Study and analysis of value stream for Yesco production

Tsung-Han Lin

University of Nevada, Las Vegas
STUDY AND ANALYSIS OF VALUE STREAM FOR YESCO PRODUCTION

by

Tsung-Han Lin

Bachelor of Science in Textile Engineering
Chinese Culture University, Taipei, Taiwan
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Tsung-Han Lin

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Examination Committee Chair

Dean of the Graduate College

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ABSTRACT

Study and Analysis of Value Stream for YESCO Production

by

Tsung-Han Lin

Dr. Robert Boehm Examination Committee Chair
Professor of Mechanical Engineering
University of Nevada, Las Vegas

This research addresses the application of lean manufacturing concepts to the make-to-order production process sector with a focus on the entertainment sign industry. The goal of this research is to investigate the production process of Young Electric Sign Company (YESCO) and develop a current state value stream map for different work orders from the time the work order is distributed by the department of layout to the time the finished product is ready to crate. Also, we will analyze production sequences, cycle time, labor time, lead-time and down time for each step of the production process. After the analysis, a more efficient and future state value stream map will be developed by eliminating the non value-added activities and suggestions and recommendations for better manufacturing strategy will be proposed.
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CHAPTER 1 INTRODUCTION

Lean Manufacturing is a performance-based process used in manufacturing organizations to increase competitive advantage. The concept of lean manufacturing, first introduced by Toyota Production System a half a century ago, has grown as a strategic tool used by all sizes of manufacturers. The benefits can be dramatic. For example, the company is capable of increasing production several times over without increasing a square foot of plant floor space by eliminating wasteful, non-value-added activities. Companies implementing lean manufacturing techniques have discovered that they can respond to customers’ needs immediately.

While lean manufacturing has encompassed many techniques and tools, a good starting point for any organization seeking to transform itself to lean is “Value Stream Mapping.” In recent years, value stream mapping has emerged as the preferred way to implement lean. Value Stream mapping is a mapping tool used to describe supply chain networks. It maps not only material flows essential to every product or service, but it also produces information flows that signal and control the material flows. The material flow path of the product is followed from the storage location of raw material to the final operation. This representation visually expedites the process of lean implementation by identifying the value-added steps and non-value-added steps in a value stream. The goal is to identify and eliminate the waste in the process, with waste being any activity that does not add value to the final product.
For the research, we mapped out activities in the make-to-order production process of Young Electric Sign Company (YESCO) with cycle times, down times, waiting times, in-process inventory, material moves, and information flow paths. Then we could easily visualize the current state of the process activities and guide it toward the future desired state. Lean Manufacturing is an enhancement of mass production. Getting the product right the first time, continuous improvement efforts, quality in products and processes, flexible production, and minimizing waste of any kind effectively produce Lean Manufacturing. Even if the type of production in YESCO belongs to make-to-order production, we still implement lean concepts, in our case by using Value Stream Mapping, and we will provide our future state map and make suggestions to the company.
CHAPTER 2

LEAN MANUFACTURING

2.1 Development of Lean Movement

Before discussing the concept of lean manufacturing, we need to know how this idea originated. As we know, lean has been defined as the elimination of muda (waste). [1][34] In *The Machine that Changed the World* published in 1990, it recounted results of a five-year study of the world’s automobile manufacturing industry. It showed that certain Japanese automotive manufacturers, especially Toyota, overtook established American and European automobile manufacturers in almost all of the key performance areas such as service levels, quality, productivity and time-to-market. The term “lean production” was created to remarkably describe the Toyota approach to manufacturing, which was contrasted to the “mass production” approach of western manufacturers. [2][22]

Many manufacturers were inspired by the book *The Machine that Changed the World* and improved their performance by applying the lean principles and approaches. Most work has been accomplished at very little cost to the companies, and companies have initiated to develop the flexible methods in order to meet their customers’ needs. Because of performance improvement in lean production, companies have been able to double their capacity and profits. As we can see Figure 2-1, the model represents our conceptualization of lean production, consisting of a number of principles characterizing
different functional areas and the overall strategy of the lean company. In addition to the
different function areas, the fundamental principles of lean, which go through all
functions, are found at the bottom of the model.

<table>
<thead>
<tr>
<th>Lean Development</th>
<th>Lean Procurement</th>
<th>Lean Manufacturing</th>
<th>Lean Distribution</th>
<th>Lean Enterprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers involve</td>
<td>Supplier Hierarchies</td>
<td>Eliminate of waste</td>
<td>Lean buffers</td>
<td>Global Network</td>
</tr>
<tr>
<td>Cross-functional Teams</td>
<td>Larger subsystems from fewer suppliers</td>
<td>Continuous Improvement</td>
<td>Customer Involvement</td>
<td>Knowledge Structures</td>
</tr>
<tr>
<td>Simultaneous Engineering</td>
<td>Integration instead of co-ordination</td>
<td>Multifunctional teams</td>
<td>Vertical Information System</td>
<td></td>
</tr>
<tr>
<td>Strategic Management</td>
<td>Black box Engineering</td>
<td>Zero defects/JIT</td>
<td>Decentralized responsibilities/Integrated functions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pull instead of push</td>
<td></td>
</tr>
</tbody>
</table>

Functional principles

- Multifunctional teams
- Vertical information systems
- No buffers
- No indirect resources
- Networks

Figure 2-1 Conceptualization of Lean Production [10]
2.2 Craft Production, Mass Production and Lean Production

The dominant international role established by the Japanese automotive firms in the 1980s was based upon development in a protected domestic industry and a concerted export drive. There have been three significant transformations in automotive manufacturing: Craft Production to Mass Production (transferring the competitive advantage from Europe to the USA in the early 20th century); “Fordist” Mass Production to European version of the same principle, incorporating high variety and relatively small volumes (providing the European assemblers with a competitive advantage in the 1950s); and the revised Mass Production to Lean Production leading to Japan’s rise since the 1950s. [29]

Each transformation has provided a national or regional manufacturing base with a period of advantage; and perhaps the best way to describe the lean production is to contrast it with craft production and mass production, the other two methods humans have created to make products.

The craft producer uses highly skilled workers and simple but flexible tools to make exactly what the customer wants— one item at a time. For example, custom furniture, works of decorative art, and a few exotic sports cars are characterized as craft production. The problem with craft production is the high cost of the product. Since the product is produced by craft method and it is exclusive, most people could not afford the high price. Therefore, mass production was developed at the beginning of the twentieth century as an alternative. [1][2]

The mass producer uses strictly skilled professionals to design products made by unskilled or semiskilled workers with expensive, single-purpose machines. These come
out standardized products in very high volume. Because the machinery costs a lot and is so intolerant of disruption, the mass producer adds many buffers--extra supplies, extra workers, and extra space--to assure smooth production. Since changing over to a new product costs more, mass-producers try to keep standard design in their production as long as possible. The results are that the customer gets lower costs but at the expense of variety, and most employees feel bored and dispirited with respect to work methods.

However, the lean producer combines the advantages of craft and mass production while avoiding the high cost of the former and the rigidity of the latter. Toward this end, lean producers employ teams and multi-skilled workers at all levels of the organization and use highly flexible, increasingly automated machines to produce volumes of products in huge variety. Lean production requires half of the human effort in the plant, half of the manufacturing space, half of the investment in tools, and half of the engineering hours for developing a new product in half the time. Most importantly, it requires keeping far less than half the necessary inventory on site, and produces a greater and ever growing variety of products. [1][2] In Table 2-1, we can easily see how lean production differentiates with craft production and mass production. In Table 2-2, in a survey of a General Motors Assembly Plant versus a Toyota Assembly Plant, we can clearly see that Toyota at the Takaoka plant was almost twice as productive and three times as accurate as GM at Framingham in performing the same set of standard activities on a standard car. In terms of manufacturing space, it was 40 percent more efficient, and its inventories were a tiny fraction of those at GM. [1][36] The extraordinary performance of lean production has resulted in being widely applied by many manufacturers worldwide since then.
<table>
<thead>
<tr>
<th></th>
<th>Craft Production</th>
<th>Mass Production</th>
<th>Lean Production</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>From 1880s</strong></td>
<td></td>
<td><strong>From 1915s</strong></td>
<td><strong>From 1950s</strong></td>
</tr>
<tr>
<td><strong>Workforce</strong></td>
<td>*Highly skilled in design, machine operations, and fitting *Apprenticeship for workers</td>
<td>*Interchangeable workers *Improvement responsibility of industrial engineer and foreman</td>
<td>*Flexible teams work the process *Little management layers *Improvement responsibility within the organization</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td>*Extremely decentralized but concentrated in one city *Most parts and design from small machine shops *Coordination by owner</td>
<td>*Vertical integration *Centralized organization (Design, Engineering and Production in one place)</td>
<td>*Network suppliers *Improvement along supply chain</td>
</tr>
<tr>
<td><strong>Tools</strong></td>
<td>*General purpose machine tools</td>
<td>*Dedicated machines</td>
<td>*General purpose</td>
</tr>
<tr>
<td><strong>Product</strong></td>
<td>*Very low production volume-1000 or fewer per year *Not two exactly alike</td>
<td>*High volume *Long product life cycle</td>
<td>*Ever-decreasing model life cycle *Niche models possible</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>*Task</td>
<td>*Product</td>
<td>*Customer</td>
</tr>
<tr>
<td><strong>Operations</strong></td>
<td>*Single items</td>
<td>*Batch and Queue</td>
<td>*Synchronized flow and pull</td>
</tr>
<tr>
<td><strong>Overall Aim</strong></td>
<td>*Mastery of craft</td>
<td>*Reduce cost and increase efficiency</td>
<td>*Eliminate waste and add value</td>
</tr>
<tr>
<td><strong>Quality</strong></td>
<td>*Integration (part of the craft)</td>
<td>*Inspection (a second stage, after production)</td>
<td>*Prevention (built in by design and method)</td>
</tr>
<tr>
<td><strong>Business Strategy</strong></td>
<td>*Customization</td>
<td>*Economies of scale and automation</td>
<td>*Flexibility and Adaptability</td>
</tr>
<tr>
<td><strong>Improvement</strong></td>
<td>*Master-driven continuous improvement</td>
<td>*Expert-driven periodic improvement</td>
<td>*Workforce-driven continuous improvement</td>
</tr>
</tbody>
</table>

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Table 2-2  General Motors Assembly Plant Versus Toyota Assembly Plant [1][2]

<table>
<thead>
<tr>
<th></th>
<th>GM at Framingham</th>
<th>Toyota at Takaoka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Assembly Hours per Car</td>
<td>40.7</td>
<td>18.0</td>
</tr>
<tr>
<td>Adjusted Assembly Hours per Car</td>
<td>31</td>
<td>16</td>
</tr>
<tr>
<td>Assembly Defects per 100 Cars</td>
<td>130</td>
<td>45</td>
</tr>
<tr>
<td>Assembly Space per Car (feet^2/vehicle/year)</td>
<td>8.1</td>
<td>4.8</td>
</tr>
<tr>
<td>Inventories of Parts (Avg.)</td>
<td>2 weeks</td>
<td>2 hours</td>
</tr>
</tbody>
</table>

Note: *Gross assembly hours per car are calculated by dividing total hours of effort in the plant by the total number of cars produced. * Adjusted Assembly Hours per Car incorporates adjustments in standard activities and product attribute. * Defects were estimated from the J.D.Power Initial Quality Survey for 1987. *Inventories are a rough average for major parts.

