



Lean Manufacturing Implementation at Central Industrial Supply

Major Qualifying Project Report
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and
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Abstract

Central Industrial Supply (CIS) is a company that specializes in contract manufacturing of electromechanical components and assemblies for original equipment manufacturers (OEMs) for many companies such as Dell, IBM and HP. Our project focuses on a Dell product called the "9G" which is used for many rack-like products that slide in and out from a position. For this product to be completely created and assembled, it takes on average 7 days. Our goal for this project is to understand different lean manufacturing methods and apply them to reduce lead time by 20% as well as improve overall process efficiency.

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1.0 Introduction

In today's business world, companies are constantly competing with one another to produce the products with the best quality while at the same time increasing their profit. One way to increase a company's profit, reduce cost and remain competitive in the market is to eliminate the unnecessary factors involved in the manufacturing process. This can be done using a variety of methods. One method, known as lean manufacturing, is a process which is designed to reduce the time and effort it takes to make a product, taking into account issues such as time, wasted material, man power, and idle equipment.

Central Industry Supply (CIS) specializes in contract manufacturing of electromechanical components and assemblies for original equipment manufacturers (OEMs). This project was aimed to assist CIS, using lean manufacturing tools, to reduce the manufacturing time process by 20% as well as improving overall process efficiency. Tools of lean manufacturing used in the project include Value Stream Mapping (VSM) and time studies. Value Stream Mapping is a lean manufacturing technique that is used to by companies to depict and analyze the flow of materials and information currently necessary to bring a product or service to a consumer. It accomplishes this by first identifying any wastes, which is any activity that does not add value to the final product, then demonstrating these wastes to the company followed by taking the necessary steps to decrease these wastes. VSMs are used to depict current operational processes, and then after identifying, analyzing and reducing wastes, a future or ideal VSM can be made which should show quicker and more efficient operational processes. Time studies are used in order to decrease the number of tasks in completing a process, therefore improving production and efficiency.

For our project, we worked with Central Industrial Supply (CIS) in Wuxi, China. The product we focused on reducing lead time from the slide roll forming process to final assembly for is the "9G" (9th generation server) rack mounting kit (RMK) that CIS produces for Dell. The "9G" is a type of Qualslide product which is a brand of telescoping ball bearing slides. On average, CIS currently produces 4,500 pairs of Qualslide products per day (a pair of slides include one left slide and one right slide. There are three processes for making the "9G": roll forming/metal fabrication, outside service and mechanical assembly. Roll forming and subsequent metal fabrication (stamping) are done in one factory, named F4. Plating is outsourced to an external vendor, which is 7 Kilometers away from F4. Final assembly is done in another CIS factory, named F6, which is 1 Kilometer away from F4 and 8 Kilometers away from the plating vendor. The 9G slide consists of 3 members; cabinet/outer member, intermediate member and chassis/inner member. For one slide member, the cycle time in the roll forming process is about 10 seconds. It takes 90-200 seconds, as it varies by different member, to go through the subsequent whole production process. In order to reduce the lead time we had to identify all wastes in each member's process and from there recommend methods that could be used to eliminate these wastes. On average, current lead time from the first process (roll forming) to finish (final assembly) is 7 days.

From the research we did prior to our arrival in Wuxi, we saw that the VSM method was used last year by another group of WPI student at CIS. This was the first time the VSM method was used at CIS to help reduce lead time. We used this method again to make an initial state VSM, or Current State Map (CSM),

and from there conducted time studies and analyzed data sheets. To improve overall process efficiency, we had to look at the whole production process, from order placement to shipping. We looked at and analyzed data sheets, conducted interviews, and made group observations. This allowed us to see where there were problems and provide solutions for CIS to use to remedy these issues. Once we had all collected all the data and analyzed it, we developed a future VSM showing the total reduction in lead time should all our recommendations be implemented.

2.0 Background

This section pertains to all the background information we needed to know before we could begin working on the project. This section was vital for us in understanding the scope of our project, the product itself we were focusing on, as well as providing us an initial direction of where to focus our goals.

2.1 Lean Manufacturing

The process of Lean Manufacturing has been the main concerns and issues of many manufacturing companies throughout the world. Many processes leading up to lean manufacturing have influenced this greatly such as Interchangeable parts, Just in Time Production, the Ford Assembly line, and the Toyota Production Systems.

Eli Whitney is considered to be the founding father of this process with his idea of interchangeable parts. Later on in the 1900s, Henry Ford introduced the idea of the assembly line, which rapidly produced automobiles. From this, there have been greater advancements in technology which have lead to faster production times and reduction of ineffectual materials. Below is a timeline showing how lean manufacturing has progressed since Eli Whitney introduced Interchangeable Parts.

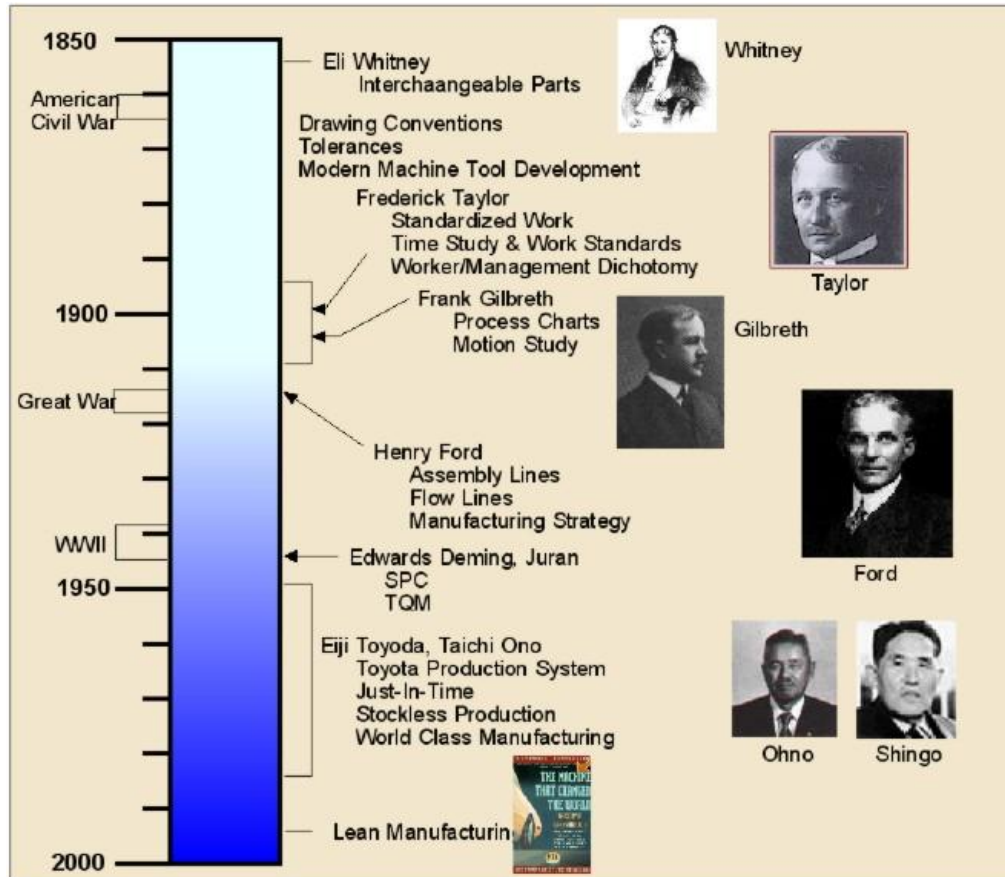


Figure 1 - History of Manufacturing

Source (Strategosinc, 2008.)

This specific process of Lean Manufacturing has been implemented and used by all types of leading manufacturing companies. Lean means "manufacturing without waste." Waste ("muda" in Japanese) has many forms. Material, time, idle equipment, and inventory are examples. Most companies waste 70%-90% of their available resources. Even the best Lean Manufacturers probably waste 30% (Strategosinc, 2008). 'LEAN' has always been important to manufacturers. When you reduce inventories, assets, overhead, wait times and out-of-specs, you generally increase profits. Simply put, lean manufacturing is a key contributor to high performance - the ability to consistently outpace competitors across economic cycles, industry cycles and generations of leadership (Russell, 2006). Overall, this process improves the manufacturing time, reduces costs and the reduction of wastes and defects.

The Japanese began to look into improving the processing of lean manufacturing in depth. They repeatedly used the word "Kaizen" which means improvement in Japanese. This strategy consists of continuous improvement of a system involving a whole company, or industry. This strategy, known as the Kaizen event, consists of using all members of a company, mapping the existing process, brainstorming on improvement and implementing these new ideas.

One of the most adapted concepts to come out of the Japanese working culture were the Five S's. The Five S's System includes sorting, setting in order, shining, standardizing, and sustaining to abolish the

waste of time and money and to achieve lean initiatives. According to Hirano's book, 5S for Operators: 5 Pillars of the Visual Workplace, "A company that cannot successfully implement the 5 Ss cannot expect to effectively integrate JIT, re-engineering, or any other large-scale change. Good workplaces develop beginning with the 5S's. Bad workplaces fall apart beginning with the 5 Ss" (Hirano, 1996).

The godfather of lean manufacturing was the Kaizen-based Toyota Production System (TPS). This system's underlying philosophy of continuous improvement became a blueprint for others - most notably Danaher Corporation, which turned it into the Danaher Business System (DBS). DBS operates on two levels. (Russell, 2006) In the Toyota Production System, the main goal is to reduce waste. This waste consists of Material, time, idle equipment, and inventories are examples. TPS emphasizes the identification of waste (often problematic) followed by specific tools and techniques to eliminate it. TPS emphasizes the participation of all employees. It uses teams integrated with work cells for motivation, work management and problem solving (Strategosinc, 2008).

First, methodologies such as Six Sigma and value-mapping are used on a daily basis to curtail excess inventory, long waiting times, over-production and defects in quality. Kaizen events run continuously, closely examining business processes to cull waste and develop standardized approaches to avoiding it in the future. (Russell, 2006)

Six Sigma at many organizations simply means a measure of quality that strives for near perfection. Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving towards six standard deviations between the mean and the nearest specification limit) in any process -- from manufacturing to transactional and from product to service. The statistical representation of Six Sigma describes quantitatively how a process is performing. To achieve Six Sigma, a process must not produce more than 3.4 defects per million opportunities. A Six Sigma defect is defined as anything outside of customer specifications. A Six Sigma opportunity is then the total quantity of chances for a defect. (Goyal, 2008)

In a case study done by iSixSigma, a magazine whose goals are to study the Six Sigma process, a process was determined to note application of lean manufacturing to six sigma. In this study, work was carried out in a large company based in the US and India in the business of converting printed paper from customers into electronic copies. It is a continuation of the earlier case study entitled "Six Sigma Case Study: Converting Paper to Electronic Documents." In this case study, seven stages were identified, which clearly related to lean manufacturing. The steps included, defining and measuring the problem, analyzing the problem, idea generation, idea modification, implementing change, checking the result, and standardizing the control. In conclusion, the combined effect of Lean Manufacturing and Six Sigma has led to improvements in product quality (98% reduction in errors) and turnaround time (50% reduction). These improvements have resulted not only in cost reduction, but also the possibility of presenting these improvement stories to the customer, building the reputation of the company as a leading supplier of quality, and thereby increasing the probability of getting higher volumes of business. (Goyal, 2008)

Another variable in the lean manufacturing process is called cellular manufacturing. Cellular manufacturing, also called work cells, represents an alternative organizational structure that seeks to reduce manufacturing lead times, improve product cost, quality and delivery and create an atmosphere of employee involvement and continuous improvement (*Granite-bay cellular manufacturing.2008*).

Cellular manufacturing consists of a series of product focused work groups, which controls all operations to manufacture a product. The cell is dedicated to manufacturing those products requiring similar operations. While the normal manufacturing environment is organized functionally with similar machines in one area cellular manufacturing operates like a series of plants-within-a-plant, each starting with raw materials and ending with finished product, with all operations being performed in the cell.

Machines in manufacturing cells are located within close proximity to reduce transportation time, a type of waste and to maintain continuous flow with zero inventory between operations. The manufacturing cell is operated by a team of skilled technicians who have sole responsibility for quality and delivery effectiveness in the cell.

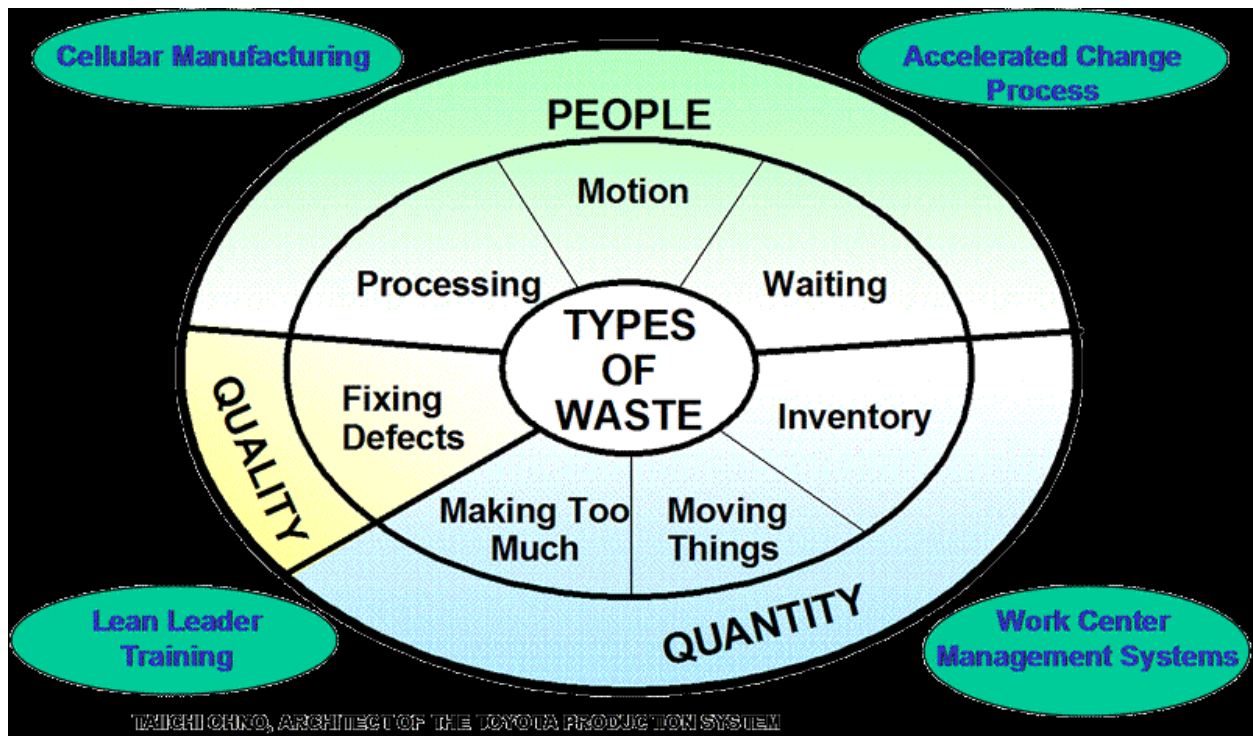


Figure 2 - Types of Waste

Source (*Granite-bay cellular manufacturing.2008*)

2.2 Value Stream Mapping

Value Stream Mapping (VSM), also known as Material and Information Flow Mapping, is a lean manufacturing technique that is used to analyze the flow of materials and information currently essential to bring a product or service to a consumer (Wikipedia contributors,). It originated from the TPS and while it is most commonly used in manufacturing it is also used in logistics, supply chain, service

related industries, software development, and product development. For the most part, it is used primarily to identify, demonstrate and decrease waste (any activity that does not add value to the final product), as well as create flow in the manufacturing process (*Value stream mapping - waste visualization*). Due to the value of what VSM can provide companies, it not just a communication tool but also a strategy planning tool and a change planning tool.

VSMs can be created by simply using paper and pencil; however more complex maps are created using computer software such as Microsoft Visio or Microsoft Excel. VSM maps look somewhat like flow charts and an example of what one looks like can be seen below:

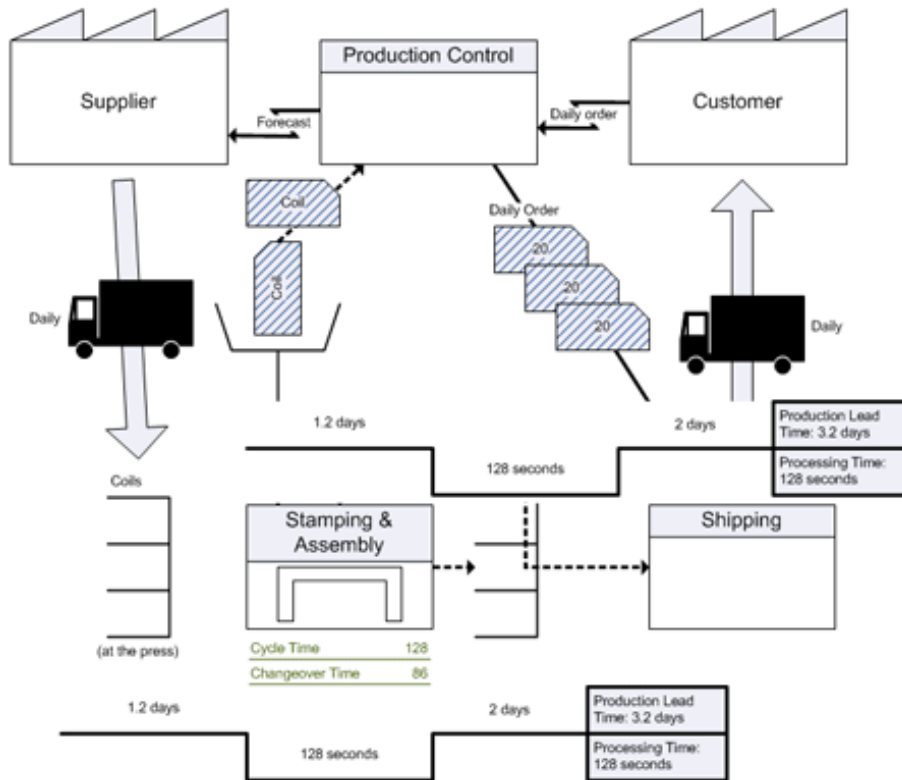


Figure 3 - Example of a Value Stream Map

The VSM method visually maps the flow of materials and information from the time products come in the back door as raw material, through all manufacturing process steps, and off the loading dock as finished products. There are several steps used in VSM and these steps are:

1. Identify the target product, product family, or service.
2. Draw a current state value stream map, which is the current steps, delays, and information flows required to deliver the target product or service. This may be a production flow (raw materials to consumer) or a design flow (concept to launch).
3. Assess the current state value stream map in terms of creating flow by eliminating waste.
4. Draw a future state value stream map.
5. Implement the future state

Source (Wikipedia contributors, 2008)

The first step, identifying the product, pertains to choosing what product the VSM will focus on. After having chosen the product to focus on, the next step is to draw the current state VSM, also known as a Current State Map (CSM). This CSM contains all the steps and the parameters used in these steps. These parameters include but are not limited to cycle times, TAKT time, Work-In-Progress (WIP), production rate, number of operators, and waiting time. Having compiled the CSM with all the information deemed necessary to perform analysis, the team then assesses the current situation. A VSM identifies where in the manufacturing process value is added and where there are non-value added steps. Upon assessing the current situation and determining where there might be non-value added steps, or wastes, the next step is to develop methods to eliminate these wastes. Upon developing these methods, a final VSM known as a Future State Map (FSM), can be drawn with these wastes removed. The final step is to implement the changes so that the drawn FSM can be followed as closely as possible. This will in turn make a more efficient lean manufacturing process (*Emerald FullText article : The seven value stream mapping tools.*).

