Understanding that interdicting the supply lines from Atlanta to Chattanooga would cut off resupply of the Confederate States of America soldiers, the Union soldiers infiltrated and attempted to steal a locomotive with the intent of destroying all of the bridges north of Atlanta. Likewise, the goal of the Siege of Petersburg, Virginia was to sever the rail lines heading north from North Carolina to Richmond. Severing the rail lines would cut off the resupply of the soldiers of General Robert E. Lee's Army. General Sherman attempted to stop the rebuilding of the rail in Georgia during his march to the sea. To prevent reuse of the rail, General Sherman had the rail removed, heated and wrapped around trees as shown in Figure 19.5.

Figure 19.5 Rail Wrapped Around a Tree as Seen in The American Civil War Museum

Protecting supply chain operations has been a problem and an issue for most of recorded history. It is just as important today as it has been over time. The difference today is that supply chains are inherently more complex and globalized, thus presenting more potential opportunities to interrupt or interdict and impede supply chain operations. The old Oldsmobile commercial stated, "This is not your Dad's Oldsmobile." Today's supply chain is "Not your Dad's Supply Chain!" The potential risks are greater from inside and outside the supply chain.

Food/Pharmaceutical Supply Chain Security

One of the areas that has received a lot of attention since the 9/11 attacks is the food supply chain and the pharmaceutical supply chain. The concern about the food supply chain led to the requirement for Country of Origin reporting requirements. These reporting requirements were designed to prevent bio-terrorism activities and are now part of the "10+2" reporting requirements discussed earlier.

However, let's take a look at some of the most recent "bio-terrorism" incidents in the United States. Most of these are not bio-terrorism at all but still had great impacts on supply chains and fall under the umbrella of supply chain security.

- Peter Pan Peanut Butter: In 2007, every jar of Peter Pan Peanut Butter was recalled due to E-coli contamination.
- Just one year earlier, in 2006, all of the fresh Spinach was recalled because of E-coli. Like the Peter Pan situation, the E-coli was not bio-terrorism but the impact on the supply chain—both forward and reverse was dramatic.
- E-coli was also responsible for problems experienced by Chi-Chi's in 2003 and Taco Bell in 2005.
- In 2008 there were salmonella and E-coli scares in the fresh foods industry. First all of the fresh lettuce was taken off the shelves; then when that did not fix the problem, all of the peppers were taken off the shelves. Turns out there were problems with the supply chain but not in the bio-terrorism area, only in the handling and processing of the foods—all within the United States.
- The largest incident of salmonella poisoning in recent history was another example of supply chain impacts—especially going backward. This like the other examples was not an incident of supply chain bio-terrorism. It was simply a problem of poor control and handling in the supply chain—primarily in the "Make" function of the supply chain.

  In this particular incident the Peanut Corporation of America provided products that were contaminated with salmonella. This resulted in over 3921 separate SKUs being recalled and almost 40,000 reported cases of salmonella poisoning. Prior to the use of Peanut Corporation of America (PCA) products, Kellogg hired a consultant company to analyze the operations at PCA. Kellogg used the lowest bidder process for this consultant and was told that there were no problems at the PCA plant. Nestle used a different consultant. This consultant reported potential cross contamination of products, rat feces in the plant, roaches in the plant and recommended against the use of the company's products. Kellogg, the parent of Keebler, had multiple products recalled due to contamination while Nestle had no products recalled due to salmonella contamination from the PCA products.
- 2014; Listeria found in cantaloupes from Colorado. In this incident a number of people died from the listeria poisoning.

- 2018 and again in 2019: Recall of Romaine lettuce due to e-coli contamination.

While bio-terrorism is definitely a potential international supply chain security problem, the most recent incidents reported have not been terrorism but self-inflicted problems. The security of the pharmaceutical supply chain poses a grave concern for everyone. In the introduction, we mentioned counterfeit items as a risk to supply chains. In the pharmaceutical supply chain this poses a greater risk. One of the counters to this risk is the use of RFID tags to identify products, lot numbers, and expiration dates.

As was seen in the recent Tylenol recall (2010), the use of ingredients that are not pure or controlled can cause problems in the pharmaceutical industry. Because of the potential impacts of contamination of ingredients in pharmaceutical products, supply chain security becomes a larger issue with potentially wider consequences. As more products are sourced globally, this concern increases. According to the Pharmaceutical Security Institute (http://www.psi-inc.org):

"Counterfeit medicinal products are a threat to the health and safety of patients around the world. They range from drugs with no active ingredients to those with dangerous impurities. They can be copies of branded drugs, generic drugs or over-the-counter drugs."[128]

The link to the supply chain is explained by the Pharmaceutical Security Institute (PSI):

"Pharmaceutical theft is defined as an illegal taking of medicines. Thefts include burglary, robbery, or an embezzlement of goods. The responsible individuals may be insiders such as employees, or outsiders such as professional thieves. The theft may occur anywhere in the distribution chain such as at the site of manufacture, freight forwarder, distribution centers, warehouses, pharmacies, or hospitals."[129]

Another aspect of pharmaceutical supply chain security being countered by the use of RFID tags is deemed "Illegal Diversion" by the PSI. Illegal Diversion is defined and described as: *"Illegal diversion occurs when a genuine pharmaceutical product is approved and intended for sale in one country, but is then illegally intercepted and sold in another country. These*

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[128] http://www.psi-inc.org/index.cfm, accessed May 31, 2010.