Source: IMVP World Assembly Plant Survey (1986)

2.3 Lean Manufacturing

As the 1980s began, Japanese manufacturing had become a world-class leader, frequently winning the competition with U.S. and European manufacturing. This discovery was a long time coming. The growth and prosperity of U.S. manufacturers produced complacency, obscuring a development that should have been recognized in many industries as early as the 1950s, when Japanese manufacturing started rising from the ashes of World War II. In the 1960s and into the 1970s, social changes in the United States and the country’s geopolitical agenda hid the changes occurring in Japanese manufacturing. Then customers found Japanese cars to be more reliable and of higher quality than the Big Three’s offerings. [5] In 1985, MIT’s International Motor Vehicle Project (IMVP) undertook a thorough study of practices in the worldwide automobile
industry. By the completion of the study, as documented in *The Machine that Changed the World*, a systematic picture emerged. The IMVP researchers found a simple underlying principle behind the Toyota Production System – they called it lean. [18]

Lean Manufacturing, established by Taiichi Ohno at Toyota Motor Company in the 1950s, was the result of the Toyota innovation, which merges the minds and hands philosophy of the craftsmen era with the works standardization and assembly line of the Ford System, and adds the glue of teamwork for good measure. [11][28] Lean Manufacturing is an enhancement of mass production. Getting the product right the first time, continuous improvement efforts, quality in products and processes, flexible production, and minimizing the waste are the enhancement of producing Lean Manufacturing. [12] Lean principle is a coordinated response to the highly competitive environment. Its foundations lie in manufacturing and are strongly influenced by the production system concepts originally developed at Toyota Production Systems. These concepts are so effective at producing at low cost, high quality, and short cycle times; and these systems are highly flexible and responsive to customer requirements.

Lean Manufacturing is aimed at the elimination of waste in every area of production; including customer relations, product design, supplier networks and factory management. Its goal is to incorporate less human effort, less inventory, less time and less space to develop products in order to become highly responsive to customer demand while producing top quality products in the most efficient and economical way possible. [2] As we can see in Table 2-3, there are some positive changes in Lean Manufacturing. In Table 2-3, the scheduling activity is altered from the push system to the pull system which means the production is based upon the customer order. The lead time is shorter
and the batch size is smaller. The inventory turns increase and the management has higher empowerment, so the manager can make the correction simultaneously. Most importantly, the layout is transformed from the functional basis to the production flow basis, so the production progress can smoothly move without any buffer, and the work-in-progress inventories can effectively be eliminated. Finally, since lean thinking can be applied to any industry from agriculture to aerospace and any process from repetitive manufacturing to customized assembly, examples of application of lean principles are becoming more and more apparent. For example, by implementing lean practices, TRW Automotive Electronics Group has reduced labor time by 80 percent, slashed the time to move raw material by 61 percent, increased production inventory turns by 28 percent and decreased capital expenditures by 70 percent. Another example is John Deere, heavy agricultural equipment producer. A high performance product focus and continuous flow with productivity incentives had resulted in a just-in-time material delivery system and pull system of production. [12] From these examples, we can conclude Lean Manufacturing is the transformation and upgrade of Traditional Manufacturing.
Table 2-3  Comparison of Traditional Manufacturing and Lean Manufacturing [6]

<table>
<thead>
<tr>
<th></th>
<th>Traditional Manufacturing</th>
<th>Lean Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduling</td>
<td>Forecast-push</td>
<td>Customer Order-pull</td>
</tr>
<tr>
<td>Lead Time</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>Batch Size</td>
<td>Large-Batch &amp; Queue</td>
<td>Small-Continuous Flow</td>
</tr>
<tr>
<td>Inventory Turns</td>
<td>Low- less than 7 turns</td>
<td>High- higher than 10</td>
</tr>
<tr>
<td>Empowerment</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Layout</td>
<td>Functional</td>
<td>Production Flow</td>
</tr>
<tr>
<td>Production</td>
<td>Stock Based</td>
<td>Customer Order Based</td>
</tr>
<tr>
<td>Inspection</td>
<td>Sampling</td>
<td>100%- Source</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>COGS</td>
<td>High and Rising</td>
<td>Low and Decreasing</td>
</tr>
</tbody>
</table>

In lean philosophy, the end customer determines “value.” It means the organization needs to identify what the customer is willing to pay for and what creates “value” for the organization. The whole process of producing and delivering a product should be examined and optimized from the customer’s point of view. Therefore, once the value is defined, we can research the value stream. The value stream is all activities, both value added and non-value added, that are currently required to bring the product from the raw material to end product to the customer. [3] After that, the wasteful steps need to be eliminated and the flow can be introduced in the remaining value-added processes. The concept of flow is ideally to make parts one piece at a time from raw
materials to finished products and to move them one by one to the next workstation without having waiting time between two workstations. Moreover, pull is the concept of producing at the rate of the demand from the customer. Finally, perfection is accomplished when employees within the organization understand that the continuous improvement process of eliminating the waste and reducing mistakes is imperative while offering what the customer really wants. Today, “lean” may no longer be fashionable but its core principles, which are flow, value, value stream, pull, and strive to perfection (minimizing waste), have become the paradigm for many manufacturing operations. [4][25]

2.4 Lean Enterprise Principles [18]

The general public has a simple and vivid mental image about auto production—an assembly plant where all the parts come together to create the finished car or truck. While this final manufacturing step is important, it only represents about 15 percent of the human effort involved in making a car. To properly understand lean production, we must look at every step in the process, beginning with product design and engineering, then go far beyond the factory to the customer who relies on the automobile for daily living. In addition, it is critical to understand the mechanism of coordination necessary to bring all these steps into harmony and on a global scale, a mechanism we call the lean enterprise. [1][9]

Under the Lean Enterprise Model (LEM), there are four enterprise principles (see Figure 2-2). These principles describe the next layer of behavior for the work units within the enterprise. [18][35]
1. The Right Thing, at the Right Place, at the Right Time, and in the Right Quantity: The lean company emphasizes delivering high-quality execution throughout the processes. Assuming the processes are chosen and designed to optimize the leanness of the company. Only the right resources need to be placed where they are needed and when they are needed. The prototype example of this principle of activity is Just-In-Time (JIT) delivery of parts to a vehicle assembly line-delivery of the right parts just as they are needed for an individual, customer-specified vehicle. The principle of the activity drives the unit manufacturing, business processes and information systems providing the knowledge workers need as they need it. In addition, it also drives the decision systems, so decisions are able to be based on up-to-date conditions and do not bring about delays in responding to customer needs.
2. Effective Relationships within the Value Stream: The value stream from the supplier to the satisfied customer for any product and support service likely involves many people, work units, and companies. The value stream flows as an extended enterprise. If we are the manufacturer, we want all elements of the value chain working smoothly. We do not want to see that the value stream is full of arguments, wasted time, effort, or money because of unclear product specifications, business arrangements, or mutual communications. Well-defined, formal specifications and agreements are the characteristics of effective relationships. The relationships also need systems compatibility and compatibility of the approach by all contributors to the value stream. Finally, effective relationships will depend greatly on mutual trust and problem-solving skills, when every contributor in the value stream responds to unanticipated events with speedy.

3. Continuous Improvement: The fundamental definition of lean manufacturing systems is that every manager and employee within the company is constantly seeking ways to improve the production process on which he or she is working. An improvement may need to be changed by reducing costs for material, energy, and labor, and reducing labor fatigue while the company tries to maintain the quality of the output. Continuous improvement requires a mindset that everyone in the company needs to continuously involve in the work which is creative and beneficial to the production process. It requires that the management encourages continuous improvement initiatives, even when those initiatives are risky and lofty.

4. Optimal First-delivered Unit Quality: It is imperative that the first unit-delivered of any product meets the quality that the customer needs and expects. Each
element of the value stream must view all the downstream elements, as well as the ultimate end-user, as customers. When companies do that, the enterprise will be assured that the designs, materials, manufacturing processes, and delivery channels are right the first time. If they are right, the waste of rework will be minimized in each of the product cycles. Because the imperative for the quality of the first delivered unit is so important, a number of methodologies and tools, such as the Total Quality Management (TQM), developed in Japan, and Six Sigma methodologies had been developed. [5][21]

2.5 The Lean Approach to Supply Chain Management [2][28]

Manufacturing has been one of the key driving forces in the growth of the economy since the early part of 20th century. The global competition, increasing technological complexity, demanding markets and explosion of knowledge has strongly encouraged companies to develop collaboration in their manufacturing processes. Companies no longer compete alone as autonomous entities, but rather as the supply chain. Today we have a competitive marketplace. The target of companies is to create better value for their customers, and the need for improving supply-chain management capability of companies is becoming increasingly recognized. When companies continuously seek to provide their products and services to customers faster, cheaper, and better than their competitors, and try to eliminate the waste and non-value-added activities, they have to work on a cooperative basis with the best companies in their supply chains in order to succeed.

In order to develop a Lean Supply Chain under the scope of logistics vision, we should eliminate or minimize the “seven wastes” (see Table 2-4) and make the
achievement of quantities targets in terms of both customer service and logistics cost. The logistics vision will be achieved through a phased approach to achieving quantities targets in relation to the following seven wastes: [24]

1. Overproduction – The making of too much, too early or just in case. The aim is to make exactly what is required, just-in-time and with perfect quality. The aim is to eliminate the root causes of unexpected demand changes.

2. Waiting – Materials or information are not moving or having value added and hence time is not being used effectively. The aim is to eliminate waiting time between operations and storage by applying single-piece flow principle.

3. Transporting – Materials or information are being transported into, out of or around the plant. Transport cannot be fully eliminated, but the aim is to minimize it through two approaches:
   - Minimizing the distance between the location of operations within the supply chain both internal and external to the plant.
   - Efficient use of the vehicles or equipment that will link separated locations.

4. Inappropriate processing – This is a result of using machinery and equipment that is inappropriate in terms of capacity or capability to perform an operation. The aim is that each operation should be performed by a machine of optimum capacity and capable of producing defect free products (i.e. rework is waste).

5. Unnecessary inventory – This element tends to increase lead time, prevent rapid identification of problems and space utilization. The aim is to reduce inventory in order to highlight other supply chain problems that are hidden by...
inventory and to free up capital for more beneficial investment by the business
and develop the supplier to achieve JIT deliveries.

6. Unnecessary motion – This involves the ergonomics of production where
operators have to make difficult or unnecessary movements in order to
complete a task which may affect both personal safety and output. The aim is
to improve the quality of work-life for employees and at the same time
improve productivity and quality.

7. Defects – Product defects include ultimately poor management, rework
defects which are caught in-line and rectified, scrap defects which are caught
in-line and scrapped, and service defects in terms of delivery reliability and
provision of information to the customer. The aim is to continually reduce the
level of defects in order to supply qualified products.