2.3 Central Industrial Supply (CIS)

Central Industrial Supply (CIS) is an international company with expertise in design engineering, project management, and manufacturing excellence all over the world. There are five regional branches located in: Grand Prairie, Texas; Houston, Texas; Glasgow, UK; Singapore; and Wuxi, China. These locations can be seen on the map below.

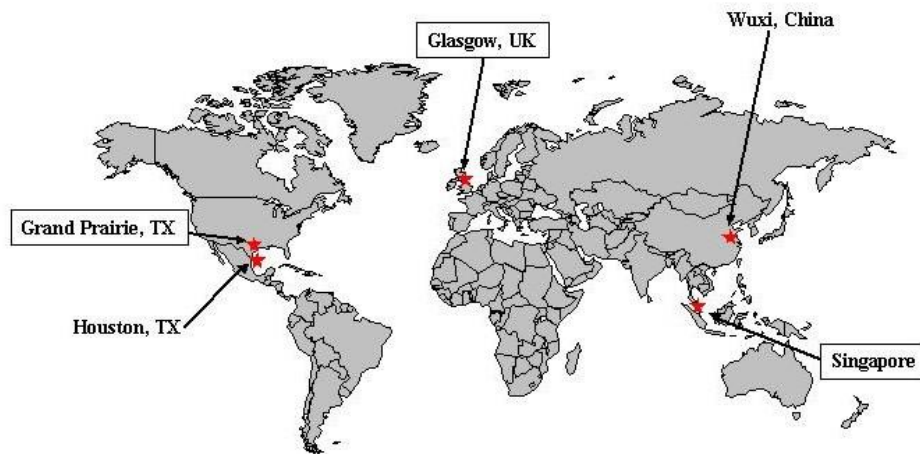


Figure 4 - CIS Global Locations

CIS originated in Grand Prairie, TX in 1955 when it supplied small mechanical components and tooling solely for the North American market. However, in 1996 it established the Asia-Pacific CIS factory. LTD (APCIS) in Singapore, providing logistics services such as material management and assembly for the Pacific market. In 1998, CIS Grand Prairie, TX achieved International Organization for Standardization (ISO) registration which allowed it to set up different branches in worldwide regions. These branches also achieved their ISO registrations. By 2003, CIS Houston, TX, APCIS Singapore, APCIS Wuxi, China and CIS Grand Prairie had achieved a high level of ISO registration which includes engineering certification in

addition to manufacturing certification. Over the past 52 years, it has been developing new products and services to meet the demands of the constantly shifting market. This allows CIS to transform from a small mechanical component supplier to a worldwide global manufacturer ().

2.4 Product: 9G “9th Generation Server” Rack Mounting Kit

The product our project focuses on is the 9G or “9th Generation Server” rack mounting kit. This product is a Quallslide brand of telescoping ball bearing slides that CIS produces for Dell. It consists of three members called Cabinet, Intermediate and Chassis. Below is an example image of the 9G with the three members labeled.

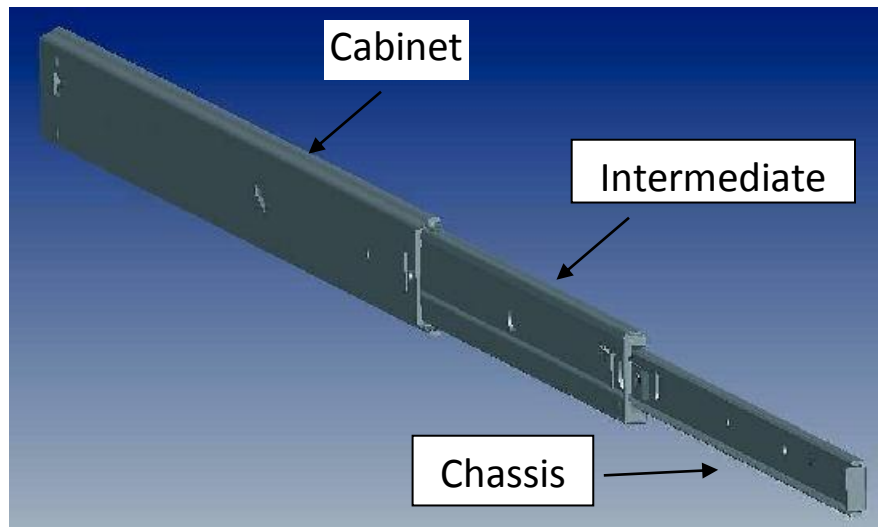


Figure 5 - 9G Image

There are three processes for making the “9G”: roll forming/metal fabrication, outside service and mechanical assembly. Roll forming and subsequent metal fabrication (stamping) are done in one factory, named F4. Plating is outsourced to an external vendor, which is 7 Kilometers away from F4. Final assembly is done in another CIS factory, named F6, which is 1 Kilometer away from F4 and 8 Kilometers away from the plating vendor. The 9G slide consists of 3 members; cabinet/outer member, intermediate member and chassis/inner member. For one slide member, the cycle time in the roll forming process is about 10 seconds. It takes 90-200 seconds, as it varies by different member, to go through the subsequent whole production process. In order to reduce the lead time we had to identify all wastes in each member’s process and from there recommend methods that could be used to eliminate these wastes. On average, current lead time from the first process (roll forming) to finish (final assembly) is 4 days.

The entire kit includes a pair of all three members, one left slide and one right slide, as well as a Cable Mounting Arm (CMA). When completely assembled this kit is used in server rack mounts. They hold the actual server, and the slides are able to move forward or backward as shown in the image below.

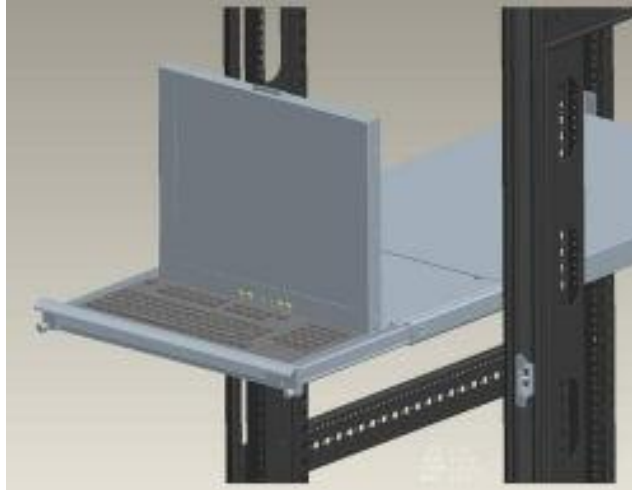


Figure 6 - 9G Completely Assembled and Mounted Image

The 9G was first introduced in April 2006, and is currently the major selling product of the CIS Wuxi plant, with the main customer for this kit being Dell.

2.5 9G Processes

While beginning to understand the flow of the information and materials in the factory, we discovered that there were a number of processes involved throughout the factories. Between factory 4, factory 6, and the plating factory, there are many processes to understand. In these factories, we met with the floor managers and began to study the flow of materials through each machine.

In Factory 4, two processes occur, which are the roll forming and stamping. In these two processes, there are many machines used to satisfy the needs of the 9G product. There are also different assembly lines corresponding to the specific member. In these assembly lines, raw material is formed using a roll forming machine, which is then cut into a specific length. After the roll forming, it is sent to the stamping machines, which consist of a number of different machines. Each stamping line varies due to the different needs of each member. These stamping machines consist of lettering, chamfering, deburring, and various stamping procedures.

From Factory 4, the pieces are delivered to the plating factory roughly seven kilometers away. Here the pieces go through an automated process which cleans, plates, and inspects thoroughly. After each piece is plated and dried, it is placed into the warehouse which is located on the grounds of the Plating Company.

After each piece has been inspected and put into boxes in the Plating warehouse, a delivery truck picks these boxes up, and transports them to Factory 6. At this factory, each of the 3 members are assembled in a specific line, depending on the product type. In these assembly lines, machines are used for various operations such as joining and drilling. Once the pieces are assembled, they are then packaged and put into inventory. When they are put into inventory, they go through an Out of Box Audit (OBA), which

tracks the entire lead time, from roll form to final assembly. After this each pallet full of products will wait to be picked up for delivery.

2.6 Background Summary

Through all of this information and all of these methods described in the background section, we will use our current knowledge to assess the current problems. Through using lean manufacturing methods, we will be able to determine the time, cost, and quality wasted, and attempt to eliminate them. By using a current and future state Value Stream Map, our group will attempt to reduce the total lead time. The research overall helped us understand the issue much more and will help us reach our goals.

3.0 Methods

This section explains all the methods used during the project to collect data. Along with these explanations are details pertaining to why we used these methods, the data we aimed to collect from these methods, and what this data would be able to show.

3.1 TAKT Time

TAKT time is defined as the maximum time allowed to produce a product in order to meet demand (Wikipedia contributors, 2008). This is important for CIS because since they deal with such a high volume of orders, it is vital for them to be able to produce products that meet the customer demands in a desirable time for the customer. This is where determining the TAKT time comes as in seeing as that by determining the daily production capabilities and comparing with the average number of ordered products per month we can see whether CIS currently produces enough products to meet customer demand. Calculating TAKT time is done by using the following formula:

$$T = T_a / T_d$$

where T is the TAKT time, T_a is the net time available to work and T_d is the total demand (units produced/time interval) (Wikipedia contributors, 2008). In order for our team to get this TAKT time and see whether CIS is producing enough products to meet customer demand, we needed to know how long each work day, what the daily production was as well as the customer demand. This information we got through interviews with Larry Zhong and Dai Chaozhong, as well as floor managers at both CIS factories.

3.2 Current State Map (CSM) and Time Studies

In order to make suggestions that can improve the production process of the “9G” product, we first had to understand how the production process works. We needed to see, first hand, how all the steps worked and from there develop methods to collect data that we would then be able to analyze and come up with suggestions for improvement. Upon our arrival in Wuxi, one of the first things we did was get a tour of F4. After having done the tour, the team got together and determined what data we needed and what methods to use to collect this data. We first determined that we needed to create a Current State Map (CSM) of each member’s production process at F4 and after having drawn that we

could then turn to focusing on the operational process. To improve the operational process, we determined that conducting time studies would be the best way for us to get the data we needed on each process. Having determined how we were going to collect our data we then focused on what part of each process we were going to use time studies, which ended up being the cycle time of each process. We created a data sheet that contained the information we deemed as necessary for us to be able to make a qualitative analysis and lead the way to coming up with suggestions. An example of one data sheet can be seen below. The others can be found in Appendix B.

Factory: F4		Member: Cabinet				Date:		Time:		
Process #	Process	# of operators	batch size	# of pieces	waiting time	cycle time	cycle time	cycle time	cycle time	cycle time
20	Roll Forming									
30	Lettering									
40	Stamp									
50	Stamp									

Table 1 - F4 Data Collection Sheet Example

From looking at this table, the information we deemed as necessary to collect was the process number and name seeing as that while for each member process the process number might have been the same, the process itself was different. We also felt that the number of operators for each process was important because from the cycle time data we were going to collect, we could determine whether the number of operators for each process was sufficient or if there needed to be a change. The batch size of the pieces at each process along with the number of pieces each machine could work on we also believed to be important in that if there wasn't a consistent batch size and if different machines could process different numbers of pieces, then the production line could possibly be not balanced or be running smoothly. These figures also play a role in the waiting time from one process to the next. To make our data collection as efficient as possible, each team member would have their own data sheet and collect four cycle times for each process along with the other four information categories. To ensure that cycle times were recorded the same, it was crucial for us to clearly determine what was to be considered "one cycle". After observing all the processes and seeing how they operate, we agreed upon that one cycle started when the machine touched the piece it was working on (actually performing its function on the piece) and stopped when the machine did the same for the next piece. After having collected the data we then combined all the times into one collective data sheet where we were able to calculate the average cycle time for each member process. We also deemed that the exact quantity for which roll forming and stamping produce each day was also important as it could help determine whether production was balanced between these processes. This information we got from Larry Zhong and Dai Chaozhong as well as the floor managers and included data from January to June 2008.

3.3 First-In First-Out (FIFO) Rule

In order to improve the overall lead time of the 9G process, we found it is necessary to figure out whether F4, F6 and the Plater follow the FIFO rule. We found out, from Larry Zhong, the operations manager in F6, that they have certain kinds of tables to record the roll formed time as well as the final assembled time, as shown in the figure below. The rows pertain to the product and what date they were roll formed while the columns pertain to the day in the month that the product was taken to be assembled.

供应商	品名	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
(L)	46-11970	6/24		7/2	7/1							7/1			7/2					
(R)	46-11970	6/20		7/1	7/1							7/2			7/2					
	46-11971	6/22		6/25	6/25							7/2			6/30					
DAFFER	46-11972	6/25		6/25	6/25							7/8			6/25					
	46-11973	6/24		6/25	6/25							6/25			6/25					

Figure 7 - FIFO Example Data Sheet

We also observed the layout of Plater’s warehouse as well as Factory 6’s layout and the way they transport semi-finished products. This allowed us to further see whether the FIFO rule was being followed strictly.

3.4 Shipping Issue

As an additional goal to our project to reduce the lead time of the manufacturing process of the 9G, Larry Zhong asked our group to research and analyze the post-assembly shipping process to attempt to reduce its lead time. Though this is outside the range of our project, our group decided to attempt to accomplish this goal. There were a number of issues that needed to be determined before analyzing this process. Our group first decided to split this goal into smaller objectives, in order to understand this process to a further extent. The following are the objectives we decided to achieve:

- Understand the roles of all managers and supervisors
- Obtain the demand of customers
 - Look at how many kits are made per shift
- Study the pick-up dates and inventory times
- Analyze data and determine problems

3.41 Understanding the Role of All Managers and Supervisors

Our first step to reduce the lead time of the shipping was to first determine the role of the managers and supervisors involved in this process. There were a number of ways to learn the positions and importance of these certain people. We needed to talk to our advisors, Larry, Dai, and Karen to get a list of names that were most important to us and the shipping process. Once we determined these names, the construction of a flow chart was necessary to determine the information flow between these people.

Once the flow chart was created, a series of questions needed to be asked in order to find out valuable information was created. These were organized according to company position, to help us ask questions relating to each person's job. Questions are shown in the Appendix C. Once these questions were developed, e-mails were sent to the managers in Singapore, seeing as that they were not present at CIS for us to ask them these questions. Interviews were conducted to those people who were located in Wuxi. These answers were logged into a report for our better understanding and analysis.

3.42 Obtain the Demand of Customers

The next step in this goal was to obtain the demand of the customers. This demand directly effects the production of kits, made by CIS Wuxi. Dell sends the number of kits to be made to CIS Singapore. After finding out who is in charge of this at CIS Singapore, we contacted him and we were able to obtain this overall demand data. This data is sent to CIS Wuxi, which states how many pieces to produce each week. Our group was able to obtain this data, and determine how many kits are made each shift.

3.43 Study the Pick-up Dates and Inventory Times

Understanding the delivery dates and inventory are a big part to this objective. Being able to find the waste in these processes helped reduce the lead time greatly. After interviewing and receiving shipping data from the shipping supervisor, who is in charge of booking containers for the pick-up of assembled kits at F6, we were able to see how often these containers come and what issues we observed in the current process. After looking at the delivery times, we analyzed the inventory size between the pick-up dates.

4.0 Results

This section contains all the results found during our data collection period. Not only did we find the data we thought to expect, we also made some additional findings as well. Throughout the project time period, we met weekly with our advisors at CIS to discuss with them these findings and they were able to provide some explanations as to why these phenomena's were occurring which helped us when making our recommendations.

4.1 TAKT Time

From our interviews we found out that a work day in F4 consists of two shifts each of 8 hours with a 30 minute break for lunch and that the factory is run from Monday - Friday. The work schedule can be seen in the table below.

Work	Maintenance	Work	Maintenance
9 am – 5 pm	5 pm – 9 pm	9 pm – 5 am	5 am – 9 am

Table 2 - Daily Work Schedule

Along with this work information, we learned that on average CIS produces about 50,000 “9G” products per month (one product consists of 1 pair of each member, one left side piece and one right side piece) and that the average number of workdays in one month is 22. After collecting this data we were able to then put these numbers into the TAKT Time formula to determine whether or not CIS currently produces enough to meet customer demand. Below are our calculations.

- Time Available (T_a): $2 \text{ shifts/day} * 7.5 \text{ work time hours/shift} * 3600 \text{ seconds/hour} = 54,000 \text{ seconds/day}$
- Total Demand (T_d)(units produced): 7680 pieces of each member/day
- Customer Demand: 50,000 products per month which requires 4546 pieces of each member per day

From this data we collected we conclude that CIS does indeed meet customer demand. To determine the production possibilities for each member we had to divide the total available time in one day by the slowest process cycle time of each member. For example, in the Cabinet member, the slowest cycle time is 10.2 seconds. So if every process in the production line had this cycle time, then the number of pieces this line could produce per day would be: $54,000 \text{ seconds} \text{ divided by } 10.2 \text{ seconds/piece} = 5294.12 \text{ pieces per day}$, which still meets the customer demand requirements of 4546 pieces per day. We could not divide the total available time to work by the complete cycle time, because while one process is working on one piece, the other processes are working on others as well.

4.2 Current State Map (CSM)

After completing our tour and writing down all the processes for each member’s production we then drew a CSM for each member. Below is a CSM of the Cabinet member which shows the process name and number, number of operators, the number of pieces each process can work on and our recorded average cycle times. The CSM’s for the Intermediate and Chassis members can be found in Appendix D.