[129] http://www.psi-inc.org/counterfeitSituation.cfm, accessed May 31, 2010.

schemes are often accomplished through the use of false statements or declarations."[130] The Associate Commissioner for Policy and Planning for the US Food and Drug Administration in testimony before Congress stated: "While the United States drug supply is among the safest in the world, we believe there are increasingly sophisticated threats from drug counterfeiters. Organizations and individuals who peddle fake medicines put unsuspecting patients at risk, by exposing them to unknown contaminants and denying them medicines known to be safe and effective at treating their medical ailments. Counterfeit drug products and illicit drug diversion are major concerns to FDA."[131]

The global impact of counterfeit and diverted products within the pharmaceutical supply chain continues to grow as supply chains become more globalized. Pfizer has taken a plan of attack of buying these counterfeit products and analyzing them to see what components are being used. One of their latest discoveries from counterfeit batch was that there were only 4% active ingredients and 96% concrete dust.

Other counterfeit items impacting the supply chain include counterfeit condoms, counterfeit cigarettes, and counterfeit liquors and wines. In fact, in 2012 there were more bottles of 1992 Rothschild wine in China than were actually bottled originally. In 2012 there was a court case involving fake 200-year-old wine and later an article online giving the details of how to counterfeit antique wines. The impact of these products in supply chain security and supply chain confidence is great and has ripple effects through the entire supply chain.

A Global Perspective

As the pandemic of 2020 demonstrated to everyone, supply chains are global, and a global pandemic can play havoc with the supply chain. The interrelationship of countries through the supply chain require global supply chain security and preparedness.

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[130] Ibid.

[131] http://www.fda.gov/NewsEvents/Testimony/ucm111840.htm, accessed May 29, 2010.

The Port of Rotterdam

Rotterdam is the largest port in Europe with over nine million twenty foot equivalent containers coming into the port each year. This means over 25,000 containers every day of the year coming into Rotterdam. This drives the over 900 barge moves daily to approximately 72 locations reachable by barge and over 200 rail moves each day from the port to customer locations to the east. The rail and barge movements into and out of Rotterdam provide support to the over 220 million people that live within a 600 mile radius of Rotterdam.

In addition to containers, rail movements, and barge moves, The Netherlands is home to over 9000 distribution centers with over $64 billion (USD) in logistics operations. These operations help to feed the logistics operations in Belgium where over 13% of the shipments move through the country via rail and into Germany where approximately 15% of the shipments arrive via rail.

Rail security in Europe, like in the United States is critical for success of supply chain operations. In the United States, there are only four major rail bridges across the Mississippi River. Every rail bridge in the United States and in Europe present targets of opportunity for supply chain security lapses.

Preparedness

It is time to move from a narrow-minded focus on supply chain security as anything that is manmade to interrupt the supply chain. This focus has helped to reduce the number of terrorist attacks globally but as we have pointed out earlier, natural events can impact the supply chain just as severely and occur more frequently.

Companies and countries need to start contingency planning based on impacts from natural events such as hurricanes, tornados, earthquakes, tsunamis, volcanos, and other major weather related incidents. This contingency planning is called **preparedness**. Every company needs to take a close look at their supply chain and start making plans to ensure that their customers are ensured an uninterrupted flow of products regardless of what happens.

According to Motorola University, the first step of six sigma is to define who the customer is, what the customer wants and how “we can do it better than the competition.” This is the foundation of preparedness – what do we need to do to take care of the customer?

Summary

Supply chain security is not a new issue but one that has the potential to have an enormous impact on the success and profitability of a company's supply chain operations. Sun Tzu warned us 2500 years ago to protect our supply lines to be successful in any operation. The supply chains of Sun Tzu's day were much less complicated than the supply chains of the twenty-first century. Supply chains were mostly local in Sun Tzu's day; supply chains are mostly globalized and inherently complex in today's world.

Supply chain security starts with a process walk of the supply chain to identify potential risks and then putting a risk management plan in place to eliminate the risks if possible. If elimination of the risk is not possible, the risk management program should seek to minimize or mitigate the impact of the potential occurrence of the risk. The goal is to protect the items in the supply chain from end to end and ensure that the products reach the intended customer without delay.

There is a link between supply chain security and homeland security—this is not a US-unique problem. There is also a link between supply chain security and velocity in a supply chain. The more secure a supply chain is the greater the chance that it may move a little slower. However, it is much better to move a little slower than stop moving at all. A good example of this is the Maersk Lines. They made a decision in 2009 to stop shipping through the Suez Canal and start shipping around the Cape of South Africa to prevent attacks by the Somali pirates. This results in a longer shipping time but a much more secure route. There are trade-offs between security and speed. This is what supply chain managers get paid to do.