As we know, supply chain management represents a state-of-the-art management
tool used to enhance the overall customer satisfaction that is intended to improve
competitiveness and profitability. [26] With this clear definition, managers should review
the production processes and eliminate non-value-added processes and activities. It is
typically responsible for maintaining a continuous supply of materials in good quality and
reduce price, minimizing the inventory, developing the supply channel and maintaining
the supply base, and maintaining the good relationship and cooperating with suppliers.
Finally, the objective of applying lean approach in logistics management, supply chain
improvement, is to develop a supply chain system outperforming competitors and thereby
create an opportunity for a company to gain a competitive advantage.
<table>
<thead>
<tr>
<th>Waste Category</th>
<th>Nature of Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overproduction</td>
<td>Smooth flow of goods difficult</td>
</tr>
<tr>
<td></td>
<td>Piles of work-in-progress</td>
</tr>
<tr>
<td></td>
<td>Target and achievement unclear</td>
</tr>
<tr>
<td></td>
<td>Excessive lead-time and storage times</td>
</tr>
<tr>
<td>Waiting</td>
<td>Operators waiting</td>
</tr>
<tr>
<td></td>
<td>Operators slower than line</td>
</tr>
<tr>
<td></td>
<td>Operators watching equipment and operation</td>
</tr>
<tr>
<td>Transportation</td>
<td>Stacking and unstacking of components</td>
</tr>
<tr>
<td></td>
<td>Many busy forklifts</td>
</tr>
<tr>
<td></td>
<td>Conveyors</td>
</tr>
<tr>
<td></td>
<td>Widely spaced equipment</td>
</tr>
<tr>
<td>Inappropriate Processing</td>
<td>Variation between operators methods</td>
</tr>
<tr>
<td></td>
<td>Variation between standard and actual operation</td>
</tr>
<tr>
<td></td>
<td>Processes that are not statistically capable</td>
</tr>
<tr>
<td>Inventory</td>
<td>Prescribed storage volume exceeded</td>
</tr>
<tr>
<td></td>
<td>Deteriorating material</td>
</tr>
<tr>
<td></td>
<td>Old dates on material</td>
</tr>
<tr>
<td></td>
<td>Stocks of containers for work-in-progress</td>
</tr>
<tr>
<td></td>
<td>Sophisticated stores system</td>
</tr>
<tr>
<td>Motion</td>
<td>Components and controls outside easy reach</td>
</tr>
<tr>
<td></td>
<td>Double handling</td>
</tr>
<tr>
<td></td>
<td>Layout not standard</td>
</tr>
<tr>
<td></td>
<td>Widely spaced equipment</td>
</tr>
<tr>
<td></td>
<td>Operators bending</td>
</tr>
<tr>
<td>Defects</td>
<td>Poor material yield</td>
</tr>
<tr>
<td></td>
<td>Work in scrap bin</td>
</tr>
<tr>
<td></td>
<td>High inspection levels</td>
</tr>
<tr>
<td></td>
<td>Difficult assembly</td>
</tr>
<tr>
<td></td>
<td>Large rework area</td>
</tr>
<tr>
<td></td>
<td>Irregularity of work</td>
</tr>
</tbody>
</table>

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CHAPTER 3

VALUE STREAM MAPPING

3.1 Introduction

Many different types of organizations are implementing lean manufacturing, or lean production, to respond to competitive challenge. Examples of lean production and improved performance have been documented in the automotive, aerospace, and consumer goods industries around the world. [8] Recently, a relative method to support implementation of a lean philosophy is Value Stream Mapping.

Value Stream Mapping was initially developed in 1995 with an underlying rationale for the collection and use of various tools to help researchers or practitioners identify the waste in individual value streams and find an appropriate route to the removal of waste. [2] Before discussing Value Stream Mapping, we must understand what Value Stream is. Value Stream is the flow of materials and information from the time products come in the back door as raw materials, through all manufacturing process steps, and off the loading dock as finished products (see Figure 3-1). However, Mapping is a critical initial step in lean conversions. The difference between the traditional supply or value chain and the value stream is that the former includes the complete activities of all the companies involved, whereas the latter refers only to the specific parts of the firms that actually add value to the specific product or service under consideration. As such the value stream is a far more focused and contingent view of the value adding process. [24]
Value Stream Mapping is a tool that maps out the value streams on a plant floor with the assistance of suitable icons to represent operations, transportations, information flows for the production control and scheduling functions, work-in-progress locations, etc. Each value stream represents flows of a component or component families, beginning from suppliers to the assembly line or manufacturing cell to customers.

![Diagram of Value Stream of Automotive Industry](image)

Figure 3-1 The Value Stream of Automotive Industry [23]

Value Stream Mapping uses a variety of icons to capture the current state of the plant floor and to make a suggestion for a future improved state of the plant. These icons are effective for recognizing value-added and non value-added activities or elements in the value stream or process flow path. The importance of Value Stream Mapping lies in its utility, simplicity and global business emphasis, considering flows of both products and information across the entire supply chain.
Finally, the process of Value Stream Mapping physically includes mapping a current state of a plant while also focusing on where the plant wants to be, or a future state map, which can serve as the foundation for lean improvement strategies. Value Stream Mapping serves as a starting point to help managers, engineers, suppliers, and customers recognize the waste and its source. It is accomplished in two steps. The first step is to draw the current state value stream map and take a snapshot of how activities are being done. This identifies sources of waste and the degree of flow through the production system. The second step is to draw the future state map in order to show how activities should be done, how value could be improved and how waste could be eliminated in future operations. Value Stream Mapping provides both a picture of the current state of activities as well as a vision of how we would like to see things work and identify the differences between the current and future states to yield a roadmap for improvement activities. Therefore, based on the Value Stream Map, we definitely can streamline work processes, thereby cutting lead times and reducing operating costs.

3.2 Benefits of Value Stream Mapping

A Value Stream Map is a powerful tool used to map out both the material and information flow for any manufacturing or administrative process. This powerful tool allows companies to map the flow of products in the back door as raw material, through all manufacturing process steps, and off the loading dock as finished product. Based on the Value Stream Map, we can streamline work processes, thereby cutting lead times and reducing operating costs. Also, benefits of Value Stream Mapping include:

1. “See” the flow of our Value Stream and help the team to identify the waste.
2. Draw both material and information flows of Value Stream on the same map.

3. Draw a blueprint for Lean transformation—the Future State Map, and prioritize activities needed to achieve the Future State Improvement.

4. Help the team to visualize the production process at the plant level not just the single process level.

5. Shows the linkage between the information flow and the material flow, making decisions about the flow apparent, forming the basis of an implementation plan and connecting the lean concepts and techniques in order to enable improvements that show up in the organization’s bottom line.

6. Ties together lean concepts and techniques to enable improvements that show up in your organization's bottom line.

3.3 Value Stream Management

The developers of Value Stream Mapping acknowledge that many value streams have multiple flows that merge together. This would typically be the case in Make-To-Order job shops since those shops make products with complex Bill-of-materials, such as welded fabrications, furniture, stamping dies, etc. Of course, YESCO also belongs to Make-To-Order job shops. In order to map multiple flows in a value stream, Rother and Shook suggest drawing such flows over one another. However, we do not try to draw every branch if there are too many branches. Also, we choose the key components first, and get the others later if we need to. [32]

Value Stream Management represents the evolution of a strategic planning means that was contributed by the Toyota Production System. Value stream management is a
simple but powerful method that can illustrate the current and future state of the entire production process. In fact, it is a multiple step methodology integrating reliable tools and techniques into a strategy-based system. It is clear for everyone to plan for a lean implementation. Value Stream Management provides the connection between what the management requires and what is needed on the manufacturing floor. Metrics and reporting are what the management requires. In addition to the planning, Value Stream Management becomes an excellent communication tool to assist aligning the entire workforce with the effort of implementing the lean. It also requires a good recognition of lean concepts and sufficient learning of lean education.

However, the Value Stream Management method is a strategic and operational approach designed to help a company or complete supply chain achieve a lean status. It also incorporates various education and policy development stages to make it a much better basis for ongoing company or supply chain development. The approach can be divided into twenty individual and consecutive stages as illustrated in Table 3-1 below:
<table>
<thead>
<tr>
<th>Illustration of Stage</th>
<th>Illustration of Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand Company Mission, Customer Environment &amp; Need and Strategic Direction</td>
<td>Understand Specific Operating Environment and Waste</td>
</tr>
<tr>
<td>Delimit key processes</td>
<td>Select Second Level Mapping Tools by Process</td>
</tr>
<tr>
<td>a. Customer Facing such as Order Fulfillment</td>
<td></td>
</tr>
<tr>
<td>b. Non Customer Facing such as Supplier Integration</td>
<td></td>
</tr>
<tr>
<td>Understand existing Roles and Responsibility</td>
<td>Undertake Detailed Mapping</td>
</tr>
<tr>
<td>Understand existing Organizational Structure</td>
<td>Identify Areas where Further Analysis is Required</td>
</tr>
<tr>
<td>Lean Enterprise Education for Senior Managers</td>
<td>Undertake Third Level Analysis</td>
</tr>
<tr>
<td>Develop Top Level “Big Picture” Cartoons of Key Processes</td>
<td>Analyze Objective and Subjective Data and Develop Timed Implementation Plan</td>
</tr>
<tr>
<td>Define Products and Processes to be Mapped in Detail</td>
<td>Develop Key Control Metrics By Process Area</td>
</tr>
<tr>
<td>Appoint Senior Level Steering Board</td>
<td>Educate and Train Implementation Action Teams</td>
</tr>
<tr>
<td>Appoint Process Champion for Each Key Process to Load Mapping Activity</td>
<td>Undertake Implementation</td>
</tr>
<tr>
<td>Lean Enterprise Education for Process Champions</td>
<td>Measure Progress Against Plan</td>
</tr>
</tbody>
</table>

After following these twenty stages, it is possible for us to realize how to analyze the production process and to summarize those stages into several steps. These steps are commit to lean, choose the value stream, lean education, map the current state, identify lean metrics, map the future state, create the plan, and implement the plan. Nevertheless, the process of Value Stream Management is really time-consuming, and we need to have the empowerment of the company, so we do not involve in this aspect for our research.
4.1 Types of Production Processes

Process planning refers to the tactical planning activities that regularly occur in manufacturing. Process selection, in contrast, refers to the strategic decision of deciding which kind of production processes to have in the plant. At the most basic level, the types of processes can be categorized as follow: [19]

A. Conversion processes: Examples are changing iron ore into steel sheets, or making all the ingredients listed on the box of toothpaste into toothpaste.

B. Fabrication processes: Examples are changing raw materials into some specific form (for example, making sheet metal into a car fender or forming gold into a crown for a tooth).

C. Assembly processes: Examples are assembling a fender to a car, putting toothpaste tubes into a box, or fastening a dental crown in somebody’s mouth.

D. Testing processes: This is not strictly speaking a fundamental process, but it is so widely mentioned as a standalone major activity that it is included here for completeness.

From the view of process flow structure, it refers to how a factory organizes material flow using one or more of the process technologies just listed. Six different
types of production processes are used to categorize production systems, as we can see below: [16][19]

1. Job Shop: It belongs to Pure Fabrication. Production of small batches of a large number of different products, most of which require a different set or sequence of processing steps. (Commercial printing firms, airplane manufacturers, machine tool shops, and plants that make custom-designed printed circuit boards are examples of this type of structure.)

2. Batch: Essentially a somewhat standardized job shop, such as a structure that is generally employed when a business has a relatively stable line of products, each of which is produced in periodic batches, either to customer order or for inventory. Most of these items follow the same flow pattern through the plant. Examples include heavy equipment and electronic devices.

3. Assembly line: It belongs to Pure Assembly. Production of discrete parts moving form workstation to workstation at a controlled rate, following the sequence needed to build the product. Examples include manual assembly of toys, appliances, personal computers, and automatic assembly (called insertion) of components of a printed circuit board. When other processes are employed in a line fashion along with assembly, it is commonly referred to as a production line.

4. Continuous flow: Conversion or further processing of undifferentiated materials such as chemicals, petroleum, or beer. As on assembly lines, production follows a predetermined sequence of steps, but the flow is continuous rather than discrete. Such structures are usually highly automated
and in effect constitute one integrated "machine" that can be operated 24 hours a day to avoid expensive shutdowns and start-ups.

5. Combination Fabrication/Assembly (Example: Automotive OEM).


However, Job Shop, belonging to Pure Fabrication, Assembly line, belonging to Pure Assembly and Combination Fabrication/Assembly are combined into one variable, which is called Discrete. Batch Production, Semi-Continuous flow, and Continuous flow are combined into one variable which is called Continuous. In order to coordinate the customer's request, there are three kinds of order fulfillment strategies, Build-to-Stock, Make-to-Order, and Build-to-Order productions. The first strategy, Build-to-Stock production, is used if the customer's expected time is zero. For example, the furniture industry is the typical Build-to-Stock Production. In this strategy, the manufacturer must hold finished goods inventory for a certain time. In Make-to-Order or Build-to-Order, the customer's expected time is greater than the manufacturer's lead time, then the manufacturer can wait until it receives an order to fulfill that order.