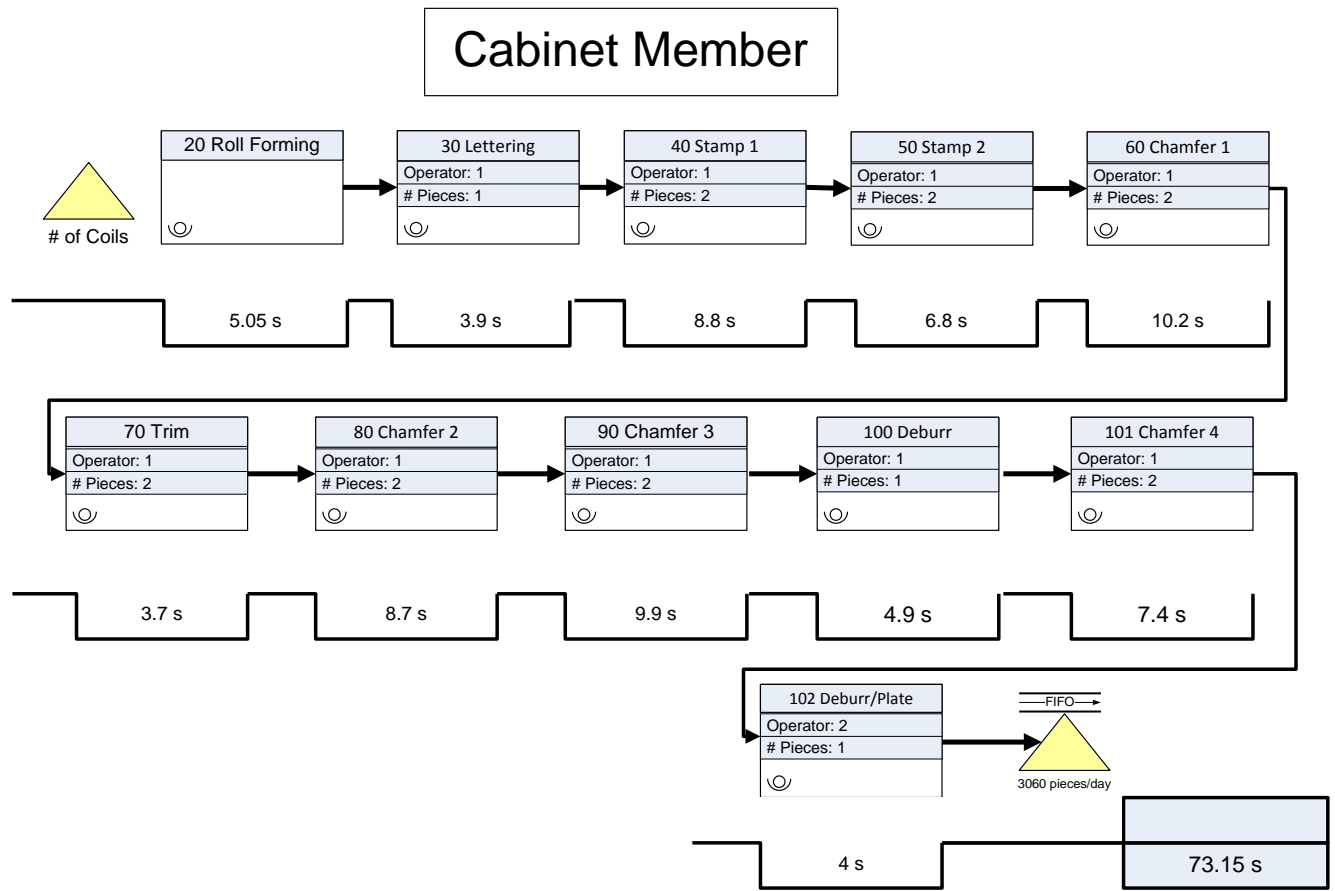


Figure 8 - Current State Map of the Cabinet Member

4.3 Time Studies

4.3.1 Factory 4 (F4)

Having completed our CSM, we then conducted our time studies and placed the collected data into a collected data sheet. Having collected a total of 20 cycle times for each process we were then able to calculate an average cycle time for each process. From our calculations the average time it takes to produce one cabinet, one intermediate, and one chassis piece are 73.15 seconds, 156.27 seconds, and 111.20 seconds, respectively.

Since we now had the cycle times for each process for each member, we then had to analyze these times. We did this by putting the cycle times in a graph we could visually look at and see if there were any bottlenecks or other problems.

4.3.11 Cabinet Member

Upon collecting our data we noticed that most of the processes in the Cabinet line work on two pieces per cycle and some only one. Taking into account the number of pieces each Cabinet member process can work on, it was difficult to analyze the data by comparing just the cycle times. We therefore made a graph, shown below, showing the time it takes for each process to work on two pieces.

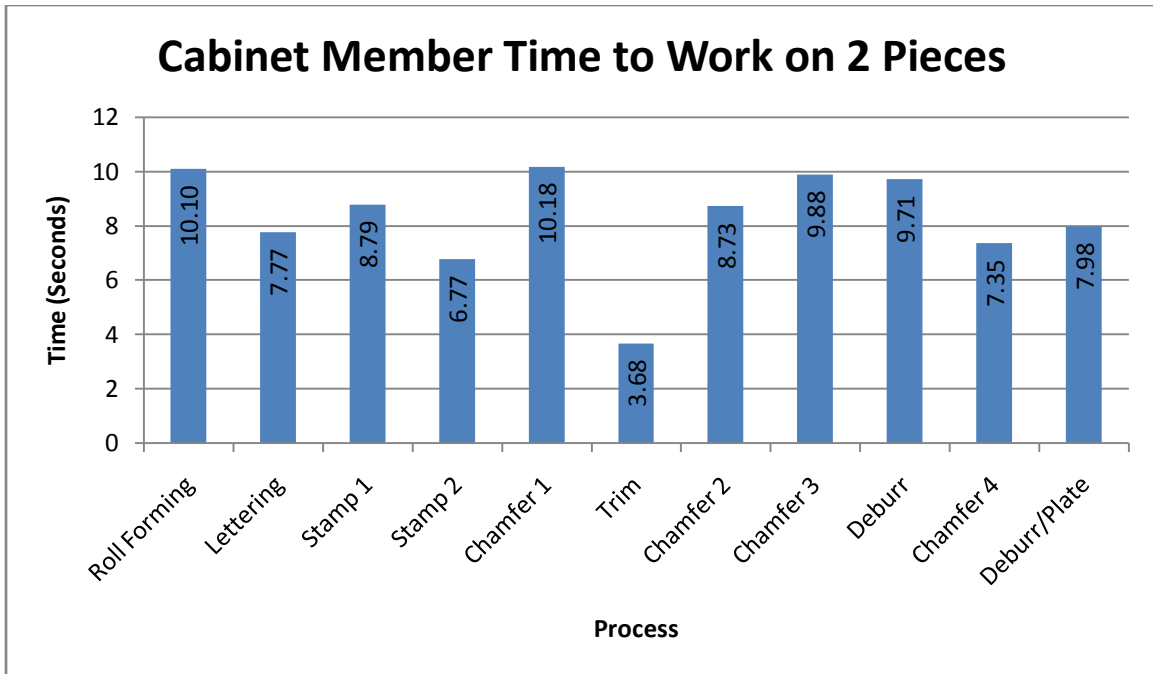


Figure 9 - Cabinet Member Time to Work on 2 Pieces

From this graph we can see that the “Trim” step is the bottleneck of the Cabinet member production process. The “Trim” step can work on two pieces about six seconds faster than “Chamfer 1” and about five seconds faster than “Chamfer 2”. This is a problem because this causes an unbalance of production. This is more of a problem for the “Chamfer 1” step because by the time the “Trim” step is done with one cycle it has to wait about six seconds before receiving more pieces to work on. This also causes waiting time for the rest of the processes, with this time being an average of 2.5 seconds for each process. This means that from “Chamfer 1” to “Deburr/Plate” there is about 20 seconds of waiting time. The issue of the “Trim” step having a faster cycle time than that of “Chamfer 2”, is not a big deal because while its cycle time is longer, the “Trim” step has to wait for the previous process to hand over pieces to work on and by the time the “Trim” step gets more pieces to work on and is ready to pass on the piece, “Chamfer 2” has just finished its cycle and is ready to work on more pieces. Here is how we calculated this; it takes about 4 seconds for the “Trim” step to complete one cycle and pass on the pieces. It then has to wait 6 seconds for the “Chamfer 1” step to pass on pieces to it. While the “Trim” step is waiting, the “Chamfer 2” step begins its cycle. After the six second wait, the “Trim” step gets its pieces to work on and performs its 4 second cycle, taking up a total time of about 10 seconds. During these 10 seconds, “Chamfer 2” has completed its cycle in about 9 seconds, leaving it with one second to wait. This waiting time of one second can be disregarded as a problem since factors such as human error and human recuperation time/human reactions (taking a breath, wiping off sweat, sneezing, etc.) can change these cycle times but only minutely.

We can also see a similar variation in the cycle times at the “Deburr” step in between “Chamfer 3” and “Chamfer 4”. However, unlike in “Chamfer 1”, “Trim”, and “Chamfer 2” steps, these three steps do not process the same number of pieces per cycle. Chamfer step 3 and 4 each can work two pieces per cycle

while the “Deburr” step can only work on one. This presents a different problem. From the above graph we see that “Chamfer 4” works on two pieces per cycle and completes its cycle in about 7.5 seconds but the step before it, “Deburr” which works on one piece per cycle, completes work on two pieces in about 10 seconds. These 10 seconds to have two pieces ready for “Chamfer 4” to work on leaves the “Chamfer 4” step with a waiting time of about 2.5 seconds. What looked like to be an issue between “Chamfer 3” and “Deburr” actually is not an issue at all. By looking at the graph we can see that it takes the “Deburr” step about the same time to work on two pieces as “Chamfer 3”, meaning that these two steps do not conflict.

4.3.12 Intermediate Member

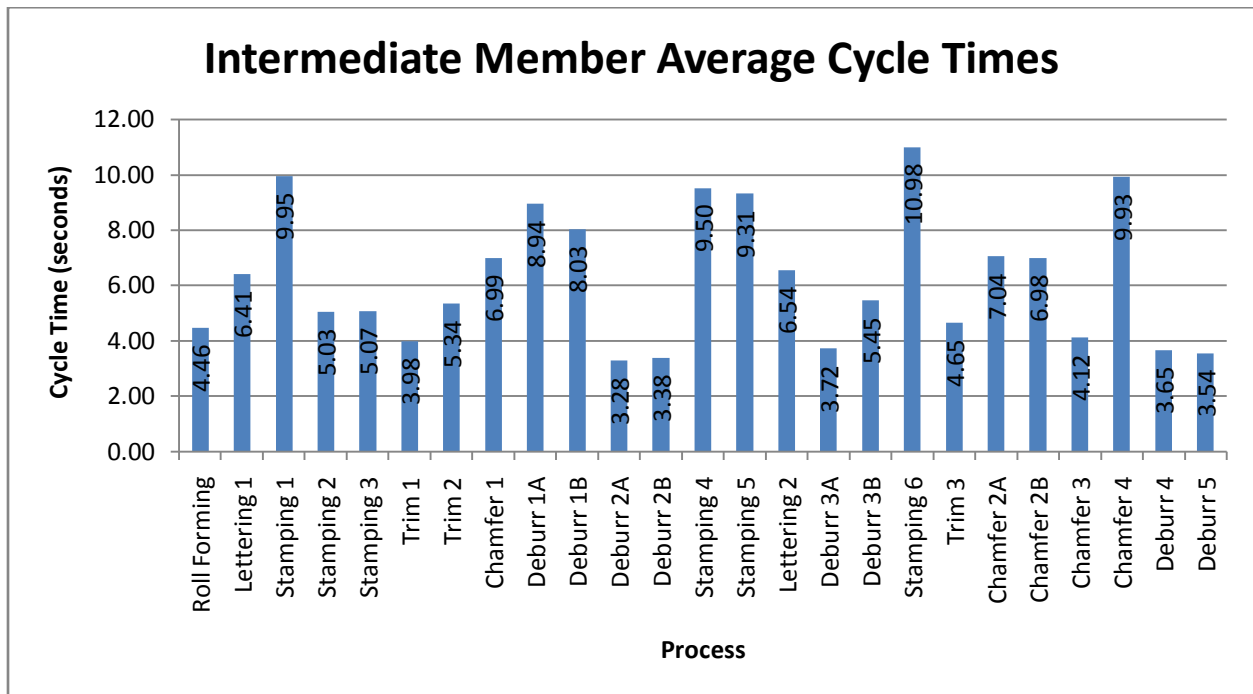


Figure 10 - Intermediate Member Cycle Time Graph

From this cycle time graph of the Intermediate member, it would appear that there are many problems with the cycle times. However, this is not the case. While there are significant fluctuations in the cycle times, what makes up for them is the number of pieces each process can work on. This information was very important because it showed to us that many of these steps that may look like bottlenecks indeed are not. They have the same situation that Cabinet member steps “Trim” and “Chamfer 2” as well as “Chamfer 3” and “Deburr” have, where that since the number of pieces that can be worked on per cycle are different, this affects production. But when calculating the time it takes for those steps that can work on one piece to work on two pieces (the equivalent of two cycles), we see they are close to the steps who can work on two pieces per cycle.

However, since there is fluctuation at several points in the Intermediate member line of the number of processes that can work on two pieces per cycle versus only one piece per cycle, it is hard to compare

them directly from the above graph. Below is a graph showing the fluctuations in the number of pieces worked on per cycle.

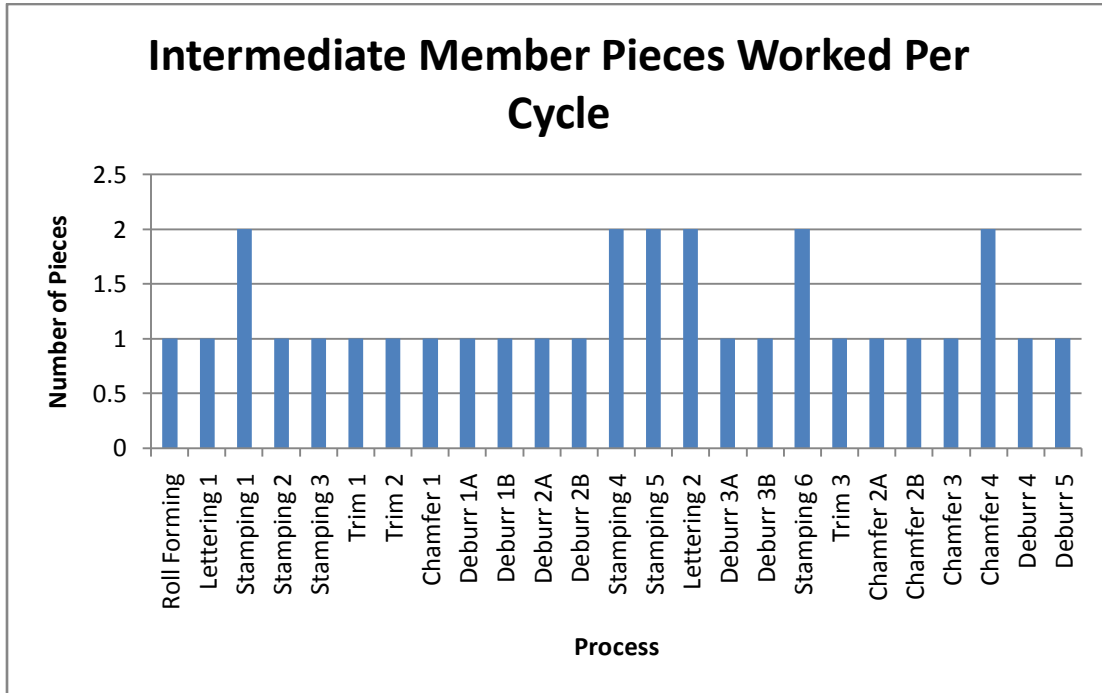


Figure 11 - Intermediate Member Number of Pieces Worked per Cycle

For us to analyze these cycle times it was necessary for us to create a graph that shows the times it takes for each process to work on two pieces. Taking this into account greatly changes how the graph looks. Below is the graph showing the times it takes to work on 2 pieces per process.

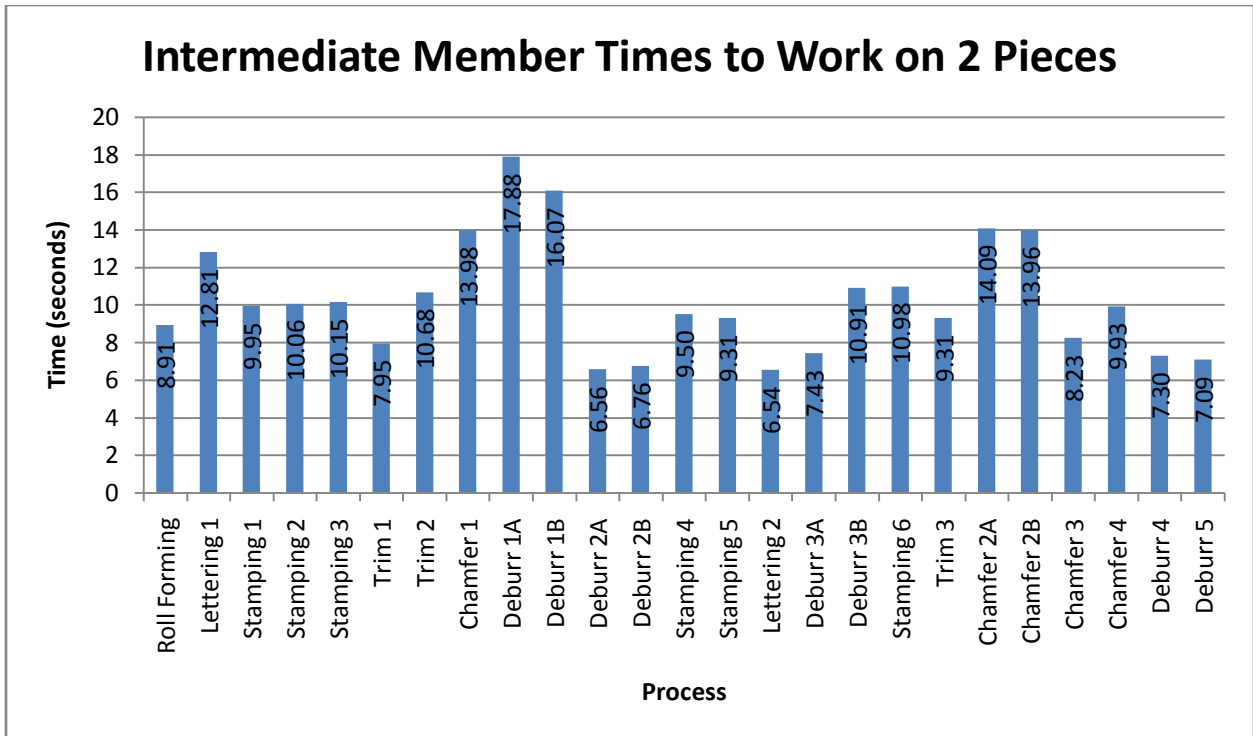


Figure 12 - Intermediate Member Times to Work on 2 Pieces

Now looking at this graph, we can see that the production line is relatively balanced, except at one point which is between “Debur 1A & 1B” and “Debur 2A & 2B”. This one point we concluded to be the bottleneck and the main problem in this member’s production line. All of these processes can work on the same number of pieces per cycle, one. But since “Debur 1A & 1B” have much longer cycle times, this causes long waiting times at “Debur 2A” of about 10 seconds.