In addition, there are natural disasters that have the same impact on the flow of goods and materials that supply chain managers and supply chain leaders need to take into consideration when planning their supply chains. If the security and preparedness of the supply chain are considered as part of the SCOR Model function of Plan the Supply Chain, companies will be postured for success and customers will be assured of an uninterrupted flow of goods and services.

Discussion Questions

1. Discuss the link between supply chain security and homeland security.
2. Pick a retail supply chain and identify potential supply chain risks.
3. Does supply chain security impact profitability?
4. Why is there a trade-off between speed and security?
5. What are the costs of supply chain security?
6. Is supply chain security a USA unique problem? Why or Why not?
7. What purpose does a process map and process walk have in supply chain security?
8. Why is the Country of Origin a concern from a supply chain security perspective?
9. Would Country of Origin reporting have prevented the problems discussed in this chapter?
10. Why should you be concerned about natural disasters impacting supply chains?
11. How does a global supply chain increase the need for both security and preparedness?
12. Search for government recalls of products, why are they being recalled? What is the link of these recalls to reverse logistics?

Chapter 20

Supply Chain Leadership

What is supply chain leadership? What does supply chain leadership have to do with operations management? Every year AMR prepares a list of the "Top 25 Supply Chains." Is supply chain leadership related to making this list? Or is supply chain leadership about making it to the Corporate Level positions as insinuated by a recent magazine article?

This chapter will provide a definition of supply chain leadership as originally put forth by the Supply Chain Leadership Institute in 2001 and will provide a framework for looking at supply chain leadership.

Figure 20.1 City Point, VA; The Location of the Largest Supply Depot for the Union Army During the American Civil War

From this very position shown in Figure 19.1 in City Point, Virginia, General Ulysses Grant learned the value of supply chain leadership as his Army developed the largest supply

chain operations in the American Civil War to support the siege of Petersburg and the eventual defeat of the Army of General Robert E. Lee and the Confederate States of America.

Supply chain leaders must provide purpose, direction, and motivation to their supply chain employees. As a recent picture of my GPS shows, sometimes even products considered world class do not provide this needed direction—you will note that my GPS has me going two directions at once to get out of the drive through window. The directions from a supply chain leader need to be clearer to the employee! The directions from a supply chain leader need to be clearly stated, clearly articulated and clearly understood by everyone that is impacted by the directions. Each employee needs to know what they need to do, why they are doing it and when it has to be completed.

Figure 67.2: Confusing Directions from GPS

"*Leadership must be demonstrated, not announced.*"

—Fran Tarkenton, National Football Hall of Famer

When President Ronald Reagan was shot in 1981, Secretary of State Alexander Haig stated, "I am in charge here." Using the guidance of Fran Tarkenton, if Secretary Haig was truly in charge, he would not have to announce it. The same problem seems to arise whenever there is a crisis, someone wants to tell everyone that he/she is in charge of the situation.

What is supply chain leadership?

What is supply chain leadership? Is it leading one of the Gartner "Top 25 Supply Chains"[132] or leading a supply chain company? Is being on the list of Top Supply Chains truly about leadership? One prominent magazine had an article in 2008 that insinuated that to be a "supply chain leader" one had to be a "C-Level" executive or part of the corporate board of a supply chain company or the Chief Supply Chain Officer. Is that really supply chain leadership?

In a presentation in 2002, the Director of the Supply Chain Leadership Center proposed that the time had come to move from simply supply chain management to supply chain leadership. In that presentation, he defined a supply chain leader as one that leads the people that are working in a supply chain.

In order to best define and study supply chain leadership, it is first important to set a foundation that includes a definition of leadership. Is leadership the same as management? Most discussions of supply chains would lead one to believe that the two may be the same.

[132] For more on the Gartner "Top 25 Supply Chains" go to www.gartner.com

Dictionary.com defines leadership as: "the position or function of a leader."[133] The Webster online dictionary defines leadership as: **"**the act or an instance of leading."[134] Neither of these definitions really gives us a good foundation to define what leadership really is. The US Army defines leadership as: "Leadership is influencing people—by providing *purpose, direction, and motivation*—while operating to accomplish the mission and improving the organization."[135] This definition gives us a little more to work with in establishing a foundation for studying supply chain leadership.

Regardless of where you are in the supply chain if you can provide your employees with purpose, direction, and motivation you will most likely get the mission of the company accomplished. If the mission is accomplished and the employees are motivated, the chances are good that the company will be improved.

The biggest mistake that people make in regard to leadership is: ***believing that they lead a company, department or unit. What they lead are the individuals that make up the enterprise or supply chain.***

Supply chain leadership is about the people in the supply chain and getting those people to do their very best every single day. That is why there is a difference between supply chain management—managing the operations of the supply chain and supply chain leadership—leading the people that are making supply chains function. The difference between good and great supply chains is leadership. To make the Gartner list of Top Supply Chains requires leaders

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[133] leadership. (n.d.). *Dictionary.com Unabridged*. Retrieved July 09, 2010, from Dictionary.com website: http://dictionary.reference.com/browse/leadership

[134] leadership. (2010). In *Merriam-Webster Online Dictionary*. Retrieved July 9, 2010, from http://www.merriam-webster.com/dictionary/leadership

[135] US Army Field Manual 6-22, Leadership, Department of the Army, Washington, DC, 2015.

that can and do get the best out of the people that make up the supply chains of the companies on the list. However, there are supply chain leaders in smaller companies that will never see their company on the Gartner list.