The difference between Build-to-Order and Make-to-Order is the lead-time of the majority of raw materials and supplied parts. If the customer's expected lead-time is less than the lead-time of the manufacturer, then the manufacturer must hold the inventory at some point in the production process. That point can be at the level of subassemblies that can be Assembled or Configured-to-Order, such as personal computers and some automobiles, or at the level of fabrication, where parts are machined and/or processed according to a specific order. For our study in YESCO, all of these variations of the order fulfillment strategy are considered Make-to-Order production.
4.2 Make-to-Order Production [14]

Customer driven manufacturing, in which production activities are driven by customer orders, is the key concept of the factory in the future. This concept results from trends of production processes of small batch sizes and customized products over the past decade. The extreme case of these trends is one-of-a-kind production, in which a product ordered by a customer is manufactured only once. Most industrial production shop is the Make-to-Order (MTO) production in which a company concentrates on providing shorter and more reliable lead times than its competition. [27] It means that a wide variety of products with customers’ specification and design is made from a combination of standard materials and components. Although products ordered by different customers would basically have different specifications, the same product, probably with changeable batch sizes and due date, may be ordered by the same or other customers. A common feature of MTO plants/shops is that the production takes place only on receipt of customer orders and the MTO production is typically in an exclusively job shop environment. In practice, the majority of the job shops have process-oriented layouts, as opposed to the cellular-oriented or continuous flow layouts. The advantage of process-oriented job shop manufacturing is its ability to meet specific requirements asked by customers and to offer a highly customized product. In order to give customers a responsive service and ensure a reliable delivery date for customer orders, MTO production requires detailed, realistic, and flexible operational plans, along with a control mechanism for tracking production status of customer orders.

Manufacturing firms fall under the category of intermittent production systems when they deal with products that are made-to-order. Intermittent production systems are
geared to produce in batches or small lots. These systems may include two types of production depending on the length of the manufacturing cycle time. These are short cycle job shops and long cycle job shops. The job shops have also been classified as machine limited shops and labor limited shops. These companies typically do not hold lots of finished good inventory as we mentioned above. In MTO production, after the customer order is received, the design and manufacturing activities will be initiated and the lead time required to complete types of jobs is high. Normally, MTO and Engineered-to-Order products fall in this category. In order to bear a wide range of products, these types of production environments are characterized by functional layout of the equipment and high flexibility of production facilities. Each finished product is unique for the design, manufacturing and technological requirement and precedence constraints. However, the processing times are highly unpredictable. Therefore, the high level of uncertainty, with respect to routings and processing times and uncertainty of customer orders, results in the difficulty of production planning and control problem. [15]

4.3 Issues of Make-to-Order Production [13][15]

A sizeable part of the engineering industry is in the MTO business. Generally, in the competitive situation, a company needs to respond to customers’ requests with parameters of the price and delivery date immediately, and those two parameters sometimes are fixed by the customer. The values chosen for these two parameters clearly have a major impact on the chance of the company securing the order. If it is secured, the order gives rise to problems of production control, scheduling, and even cost because workload suddenly adds to various facilities. The process of generating a quotation is a
key function in the management of the company and that can help the company or break
the company. This process commonly receives much less attention than it warrants.
However, our study basis does not focus on the connection and coordination between the
customer and manufacturer.

In the MTO manufacturing industry, the detail about the product specification is
the details known in phases from development, design and process planning. This makes
the production scheduling less accurate, and causes the operations schedule to be revised
frequently during the production. In order to reconfigure the existing schedule, collection
of monitoring data from the shop floor becomes essential. [6]

An additional issue arises from the situation that even if one person could reach a
solution to the problem, the solution may quickly become invalid because of the
unpredictable behavior of the manufacturing system. On the other hand, it may be
unnecessary for frequent scheduling unless the original schedule is well planned.
Scheduling requires operational decisions making with on-the-spot reaction to handle the
internal and external uncertainties. Internal uncertainties are unplanned contingencies
such as machine breakdowns, missing tools, late deliveries of components, rework etc.,
while external ones are market-driven, evoked by fast changing customer demands.

MTO companies have a few standard products. They provide a quotation,
including the price and the delivery lead time, for a particular job in response to
customer’s order. If companies want to remain competitive, they must maintain their
promised lead times. In order to ensure that products are delivered on time, the company
should respond to customers’ enquiries and monitor the progress of jobs during the
production. The job-releasing mechanism plays a key role in meeting the on-time
delivery. By holding jobs in a “pool” prior to releasing them on the shop floor, it is possible to reduce the WIP inventory since the dispatching task is easier, and urgent jobs are more likely to be noticed and dealt with accordingly while there are fewer jobs on the shop floor.

In the MTO production, it is difficult to predict how the work will be distributed among machine groups in the plant at any point in time. The finite nature of the manufacturing resources creates inevitable conflicts of delivery priorities that are made even more difficult by delays in the delivery of materials and components. There are usually severe fluctuations over the short and medium term in the demand on the plant due to the indefinite supply of customer orders. A general result is that manufacturing lead times are often long and only a small proportion is the actual production time.

4.4 Value Stream Mapping in a Make-to-Order Environment [31]

Long lead times, missed delivery times, demanding or nonpaying customers, too many unsuccessful quotes, too much shop overtime life always belong to characteristics of job shops. The term "job shop" refers to customized manufacturing and Make-to-Order businesses. These companies share some common characteristics differing from repetitive manufacturing settings, such as using a quoting process to secure work, and producing work on an order-to-order basis in order to meet customer specifications. While some job shops do purely custom work, many manufacturing companies have a mix of custom and repeat orders. "Job shops are distinct from repetitive manufacturers," said by Larry Baker, a Wisconsin Manufacturing Extension Partnership (WMEP) manufacturing specialist. He also said “Because there is variation in what they do, job
shops think there is no systematic approach that is going to help them seeing patterns in their operations and improve their processes.” However, there are tools that job shops can use to achieve sustainable improvement, and one of potential tools is Value Stream Mapping.

One of the most valuable improvement tools for job shops is also a simple one. Given the significance of front-end processes in securing orders, it is particularly critical for job shops to include this map in their value streams. The resulting map helps companies to review each aspect of their operations and identify areas for improvement. One very important outcome of value stream mapping is to illustrate where a job shop has distinct types of product “streams,” containing its own customer and production requirements. Also, defining the right value streams for products can prevent priority conflicts and answer the question of what gets produced in what sequence.

Many companies produce a mix of repetitive and customized work and utilize the same plant process which can cause confusion on which job goes first. There are often bottlenecks or constraining processes, and in many cases duplicate equipments are being used to perform the same work. Recognizing the different product streams may result in dedicating one piece of equipment or one welder to a specific product line versus attempting to schedule everything on every machine. Besides that, maintaining a First-In-First-Out (FIFO) sequencing and limiting the number of jobs for the customized work also can result in better flow for both custom and repetitive work. To accomplish this requires recognition of the different product streams. However, by implementing the Value Stream Mapping in MTO production environment, although we are going to meet some problems, we will find strategies to achieve our goals. Those strategies are: [17]
1. Effective Costing: When a plant discovers that it has different product streams, it can look very closely at its costing strategies. Many manufacturers have both custom and standard work, but they never get one flat rate; they get undercharging on one side and overcharging the other. They might have a $50 per hour rate across all products when it takes much more overhead to support the extra design and engineering work required for custom products. Therefore, one solution is to have different costing strategies, splitting the job shop operations and its costing systems to acknowledge how its resources are really being used. As an example, for a custom job requiring considerable design work, the shop can charge for one-time engineering/design services, instead of automatically absorbing those costs into the shop overhead and reducing or wiping out the job actual profit margin.

2. Reducing Lead Times: While trying to reduce lead times, people try to focus on where the action seems to be and what the product they need to make in the shop. In fact, for most job shops the majority of the time is spent on getting prepared to start making the parts, not in the shop itself. It is the front-end processes. For example, one company initially worked on a very large semi-custom product for a 16-week lead time, and the production manager tried to reduce that time on the manufacturing side. Nevertheless, when they looked more closely, they found that the order only spent three to four weeks in the shop. The rest of the lead time was on the administrative side such as the quote process and the engineering design. Therefore, focusing on improving these functions and reducing the front-end lead time by half are critical the MTO production process. By reducing lead time, a shop can be more competitive, gain more customers, and it can charge premium rates since it can deliver faster than its competitors.
3. Know the Customers and Winning the Right Customers: Knowing your customer helps the company to ensure that we will provide what your customer and ultimately the end user need and expect. Job shops provide a service to their customers and, in most cases, not the end product. The better they understand how the product is eventually used, the better they are able to meet the customer need. Moreover, good customers know and communicate their complete product requirements, pay their bills on time, and understand that changes made before delivery impact cost and delivery time.

From the cost-oriented point of view, we cannot hold a supermarket of finished goods to help the company level the volume of work in MTO production. However, there are two methods we can apply in combination: First of all, we need to maintain some inventory of work in the FIFO or sequential – pull queues between processes, especially ahead of the bottleneck process. The smaller the FIFO lane, the less work on the floor and the shorter the lead time. Second, we need to stop releasing work in increments of customer ordering, and instead release work based on a standard time increment or "pitch."
CHAPTER 5

YOUNG ELECTRIC SIGN COMPANY (YESCO)

5.1 History of YESCO

Thomas Young opened up Young Electric Sign Co. (YESCO), the first new sign shop in Ogden, Utah. It is North America's Light Emitting Diode (LED) sign manufacturer. There are eight different locations of sale offices, maintenance facilities, and manufacturing plants throughout the United States. After World War II, YESCO took on a new challenge – Las Vegas. With the sale of the city's first spectacular sign, the "Boulder Club," YESCO opened a manufacturing plant in the neon capital of the world. Casinos and gaming remain the number one attraction for millions of visitors arriving in Las Vegas every day. The hospitality industry has a huge demand for purchasing the novel signs that could effectively communicate with potential customers through the use of message boards. The company designed and built the famous Fremont Street Experience which is the main attraction of downtown Las Vegas and has produced many of the landmark signs that embellish Las Vegas, Reno and the world.

However, competition in the neon sign business is increasing day by day. The cost of labor is getting higher, and the difficulty of finding well-trained and productive employees is making the margin of profit in neon sign manufacturing gradually decrease. To assist YESCO we have chosen to analyze their production process to determine
efficient and productive ways to manufacture signs, to prevent any waste of resources, and to try to achieve the concept of lean manufacturing by using Value Stream Mapping.

5.2 Pre-production in Interior Division of YESCO, Las Vegas

Signs are unquestionably a useful and necessary method of communication between the business and the customer. Therefore, in order to produce quality signs, it is very important to establish a perfect and effective production process in this sign manufacturing plant. In YESCO, there are two divisions in the organization. One is the exterior division; mainly manufacturing signs for the outside of casinos, lodging industries, restaurants, department stores, and commercial plazas. The other is the interior division; manufacturing signs for the inside of casinos. Most interior signs are installed on the top of slot machines and hung on the outside wall of restaurants. In our study, we are going to illustrate the production process in the interior division of YESCO under the ideal situation.

In YESCO, as soon as the order is placed, sale representatives will bring in a approval sign design with estimated information and work order to the manager who is responsible for each production process in the whole interior division. After the production manager’s review of the work order, the production manager will assign the project manager, also called project coordinator. His duty is to take over the work order and review the work order again. However, under this circumstance, there are two different situations happening right away:

1. Approval: means the work order is reviewed by the project coordinator and he does not give any comments or suggestions. After that, the work order will immediately
go through the Department of Layout, and the drawing along with the production instructions will be created.