4.3.13 Chassis Member

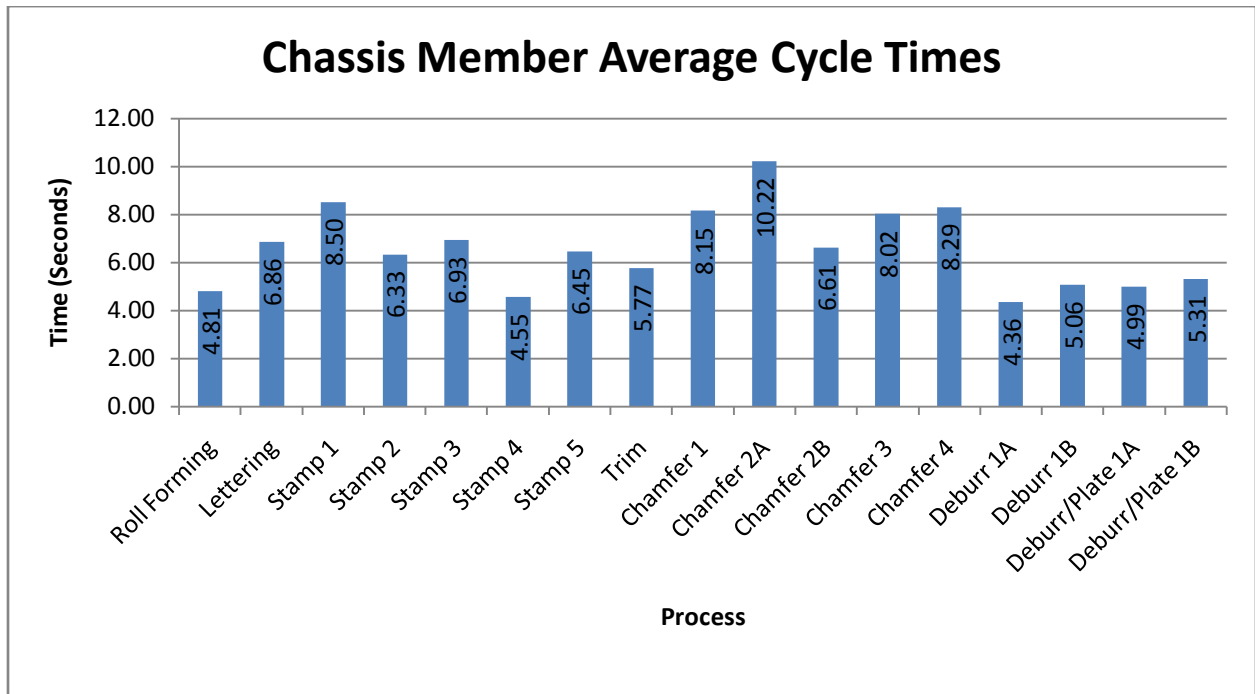


Figure 13 - Chassis Member Average Cycle Times

The Chassis production line, from the looks of the graph, looks relatively balanced. However, similarly to the Intermediate line it has fluctuations in the number of pieces each process can work on. Once again, we had to make a graph showing the time it takes for each process to work on two pieces which is shown below.

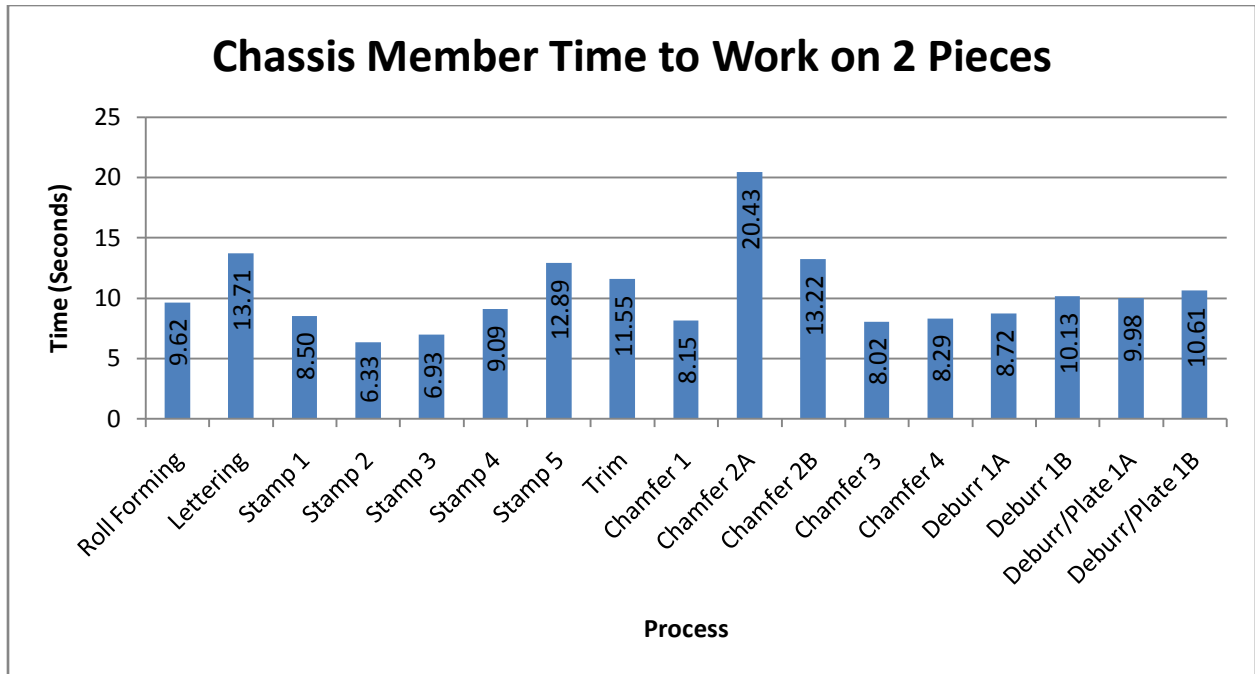


Figure 14 - Chassis Member Time to Work on 2 Pieces

This graph allowed us to better analyze the Chassis member, just as we were able to better analyze the Intermediate line. From this graph we can see two points that needed to be looked at. The first area is from “Lettering” to “Stamp 1” process. We can see from the graph that “Stamp 1” has to wait about 5 seconds to receive pieces from “Lettering”. However, this is not the case seeing as that “Lettering” is found right next to the Roll Forming process and there is a gap between itself and “Stamp 1” (this is the same for the other two members as well). Also, “Stamp 1” always has a cart of pieces to work on, so it never has to wait for pieces from the “Lettering” process. The pieces from the “Lettering” process get moved to the “Stamp 1” when a worker notices that “Stamp 1” is about to need more pieces ((this is the same for the other two members as well). The second point of interest is between “Chamfer 1”, “Chamfer 2A”, “Chamfer 2B”, and “Chamfer 3”. As we can see from the graph above, “Chamfer 2A” and “Chamfer 2B” appear to be bottlenecks in this member’s production line but “Chamfer 2A” is the bigger problem. “Chamfer 1” is able to complete two cycles and pass on the pieces before “Chamfer 2A” finishes one cycle. This means that there is a constant pileup of pieces waiting to go through “Chamfer 2A”. This is due to the fact that “Chamfer 2A” can only work on one piece at a time while “Chamfer 1” can work on two. Also, “Chamfer 3” has a waiting time of about 8 seconds (5 seconds waiting for “Chamfer 2B” to complete 2 pieces and 3 seconds “Chamfer 2B” has to wait for “Chamfer 2A” to complete its cycle). This is also due to the fact that it can process 2 pieces per cycle while “Chamfer 2B” can only process one and also has to wait about 3 seconds to receive a piece to work on from “Chamfer 2A”.

4.3.2 Factory 6 (F6)

When we went to F6 to observe the assembly and conduct our time studies, we learned that each product, London, Berlin, and Montreal each had its own assembly line consisting of three lines. These

lines were assembly of the left slide, right slide and the Cable Mounting Arm (CMA). We also discovered that the engineers there had already conducted time studies and had the collected data in combined data sheets. They had conducted these time studies because there was a problem in the assembly process but it wasn't with the cycle times. We were able to obtain a copy of these sheets and confirm that there was no real bottleneck in terms of cycle time. The issues the engineers were trying to fix, which one of the floor managers told us about, was the issue of one direction flow. This occurred in the lines that assembled the slide pieces together. Below is a simple figure displaying the current assembly process flow.

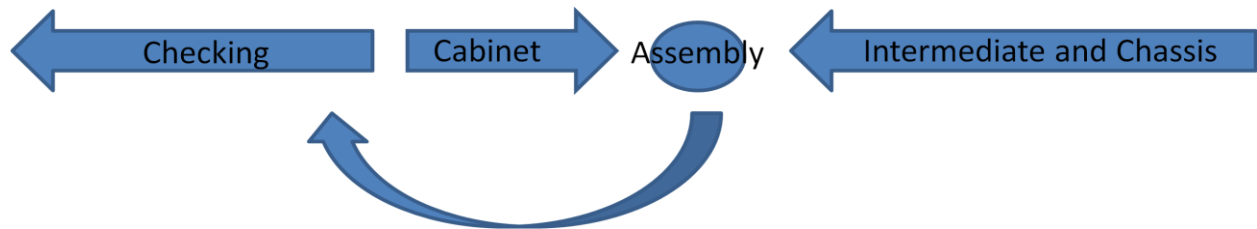


Figure 15 – Current F6 Assembly Line Flow

From this diagram we can clearly see that there is not one direction flow. The first few machines in the assembly line were responsible for assembling the Intermediate and Chassis members and combining them together. Upon them being combined together they were sent to a final assembly workstation to be combined with the Cabinet member. On the other side of this workstation were the assembly machines of the Cabinet member. This assembly process flowed in the opposite direction and ended at the final assembly workstation, where the worker there put the pieces together to make a complete slide and then “jumped” the pieces to the checking processes. This is an issue as it causes congestion in the assembly process and does not create one direction flow, which is the most time efficient way to complete process. During our process of designing methods to fix this problem, we learned that the engineers were in the process of developing their own methods to solve the problems. We were able to develop one suggestion early on, but since the engineers were developing their own methods, our suggestion was disregarded. Nonetheless, we continued to develop this suggestion and recommend it as another alternative should whatever method the engineers come up with turn out to be inefficient or not cost effective.

4.4 First-In First-Out (FIFO)

供应商	品名	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
(L)	462-11970	6/24		7/2	7/1							7/1			7/2					
(R)	462-11970	6/24		7/1	7/1							7/2			7/2					
	462-11971	6/22		6/25	6/25							7/2			6/30					
Dagger	462-11972	6/25		6/25	6/25							7/8			6/25					
	462-11973	6/24		6/25	6/25							8/25			8/25					

Figure 16 - FIFO Data Sheet

The figure above, shows the Dagger (another slide CIS produces for Dell) FIFO information. As we can see from the figure, the FIFO rule is followed strictly. Parts that were roll formed on 7/2 were taken to be assembled before parts roll formed on 7/1. We also found the same condition for the 9G products, showing that the FIFO rule is not followed strictly.

We discussed the reasons amongst our group and our advisors and find that this problem is mainly related to Factory 6 and the Plating factory but mainly the Plating factory. For instance, the inventory in F6 and the Plating factory is not well organized. Although it is related to both factories, F6 organizes their inventory based off of how the pieces arrive from the Plater. Therefore this issue is more prevalent to the Plater. We found that roll formed pieces are not being organized by date nor are they being separated by type of member as shown in the diagram below.

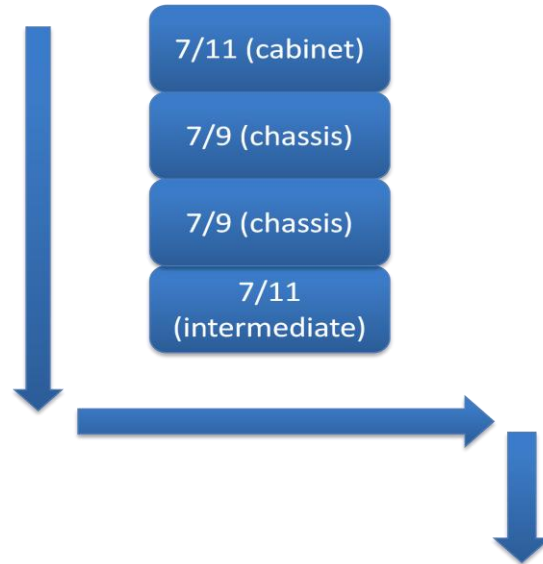


Figure 17 - Plating Factory Inventory Organization

This causes pieces that are roll formed more recently to be sent to F6 before pieces that are older. This causes lengthening of the lead time in that the longer the older pieces remain at the Plater, the longer the entire lead time for the kit those pieces are assembled into are.

We also found that the transportation between these two factories has discrepancies that cause the FIFO rule to not be followed strictly. Since the inventory at the Plater is not well organized, this causes pieces that are to be sent to F6 to be not placed by date on the truck. This then causes them to be taken off the truck at F6 as they are and then placed into inventory still not organized by date. This clearly shows that the FIFO rule is not being followed by the Plater.

4.5 Shipping Analysis

After meeting with Larry, he gave us a better understanding how the orders get placed and how it flows downstream between managers and factory locations. Along with this, he gave us a list of contacts, so we would be able to talk to them and ask questions. The figure below is a flow chart of how the information about orders gets passed down to each manager and supervisor.

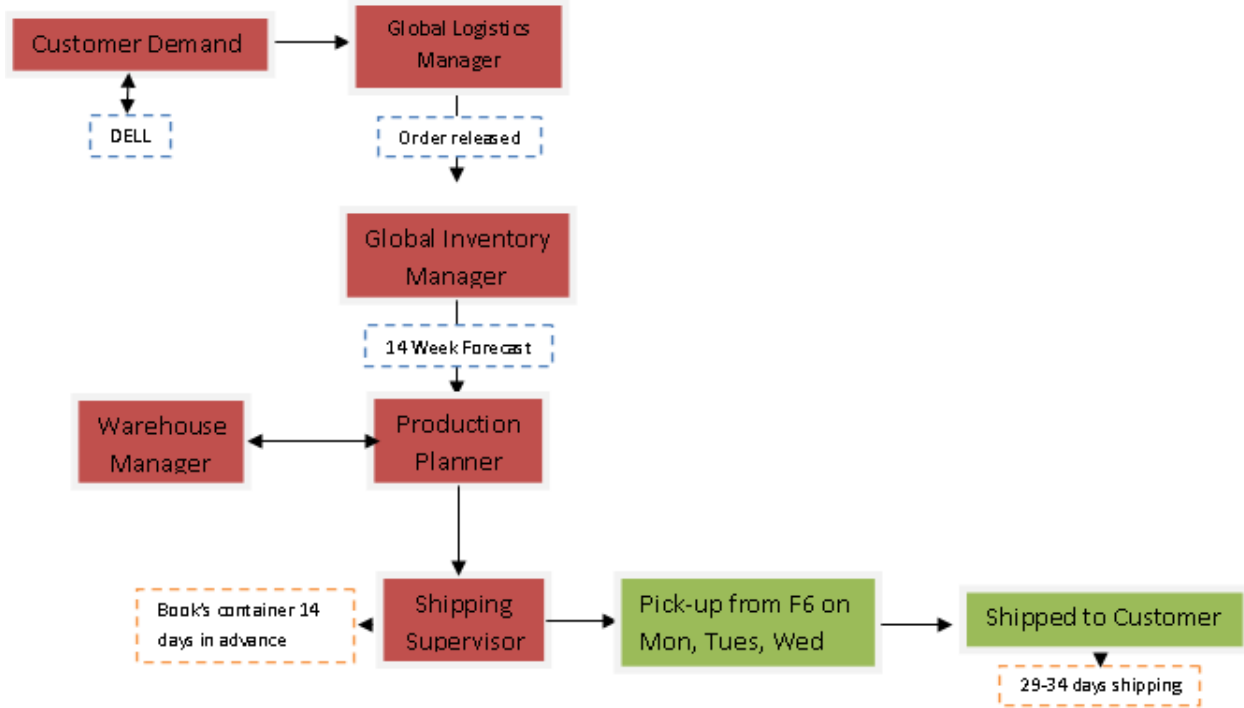


Figure 18 - Shipping Information Flow Chart

To understand this figure further, Dell receives a specific demand from various customers. Dell then sends this demand to the Global Logistics Manager, Ong Shin Shin, at CIS Singapore. Ong Shin Shin, releases this order to the Global Inventory Manager, Yeo Boon Seng, who is also located at CIS Singapore. Yeo Boon Seng creates an excel file that spreads out this demand into a 14 week plan for CIS Wuxi. This report tells CIS Wuxi how many kits to produce each week, according to the demand period. For example, the demand for 9G kits may be higher in June and July, therefore, more kits need to be made during these months. This 14 week forecast of products to be made is sent to the Production Planner, Zou Lixia, who makes sure the pieces are made weekly. Zou works directly with the Shipping Supervisor, Linda Li, who books containers for pick-up, weekly. These containers, which are sent by DHL, need to be booked 14 days in advance, in order for them to show up on the right days. These pick-up days are on Monday, Tuesday, and Wednesday, according to Linda, due to DHL's control over containers.

After this information is all processed through Dell, Singapore, and Wuxi, the pieces are ready for delivery. This shipping process involves many steps and waiting times. This process is shown in a simple flow chart shown below.

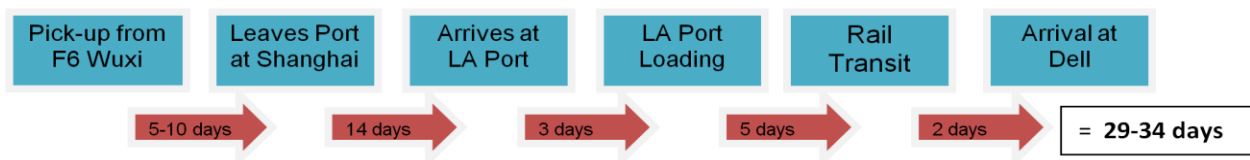


Figure 19 - Shipping Process Flow Chart

After the assembled pieces are packaged and put on their pallets, they get picked up from Factory 6 in Wuxi, which then leaves for Shanghai. It takes about 5 to 10 days for these pallets to get to Shanghai and loaded onto a freighter. It then departs from Shanghai and spends 14 days in transit on the ocean, until it reaches the Los Angeles port. After this it spends about 3 days to unload, and another 5 days to load onto a Rail cart. The rail transit then spends about 2 days to reach its final destination in Houston, at the Dell Company. A VSM for the whole shipping process is shown in the figure below. The total time it takes to ship to Houston is about 42-49 days.