Before we get deep into the look and study of supply chain leadership, as part of our foundation, let's look at management. We have spent a lot of time discussing project management, process management, supply chain management, warehouse management, and inventory management. How does management differ from leadership? Management is defined as: "the act or manner of managing; handling, direction, or control; the person or persons controlling and directing the affairs of a business, institution, etc."[136] This is a very nebulous definition and does not really distinguish management from leadership. The bottom-line difference between leadership and management comes from a discussion with a former military professor that I had in college. LTC Billy Baucom was the first person to explain the difference between leadership and management in a way that made sense to me —"You lead people and you manage things." That being the case, supply chain leadership differs from supply chain management in that supply chain management deals with managing the supply chain activities and affairs as alluded to in the definition of leadership. Supply chain leadership deals with leading the people that make up all of the activities and organizations that are involved in supply chain operations.

Having defined leadership and management, we need one last piece to form the foundation of our study of supply chain leadership. That missing piece is to define what

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[136] management. (n.d.). *Dictionary.com Unabridged*. Retrieved June 10, 2010, from Dictionary.com website: http://dictionary.reference.com/browse/management

leadership is not. Contrary to popular opinions, leadership is not about telling people what to do. Leadership is not about the leader. Leadership is not about the leader's career. Leadership is not about arrogance, although looking at some people placed in leadership roles, it is hard to realize that. Leadership is certainly not about the leader's ego. Overheard a few years ago from a person in a leadership, "I don't care how you do it as long as you make me look good." That is not leadership, that is arrogance and ego getting in the way of taking care of people and providing the proper motivation.

With this dichotomy between leadership and management established, it is time to look at supply chain leadership and its relationship to the operations management chain. What defines a supply chain leader? What are the qualities of a supply chain leader than enables him or her to lead the employees of his or her supply chain to new levels of excellence?[137] Supply chain excellence is the result of good supply chain leadership. The following discussion looks at the attributes of world class supply chain leaders as shown in Figure 20.3

[137] *Modeling and Benchmarking Supply Chain Leadership,* Walden, Joseph L., CRC Press, 2009, provides a very detailed look at the qualities and attributes of supply chain leaders. The Supply Chain Leadership Institute first presented the concept of supply chain leadership in 2002 as the next evolution in supply chains as the industry moved from supply chain management to supply chain synthesis to supply chain leadership.

- **Loyalty/Respect/Character**
- **Ethics/Honesty**
- **A3 - Attitude/Aptitude/Accountability**
- **D4—Devotion, Dedication, Determination, Discipline**
- **E4 - Employee Retention/ Employee Recognition/ Example/Expectations/Enthusiasm**
- **R2 - Responsibility/Reliability**
- **S3 - Self Confidence/Self Knowledge and Self Development/Standards**
- **H5—Humor/Humility/Heart/Happiness/Health**
- **I4—Integrity/Inspiration/Initiative/Interest in Employees**
- **P4—Planning, Professional Pride, Perseverance, Passion, People**

Figure 20.3: Attributes of Supply Chain Leaders

Loyalty, Respect and Character:

Every leader of supply chains must develop loyalty among his/her employees. In doing so the leader has to not only show respect but also command respect from his/her employees. Loyalty must be earned by the leader. During certain periods of history, the loyalty of the soldiers could be bought by either side. In today's sporting world also, as demonstrated by recent free agent deals, loyalty can be bought. In today's supply chain, loyalty must be earned, and loyalty must be demonstrated. In order to be successful as a leader of the employees in a supply chain, the leader must demonstrate to his/her employees that not only does he/she expect loyalty but must prove daily that he/she is loyal to them. A "leader" that does not demonstrate loyalty cannot achieve supply excellence.

Like loyalty, respect has to be earned. And earned every day. As a leader it is important to remember that respect must be given to be received. As a supply chain leader, it is important

to remember that the ultimate reason for having a supply chain is to provide goods to the customer. In order to attract and retain customer loyalty, the supply chain leader has to give respect to the customer and to the employees of the supply chain. There is more than one form of respect. There is respect that goes with being a supply chain manager, a branch chief, or a division chief—this is positional respect and usually is tied to the job or job position and usually does not transfer when the employee transfers to a new position. This is also referred to as professional respect.

The more important form of respect is personal respect. Personal respect is given regardless of the position or company. Personal respect follows a leader from position to position and remains even after the job is finished. This form of respect attracts and retains quality employees and attracts and retains loyal customers.

If the employees do not feel like the leadership is showing respect and loyalty to them, they will not help in developing loyalty and respect for the customer. And without customers the supply chain link is broken, and the company goes out of business.