2. Red-Lining: means the work order is not agreed to by the project coordinator. The project coordinator will make the red line with comments and suggestions on the paper. The work order will return to the Department of Sales for reviewing with the customer again, to the Department of Estimate for estimating parts, and to the Department of Design for modifying and revising the design. After all these departments verify the correction, the work order will go through the Department of Layout, and the drawing along with the instruction is created.

Once the Department of Layout finishes the drawing, and each of the manufacturing divisions picks up the file of instruction and drawing, production is ready to begin.

5.3 Production Process in Interior Division of YESCO, Las Vegas

There are four major operations for manufacturing interior signs after the Department of Layout comes out with the drawing file. We are going to demonstrate in detail each operational task:

1. Router and Laser: In this operation, we have one Laser Machine and two CNC Routers to cut the materials: metal, aluminum, or plexiglas. The original sheet metal for making the body of the sign is aluminum, and the face of the sign is plexiglas. Also, the machine set-up time is 0.5 hours for the Laser Machine and 0.5 hours for CNC Router. (See Appendix II) After the cutting process, the finished cut metal is placed on shelves,
so the personnel from the Department of SheetMetal can pick up parts when they start to construct the sign.

2. **SheetMetal:** Welding and grinding are two major tasks for this operation. Personnel pick up the cut sheet metal, build the housing or box of the sign, and make some decorations to attach to the body of the sign. After finishing assemblage, the sign is transported to the Department of Painting. The set-up time of this operation is usually 0.5 hour. (See Appendix III)

3. **Painting:** In this operation, the time is the shortest among these production processes. Normally, the number of time for procedure of coating is 4 to 5 times, and the drying time is at least 2 hours. Also, the set-up time of this operation is 0.5 hour. (See Appendix III)

4. **Electronic and Electric:** In this operation, we progress two different tasks simultaneously. For electronic work, a person takes care of programming and displaying different patterns of Light Emitting Diode (LED). For electric work, a person needs to install wires, luminaries, transformers, fans, and so on and do the final assembly. Most importantly, they must follow UL regulations for safety concerns. (See Appendix III)

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1. Abbreviation of light emitting diode, an electronic device that lights up when electricity is passed through it. LEDs are usually red. They are good for displaying images because they can be relatively small, and they do not burn out. However, they require more power than LCDs. [37]
CHAPTER 6

RESULTS AND DISCUSSION

6.1 Value Stream Mapping in the Interior Division of YESCO

Value Stream Mapping was undertaken to highlight opportunities for the application of lean thinking within one of the main value streams within the company. A representative product was chosen which generated a high percentage of total revenue, was supplied to a strategic customer, and was typical of the generic value streams at this particular site. In our study, we selected our four projects that were chosen by the production manager of YESCO at random. These four projects were really common designs in their market, so we could track the working part easily. Those work order numbers of projects were L50813 (Bellagio Megabucks), L50811 (Mandalay Bay), L50885 (Texas Station), and L50986 (Palace Station). Pictures of these projects are shown in Appendix I.

6.1.1 Value Stream Mapping of L50813 (Bellagio Megabucks)

As we could see the Value Stream Mapping of this project (Figure 6-1), we could easily see that the cutting process of the Router Machine took about 4.5 hours including 0.5 hours of set-up time and 4 hours of production time. The cutting process on the Laser Machine took about 3.5 hours including 0.5 hours of set-up time and 3 hours of production time. Then the welding and assembling process of Department of

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SheetMetal took about 32 hours to finish the task, and this workstation included two separate operations. The painting process only took about 4.0 hours which was the shortest operation time in the whole production flow since the sequence of this process was really simple. After the painting process, we could find the overlapping of works within three individual production processes; the Graphing, SheetMetal, and Electronic and Electric. The Electronic and Electric processing took 17 2/3 hours to arrange the wiring, including installing the transformers, luminaries, LEDs, etc. Once the electrical work was done, it took about 0.5 hours to install the meter and polish the outside of the sign. Finally, the sign was ready to be crated and shipped to the customer. The production time of Electronic and Electric could have been 9 2/3 hours instead of 17 2/3 hours because one person was sick for one day and missed 8 hours of work. Nobody replaced him and continued the task. Therefore, we could say this is a non value-added activity.

6.1.2 Value Stream Mapping of L50811 (Mandalay Bay)

In the Value Stream Mapping of this project (Figure 6-2), we discover that the cutting process on the Router Machine took about 8.5 hours including 0.5 hours of set-up time and 8 hours of production time, and the cutting process of the Laser Machine took about 3.5 hours including 0.5 hours of set-up time and 3 hours of production time. Then the welding and assembling process of the Department of SheetMetal took about 36.5 hours to finish, and this workstation included two separate operations. The painting process took about 4.0 hours. Like we mentioned in the last project, the operation time of painting was the shortest in the whole
production flow. After the painting process, we could again find the overlapping of work within the individual production processes; Graphing, SheetMetal, Electronic and Electric. We found the Electronic and Electric processing took 24.5 hours to do. This included wiring, installing the meter, and polishing the outside of the sign. Once the cleaning work was done, the sign was ready to be crated and shipped to the customer.

6.1.3 Value Stream Mapping of L50885 (Texas Station)

As we could see the mapping of this project (Figure 6-3), we could understand the cutting process only needed the Router Machine. This took about 4.0 hours including 0.5 hours of set-up time and 3.5 hours of operation time since this project did not need many cutting parts. The welding and assembling process of the Department of SheetMetal took about 28 hours. The painting process was not necessary in this project since the material of the body sign we used was Gold Polish Aluminum (GPA), possessing a shiny appearance. Once we jumped over the painting process, we could find the overlapping of works within two individual production processes, the Graphing and Electronic and Electric. Because this is a smaller sign, the Electronic and Electric Processing took about 4.5 hours to arrange the wiring, including installing the transformers, luminaries, LEDs, etc. Once the electrical work was done, it took only about 0.5 hours to put the face on, clean, and polish the outside of the sign. The cleaning work was done, and the sign was ready to be crated and shipped to the customer.
6.1.4 Value Stream Mapping of L50986 (Palace Station)

In the mapping of this project (Figure 6-4), we discover the cutting process on the Router Machine took about 1.0 hours including 0.5 hours of set-up time and 0.5 hours of production time. The cutting process of the Laser Machine took about 3.0 hours including 0.5 hours of set-up time and 0.5 hours of production time. After that, the welding and assembling process of the Department of SheetMetal took about 26.5 hours. The painting process was not necessary in this project since the material of body sign we used was Gold Polish Aluminum (GPA), possessing the shining appearance. Therefore, we again skipped the painting process, and we could find the overlapping of works within two individual production processes, the Graphing and Electronic and Electric. The Electronic and Electric processing took about 17.5 hours to arrange the wiring, including installing the transformers, luminaries, LED, etc. Once the electrical work was done, it took about 0.5 hours to put the face on, clean, and polish the outside of the sign. Finally, once the cleaning work was done, the sign was ready to be crated and shipped to the customer.
Notes:
1. In the production, there is not any work-in-progress inventories between two workstations
2. Represents the Information Flow throughout the process
3. Represents the Material Flow throughout the process

Figure 6-1: Current State Value Stream Map (L_50813 Bellagio Megabucks)
Notes:
1. In the production, there is not any work-in-progress inventories between two workstations
2. Represents the Information Flow throughout the process
3. Represents the Material Flow throughout the process

Figure 6-2: Current State Value Stream Map (L 50811 Mandalay Bay)
Notes:
1. In the production, there is not any work-in-progress inventories between two workstations
2. Represents the Information Flow throughout the process
3. Represents the Material Flow throughout the process

Figure 6-3: Current State Value Stream Map (L 50885 Texas Station)
Notes:
1. In the production, there is not any work-in-progress inventories between two workstations
2. Represents the Information Flow throughout the process
3. Represents the Material Flow throughout the process

Figure 6-4: Current State Value Stream Map (L 50986 Palace Station)
6.2 Time Observation of Production Process in Interior Division of YESCO

After performing the Value Stream Mapping, we realize what the production process is and how the materials and information flow are. In order to realize how much time the whole production process consumed (cycle time), how much time each operation consumed (process time or lead time) and how much the waiting time (down time) is used, we could make some tables and graphs about our time observation of production in each project and analyze them independently.

6.2.1 Time Analysis of L50813 (Bellagio Megabucks)

As Table 6-1 and Figure 6-5 below show, the total production time is 66 2/3 hours, 36% of the total operation time. On the other hand, the waiting time is 116.0 hours, 64% of the total operation time and 40 hours longer than the production time. In a detailed analysis of Figure 6-6 and Table 6-2 below, we find the production time of SheetMetal is 35 hours, 52.5% of the total production time, and it is the longest among all processes. Also, the production time of Electric ranks second among all processes, and it is 17 2/3 hours, or 25.7% of the total production time.

Table 6-1 Time Observations for L50813 (Bellagio Megabucks)

<table>
<thead>
<tr>
<th>Category</th>
<th>Time (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production Time (Lead Time)</td>
<td>66 2/3</td>
</tr>
<tr>
<td>Total Waiting Time (Down Time)</td>
<td>116</td>
</tr>
<tr>
<td>Total Time (Cycle Time)</td>
<td>182 2/3</td>
</tr>
</tbody>
</table>
Figure 6-5 Proportion of Production Time and Waiting Time for L50813 (Bellagio Megabucks)

Figure 6-6 Proportion of Each Production Process for L50813 (Bellagio Megabucks)
Table 6-2 Time and Proportion of Each Production Process for L50813 (Bellagio Megabucks)

<table>
<thead>
<tr>
<th>Production Time (hrs)</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser 3.5</td>
<td>0.052(5.2%)</td>
</tr>
<tr>
<td>Router 4.5</td>
<td>0.067(6.7%)</td>
</tr>
<tr>
<td>SheetMetal 35</td>
<td>0.525(52.5%)</td>
</tr>
<tr>
<td>Painting 4</td>
<td>0.059(5.9%)</td>
</tr>
<tr>
<td>Electronic and Electric 17 2/3</td>
<td>0.257(25.7%)</td>
</tr>
<tr>
<td>Graphing 1.5</td>
<td>0.022(2.2%)</td>
</tr>
<tr>
<td>Install Meter and Polish 0.5</td>
<td>0.018(1.8%)</td>
</tr>
<tr>
<td>Total Production Time 66 2/3</td>
<td>1(100%)</td>
</tr>
</tbody>
</table>

From Figure 6-5, we find that the waiting time, which is production down time, is 64% of the total time. This is 77% higher than the production time since there was not enough labor at that time. The manager of the Department of SheetMetal could not schedule additional labor to start the order, and that's why there was a 64-hour waiting time between the operation of SheetMetal and Router. From the Figure 6-6 and Table 6-2, we know the production time of the SheetMetal operation is the longest process (52.5% of the total production time). This operation possesses approximately 30 separate parts to be assembled, and there is only one assembly personnel to accomplish the task. Therefore, for this order, we should pay attention to the scheduling problem.

6.2.2 Time Analysis of L50811 (Mandalay Bay)

As Table 6-1 and Figure 6-5 show, the total production time is 82.5 hours, 60% of the total operation time. On the other hand, the waiting time is 54 hours, 40% of the total
operation time and 28.5 hours shorter than the production time. Compared to the waiting
time of the previous project (waiting time is 40 hours), the efficiency of the operation in
this project is better. Seeing Figure 6-8 and Table 6-4, we find the production time of
SheetMetal is 40.5 hours, 49.1% of the total production time, and it is also the longest
among all processes. Moreover, the production time of Electronic and Electric ranks the
second among all processes, and it is 24 hours, 29.1% of the total production time.