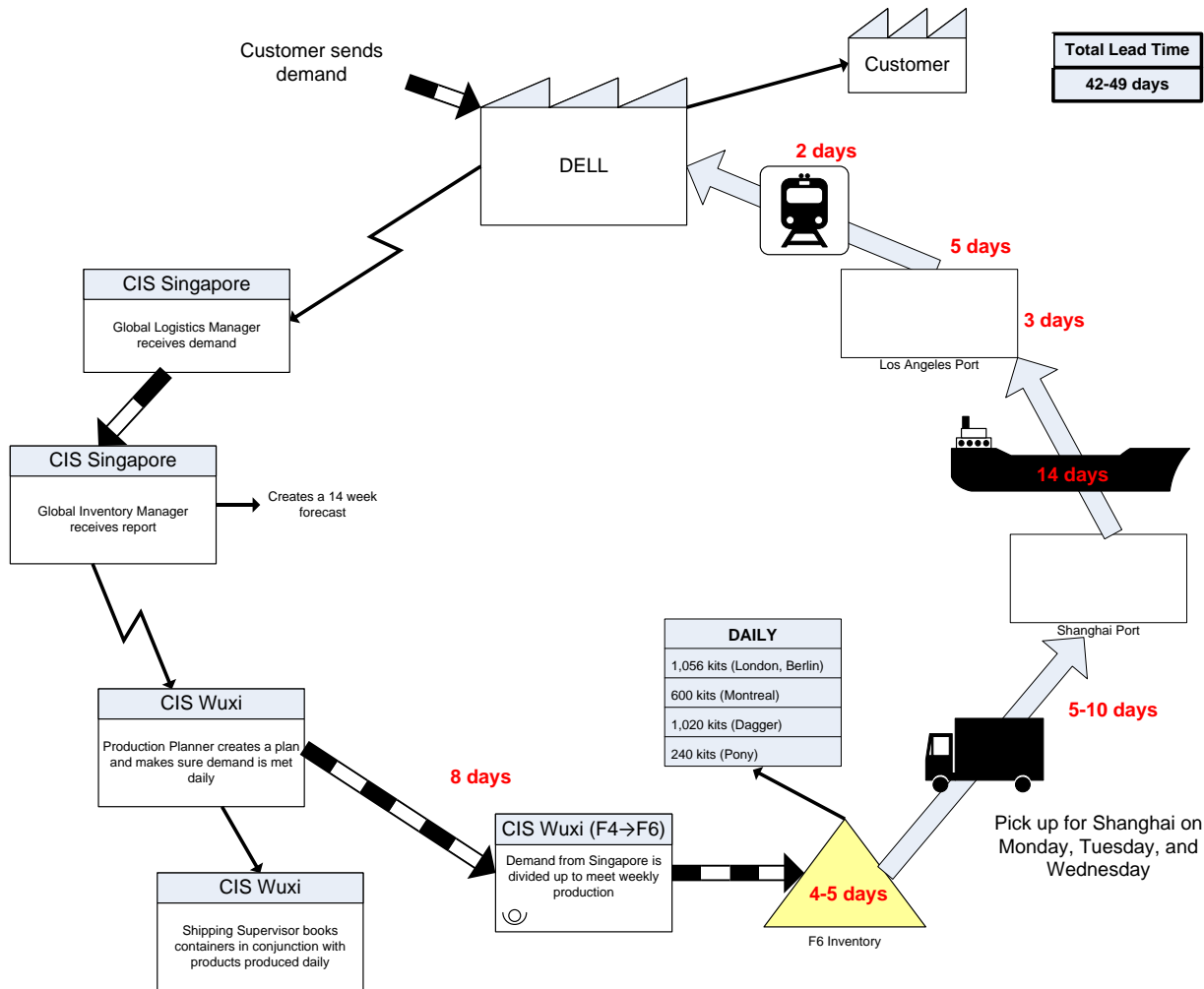


Figure 20 - VSM of Information and Shipping flow to Houston

4.5.1 Demand of Customers

The number of kits to be produced weekly was a very important piece of information to our group in order to begin analyzing the shipping process. We needed to determine how many containers we needed per week. According to Linda Li, the shipping supervisor, about 10 containers are booked each week. We also received the 14 week forecast from Yeo Boon Seng, so we could see how much Factory 6 needed to produce weekly, shown in the figure below. We also received the Ageing Log for F6, shown in Table 4, to show how many pieces were being assembled per day and what days they were being

assembled, which was helpful to us for understanding the inventory space. Before looking at this table, an understanding of the part numbers is needed, shown in Table 3.

Part #	420-11349	420-11350	420-11418	420-11410	420-11412	420-11433
Product	Dagger	Dagger	9G London	9G Berlin	9G Montreal	Pony

Table 3 - Part Number and Product Description

S/N	Part #	Product name	Qty	OR#	Date assembled	Delta
1	420-11414	Geode	270	8-00943	07/10/08	14
2	420-11414	Geode	540	8-00943	07/11/08	13
3	420-11414	Geode	630	8-00943	07/13/08	11
4	420-11414	Geode	450	8-00943	07/14/08	10
5	420-11410	9G	198	8-0015	07/09/08	15
6	420-11410	9G	1056	8-0015	07/10/08	14
7	420-11410	9G	990	8-0015	07/11/08	13
8	420-11410	9G	1056	8-00920	07/12/08	12
9	420-11410	9G	792	8-00920	07/13/08	11
10	420-11410	9G	660	8-00920	07/14/08	10
11	420-11418	9G	1650	8-00930	07/08/08	16
12	420-11418	9G	528	8-00931	07/09/08	15
13	420-11418	9G	1320	8-00931	07/10/08	14
14	420-11418	9G	1452	8-00932	07/11/08	13
15	420-11418	9G	792	8-00972	07/12/08	12
16	420-11418	9G	1518	8-00972	07/13/08	11
17	420-11418	9G	726	8-00896	07/14/08	10
18	420-11412	9G	200	8-00980	07/07/08	17
19	420-11412	9G	600	8-00980	07/12/08	12
20	420-11422	Lippizan	200	PI120009	07/03/08	21
21	420-11422	Lippizan	1300	PI120009	07/07/08	17
22	420-11349	Dagger	660	8-00964	07/01/08	23
23	420-11350	Dagger	540	8-00991	07/11/08	13
24	420-11013	ML	300	8-00770	07/03/08	21
25	420-11333	ML	250	8-01044	07/07/08	17
26	420-11346	Minitower	108	NO OR	05/23/08	62
27	420-11401	IBM	220	NO OR	06/13/08	41

Table 4 - F6 Ageing Log

An example of a couple weeks demand is shown in the forecast, shown in the figure below. This is helpful because it shows how many pieces of a certain product need to be produced weekly and where the customer is located. Part number 420-11410 (Berlin) is expanded to show how it is split into areas of the customers.

Customer	CIS			WW25	WW26	WW27	WW28	WW29
Part#/Name	Part#	Hub	OPS	6/16	6/23	6/30	7/7	7/14
FJ451	420-11349	Total Qty:	480	1,440	1,440	1,560	1,440	1,320
GJ181	420-11350	Total	480					

		Qty:		-	300	240	1,440	240
HJ236	420-11351	Total Qty:	40	-	-	-	-	-
WT061	420-11433	Total Qty:	80	-	200	200	200	20
		US		880	4,400	3,960	2,640	4,620
		Europe		-	-	-	-	-
		CCC		-	-	-	-	-
		APCC		-	-	-	-	-
		WWT Brazil		-	-	-	-	-
UN441	420-11410	Total Qty:	720	880	4,400	3,960	2,640	4,620
			No of shifts needed	17.44	23.01	21.92	19.50	24.75

Table 5 - 28 Week Forecast

Having these numbers of kits that need to be produced each week helped us determine how the shipping supervisor knows how many containers to book each week. We also learned that the orders are released individually. For example, the containers can only hold kits of one certain product, instead of multiple products in one load. Shown below is a table to better understand how many pieces can be produced each shift, how many kits per container, and how many kits per pallet.

Part #	Product	Kits per Shift	Kits per container	Kits per pallet
420-11349	Dagger	1020	2400	60
420-11350	Dagger	1020	2400	60
420-11418	9G London	1056 (1419 OT)	1320	33
420-11410	9G Berlin	1056 (1419 OT)	1320	33
420-11412	9G Montreal	1056 (1419 OT)	1320	33
420-11433	Pony	200	400	10

Pallets per Container	40
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Table 6 - Product Information Used for Shipping Analysis

An analysis was done to see how many containers were needed to fulfill the needs of Dell, and then another method was made by our team to attempt to reduce the amount of containers, and lead time

for the shipping. Currently the containers show up to Factory 6 for pick-up on Monday, Tuesday and Wednesday. Shown in the figure below is a table our group drew up to show the situation of Factory 6.

	Mon	Tues	Wed				
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
London (420-11418)	1056	1419	1056	1056	1056	1221	1056
Berlin (420-11410)	1056	1056	1056	1056	1056		
Dagger (420-11349)	480		480	240			
Dagger (420-11350)	480	0	480	660	0		
Pony (420-11433)	0				200		

Table 7 - 7/21 Projected Kit Production

The pick-up days are shown in Orange, Blue and Red in the table above. Recently the DHL changed the pick-up days to Monday, Tuesday, and Wednesday. We feel that they did this because in one day, Factory 6 cannot produce enough kits to fill a container, leaving too much in the inventory daily.

For the current situation, after the pick-up during the day on Wednesday, this means that the kits produced from Wednesday to Sunday (Day 3 to Day 7) will be kept in the inventory until the following Monday (Day 1), which is a massive amount of kits in the inventory. These kits are kept in the inventory for 5 days, which leads to a possible congestion in the factory, show in the Figure below.



Figure 21 - Congested Factory

This leads to the container issue. Because the orders are only individual, this leads containers unfilled, and addition containers are needed. As an example an analysis for the Week of 7/21 was done to test our idea. Along with the table above, calculations were done to see how many containers it would take to fill that week's kits. Shown in the table below are our results:

	Sum	Pallets	Containers	Filled?
London	7920	240 plt	6	Yes
Berlin	5280	160 plt	4	Yes
Dagger	2820	47 plt	2	No
Pony	200	20 plt	1	No
			13	

Table 8 - Containers needed for 7/21 kits

This shows that containers for these kits are unfilled, and an extra container is needed. 40 pallets are needed to fill a container, and 2 products show that containers are not filled (Dagger and Pony). Our group then decided to make up a production and shipping plan of our own to test if we can reduce inventory and lead time. First we changed the pick-up dates to Monday, Wednesday, and Friday. After doing this, we decided to produce a certain amount of kits per day, so that a container can be filled with different products. Shown below are our results.

	Monday pickup
	Wednesday pickup
	Friday pickup
	Days in Inventory

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
London	1056	1419	1056	1056	1056	1221	1056
Berlin	1056	1056	1056	1056	1056		
Dagger	960	0	960	900	0		
Pony	0			10	160		30

Containers	2	2	2	2	2	1	1	12
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Table 9 - Products produced daily with mixed containers

With this combination of kits being produced each day, there is an even number of pallets that fit perfectly into containers. At the end of the week, Factory 6 will only need 12 containers, and they will all be full of pallets, not wasting any space. Also by spacing out the days of pick-up days this will reduce the stock in the inventory (1-2 days), which will also help the loading time be reduced. This will save money

for booking containers, reduce inventory time, and reduce lead time for shipping by at least 3 days. By using this process it will reduce the lead time by about 7%.

4.6 Other Findings

4.6.1 F4 Inventory

During our observations, we found that there are two days inventory in Factory 4. According to our interviews, the safety inventory between roll forming and stamping is one day. However, every time we went to Factory 4 randomly, we would find pieces which were roll formed two days previously. This shows that there is an inventory problem. We interviewed the manager Dai Chaozhong, and asked the production line manager the reason why this was happening. Both of them told us it is the result of the die which is used in #100 Stamping process for the Intermediate member being continuously damaged. What is even worse, it takes half a shift or even one shift to fix the die.

Another reason they told us as to why there might be this inventory might be due to an unbalanced production line between the roll forming and stamping processes. Therefore, we decided to figure out the production line ability of roll forming and stamping to see if this was the case. Normally, the day shift of stamping can produce 1920 kits of 9G products and the night shift finishes 720 kits for a total of 2640 kits. In order to figure out the quantity of pieces that the roll forming process can make, we needed to know its cycle time and the value-added time. During our observations, we took the cycle time for roll forming measuring the time between two pieces being cut at the end of roll forming. The result we got was 10 seconds. After getting the cycle times, we needed to know the total value-added time of roll forming. By interviewing the manager Dai Chaozhong, we attained the following important data:

- Roll forming works 24 hours per day.
- It pauses 16 times per day, 22 minutes for each pause, because of the engine over-heating. This means that there is a downtime of 352 minutes (5.87 hours) per day.
- It takes 20 minutes on average to adjust the raw steel to the machine and the raw steel is changed every 2 hours. This means that there is a downtime of 240 minutes (4 hours) per day
- The break time for meals is one hour per day.

From this information we were able to calculate the total value added time per day for roll forming as well as total production quantity. Below is our formula for calculating this time.

- Total value added time per day:
 - $(60 \text{ minutes/hour} * 24 \text{ hours/day}) - (16 \text{ pauses/day} * 22 \text{ minutes/pause}) - (20 \text{ minutes/adjustment} * 12 \text{ adjustments/day}) - 60 \text{ minutes/day (for food)} = 788 \text{ minutes}$
- The total production quantity:
 - $60 \text{ seconds/minute} * 1 \text{ piece made/10 seconds} * 788 \text{ minutes} = 4728 \text{ pieces. That is 2364 kits.}$

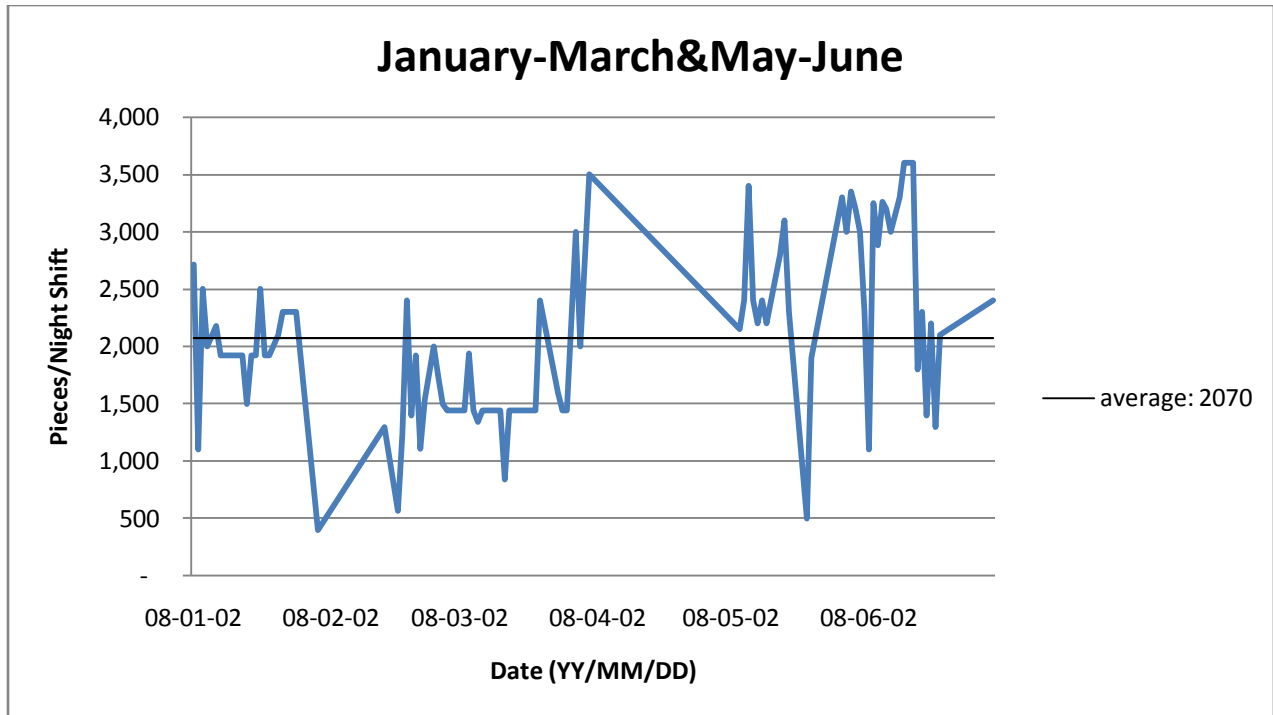


Figure 23 - Pieces Made Per Night Shift for Certain Months

According to these two maps, the actual average production quantity is $2484 + 2070 = 4554$ pieces. The difference between the theoretical calculation, 4728 pieces, and the actual average production quantity, 4554 pieces, is only off by 3.7%. This is shown below and proves that our theoretical calculation method is relatively accurate.

$$1 - (4554 \text{ pieces} / 4728 \text{ pieces}) * 100\% = 3.7\%$$

Since we knew the production line ability for roll forming and stamping we were able to figure out whether these two production lines are balanced. According to our results, the stamping line makes 2640 kits which consist of 5280 pieces. But the roll forming line can only produce 4554 pieces per day. The gap is 726 pieces per day, which shows that these two lines are not balanced. It is also one of the reasons why roll forming must keep a one day safety inventory. This led us to believe that the problems of the engines over-heating and the time adjusting the machines for the raw steel are the key aspects as to why the production lines are unbalanced and why the safety inventory is necessary.

4.6.2 Plating Factory Issues



Figure 24 - Plating Factory Warehouse

As seen in the figure above, the boxes are put in line against the wall. The products in these boxes have all been plated. According to Lao Hu, one of the bosses at the plating factory, the boxes closest to wall first get picked up first for transport. When examining these boxes we found that the boxes were not placed in order of the time they were roll formed, meaning that the FIFO principle is not being followed strictly. On occasion we found that some products had date codes showing that they have been in the plating factory warehouse for a long period of time. For example, on July 7, 2008, we visited the warehouse and found some products there that were roll formed on July 1, 2008, as shown in figure below.

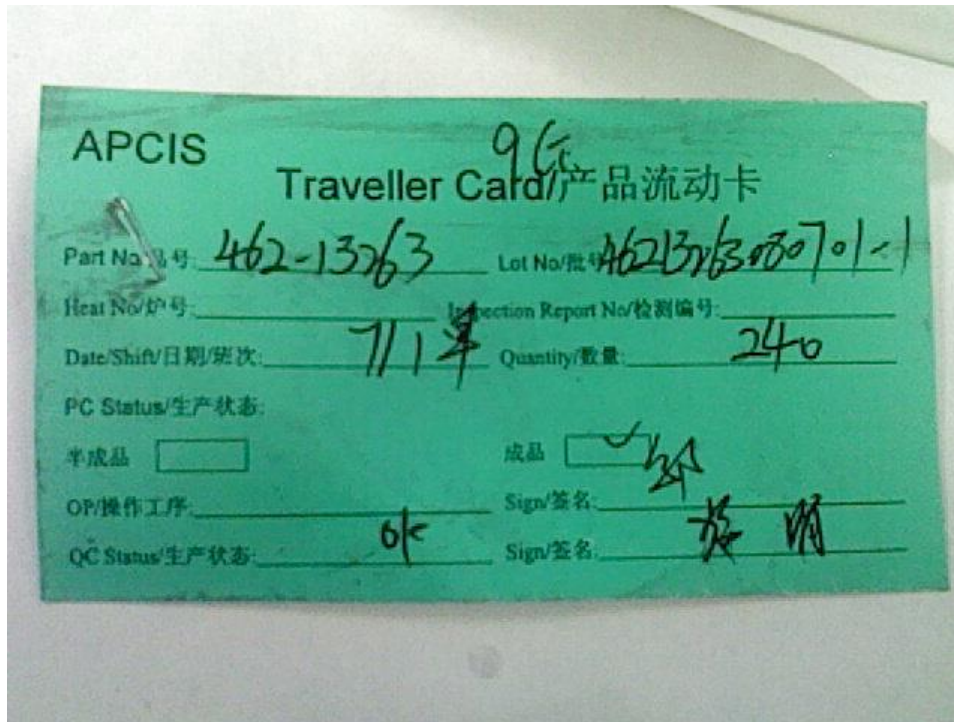


Figure 2 - One of traveler cards found on July 7, 2008

Additionally, we continuously found a variety of products having different date codes, meaning that the plating factory is mixing pieces together. During our interviews at the plating factory we were told that not all of the slides are 100% completely plated. Qian, the head manager of the plating factory, told us that about 10% of the Chassis and Cabinet members need to be re-plated due to defects. Because of the complicated structure of Intermediate piece, more than 20% of the Intermediate members have to be re-plated. Furthermore, we found that after these pieces are re-plated, the workers in the plating factory will mix the re-plated goods with the pieces that do not have to be re-plated. Because some of the products have to re-plated, they would be put aside and as a result some boxes would not be filled to capacity anymore. In order to fill these boxes to full capacity, the Plater will take some products from other boxes that have different date codes and place them into the boxes that had defective pieces removed. This helped us to understand why we were finding pieces with different date codes in many boxes.