It is important to remember in supply chains that loyalty and respect must go up the supply chain and down the supply chain.

What is character? How does this fit with loyalty and respect? Character is how you act when no one is watching. Some folks have their professional appearance but their actions away from work are just the opposite of what they appear to be at work. How you act when no one is watching or when no one else will know is the mark of your true character.

Ethics and Honesty:

In supply chains there is no more important value or attribute than ethics and honesty. Buck O'Neil, former Negro Leagues Baseball Player and Manager, said that when he was

growing up his father told him, "Always tell the truth and if that is not possible, tell the truth anyway."[138] Not only is this good advice for life but very good advice for the supply chain leader. If the supply chain leader wants to attract and retain quality employees and customers, he/she has to demonstrate honesty and ethics in every action and transaction. We discussed the importance of ethics in Chapter 3. The importance of ethics in decision making is just as important in supply chain leadership. Without ethics, a supply chain manager will never become a supply chain leader. Without honesty there can be no trust, without trust a supply chain cannot be successful.

Without trust, ethics, and honesty that particular link becomes the weakest link in the supply chain and the reaction from supply chain partners will be the same as the response on the British-imported television show, *The Weakest Link.* For those that have not seen that show, the hostess of the show dismissed the contestants voted off the show with the words, "You are the weakest link, Goodbye!" The last thing any supply chain leader wants to hear from their supply chain partners is those words. Honesty, ethics, and trust will prevent the leader from hearing those words.

Every supply chain is built on trust—trust that the proper item will be delivered in the right quantity; trust that the right quantity will be delivered to the right location at the right time and in the right condition. Regardless where you are in the supply chain you are dependent on

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[138] For more information on the Negro Leagues Baseball history and the Negro Leagues Baseball Museum in Kansas City, Missouri, go to http://www.nlbm.com. Buck O'Neil not only played in the Negro Leagues, he also managed the Negro League World Series Champion Kansas City Monarchs and was the first African American coach in the National League as a coach for the Chicago Cubs.

that trust whether you are a supplier, manufacturer, carrier, or the ultimate customer. Honesty and ethics are critical to establishing and maintaining that trust.

Attitude and Accountability:

What does attitude have to do with supply chains and supply chain leadership? Everything! Sam Walton stated in his autobiography, *Made in America*, that it takes about two weeks for the attitude that a leader shows toward his/her employees to show up in the attitude that the employees show toward the customers. Former Philadelphia Eagles/St. Louis Rams/Kansas City Chiefs Head Coach, Dick Vermeil, once stated that a bad attitude is like a cold and easy to catch—the same is true for a good attitude. What attitude do you want your employees to catch?

How many times have you heard someone say, "You have an attitude?" Of course, you have an attitude. The question is as a leader do you display a good attitude or a bad attitude for your supply chain employees to catch?

As a supply chain leader, it is important to display a positive attitude for your employees as well as for your supply chain partners and customers. As a customer who would you rather do business with the positive attitude supplier or the supplier that has an attitude that reminds you of Eeyore? As a supply chain employee, who would you prefer to work for a supply chain leader with a negative attitude or the positive, enthusiastic supply chain leader that establishes an atmosphere where everyone wants to do business with the company and all of the employees look forward to coming to work every day? The supply chain leader can and does establish this environment for the entire supply chain and for all of the employees that he/she leads.

What about accountability and supply chain leadership? Supply chain leaders have to be accountable to their supply chain partners. Accountability ties back to the previous discussion

about trust. In addition to honesty, accountability helps to develop the trust necessary to be successful.

However, accountability for supply chain leaders also means being accountable for their actions. A recent incident concerning the Athletic Director of a major university demonstrates a lack of accountability. This particular Athletic Director was picked up for suspicion of driving under the influence of alcohol—rather than taking accountability for his actions, he kept telling the police who he was as if that should be an excuse or a reason for letting him go. A supply chain leader admits when he makes a mistake by taking accountability for his/her actions.

In addition to taking responsibility and accountability for his/her actions, a good supply chain leader also accepts responsibility and accountability for the actions of his/her employees. By shouldering the accountability for the actions of the employees, the supply chain leader establishes an atmosphere where employees do not fear making a mistake. When employees do not fear making a mistake, they are motivated to take actions that will benefit the company and the customers. This leads to more satisfied customers and more successful supply chains.

Devotion, Dedication, Determination:

The job of a supply chain leader never stops. This coupled with the complexity of global supply chains and the desire of customers to have the product NOW, places a great deal of stress and demands on the supply chain leader.

The demands on the time of the supply chain leader require a devotion not only to the supply chain and the accomplishment of the missions and goals of the supply chain, but also a devotion to the family and friends of the supply chain leader. Everyone in every line of business talks about the need to find a balance between life and work. And everyone that preaches this usually violates what they preach. It is a classic case of "do as I say, not what I do." As a supply

chain leader, it is important to set that example for employees and supply chain partners to emulate. Finding the balance between quality time with your family and friends is not an option. The job will be there when you get back, but the family and friends may not be there when you finally find the time to find a balance. I have watched folks go through two, three, or four families before they wake up and realize that being a workaholic is not healthy. Too many supply chain leaders seem to think that they are irreplaceable. Try putting your finger in a cup of coffee, and then pull it out. How big a hole does it leave? Everyone can be replaced. If a leader is doing their job right, they will train their employees and then trust the employees to do their jobs even in the absence of the leader.