<table>
<thead>
<tr>
<th>Category</th>
<th>Time (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production Time (Lead Time)</td>
<td>82.5</td>
</tr>
<tr>
<td>Total Waiting Time (Down Time)</td>
<td>54</td>
</tr>
<tr>
<td>Total Time (Cycle Time)</td>
<td>136.5</td>
</tr>
</tbody>
</table>

Figure 6-7 Proportion of Production Time and Waiting Time for L50811 (Mandalay Bay)
Proportion of Each Production Process

<table>
<thead>
<tr>
<th>Process</th>
<th>Production Time (hrs)</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser</td>
<td>3.5</td>
<td>0.042 (4.2%)</td>
</tr>
<tr>
<td>Router</td>
<td>8.5</td>
<td>0.103 (10.3%)</td>
</tr>
<tr>
<td>SheetMetal</td>
<td>40.5</td>
<td>0.491 (49.1%)</td>
</tr>
<tr>
<td>Painting</td>
<td>4</td>
<td>0.048 (4.8%)</td>
</tr>
<tr>
<td>Electronic and Electric</td>
<td>24</td>
<td>0.291 (29.1%)</td>
</tr>
<tr>
<td>Graphing</td>
<td>1.5</td>
<td>0.018 (1.8%)</td>
</tr>
<tr>
<td>Install Meter and Polish</td>
<td>0.5</td>
<td>0.006 (0.6%)</td>
</tr>
<tr>
<td>Total Production Time</td>
<td>82.5</td>
<td>1 (100%)</td>
</tr>
</tbody>
</table>

Figure 6-8 Proportion of Each Production Process for L50811 (Mandalay Bay)

Table 6-4 Time and Proportion of Each Production Process for L50811 (Mandalay Bay)

From Figure 6-7, we find that the waiting time, which is production down time, is 40% of the total time, and only 67% of the production time. The waiting time between the operation of SheetMetal and Router decreases from 64 hours for the previous order to 24 hours. From Figure 6-8 and Table 6-4, we know the production time of the operation of SheetMetal is also the longest process (49.1% of the total production time). This
operation requires that approximately 30 different parts be assembled. In the operation of SheetMetal of this order, there is only one assembly person to accomplish the main task, and two personnel to assist the main installer.

6.2.3 Time Analysis of L50885 (Texas Station)

As Table 6-5 and Figure 6-9 show, the total production time is 38.5 hours, 65% of the total operation time. On the other hand, the waiting time is 20.5 hours, 35% of the total operation time and 18 hours shorter than the production time. Compared to the previous two projects, the operational efficiency in this order is much better since the total parts and materials this project needed are less than the first two orders, and fewer individual parts take shorter time for transporting and assembling. Because the raw material of the sign is Gold Polish Aluminum (GPA), the shining characteristic eliminates the paint process. By examining Figure 6-10 and Table 6-6, we find the production time of SheetMetal is 28 hours. (72.7% of the total production time), and it still accounts for the longest among these individual processes.

Table 6-5 Time Observations for L50885 (Texas Station)

<table>
<thead>
<tr>
<th>Category</th>
<th>Time (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production Time (Lead Time)</td>
<td>38.5</td>
</tr>
<tr>
<td>Total Waiting Time (Down Time)</td>
<td>20.5</td>
</tr>
<tr>
<td>Total Time (Cycle Time)</td>
<td>59.0</td>
</tr>
</tbody>
</table>
Figure 6-9 Proportion of Production Time and Waiting Time for L50885 (Texas Station)

Figure 6-10 Proportion of Each Production Process for L50885 (Texas Station)
Table 6-6 Time and Proportion of Each Production Process for L50885 (Texas Station)

<table>
<thead>
<tr>
<th>Process</th>
<th>Production Time (hrs)</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Router</td>
<td>4</td>
<td>0.104(10.4%)</td>
</tr>
<tr>
<td>SheetMetal</td>
<td>28</td>
<td>0.727(72.7%)</td>
</tr>
<tr>
<td>Painting</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electronic and Electric</td>
<td>4.5</td>
<td>0.117(11.7%)</td>
</tr>
<tr>
<td>Graphing</td>
<td>1.5</td>
<td>0.039(3.9%)</td>
</tr>
<tr>
<td>Install Meter and Polish</td>
<td>0.5</td>
<td>0.013(1.3%)</td>
</tr>
<tr>
<td>Total Production Time</td>
<td>38.5</td>
<td>1(100%)</td>
</tr>
</tbody>
</table>

From Figure 6-9 above we find that the waiting time, or production down time, is 35% of the total time, and only 54% of the production time. The waiting time between the operation of SheetMetal and Router decreased from 64 and 24 hours for the previous two orders to only 0.5 hours. This is a tremendous change for achieving smoother production. The reason for the improvement is not the efficiency of workers. It depends on the priority of the order. Once the customer changed the delivery due date, the production manager needed to move back older but longer-delivery-time orders and start the new order immediately. From Figure 6-10 and Table 6-6, we know the production time of the operation of SheetMetal is also the longest process (72.7% of the total production time). This operation takes approximately 12 different parts to be assembled. In this order, there is only one assembly person to accomplish the operation of SheetMetal.
6.2.4 Time Analysis of L50986 (Palace Station)

As Table 6-7 and Figure 6-11 show, the total production time is 50.0 hours, 75% of the total operation time. On the other hand, the waiting time is 16.8 hours, 25% of the total operation time and 33.2 hours shorter than the production time. Compared to the previous three orders, the efficiency of operation in this project is the best since less total parts and materials are needed here than first two orders, and fewer individual parts take a shorter time for transporting and assembling. Another reason for shorter production time is that this is only a one-sided sign and there is no need for painting in this order because of the use of a Gold Polish Aluminum (GPA). By examining Figure 6-12 and Table 6-8, we find that the production time of SheetMetal is 26.5 hours, 53% of the total production time, and it still accounts for the longest among these individual processes. The second longest is 17.5 hours, which is due to the operation of electronic and electric. It accounts for 35% of the total production time.

<table>
<thead>
<tr>
<th>Category</th>
<th>Time (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production Time (Lead Time)</td>
<td>50.0</td>
</tr>
<tr>
<td>Total Waiting Time (Down Time)</td>
<td>16.8</td>
</tr>
<tr>
<td>Total Time (Cycle Time)</td>
<td>66.8</td>
</tr>
</tbody>
</table>
Figure 6-11 Proportion of Production Time and Waiting Time for L50986 (Palace Station)

Figure 6-12 Proportion of Each Production Process for L50986 (Palace Station)

Table 6-8 Time and Proportion of Each Production Process for L50986 (Palace Station)

<table>
<thead>
<tr>
<th></th>
<th>Production Time (hrs)</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser</td>
<td>3</td>
<td>0.06(6.0%)</td>
</tr>
<tr>
<td>Router</td>
<td>1</td>
<td>0.020(2.0%)</td>
</tr>
<tr>
<td>SheetMetal</td>
<td>26.5</td>
<td>0.530(53.0%)</td>
</tr>
<tr>
<td>Painting</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electronic and Electric</td>
<td>17.5</td>
<td>0.350(35.0%)</td>
</tr>
<tr>
<td>Graphing</td>
<td>1.5</td>
<td>0.030(3.0%)</td>
</tr>
<tr>
<td>Install Meter and Polish</td>
<td>0.5</td>
<td>0.010(1.0%)</td>
</tr>
<tr>
<td>Total Production Time</td>
<td>50.0</td>
<td>1(100%)</td>
</tr>
</tbody>
</table>

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From Figure 6-11 we find that the waiting time, which is production down time, is only 25% of the total time, and only 33% of the production time. This is a result of the waiting time between the operation of SheetMetal and Router being decreased from 64 hours on order L50813 (Bellagio Megabucks), and 24 hours on order L50811 (Mandalay Bay) to only 1 hour. The reason for this tremendous change is the same as the last order. It depends on the priority of the order. Once the customer wanted the product as soon as possible, the production manager needed to schedule one team to start the new order right away no matter the impact on the other orders. From the Figure 6-12 and Table 6-8, we know the production time of the operation of SheetMetal is also the longest process (53% of the total production time). This operation takes approximately 8 different parts to be assembled. In this order, there is still only one assembly person to accomplish the operation of SheetMetal.

6.3 Comparison of Time Observation in the Production Process for Four Different Orders

After analyzing four different orders independently, we are going to make a time observation for orders L50813, L50811, L50885, and L50986 considering two aspects. One aspect is to see the comparison of proportion of production time and waiting time in the four different orders. The other is to see the comparison of proportion of each operation time in the four different orders. See Table 6-9 and Table 6-10:
### Table 6-9 Comparisons of Time Observations For Different Orders

<table>
<thead>
<tr>
<th></th>
<th>L50813 Bellagio Megabucks</th>
<th>L50811 Mandalay Bay</th>
<th>L50885 Texas Station</th>
<th>L50986 Palace Station</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Time (hrs)</strong></td>
<td>66 2/3 36%</td>
<td>82.5 60%</td>
<td>38.5 65%</td>
<td>50.0 75%</td>
</tr>
<tr>
<td><strong>Waiting Time (hrs)</strong></td>
<td>116 64%</td>
<td>54 40%</td>
<td>20.5 35%</td>
<td>16.8 25%</td>
</tr>
<tr>
<td><strong>Total Time (hrs)</strong></td>
<td>182 2/3 100%</td>
<td>136.5 100%</td>
<td>59.0 100%</td>
<td>66.8 100%</td>
</tr>
</tbody>
</table>

### Table 6-10 Comparisons of Each Production Time for Different Orders

<table>
<thead>
<tr>
<th></th>
<th>L50813 Bellagio Megabucks</th>
<th>L50811 Mandalay Bay</th>
<th>L50885 Texas Station</th>
<th>L50986 Palace Station</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Time (hr)</strong></td>
<td>3.5 5.2%</td>
<td>3.5 4.2%</td>
<td>0 0</td>
<td>3 6%</td>
</tr>
<tr>
<td><strong>Router</strong></td>
<td>4.5 6.7%</td>
<td>8.5 10.3%</td>
<td>4 10.4%</td>
<td>1 2%</td>
</tr>
<tr>
<td><strong>SheetMetal</strong></td>
<td>30.5 52.5%</td>
<td>40.5 49.1%</td>
<td>28 72.7%</td>
<td>26.5 53%</td>
</tr>
<tr>
<td><strong>Painting</strong></td>
<td>4 5.9%</td>
<td>4 4.8%</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td><strong>Electronic and Electric</strong></td>
<td>17 2/3 25.7%</td>
<td>24 29.1%</td>
<td>4.5 11.7%</td>
<td>17.5 35%</td>
</tr>
<tr>
<td><strong>Graphing</strong></td>
<td>1.5 2.2%</td>
<td>1.5 1.8%</td>
<td>1.5 3.9%</td>
<td>1.5 3%</td>
</tr>
<tr>
<td><strong>Install Meter and Polish</strong></td>
<td>0.5 1.8%</td>
<td>0.5 0.6%</td>
<td>0.5 1.3%</td>
<td>0.5 1%</td>
</tr>
<tr>
<td><strong>Total Production Time (hr)</strong></td>
<td>66 2/3 100%</td>
<td>82.5 100%</td>
<td>38.5 100%</td>
<td>50 100%</td>
</tr>
</tbody>
</table>

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From Table 6-9, the production time of order L50811 is the longest since it requires maximum individual parts among these four orders; and as we mentioned before, it accounts for almost four times more than order L50885. The waiting time of order L50813 is the longest because the waiting time between the operation of SheetMetal and Cutting is 64 hours, and the waiting time between the operation of Electronic& Electric and Installing is 27 hours. However, the previous waiting time is caused by a scheduling jam, and the latter is caused by International Gaming Technology (IGT). They make the meter for each sign and deliver to YESCO. For this case, they could not make just-in-time delivery, so YESCO used another meter. Finally, because of the unexpected longest waiting time, the cycle time of order L50813 is the longest.