4.6.3 Box Problem

During the creation and analysis of our CSM we noticed that there is a 1-2 day lead time for pieces going from F4 to the Plater. This prompted us to conduct further investigation. After looking into this situation we discovered that there is an unstable supply of boxes in F4. This causes a large inventory in F4. Not only this, but we see that there is one direction flow between F4 and F6. For example, F6 only sends empty boxes to F4 when there are large quantities of empty boxes to send. However, should F4 be short of boxes, F6 is not notified of this to be able to send whatever empty boxes they have to F4. Therefore we deem that F4 is somewhat too dependent on F6. Upon collecting data we were able to come up with recommendations to remedy this issue which should reduce this 1-2 day lead time.

4.6.4 Raw Material

While doing our data collection and observations we did notice something else that we believe play a role in the lead time. We noticed one day during our cycle time data collection that one of the production lines was not running. When we inquired as to why this phenomena was occurring we were told that it was due to the fact that there was a shortage of raw material. This prompted us to begin an investigation to discover why this happened. We deemed this as part of our project seeing as that the lead time we were to reduce was from roll forming to final assembly and when a line goes down due to supply shortage, this causes an unbalance of production and increases the lead time. What we discovered through our investigation consisting of interviews was that the supply of material is ordered three months in advance of when it is needed. This order is placed based off the 14 week production forecast provided by the Global Inventory Manager. We also learned that from June 20 to July 5 there was an increase in the price of the raw material and there was an even greater shortage of material. From this information we determined that this method of maintaining material could be better improved and we developed a few suggestions that could keep this problem from occurring in the future.

We also noticed another issue with the raw material. When the material is needed to be placed in a roll forming machine we observed that there is no indication on the wrapping on the material where the beginning is (and by beginning we mean the end of the roll that would be the first part inserted into the roll forming machine). This causes a dilemma because the process used to determine this can be side stepped using simple marking. The process consists of the workers having to take the material from inventory using a forklift, since it weighs a lot, and placing it in an area where it can be unwrapped followed by finding the beginning of the material. After finding the beginning of the material, the workers then have to turn it so that it can be placed correctly into the roll forming machine at which point the forklift comes to lift the material and transport it to the machines. The time it takes to do all this is about 10 minutes, but this time can be significantly reduced using simple marking on the material wrapping.

4.6.5 F4 Machine Layout

Another finding we discovered has to do with the first stamping process for the Cabinet and Chassis members. We noticed first that this operator works on 8-10 pieces before sending all those pieces down a slide to the next process as well as that this operator cannot see when the operator at the next process is done working on their pieces and needs more. Below is an illustrated layout of the Cabinet member line starting at the first stamping process showing this obstructed view.

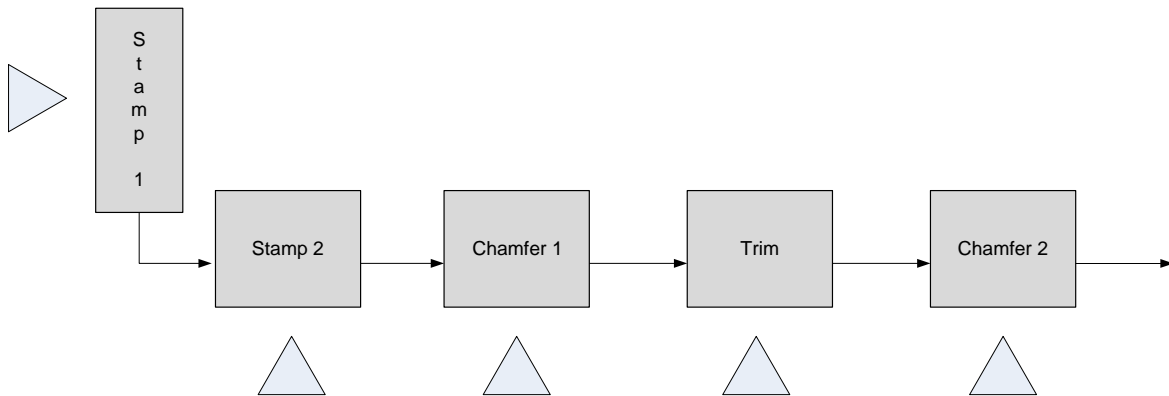


Figure 25 - Production Line Layout Starting at First Stamping Process

Since the operator of the first stamping process cannot see when the operator of the next process is done working on their pieces, and since the next process in all three lines has a faster cycle time than the first stamping process, there is waiting time between these processes. This waiting time varies between the Cabinet and Chassis. To see this we created a graph showing the time it takes for the first stamping process to work on 10 pieces and the time it takes for the process next to it to do the same for all three members. This graph can be seen below.

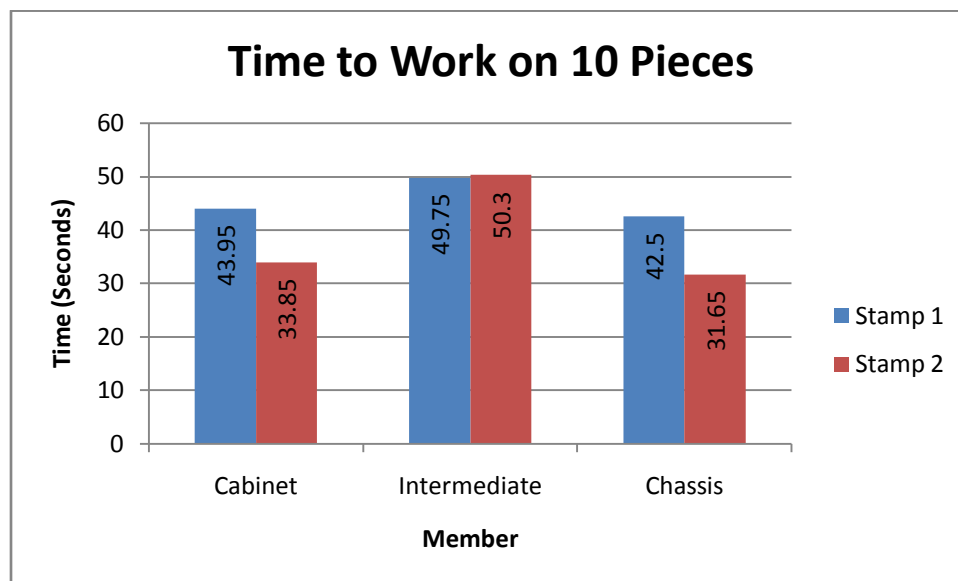


Figure 26 - First Two Processes Comparison

From this graph we can see that the average waiting time for the Cabinet and Chassis members are 10.1 seconds and 10.85 seconds respectively. These waiting times are wastes, yet they are wastes that can be eliminated. The Intermediate member however, does not have this problem due to the simple fact that unlike the Cabinet and Chassis members, the second stamping process in this line cannot work on two pieces at one time; it works on one. Calculating the time it would take the process to work on 10 pieces is almost equivalent to the time it takes the first stamping process to work on 10 pieces.

4.7 Operational Improvement Cost and Time Analysis

Before making our recommendations on how CIS can rectify the operational problems we had to conduct some cost and time analysis. This allowed us to see which of our original ideas to solve these operational problems were practical and which ones were not. These ideas which consist of adding machines, changing the dies in the machines, and changing the process order, we were able to analyze and it is important for the reader to understand these figures before reading the suggestions.

The following cost figures, which are averages, were given to us by Larry Zhong and Wang Liying, and without them these figures might not have been attainable and made our suggestions much less convincing. The cost of adding a machine in F4 is 100,000 RMB and the cost of replacing or redesigning a die in F4 is 20,000 RMB. The cost for adding a machine in F6 is 10,000 RMB and the cost of replacing or redesigning a new die for F6 is 4-5,000 RMB. All new employees undergo a three day basic orientation. Having completed this basic orientation, if the new worker will be working in F4, they go through one day of “on the job” training which costs 200 RMB, whereas if the new worker will be working in F6, they must go through 15 days of “on the job” training which costs 643 RMB. This helped us tremendously in that it showed us that our first thought of to just add more machines are now not as practical as to suggest replacing a die or changing the process line. For example, from this data we were able to calculate that to add a new machine in F4 would cost 120,000 RMB which includes ordering the machines, ordering/designing the die and training an employee to use the machine. Adding a machine in F6 would range from 14,643 – 15,643 RMB. Therefore, it is much less expensive and more practical to recommend more die changes (20,000 RMB for F4 and 4-5,000 RMB for F6) and process layout changes than ordering a new machine. We were not able to receive exact figures of the cost to change the process line because there are many factors that affect this including how many machines will be moved, how far they will be moved, etc, but usually it is cheaper to change the process layout than add a new machine. The CIS maintenance people can usually move most of the machines in one day and there is generally no real cost involved.

Having this cost information was only a part of what we needed. We also needed time information. This information was given to us again by Larry Zhong, and the information we received were averages. We learned that adding a new machine at F4 would take anywhere from 8-10 weeks and 4-5 weeks at F6. We also learned that it takes 2 weeks to design a new die and 3-4 weeks to manufacture it, making the total die design time 5-6 weeks. Also, the time it takes to replace a broken machine in F4 and F6 is 5-6 hours and one hour, respectively. From this information we were able to see again, that making die changes and changing process layout are more practical and time efficient. For example, suggesting a die change in F4 would take about half the time to accomplish than ordering a new machine in F4. This time in F6 though, only has a 1-2 week difference. The reason for this is that the machines in F4 are much bigger than the machines used in F6. For changing the process layout, it generally takes about one day to make the changes.

5.0 Recommendations

This section includes all of our recommendations we have made to reduce the lead time for the entire 9G production process. In this section we make recommendations for the issues we found and mentioned in the previous section. Should CIS implement these recommendations, they will be able to reduce the lead time significantly.

5.1 Operational Improvements

5.1.1 F4

Our first suggestion deals with turning one machine to face a different direction. This is in regard to the “Stamp 1” machine near the beginning of the each line. From our conclusions we deduce that by turning the machine so that the operator is facing the machine in the same direction as the rest of the workers, as illustrated in the figure below, this will allow the “Stamp 1” operator to see when the next process is either waiting for pieces or is getting low on pieces.

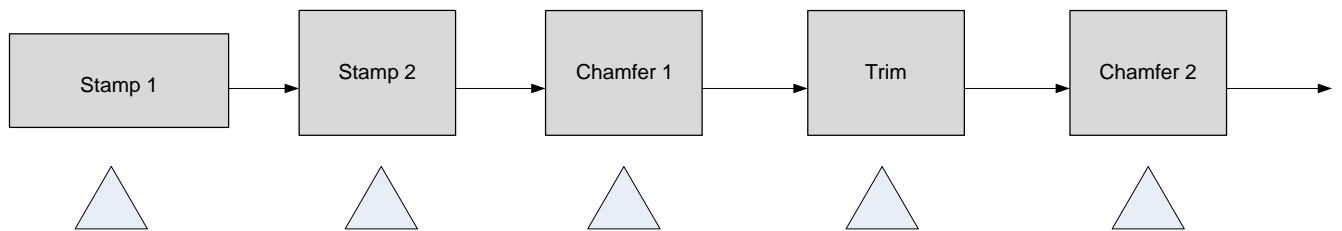


Figure 27 - Suggested F4 Process Layout

As mentioned in our conclusions, the operator at this machine works on 8-10 pieces before sending them down to the next process which causes some waiting time and the next stamping process. We also recommend that as opposed to working on all these pieces before sending them to the next process, the operator send however many number of completed pieces they have worked on down to the next process when they see that the next process is waiting or getting low on pieces to work on. With this machine being turned, this will allow the operator to indeed see when the next process needs pieces. This will reduce the waiting from the 10 seconds we concluded to virtually zero seeing as that the “Stamp 1” operator will constantly pass on pieces to the next process when needed.

5.1.11 Cabinet Member

For the issue of solving the “Trim” bottleneck in the Cabinet line we have come up with two recommendations. The first one is to move this “Trim” step to the back part of the production line making it the last process. This will reduce the waiting time from 20 seconds, as explained in our conclusions, to about 4.5 seconds (the time “Trim” would have to wait for pieces from “Deburr/Plate”). This 15.5 second reduction in waiting will allow the production line to run more efficiently and increase the number of pieces produced. The graph below illustrates this.

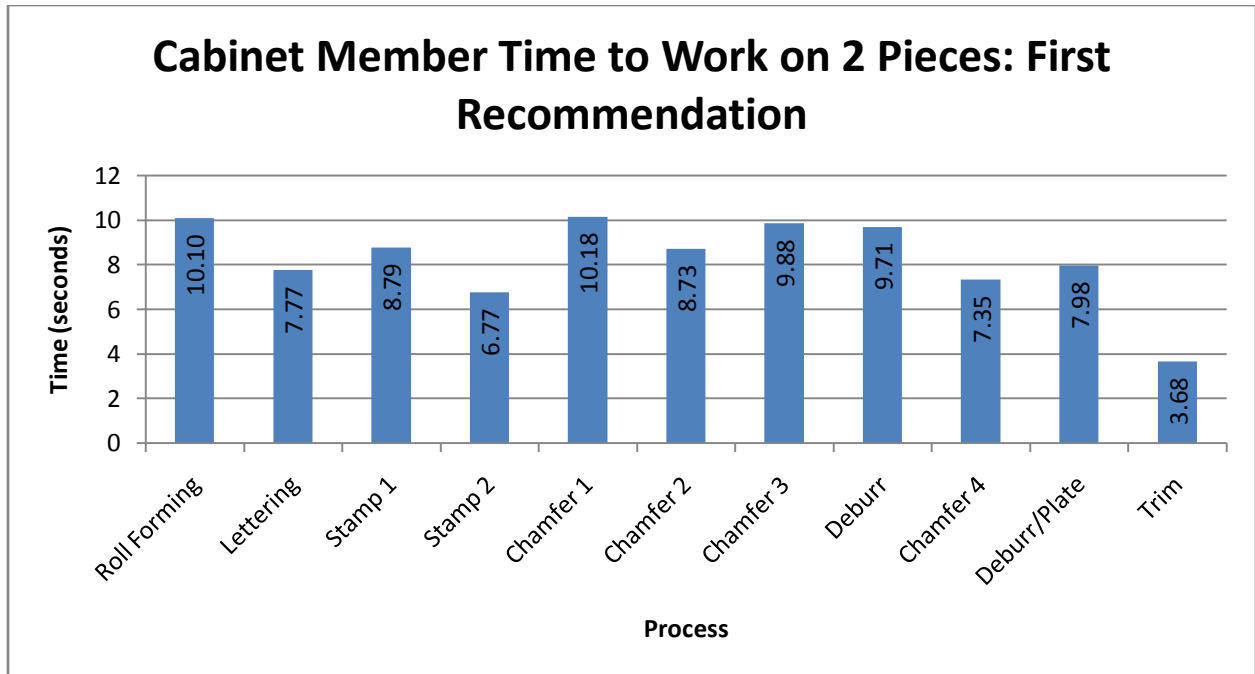


Figure 28 - Cabinet Member Time to Work on 2 Pieces if Recommendation 1 is Implemented

The second suggestion is to alter the machine of the “Trim” step to process only one piece per cycle. The cost of altering the machine can vary seeing as that it will need to be determined whether the current machine can be altered or whether a new machine would have to be designed and ordered. The operator wouldn’t have to be retrained since the process itself is still the same; the only difference is the number of pieces it can work on per cycle. Changing this machine to work on one piece per cycle means that the time it takes to work on 2 pieces would approximately double to about 7.5 seconds. This changes the waiting time to about 2 seconds, and reduces the overall waiting time from the “Chamfer 1” process to the “Deburr/Plate” process to about 10 seconds, which is half of the current waiting time. Below is a graph that shows this change.

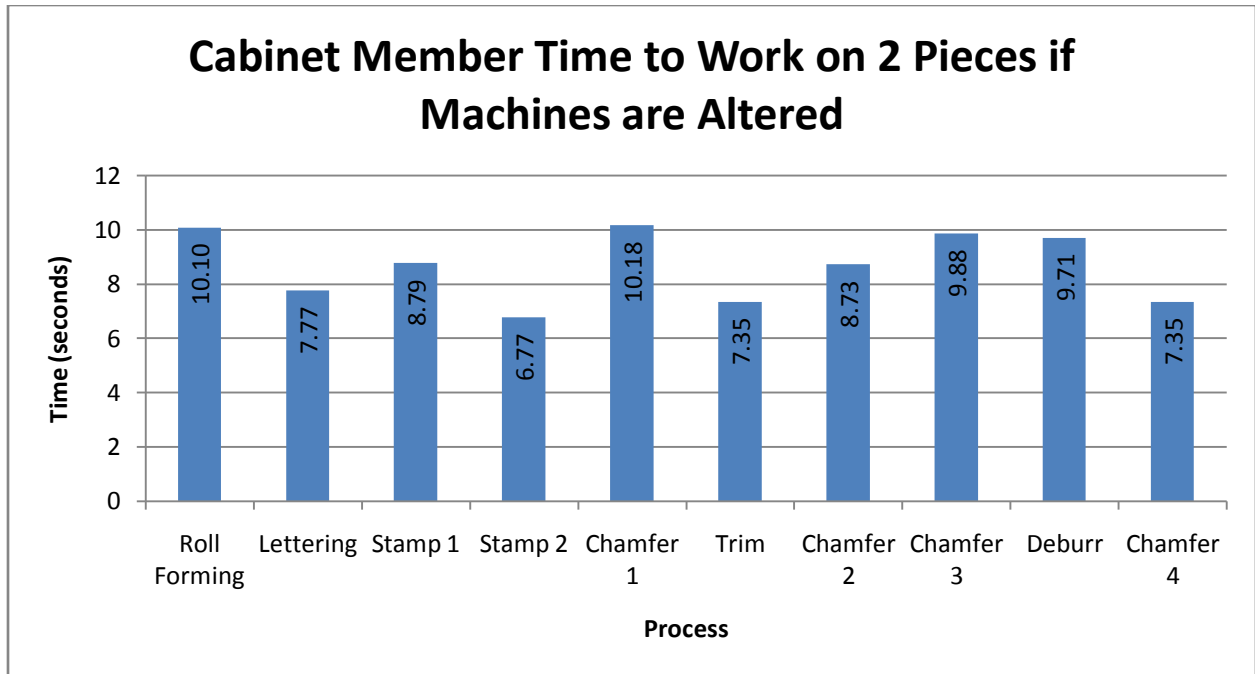


Figure 29 - Cabinet Member Time to Work on 2 Pieces if Machines are Altered

5.1.12 Intermediate Member

We have also come up with two suggestions for improvement of the Intermediate member line. The first suggestion is to move “Chamfer 1”, “Deburr 1A” and “Deburr 1B” to in between “Trim 3” and “Chamfer 2A”. Our reasoning for this is because “Chamfer 2A” has the slowest time to work on two pieces besides “Deburr 1A” and “Deburr 1B”. By moving these machines to this point, this will reduce the waiting time at this point from 10 seconds to four, which is the difference in time between “Deburr 2A” and “Trim 2”. This will also make the production line more balanced as there would be less fluctuation in the times to work on two pieces. The graph below shows this.