Dedication is an attribute of supply chain leaders. Supply chain leadership involves dedication to taking care of the customers; dedication to taking care of their links in the supply chain to ensure strength in the links; dedication to taking care of their families, and dedication to taking care of their employees.

Determination is required of supply chain leaders in order to lead their links in the supply chain to new levels of excellence. Determination is the attribute that enables supply chain leaders to set goals, establish the vision for the future and then set the conditions for the achievement of the goals and vision. Determination is the attribute that focuses the supply chain leader on not only setting the goals for the supply chain but also the achievement of those goals. Determination is also the supply chain leadership attribute that keeps the supply chain leader focused on making ethical decisions.

You need to always have goals to work towards. You need short term goals and long term goals. These goals have to be SMART goals. By SMART goals, I mean

Specific – be as specific as possible about what you want to accomplish

Measurable – if you can't measure it, how will you know when you have achieved it?

Achievable – don't sell yourself short by setting easy goals but make sure that they are achievable. This ties to the next aspect.

Realistic – don't set your goals to be the CEO of the company the year that you start with the company unless it is your own company that you are starting. You have to work for your goals. You have to decide what you are willing to do to achieve them.

Time based – set a timeframe that you want as the target to achieve each goal and write it down.

Employee Recognition and Retention:

Many companies discuss their employee turnover rates which are really a direct reflection of the leadership of the company in most cases. A more positive spin from a supply chain leadership perspective would be to discuss employee retention. What are you doing as a supply chain leader to keep your quality employees? Employee recognition may be the key to retaining your quality supply chain employees. How much does it cost to catch employees doing something right? Remember the discussion in Chapter 4 about Deming's 14 points? One of those points is to create employee pride. By recognizing your supply chain employees, you can develop employee pride.

In the Army we give out "Commander's Coins" to recognize employees for doing something outstanding. The growth of coins became a challenge for the Soldiers to get caught doing something right. The coins as shown in Figure 20.4 shows some of the coins that I passed out as a commander. They have no monetary value but are valued by the Soldiers receiving them

and played a big part in motivation, pride and retention of Soldiers. What can you do to recognize your employees to help keep them motivated and feel appreciated?

Figure 20.4: Commander Challenge Coins

One method of recognizing supply chain employees and developing employee pride is by "naming the aisle" in the distribution center. This is a very simple process—every aisle has a team that is responsible for the maintenance, housekeeping, and inventory accuracy for the aisle. The team may also be responsible for the picking of the items from customer orders that come from the supplies of that aisle. By placing the team name or the supervisor's name on the aisle and a board is displayed with all of the metrics that the distribution center is using for inventory accuracy, location accuracy, pick rates, pick accuracy, and so on. Not only will this enhance employee pride (one of Deming's 14 points) but will also stimulate some internal competition to become the leader in the metrics "game."

Recognizing employees in front of their peers goes a long way in retaining quality employees. The recognition may be as simple as the aisle naming. Some companies that I have visited have passed out dinners for the worker and their significant other, movie tickets or tickets

to sporting events for employees that have done something extraordinary. The key is that the recognition has to be timely and should be made in front of the coworkers so that the coworkers see what they can expect if they give the extra effort.

Trying to understand the employee is another technique for enhancing employee retention. What motivates your supply chain employee? There is not a one-size-fits-all motivation technique. One of Steven Covey's *7 Principles of Highly Effective People*[139] is to seek first and then be understood. This is similar to our approach of walking the process to understand what is being done before making changes. Applying that principle to the art of supply chain leadership means that the supply chain leader gets to know his/her employee in order to understand the employee and what motivates the employee. Understanding what motivates each employee will enable the supply chain leader to increase employee retention which will have a collateral benefit of increasing customer loyalty and retention.

Responsibility:

A supply chain leader takes responsibility for his/her actions as well as the actions of their supply chain employees and the actions of the boss. Just exactly what does this mean? Let's break it down.

Taking responsibility for your own actions means being able to admit when you are wrong. Taking responsibility for the actions of the boss is necessary to display loyalty. How many times have you heard someone say, "I told the boss that this will not work but he said do it anyway?" So, what happens? The project or product fails and then the supervisor shifts the blame to the boss. Not only does this display a lack of respect and loyalty, but it also sets the

[139] Covey, Steven R., *Seven Habits of Highly Effective People,* Simon and Schuster.

example and atmosphere that tells the employees that the supervisor will not back the employee if something goes wrong.

Taking responsibility for the actions of the employees tells the employees that the supply chain leader will support the employee even if something does not go according to plan. This sets the atmosphere where the employees realize that they can take some risks without getting chopped off at the knees for taking an action.

Although the supply chain leader takes responsibility for the actions of the supply chain employees, he/she should be quick to pass along the praise for the program or product to the employees rather than taking the praise for him/herself.