From Table 6-10, there is not any time difference on the operation of the Laser Machine except for order L50885 because the Router Machine can afford the workload for the cutting process, and there is not any need from the Laser Machine. For the production time of SheetMetal and Electronic and Electric, order L50811 required the longest time due to the complexity of wiring, fiber optics, and decorating the sign. In the same manner, order L50811 took the longest total production time among these four orders.
CHAPTER 7

DISCOVERING PROBLEMS AND RECOMMENDATIONS

7.1 Identifying and Solving Floor Problems

After doing the Value Stream Mapping of these four projects at YESCO, we discovered several obvious problems happening on the plant floor. Let us examine those shortcomings. Most importantly, we will find some ways to solve them:

1. In L50813 (Bellagio Megabucks)(See Figure 6-1, Figure 6-5 and Table 6-1), the proportion of waiting time is the longest among these projects since the waiting time between Cutting and SheetMetal is 64 hours. There are two reasons for this problem. The first reason was the bad communication between the Department of Cutting and Department of SheetMetal. As far as I knew, the cutting part had already been finished and stayed on the shelves, but the personnel from the Laser and Router Dept. did not notify the Department of SheetMetal, so the personnel from the SheetMetal Dept. thought the part was still uncut. The other reason was the difficulties in scheduling since there was a shortage of personnel at that time.

**Problem Solving** → For this problem, the waiting time between Cutting Dept. and SheetMetal Dept. is non-value-added activity. In order to eliminate the waste happening on the shelf of finished components, we should establish the Immediate Response System, like Just-In-Time message delivery. It means the production coordinator of each order should have the full responsibility for monitoring the working
part, handling the movement path and communicating among those different departments. Moreover, each department manager should control the scheduled process all the time and estimate the workload of each worker, so the production line can start the incoming order immediately.

2. In L50813 (Bellagio Megabucks)(See Figure 6-1), the waiting time between Wiring and Installing Meter & Polishing is 27 hours. The sign had already been finished, except for the meter. The reason for that was International Gaming Technology (IGT) had not shipped the meter yet; the personnel could not install it and complete the project.

Problem Solving → For this problem, it was not quite so simple since the shipping time of the meter was always decided by IGT, and YESCO did not have any meter in stock. Generally speaking, the operations of slot machines depend on the design of meters. If the design of meters for slot machines was not done, meters could not be shipped to YESCO. Therefore, it resulted in longer waiting time as well as producing non-value-added activity. In my opinion, the executives of YESCO should negotiate with IGT to try to produce and deliver meters on time or in advance. The finished sign without the meter installed still represented a work-in-progress inventory in the production process.

3. In L50885 (Texas Station)(See Figure 6-3), the waiting time between wiring and putting the face on is 8.5 hours. There are two reasons for explaining this situation. One is overconfidence. According to my observation, after the electrical person had finished the wiring, he suddenly found the Department of Graphing had not made the face. The Department of Graphing thought they had already made the face. The personnel from the Department of Graphing were overconfident on performing their tasks.
Although they were experienced, they failed to determine the schedule of finishing their task. The other reason is lack of communication. Between the Department of Electronic and Electric and the Department of Graphing, personnel did not communicate with each other about the progress of each order.

**Problem Solving** → This problem was not only due to the overconfidence, but also to the lack of coordination within the different departments. The Department of Graphing should have paid attention to what they had done, and prepared the finished face in advance. Most importantly, the project coordinator was responsible for monitoring the progress of the sign. Before finishing the wiring process, he should have known if the face was finished, or not finished. In addition to emphasizing the mission of the project coordinator, it was very important to apply Lean concepts by arranging a contact person who could negotiate these details between two departments and get the update progress on the floor. With this solution, we can minimize not only the traveling time of information but also the waiting time of unfinished components.

4. After observing these four projects, especially in the Department of SheetMetal, I found that workers did not have the completed file and paper work for each project. They only got the design of color graphic for the sign. Therefore, when they finished the work, they found they had missed welding or assembling one piece, and they needed to go to the Department of Router to ask them to make the part. This resulted in another non-value-added waiting for the SheetMetal process. Besides that, I also found the workers needed to rework the sign because of wrong dimensions and incorrect installation position.
**Problem Solving** → The reason for this problem was the worker did not have complete instructions for installation and the correct dimensions of the sign for the Department of SheetMetal, so the worker did not follow the specification requested by the customer, and only relied on his experience. This resulted in the misunderstanding of the actual design. In my opinion, the Layout Dept. should print out complete files for every department. Do not make separate files for different departments. For this reason, each department could mutually understand the specification and make the right thing at the right time.

5. I tracked the individual parts from the drawing of the design. In fact, the parts had already been welded by the Department of SheetMetal, but the personnel from the Laser Division did not know those parts had already been finished. This resulted in the difficulty of tracking the moving parts and handling the schedule by the workload.

**Problem Solving** → Everybody is responsible for the entire production process. Nevertheless, the production manager has many more responsibilities to notice and educate every subordinate about paying attention to what order they had done, or had not done recently. After all, by implementing lean manufacturing, the whole production process is a teamwork, not an individual work.

6. In L50811 (Mandalay Bay)(See Figure 6-2), I found the personnel of SheetMetal spent much time looking for parts on the shelf of finished cut parts. Due to the misplaced finished cutting part, the worker could not find the part where it should have been. After spending about 10 minutes, he finally found the part he needed on the floor.
**Problem Solving** → In fact, the shelf only could hold 6 to 8 orders, and some parts of different orders were overlapping. Therefore, all they need to solve this problem is to build bigger and wider shelves, and clean those shelves periodically.

7.2 Discussion and Recommendations

Although it is feasible to implement lean manufacturing for a Make-to-Order production company, such as Young Electric Sign Company (YESCO), we still need to consider the application method. In the past, plants trying to create a lean manufacturing environment within their businesses have sometimes made common mistakes. Those could be avoided with careful thought and knowledge of the pitfalls faced by lean pioneers. Those mistakes include:

1. Failure to Practice Basics: Hooking machines together before they are capable and reliable is one of the most common mistakes plants make while working toward lean. Departmentalization can hide problems for several years. Two wrong activities do not make a right, and two incapable machines do not perform well because workers marry them into a cell. It is also significant to make sure that workers do not increase their chances for downtime and excessive setup time by mating machines together in a premature effort to achieve one-piece flow. It is tempting to show your customer a cellular manufacturing arrangement, but if your machines are inoperable, say, 50 percent of the production time, you break up your promise to meet your customers' needs. The company must focus on practicing fundamentals. However, in the production environment of YESCO, even if every worker is fully experienced in the manufacture of the signs, he or she should pay attention to basic detail in order to prevent rework and
non-value-added activity. In addition to the individual, YESCO should centralize the
order information and specification by using computers in each department rather than at
the Department of Layout only.

2. Changing Things Rather Than Behavior: For instance, Du Pont's famous Safety
Training Observation Program (STOP) illustrates that 96 percent of all accidents are
behavior-related. Companies having lean initiatives can face serve consequences because
of their failure to change behavior. Many companies fail to apply enough effort to
changing their standard work procedures (behaviors) when they implement changes.
Modifying the work process is necessary to prevent jumping into the old way of
performing tasks, producing a lot of waste, and giving the new process a chance to
become a habit for every individual. On the other hand, if we only change physical
things, those things will get lost, broken or replaced when nobody is looking.
Simultaneously, we are going to be back to the old condition. YESCO does not possess
standard work procedures. It is urgent for YESCO to establish a standard work procedure
to prevent the repetitive and non-value-added activities. This is especially needed in the
Department of Electronic and Electric. Due to the restrictions of UL\(^2\) safety regulations,
if a worker does not have a standard procedure for wiring, he or she may need to
disassemble those wires and components already installed on the sign and rework the
procedure again.

3. Failure to Reduce Setup Times: In the Toyota Production System, they focus
on single-minute exchange of dies (SMED), and the company has taught the industry that

\(^2\) Underwriters Laboratories (UL) is an independent, not-for-profit organization chartered "to establish,
maintain, and operate laboratories for the investigation of devices, systems, and materials with respect to
hazards affecting life and property." "Listing", the most widely recognized of UL's services, means that
samples of a product have been evaluated, and they comply with UL Standards. Products tested and
recognized by UL are listed in a Component Directory.
they never accept setup times as a fixed parameter. It can be very expensive for plants to try to match Toyota's level of success in setup reduction. Nevertheless, the single-digit exchange of dies (SDED) is not as difficult as we might think. Reducing machine setup time to a single digit (less than 10 minutes) is necessary and imperative. In fact, an average of 10 minutes or less for each setup is an important goal that every plant should set for itself. Most importantly, if the company pretends to be a small-lot manufacturer and spends more than 10% of a working day in a setup mode, the company eventually will get the trouble. The cost of operation will simply overtake their ability to generate cash. However, in YESCO, workers produce most of the set-up time. They need to prepare tools, recall the previous progress, or look for missing components. Normally, the set-up time of CNC Router and Laser Machine is about 10 minutes. Therefore, how to decrease the set-up below 30 minutes among all operations becomes the major mission for the workers on the floor.

4. Focusing on Machine Optimization Rather Than Flow: Keeping the material flowing is the most important message that workshops can receive and put into practice. Toyota, John Deere, and other companies are masters of flow. The flow might look different in a Make-to-Order shop. This is because the flow might take the form of one-unit flow, one-pallet flow, or one-truckload flow instead of a perfectionist idea of one-piece flow. There's nothing wrong with perfection, of course; but you need to recognize that there is no reason to wait for absolute perfection before you get started. It is useful to make problems on the floor visible to everybody. For example, everyone needs to attach a red ribbon (or a flashing light) to any pallet of material staying still for more than a half hour. Since workers downstream will find that signal immediately and move the waiting
material for machining, the machine can reach the optimization. It is necessary to make sure that everyone knows that the goal is not to operate a machine just to keep it busy. The final goal is to do whatever keeps parts moving through the shop. In YESCO, although the production flow looks like one-piece flow, some work-in-progress components sometimes need to wait for another working part. Therefore, a waiting time occurs in this situation. Besides that, some components from upstream need to wait for availability of downstream. If there is not sufficient labor downstream, components from upstream had to wait about 64 hours. In our study, YESCO uses priority treatment on some orders, and it can control the overall progress quite well. However, the most critical approach to optimize the machines and workers is to have an up-to-date planning and control system for appropriately scheduling task. Ideally this would result in a uniform workload throughout the year.

5. Failure to Think Outside the Box: Job shops are often operated by entrepreneurial-free thinkers, who started their business in a garage or rented warehouse. Upon becoming successful, these same free thinkers often become their own worst enemies. They are usually very good at what they do by now. However, they ignore the fact that others may have discovered a better approach. Just as you might hire a golf professional to help you with your short game or a guide to teach you where and how to fly-fish, you may need to take some advice from someone who has figured out a great way to do something you do very well. Recognizing a need for coaching does not diminish or call into questioning a person's ability. On the other hand, it shows intuitiveness and wisdom. Seeking the design help for present equipment or with implementing lean initiatives can assist every owner in moving their company to the next
level of performance. In YESCO, profits from the entertainment sign business now are not as good as before, and most competitors can provide a better price than YESCO. The executive thought the selling price influenced the profit. In fact, they need to pay attention to the cost of the production process, and they need to consider the optimization of labor, machine, facilities, and plant floor. Also, the waste of unused cutting parts represents a critical cost of the production.