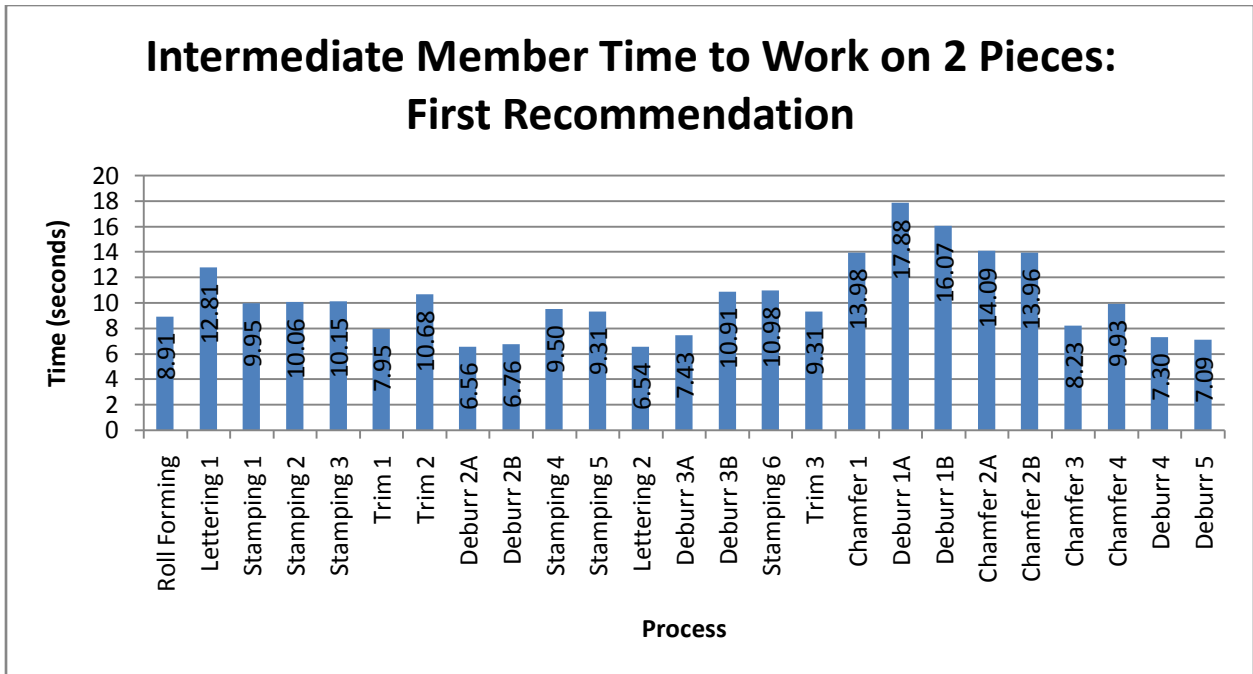


Figure 30 - Intermediate Member Time to Work on 2 Pieces if Recommendation 1 is Implemented

The second suggestion is to alter “Chamfer 1”, “Deburrr 1A” and “Deburrr 1B” to be able to work on two pieces per cycle. This will reduce the time it takes to work on two pieces by about half, therefore significantly decreasing the waiting time of “Deburrr 2A” and “Deburrr 2B” from about 10 seconds to two seconds. Below is a graph showing this.

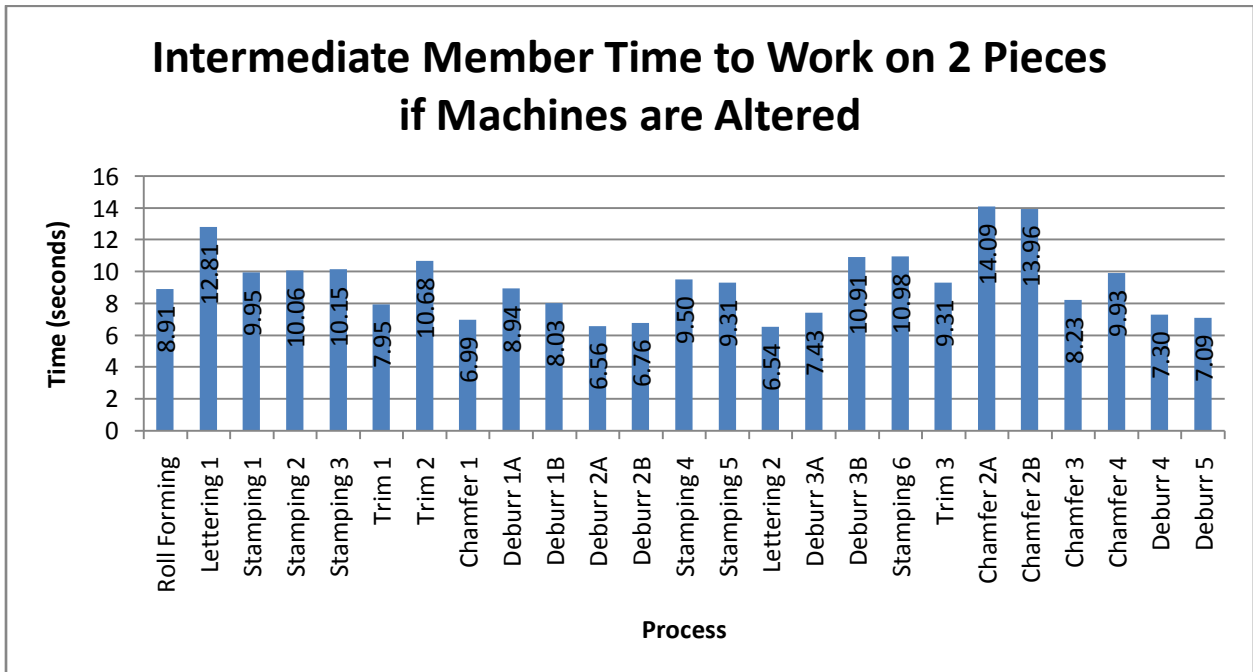


Figure 31 - Intermediate Member Time to Work on 2 Pieces if Machines are Altered

Again determining the cost to alter the machine depends on whether the current machine can be altered or whether a new machine would have to be designed and ordered. No additional employees would have to be hired and no employee would have to be retrained seeing as that the process is still the same; the only difference again would be the number of pieces it can work on per cycle.

5.1.13 Chassis Member

Our only recommendation for the Chassis member line is to alter “Chamfer 2A” and “Chamfer 2B” to work on two pieces per cycle. This will reduce the time it takes to work on two pieces in half and make the entire line relatively balanced as well as reducing the waiting time for the rest of the remaining processes. Below is a graph showing this.

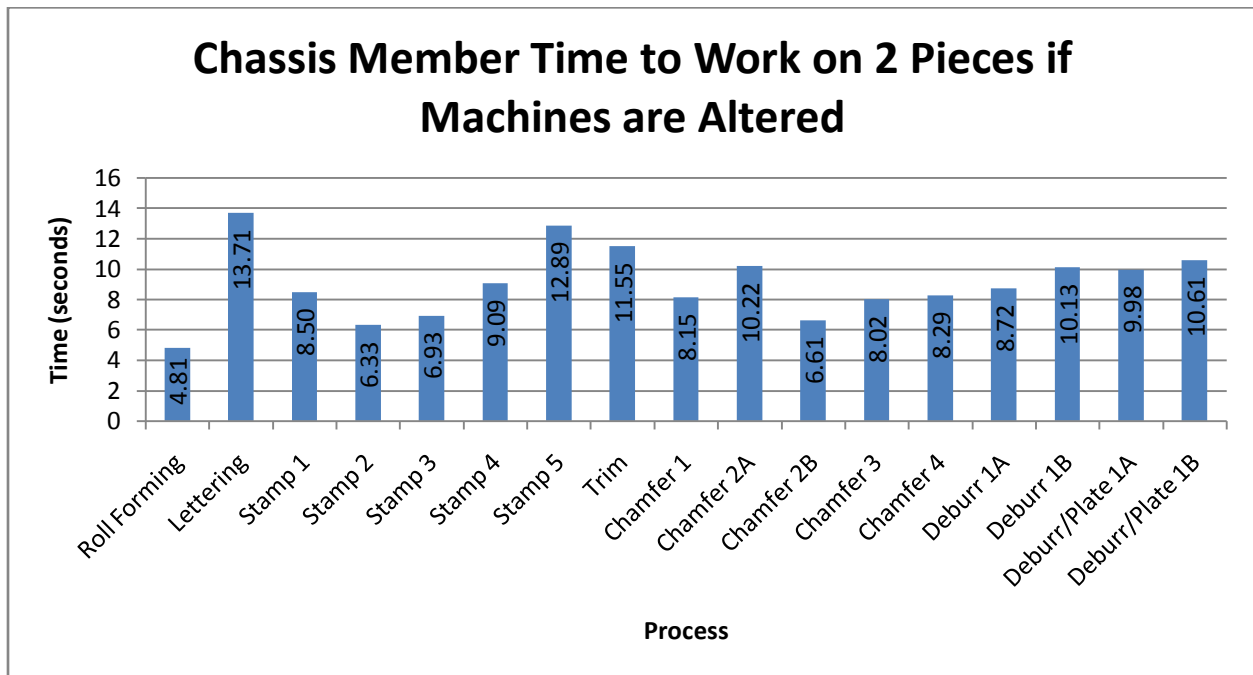


Figure 32 - Chassis Member Time to Work on 2 Pieces if Machines are Altered

5.1.14 Production Line Balancing

To ensure that the entire production line is as balanced as possible we also recommend that whenever one production line is shut down, that the other lines be shut down as well. This will ensure that there is not more inventory of one or two pieces than the others.

5.1.2 F6

The only suggestion we have for operational improvement at F6 is to change the process layout so that it has one direction flow. We understand that the engineers at F6 are designing and testing their own method seeing as that suggestion, which was originally going to be tried, was denied by the engineers. Nevertheless, we still are still making this suggestion as another alternative. Our recommendation is to move the Cabinet member assembly to sit opposite of the Intermediate and Chassis assembly line. From there they would meet at the final assembly workstation and then move on

to checking, thus creating a one direction flow assembly line. Below is an illustration showing this layout.

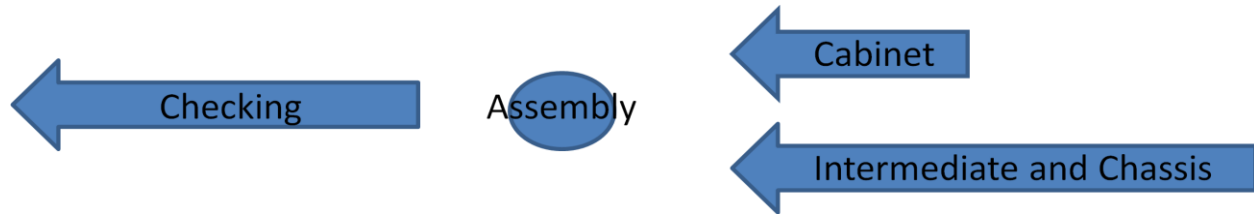


Figure 33 - Suggested F6 Assembly Line Layout

5.2 Reducing F4 Inventory

5.2.1 Improving the Dies for the Stamping Machines at F4

In order to reduce the times for changing the dies, we advise to use better qualified material to make the dies. Although it increases cost, it will reduce the total number of times the machines breakdown which will in turn reduce the downtime. Not only will using a better material reduce the total number of breakdowns for these machines, it will decrease the number of dies needed per day for replacement so the cost of changing to a better material should balance out relatively quickly.

5.2.2 Balancing the Roll Forming and Stamping Processes

According to Dai, the raw steels which are made in different furnaces have a different thickness and the range of tolerance is wide. When replacing the raw steel, which is made in different furnace, from the previous steel, it takes more time to adjust the machine. But if the raw steel is made in the same furnace as the previous one, then there is no real need to adjust the roll forming machine to meet the thickness of the new steel. From this we have come to the conclusion that it saves time spent on adjusting the machine if the raw steel was made in the same furnace as the previous one. However, it is difficult to make sure all the raw steel in the warehouse are made in the same furnace. Therefore we recommend that CIS categorize the raw material by the furnace it was made in and process the steel which has the same heat number with the previous one. This will reduce the amount of times needed to adjust the machine to day, which will increase production for the Roll Forming process and decrease lead time.

5.2.3 Balancing the Roll Forming and Stamping Processes

From interviewing the manager Dai Chaozhong, we know that the roll forming pauses 16 times per day, and 22 minutes each time because of overheating of the engine. Currently, the roll forming can produce 2277 kits per day on average, but it is not at full potential because the overheat problem limits its production capability. To increase the production capability for the Roll Forming process we advise CIS to diminish the time it takes to cool down the engine to the normal temperature. By further analyzing, there are two factors which have an influence on the length of the time which can be used to remedy this situation. One is the time that the engine is down due to over-heating. The other is the time which is spent on cooling the engine for each pause. We have devised two ways to handle this problem and recommend implementation of one, if not both, of the solutions to make the production line balanced between Roll Forming and Stamping. The first one is to decrease the times that the engine stops. Suppose the engine pauses “x” times, 22 minutes for each pause, then we will get the equation: [(60

minutes/hour * 24 hours/day) – (“x” pauses/day * 22 minutes/pause) – (20 minutes/adjustment * 12 adjustments/day) - 60 minutes /day (for lunch)] * 6 pieces/minute = 5280 pieces (the number of pieces the stamping process produces per day). The result is x = 11.8 times. So if CIS can reduce the number of times the Roll Forming machines breakdown to under 12 times per day then there will be balance between Roll Forming and Stamping. In order to reduce the number of times the machines breakdown, one solution is to use a different lubricant or increase the cooling efficiency of the fans in the machine. Similarly, assuming the engine pauses 16 times, “y” minutes for each pause, then we will make this equation: :[(60 minutes/hour * 24 hours/day) – (16 pauses/day * “y” minutes/pause) – (20 minutes/adjustment * 12 adjustments/day) - 60 minutes /day (for lunch)] * 6 pieces/minute = 5280 pieces (the number of pieces the stamping process produces per day). The result is y = 16 min and 15 seconds. So if CIS can decrease the time spent in cooling down the engine to 16 minutes and 15 seconds or faster, then balance between roll forming and stamping also can be achieved.

5.2.4 Adjust the working schedule

Assuming that CIS accomplishes balancing between Roll Forming and Stamping, we have also made recommendations to eliminate the safety inventory between roll forming and stamping. This suggestion we make is all based assuming that there is balance between these two processes. Our suggestion is to change the work schedule of roll forming and the time that the lettering changes the date code to eliminate the safety inventory. The recommended work schedule is as follows:

- Roll forming
 - Night shift:21:00-9:00
 - Day shift:9:00-21:00
- Stamping (stays the same)
 - Day shift:9:00-17:00
 - Night shift:21:30-5:00
- Date code changing time:21:00

With this suggested schedule implemented, the date code is changed at 21:00 every night. Hence, the night shift is the start of the lead time and the whole shift can produce 1320 kits. According to the production efficiency of stamping, which is 240 kits per hour on average, it takes 5.5 hours (1320 kits/240 kits per hour) to finish processing these 1320 kits. So when the pieces which are roll formed by the night shift are finished stamping, the time will be 15:00 which is 6 hours later from the beginning of stamping, after adding 30 minutes break for lunch at noon to the 5.5 processing hours. During these 6 hours, the roll forming can produce 110 kits/hour * 6 hours = 660 kits. So until 15:00, the pieces which have been roll formed are 1320 + 660 = 1980 kits. The production quantity of the day shift of the stamping process is 1920 kits. Therefore, the roll forming can keep the pace of stamping. From 15:00-21:00, the total pieces which have been roll formed and wait to be stamped are 720 kits which equal the quantity of what the night shift of stamping can produce.

5.3 FIFO Issue

Finding Work-In-Progress (WIP) pieces which have mixed date codes in the same batch at F6, we tracked the non-assembled pieces back to the plating factory. In the warehouse of plating factory, we found out that the pieces which have been plated were not stored in the order of the date code. Based on these findings, we strongly recommend the Plater to take advantage of the ramp system which they have not used for a long period of time. Assuming that the ramp is used, the piece flow in the warehouse of the Plater will be standardized by FIFO rule. Also, when shipping out these pieces, the pieces which are older should be packed into the truck first and the newer ones packed last. The pieces that are put in first should be the last ones off the truck. After arriving at F6, the non-assembled products will be stored temporarily in the same order. This will allow the older pieces to be assembled first before the newer ones, thus following the FIFO rule and reducing lead time. The two figures below show how the products should be loaded and unloaded.

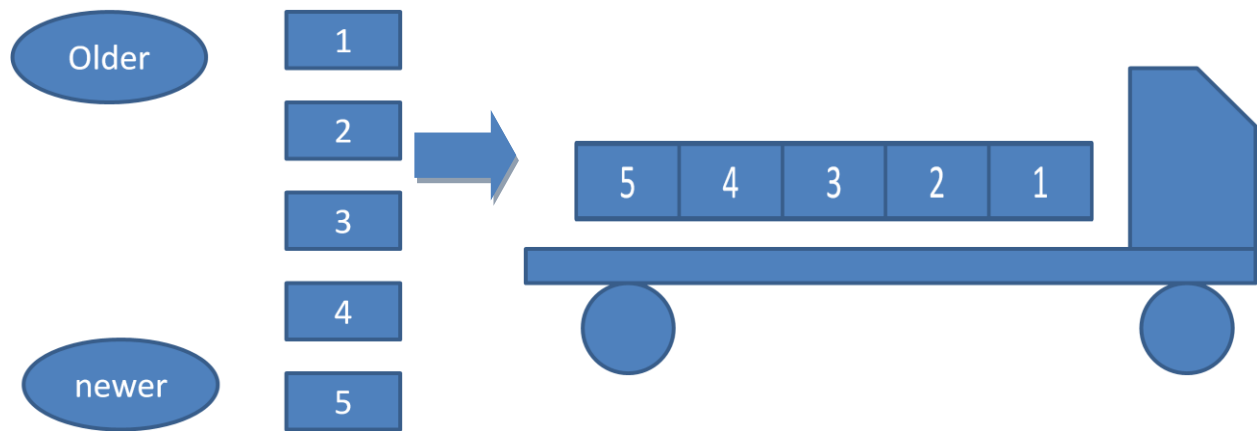


Figure 34 - Suggested Truck Loading

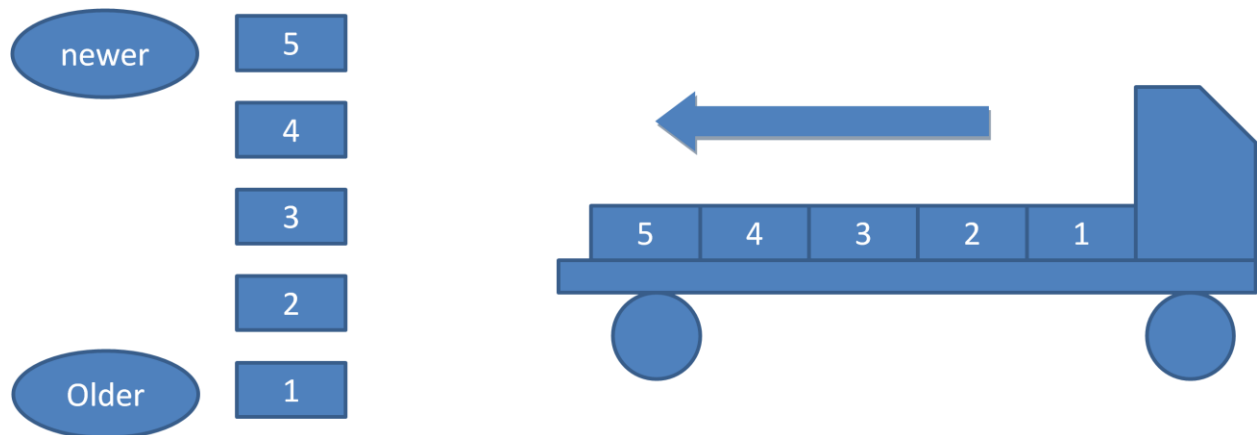


Figure 35 - Suggested Truck Unloading

By implementing these recommendations we expect to reduce the lead time by 1-2 days. The first reason is that it guarantees the Plater to follow the FIFO rule. The pieces which have older date codes will be shipped out to be assembled ahead of the others.