Self Confidence and Self Knowledge:

As we mentioned in what leadership is not (and bears repeating here), leadership is not about arrogance or ego. However, supply chain leadership is about self-confidence. Self-confidence comes from knowing your business. This is not an "I know it all" attitude; this is about knowing your job, knowing your profession, and knowing the jobs of your employees. The combination of knowing your profession—possessing technical skills and proficiency—and knowing the jobs of your employees gives the supply chain leader self-confidence. A leader with self-confidence will inspire confidence and self-confidence in the supply chain employees. This enables the leader and the employees to take the company/department/division to new heights of excellence. Self-confidence leads to competent and confident leaders and employees.

Self-Knowledge is based on the words of Sun Tzu: ***"Know yourself and know your enemy and in 100 battles you will be successful."*** A supply chain leader has to know himself or herself. This includes knowing the leader's strengths and weaknesses. Every leader should conduct a personal Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis of

his/her strengths and weaknesses in order to "know yourself" and to identify personal opportunities and threats to "know your enemy." Armed with this knowledge, a supply chain leader can establish a program of self-development to improve his/her weaknesses and strengthen his/her personal strengths.

Humor:

Readers' Digest has long held the position that "Laughter is the best medicine." Laughter and fun in the workplace is also good medicine for productivity and achieving excellence. In the supply chain world, it is important to have fun at work. Let's be honest, one of the most mundane jobs in the supply chain world is driving a forklift. But driving a forklift can be fun if some little competition is put in the workplace. In Kuwait at the Department of Defense Theater Distribution Center, I would challenge the workers to a "game" of who could properly load the trucks the fastest. This made work a little more fun for the full-time forklift drivers—everybody wanted to beat the old man on the forklift. It also provided an extra motivation to the workers.

When we talk about humor in the workplace, we are not talking about the kind of humor that offends others. This type of humor has no place in any workplace, especially the supply chain workplace. What we are talking about for the supply chain leader is the ability to laugh at yourself. All of us have done something stupid or not real smart and have been observed doing this in some cases by our employees or fellow workers. The key is—would you prefer to be laughed at or laughed with?

Take your job very seriously. But do not take yourself so serious that you cannot laugh at yourself!

Integrity:

Like honesty and ethics, this is the most important of the supply chain leader attributes. Without integrity a leader does not possess the ability to be a successful supply chain leader. Integrity cannot be compromised and without it there is no leadership. You may fool others but the person looking back at you every morning in the mirror knows if you have compromised your integrity and the integrity of your company. Is any deal worth compromising your personal integrity for? All you really own is your word and your integrity—why would you want to give that away?

If you have integrity, I can train you to do any job in the supply chain world. But, if you don't have integrity, I don't care how talented you are. If I cannot trust you, I will not hire you.

Professional Pride/Passion/People:

One of the most important roles of the supply chain leader is to instill professional pride in his or her employees. Remember one of Deming's points was to instill worker pride. Every product your supply chain delivers has your company's name on it—even if the delivery is made by a Third-Party Logistics Provider or contract carrier. Therefore, it is important to not only instill pride in your link in the supply chain but also in all of your supply chain partners. Good or bad your name is on the product, which do you prefer: having the professional pride to put your name on the product because it is good or be known for bad products or bad customer service? The choice is up to the supply chain leader.

Passion is a critical attribute for any leader but for the supply chain leader it is even more important. We are talking about a passion for getting the job done, a passion for taking care of the customer, a passion for the job itself, and a passion for taking care of people.

The passion for the job is the easiest—as everything in the world is supply chain connected, it is not hard to get excited about supply chain operations. What other profession in the world has direct impact on customers every single day? A recent article on the impacts of the corona virus summed up the article with the words: "it is the medical profession that will save lives... but it is the supply chain management profession that will save our livelihoods."

If you are not a supply chain major, the question is still "what makes you happy?" The job may not be the highest paying job but if you are not enjoying what you are doing you will be miserable. Find a job that you can be passionate about and then work to become the absolute best at that job.

Passion for getting the job done is connected to the passion of working in the supply chain. The passion for taking care of people is the cornerstone of leadership at all levels. All too often, leaders lose sight of this purpose and start believing that they are more important than the people that they are leading. Never lose the passion for taking care of employees.

People are the foundation of every organization. Regardless of what business a leader may think that he or she is in, you are in the people business. Supply chains are people oriented or at least they should be. And any business that is people oriented requires a passion for taking care of people. When people are involved, as they are in supply chains, leadership is necessary. In the supply chain world, there has been a great emphasis on automation and information systems, but the foundation has to be a passion for taking care of people.

Summary

> A life is not important except in the impact it has on others' lives"
>
> —Jackie Robinson

Leaders have the mission of impacting the lives of others. Supply chains by their very nature impact the lives of the customers. Supply chains are inherently complex, and the globalization of supply chains has placed a greater reliance automated systems. This focus on systems and systems architecture in some companies has put the most important resource of supply chains on the back burner. The most important resource in a supply chain organization is the people. As supply chain leaders we are in the people business. People require leadership and supply chain leaders must possess certain qualities, attributes, and values as discussed in this chapter in order to lead the people of their supply chain organizations to new levels of excellence.