6. Failure to Train Teams: Giving teams a clear vision of where the company is moving is all-important. It is equally important to educate teams in the use of skills that they will need to get the job done. Cheerleading will not improve a football team's skill set or chances of winning. They need a coach to teach and guide them in the fundamentals. They also need a playbook that can help transform their individual efforts into a winning team result. The same method can be applied to work teams. In YESCO, a lack of communication and coordination result in a high frequency of rework and waiting, and it is not reasonable to implement a lean manufacturing by using Just-In-Time concepts. Since there is no Just-In-Time message from the upstream to downstream, the worker downstream cannot pick up the part. In their mind, they think the part is still being manufactured, and they wait for the wrong news. It is fundamental for different operational departments to work as a one team. Therefore, different department can share and discuss the same ideas and purposes at the same time.

7. Commanding Change, Ignoring Support: In order to get better every day, we should possess knowledge, diligence, effort, focus, and resources. We cannot simply give a team a book about lean manufacturing and then turn on our heels and walk away after commanding them to implement the process under the concept of lean manufacturing; it
won't work. The result will be a short-term improvement and a long-term frustration. Most importantly, company leadership must take an active role in steering the efforts of the team closely. The direction and discipline to keep everyone working on the model line must come from the action at the top. Otherwise, we won't optimize our resources, and our project will suffer a shotgun effect—scattered effort, diluted objectives, and an obscured vision. In YESCO, the production manager, all department managers, and even the project coordinator are involved in the working progress of each project. They do not just give an order due to their higher position and authority. However, YESCO applies workforce empowerment so the department manager and department coordinator decide the continuity and validation of the work order.

In general, our goal is not to focus on the negative, but rather to recognize the risks associated with failing to consider some of the lessons learned by companies, which have worked hard and struggled to apply the lean manufacturing techniques. Also, great sports teams learn from watching videotapes of themselves and their competitors. Likewise, in YESCO we can learn much from talking with other companies about their successes and struggles while on this path to the leader of national wide, and even world-class performance. Most importantly, recommendations I noted in the previous paragraph only represent my opinion. I hope they are beneficial to the company.

7.3 Future State Value Stream Mapping

Drawing the “current state” map enables us to have a pictorial understanding of the production process, but the real utility of the tool is the ability to develop a vision of good value stream for the product flow. This vision is to come out with a “future state”
map. The future state map shows where the firm can introduce continuous flow by implementing concepts of Just-in-Time and pull system in lean manufacturing. The benefits of creating a lean enterprise includes reduced the inventory, reduced space requirements, improved capacity, reduced manufacturing lead time, reducing scrap/ rework, increased throughput, and improved on-time shipments.

In our future value stream map (see Figure 7-1), we have made some modifications from the current state map for the improvement. The changes are:

1. In the current state map, the information flow is based on the manual delivery that the design and specifications of the order is picked up by the worker between two departments. For our future state map, we use electronic transmittance instead of a manual one. This can reach the idea of Just-in-Time delivering the information, and eliminate the waste of non-value-added activities. Every department can immediately receive the information from the department of layout and especially the production manager and every project coordinator can receive the up-to-date production process without monitoring the project back and forth. Most importantly, each department manager can know the progress of each order and effectively schedule the following new order without the lack of workers.

2. In the current state map, the departments of the router and the laser are separated. For the future state map, we are going to try to combine these two departments without any cost concern. This alteration can establish a cross-helping team along the cutting process. Within these two teams, workers will know the cutting progress of each department and support each other if there is lack of the capacity for either of the two departments. Also, it can eliminate the waste of non-value-added activities. Since the
location of department of laser is 200 feet away from the location of main production flow, we can eliminate the travel distance if we combine these two departments.

3. In the future state map, we want overlap the production process by combining the departments of Electronic and Electric, Graphing, SheetMetal, and Painting since we want to apply the concept of cross-training. Since the production time of wiring is the longest among all processes, we want every person from different department to help each other and accomplish other unfinished parts before the wiring is done. It can decrease the waiting time between the overlapping process and crate process. Therefore, we want to establish a cross-training team and let every member of the various departments of this team perform all easy tasks other than their own.

4. In the current state map, we do not possess a department of production control, even if we have one production manager and a project coordinator for each project. In order to understand the progress of the flow and track the order, the production manager and every project coordinator need to spend some time and effort monitoring the problems happening on the plant floor. They cannot track the multiple orders and solve floor problems at once. In the future state map, we add one department in which we establish a software system by combining the effort and production manager and project coordinators. In this system, we are able to receive the information not only of the production progress from each department but also of the modifications from the customers. Therefore, those managers can immediately notify the department of design and estimation, and these two departments can update the specifications of the order.

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5. In the future state map, we apply the Kanban plans and pull system in the production. The use of a kanban card is a simple system of planning and controlling production, and it helps the production process by reducing the work-in-process inventories since no parts can be produced or moved without a kanban card. Unlike the push system of the present production process, the application of a pull system determines the production scheduling and job release date by customer demand. Most importantly, by applying a pull system, the production lead time can be greatly reduced because the department of production control can receive the brand new message from the customer once the specification and delivery date are changed.

6. In the future state map, we apply the concept of First-In-First-Out and maintain a First-In-First-Out (FIFO) sequencing for the production flow. This work can result in better flow for both custom and repetitive work. In the cutting and painting operations, we need to maintain some inventory of work in the FIFO or sequential – pull queues between processes, especially ahead of the bottleneck process. On the other hand, in the production process of YESCO, the concept of priority exists in the model of production process.

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3 Kanban, in Japanese, means card or marquee as on the front of a movie theater. In the context of Just-in-Time, Kanban is the means of signaling to the upstream workstation that the downstream workstation is ready for the upstream workstation to produce another batch of parts. It also means production system based on conveyance and production cards that determine the movement of production orders between workstations. [6]
Figure 7-1: Future State Value Stream Map within Production Process
CHAPTER 8

SUMMARY AND CONCLUSIONS

8.1 Summary of the Research

In this research the use of a key lean manufacturing tool—Value Stream Mapping in the Make-to-Order production process—is addressed. This is applied to the entertainment sign industry as represented by Young Electric Sign Company (YESCO). As we know, the value stream includes all the actions, both value-added and non-value-added, required to bring a product from the raw material to the finish good through the main flow. In MTO production in the entertainment sign industry, a set of production jobs with varying routings and material requirements are needed to make a multi-level product. Therefore, it was very difficult to track the flow of the individual part. However, the four projects analyzed in this paper had a single production line for one order, custom design, less individual parts, and one batch size, so it is easier to apply the Value Stream Mapping tool and to analyze the production process.

Value Stream Mapping is done in two steps. The first step was to draw the current state value stream map which included the design of the product, the flow of the product and the flow of the information necessary to trigger and support these flows. It takes a snapshot of how things were being done. From developing the current state value stream map, we could know the production sequences, information flow, and material flow. We
also could get setup times, production times (production lead times), waiting times (production down times), and cycle times for each step of the production process.

The second step is to draw the future state value stream map to show how things ought to be done by implementing lean concepts and by eliminating the non value-added activities. In addition to developing the current state and future state value stream maps, some problems were identified along the production process, and some solutions were also provided for improvement. Also, for YESCO, because they were in hurry to implement lean manufacturing, they made some common mistakes within the production process. We have discussed some possible strategies that should result in improvements.

Last, the main goal of this thesis was to develop a general methodology to identify the value-added steps in a value stream of YESCO, eliminate the non-value-added steps/waste (muda), and implement lean manufacturing tools and techniques in the success of Value Stream Mapping.

8.2 Conclusion

Physical plant layout redesigns or changes of the supply chain infrastructure eventually have a critical influence on the cost to the company. Through Value Stream Mapping, every person within the company can see the impacts and production flow before implementation and can help transforming the company to a lean thinking at a minimal cost.

We had hoped to do some simulation work. Due to the long duration and difficult time required to receive company’s authorization of the simulation, we do not unite the
Value Stream Mapping and simulation. In my mind, there are several benefits in applying the Value Stream Mapping along with the simulation:

1. Value Stream Mapping is an extremely valuable tool in lean manufacturing and the continuous improvement effort.

2. Simulation adds the fourth dimension, the material flow, the information flow and time to a value stream map. After being simulated, the Value Stream Mapping is no longer just a snapshot; it is a moving picture and offers insights of the production process that may have been missed if we use the floor seeing only.

3. After the simulation, Value Stream Mapping not only makes testing ideas easier, cheaper, and quicker, but also gives immediate assessment of proposed changes to the system.

4. Value Stream Mapping provides the model and data, so it makes the simulation easier to accomplish.

5. Value Stream Mapping and simulation are a natural combination and each enhances the other’s value in the lean manufacturing effort.

Despite the success by combining the Value Stream Mapping and simulation, Value Stream Mapping possesses some drawbacks:

1. Value Stream Mapping is a technique based on “paper and pencil” primarily to document value streams in the plant floor. By “walking” only, we physically record what happens on the floor along the production flow. This will restrict both the level of detail processes and the number of different versions that we can handle.
2. Although Value Stream Mapping map can reveal the value streams of the production process, many people fail to see how it translates into reality. Therefore, the risk of value stream map ends up as nice poster, and there is not further use for the map.

3. In a real world, many companies are the high variety and low volume type. It means that many value streams are composed of many tens or hundreds of industrial parts or products. This results in a level of complication or variability that cannot be addresses by Value Stream Mapping.

Finally, it is not impossible to implement the lean concepts on the Make-to-Order production process of YESCO. Although it has its own way to perform the production process now, it must make some improvements to eliminate non-value-added activities and waste. Since some competitors outperform YESCO in the entertainment sign business, and the profit margin is becoming less and less, it is an appropriate time for YESCO to have some lean thinking.

In our study, we have used Value Stream Mapping to identify the differences between the current and future states and yielded a roadmap for future improvement activities and some recommendations. However, since the waiting time between two processes is wasted, the next step we can suggest is try to establish a mathematical model to illustrate the waiting time between two workstations under the assumption that the production is a continuous process instead of discrete process. After all, I hope this research and analysis are helpful to Young Electric Sign Company (YESCO).
APPENDIX I

PHOTOS OF FINISHED SIGNS AT YESCO
NOTE:

- Finished Product of L50813 (Bellagio MegaBucks) *Double-Side Face

- The picture above represented the sign which lacked of the display meter
NOTE:

- Unfinished Product of L50885 (Texas Station) *Double-Side Face

- Both pictures represented the sign was waiting for the face
NOTE:

- Unfinished Product of L50986 (Palace Station) *Single-Side Face

- Both pictures represented the sign was waiting for the face and meter
NOTE:

- Finished Product of L50986 (Palace Station) *Single-Side Face
APPENDIX II

PHOTOS OF CNC ROUTERS AND LASER MACHINE, CNC ROUTER AND LASER MACHINE IN YESCO AND EACH PRODUCTION DEPARTMENT
NOTE: STANDARD CNC ROUTER [33]

NOTE: STANDARD LASER MACHINE [37]
NOTE: CNC ROUTER in YESCO

NOTE: LASER MACHINE in YESCO

Department of SheetMetal

Department of Electronic and Electric

Department of Painting
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VITA

Graduate College
University of Nevada, Las Vegas

Tsung-Han Lin

Local Address:
4185 Paradise Road Apt.2251
Las Vegas, Nevada, 89109

Home Address:
5F-3, No. 98, Fu Kuo Road, Shih Lin
Taipei, Taiwan, R.O.C

Degree:
Bachelor of Engineering, Textile Engineering, 1997
Chinese Culture University

Thesis Title:
Study Analysis of Value Stream for YESCO Production

Thesis Examination Committee:
Chairman, Dr. Robert Boehm, Ph. D.
Committee Member, Dr. Zhiyong Wang, Ph. D.
Committee Member, Dr. BingMei Fu, Ph. D.
Graduate Faculty Representative, Dr. Joel Wisner, Ph. D.