The qualities, values and attributes form what the Supply Chain Leadership Institute calls the "House of Quality." This house takes its inspiration from the quality tool known as the house of quality and looks like the depiction in Figure 20.5.

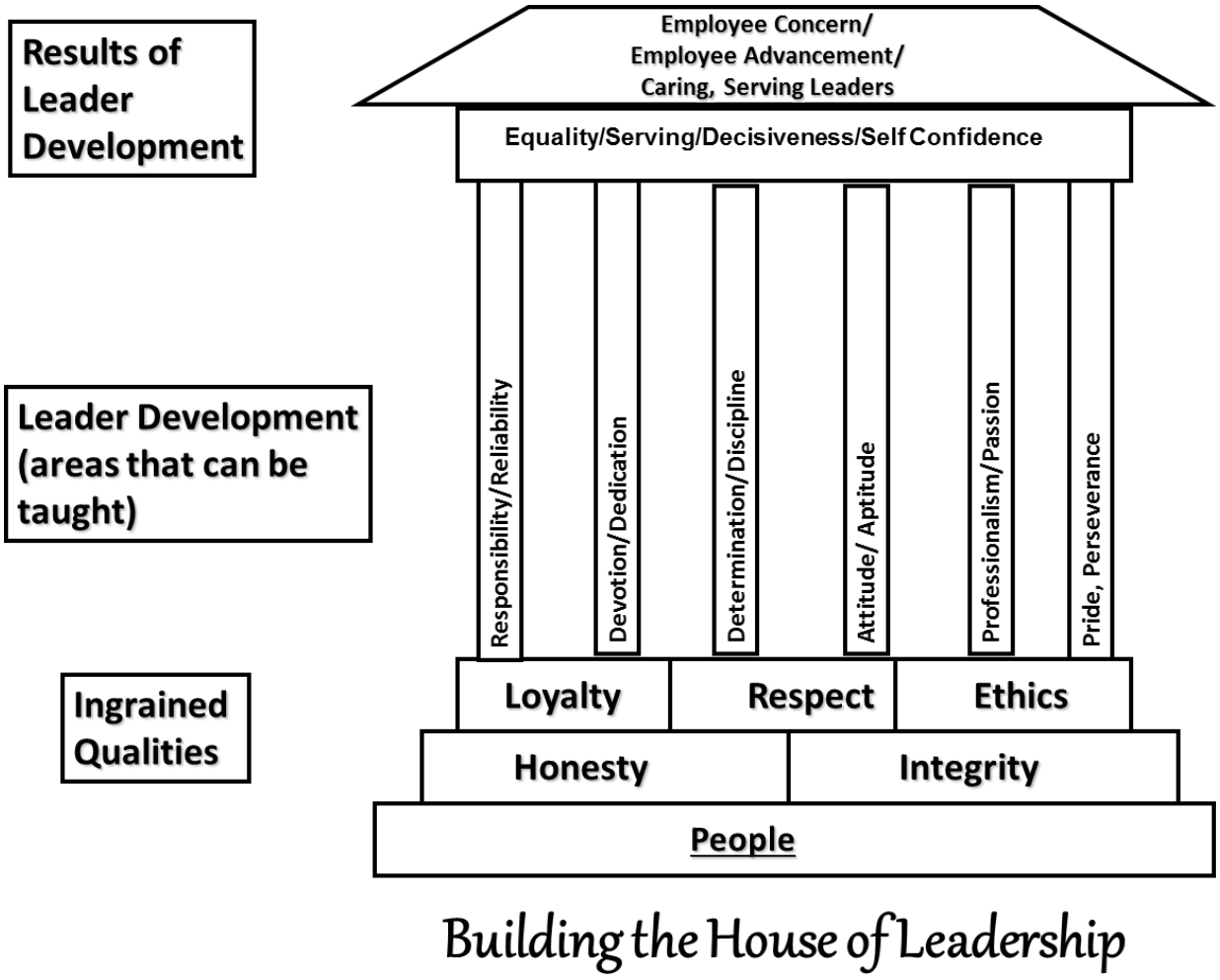

Figure 20.5: The House of Leadership

Discussion Questions

1. Is there such a thing as situational ethics for a leader?
2. How is professional pride fostered in your organization?
3. Think about a situation at a job that you have worked at that could have benefited from a focus on people rather than a focus on profits.
4. Why is leadership so important to supply chain operations?
5. If you scored yourself on the attributes of leadership, how well would you do?
6. Use these attributes to develop a plan to improve your personal leadership skills.

Professional Organizations

Association for Supply Chain Management: this organization provides free membership for students and is the largest professional organization worldwide for supply chain and operations management. www.ascm.org

Council of Supply Chain Management Professionals: another very good professional organization with good networking opportunities. www.cscmp.org

Institute for Supply Management: this organization focuses mainly on procurement and also provides free student memberships. www.ism.ws