Another reason that the ramp is useful is that it can be used to reduce the inventory and prevent the possible pause in the production flow. For one thing, the ramp limits the maximum of the inventory, in which case, it urges to speed up the shipping between the plating factory and F6. Thus, it decreases the inventory. Another reason is it is easy to figure out the minimum inventory in order to make sure the safe stock is guaranteed.

5.4 Plating Factory Recommendations

In light of the large quantity of the re-plated products and the way the Plater deals with the re-plated products, we think the rework done in the Plater is one of the main reasons that the FIFO principle isn't followed strictly there nor at F6. The figure below shows one of the possible ways.

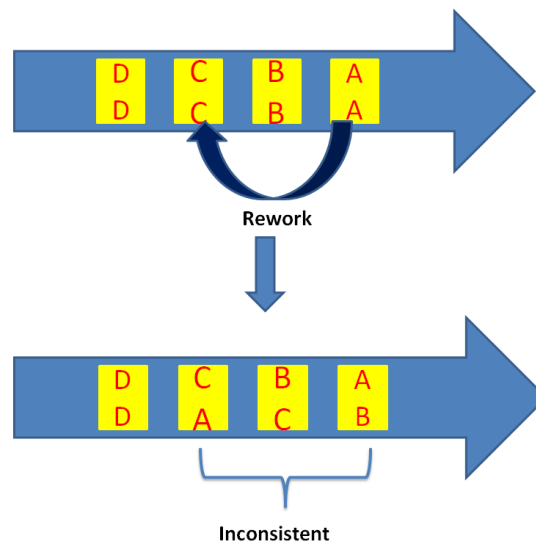


Figure 36 - Plating Rework Example

Under the ideal condition, product A with the oldest date code should go first to the plating factory and be the first to be sent to F6. According to the time order, second comes product B. Now, assume that some of product A needs to be re-plated. Because some of product A needs to be re-plated, it cannot come out from the plating-factory first. It instead has to be reworked and sent with either product B or C. Meanwhile, to fill the boxes containing pieces of product A to full capacity, product B will be placed into those boxes. As a result, rework in the Plater may cause more than one day delay of those products. This is because the OBA checker will choose the date of the oldest member in the box and regard it as the end of that product's lead time, regardless if it was reworked or not. Considering the situation of replating work in the plating factory, we have come up with multiple suggestions.

Our first suggestion is that the re-plated products be treated differently than products that do not need to be re-plated. Once the Plater finishes the re-plating work, all the re-plated should be placed into different boxes by themselves, not to be mixed with the original ones or mixed with any other pieces. Then, the Plater needs to mark the boxes that contain re-plated members and inform the workers in F6 about the re-plated products. As for F6, once it receives the re-plated members from the Plater, the checkers there should take a tightened inspection and make a detailed record of these re-plated members, such as the defective ratio, the quantity, the time they come to F6 and so on.

Our goal is to ensure that the three members in one kit have the same date code. But if we treat the re-plated members in the way above, there still remains the possibility that re-plated members may be assembled with those that did not need to be re-plated. Nonetheless, doing this will cause most of the members to be assembled with the same date code.

We also recommend a new layout of the warehouse at the plating factory. Our recommended layout for the plating factory can be seen in the figure below. First of all, we separate the warehouse into two sections. One is for loading and unloading and the other is for storage. The loading/unloading area is next to gate. Furthermore, the storage area is divided into two parts. About 80% of the storage area is for plated products and the rest is for re-plated products. In both the plated area and re-plated area, the products are arranged in line, according to the time order. The products with the oldest date codes are put against the wall with the more recent ones further away from the wall. We also recommend that the products in one line should be the same member—Chassis, Intermediate or Cabinet as shown. We even take this recommendation a step further, suggesting that the lines for a certain kind of product, like London for example, should be put next to each other. In addition, it is better to arrange the members with the same date code in a row, which can ensure that those members are sent to F6 at the same time which will allow them to be assembled together

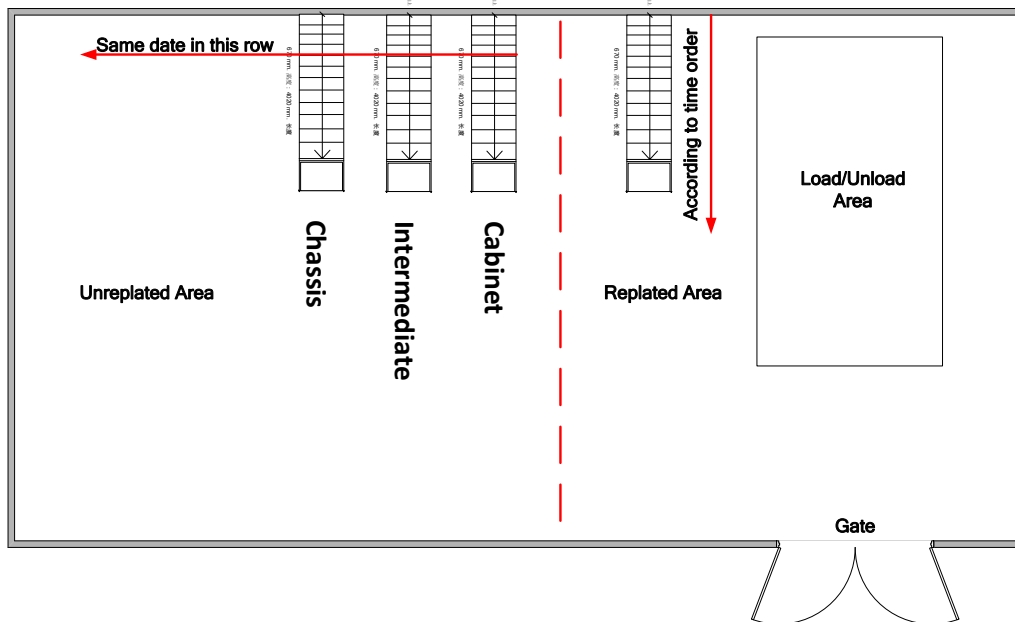


Figure 37 - Suggested Plating Factory Warehouse Layout

5.5 Box Issues

F4 depends too much on F6. Once F6 does not send enough boxes to F4, or not in time, F4 will easily run out of box and result in other problems. It is easy to find that the communication about boxes between these two factories is not sufficient. For example, sometimes a box shortage will happen in F4, but F6 would not be notified of the situation. If the finished goods in F4 cannot be delivered to the Plater in time, the lead time would be prolonged by at least one day. In order to ensure an adequate box supply for F4, we recommend implementing the following suggestions.

First is to divide the current box cycle into several small cycles as shown in the figure below.

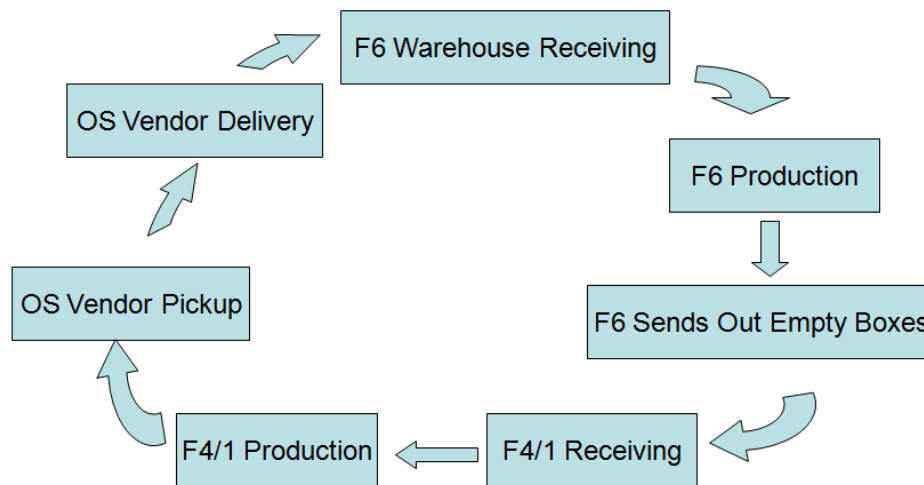


Figure 1-Current box cycle between F1, F4, F6 and the Plater

(Source: CIS production department, July, 2008)

Currently there is just one kind of blue box used by F4, the Plater, and F6. Under normal conditions, F6 holds the largest quantity of boxes. In order to ensure adequate box supply for F4, we recommend using red boxes just between F4 the Plater and blue boxes between the Plater and F6 as shown in the diagram below.

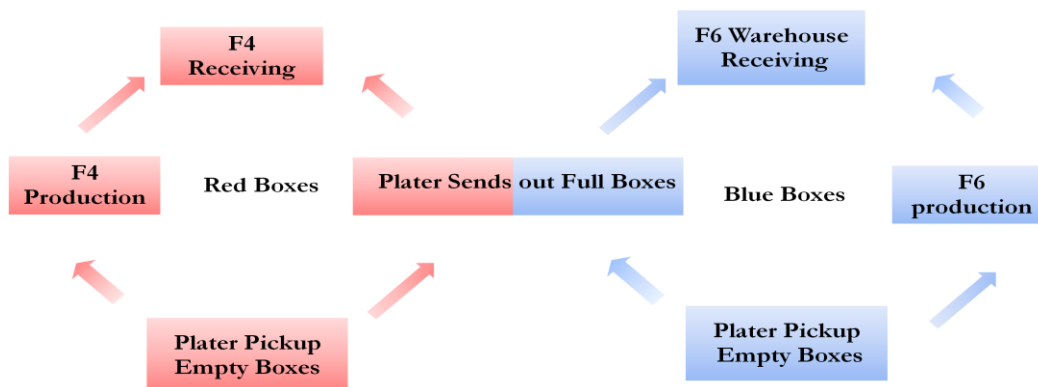


Figure 38 - Recommended Box Usage

We also recommend this change to different colored boxes because the boxes from F4 are very dirty and adhered with oil, making them not proper to hold the pieces that have been plated. Although the Plater will use extra paper to pack the plated pieces and then put the packed pieces back into those dirty boxes, this work is time-consuming and energy-consuming. But if we have those two box cycles mentioned above, that problem can be solved. The boxes in the first cycle are dirty, but boxes in the second cycle are clean. The workers do not have to pack the plated pieces with paper any more.

We also recommend that the Plating factory take on another role. Originally, the Plater just has to pick up full boxes from F4 and send plated pieces to F6. In order to adhere with the small cycle method we recommended, the role of the Plater needs to be changed as well. Every time the Plater goes to F4, it has to bring the empty boxes there. Then the Plater picks up the full boxes of F4 and back to the plating factory. Furthermore, after the Plater has brought plated pieces to F6, it has to take the empty boxes in F6 back to the Plater.

Furthermore, because every day the Plater has to pick up products from F4, it is much easier for F4 to tell Plater the box situation at F4. After comprehensive consideration of the work time, production capability and other factors, we calculated the most ideal time and quantity for the Plater to send or pick up the empty boxes in the cycle between F4 and plating factory, as shown in table below.

Time	Empty boxes sent to F4	Full boxes picked up from F4
7:00am	40	50
9:30am	20	45
2:30pm	90	55

Table 1 - The Time and Quantity of Boxes in the Cycle Between F4 and the Plater

5.6 Raw Material

To solve the issues of the raw material, the first being the material not being marked where the beginning is, we recommend that CIS contact the supplier and discuss with them marking on the material wrapping, in a black tape or marker, where the beginning of material is to simplify the material replacement process. We also recommend that CIS maintain a constant supply of material on hand. This will ensure that there is not a material shortage like that had occurred from June 20 – July 5. To maintain a constant supply we suggest that CIS order the raw material monthly and base how much they need to order off of monthly production capabilities of each member.

5.7 Shipping Recommendation

After completing an analysis on the shipping times and inventory, we believe that we have gathered much valuable information to the company. We have fully understood the information flow process for orders and container booking. Along with this information, we have received and studied the data about customer demands and daily kit production. Our group has a great understanding of how the company works and functions, and through this we were able to make suggestions to improve these processes. We’ve found that having pick-up dates on Monday, Tuesday, and Wednesday will increase safe stock, and create a large inventory in the factory at the end of the week. According to Linda Li and other managers, the time it takes to roll form to arrive at Dell is 42-49 days. This is an area for improvement,

because this is a major waste. Also we have also found that due to individual orders, this creates containers that are not being filled, which is a waste of money, space, and adds an addition container. This makes the inventory much more confusing and makes the loading period longer.

We suggest that the company come into contact with Dell and DHL to work out a solution where they can mix containers. Along with this, we suggest that the company move the shipping days back to Monday, Wednesday, and Friday. This will save the inventory space, container usage, and money as mentioned in our conclusions. This will also reduce lead time for shipping to Houston, which was our studied destination. At the end of the day's production, it should organize the inventory into sections of the warehouse of these kits, so it is easy to tell which pallets go onto each container.

5.8 Future Projects

We also recommend conducting a future project to look into reducing the number of defects. By being able to reduce the number of defects, CIS will be able to reduce inventory and further reduce lead time by not having to return semi-finished products to be fixed and then shipping them out once the defects have been fixed.

6.0 Conclusions

From the recommendations we have based off all the data we collected and analyzed we have determined that is possible to reduce the lead time of the 9G from Roll Forming to Final Assembly by 20%. We can even say that should all our recommendations be implemented that the total reduction in lead time can be up to 61%. This time reduction is spaced out over all the processes involved in the 9G production and assembly process and can be seen in our Future State Map (FSM) in Appendix A.

The team believes that the biggest issues in the 9G production and assembly process lie with the FIFO rule, the inventory of parts. By ensuring that the FIFO rule is followed as strictly as possible, the lead time can be reduced significantly just off of this principle. Following this rule will also ensure that parts are not mixed as frequently and will make the inventory much more organized. The inventory of parts can be reduced to a minimum by applying most, if not all, of our operational improvements. Making the production lines in F4 as balanced as possible will ensure that there isn't more inventory of one member or members than others. Also, by ensuring balance between the Roll Forming and Stamping processes, CIS can eliminate the one day safe stock currently needed due to the under production of Roll Forming compared to Stamping. In F6, by making the assembly process follow a one direction flow, this will decrease congestion and allow assembly to flow more quickly and efficiently, thus allowing F6 to assemble more kits daily. Although not originally part of our project, we also deem the shipping process a big role in the lead time. By adjusting the current shipping schedule and the combining of parts in containers, CIS can reduce the lead time for shipping alone by 3 days.

Value Stream Mapping was very useful for us in being able to visually see how the entire production process worked, as well as seeing how the individual processes worked. By being able to combine information and material on one map, this allowed us to see where the big issues were in regards to lead time. We were able to then analyze the big issues and make recommendations to remedy these

problems. By using lean manufacturing methods we were able to come here to CIS Wuxi and in 7 weeks provide them with many recommendations to reduce the lead time for the 9G by not just 20%, which was our original goal, but by up to 61%.

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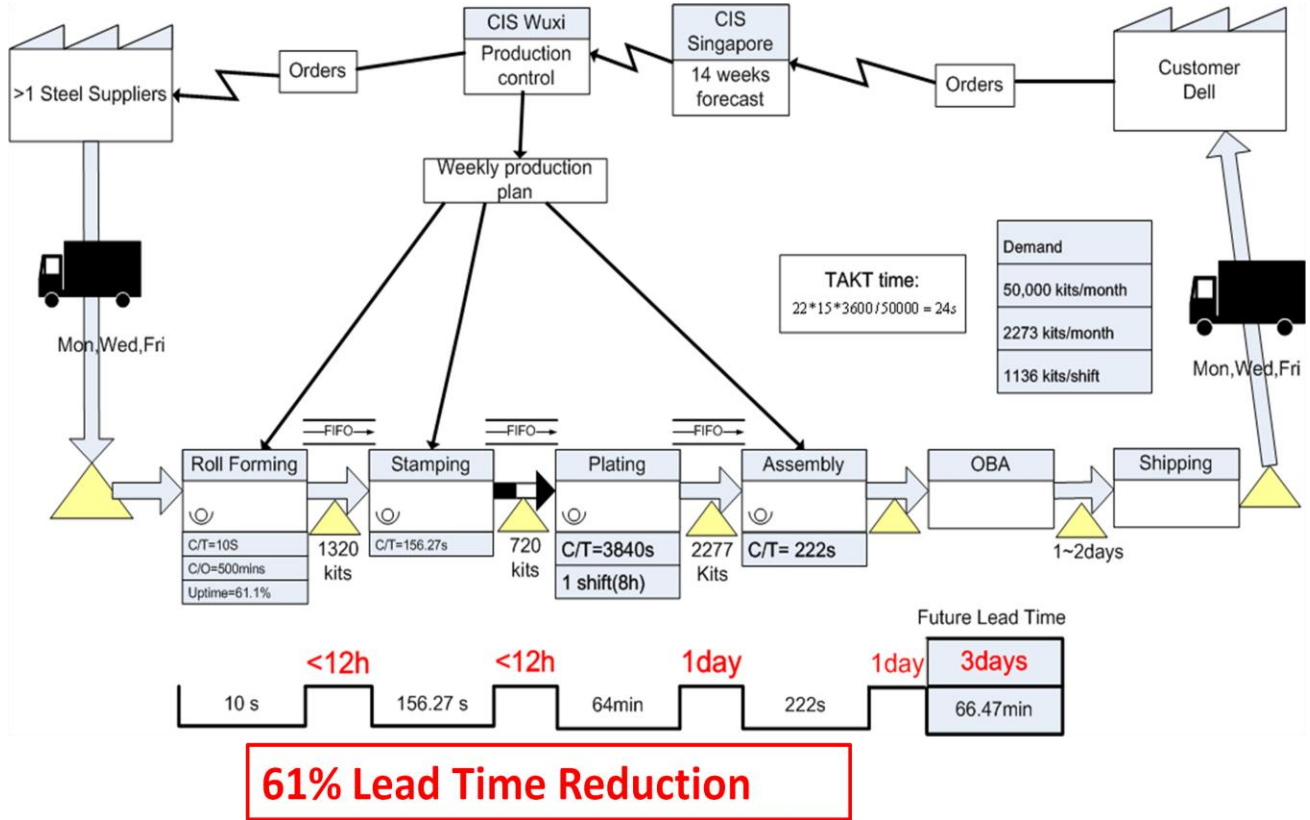
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Appendix A: Future State Map



Appendix B: Cycle Time Data Collection Sheets

Factory: F4		Member: Chassis				Date:			Time:		
Process #	Process	# of operators	batch size	# of pieces	waiting time	cycle time	cycle time	cycle time	cycle time	cycle time	cycle time
20	Roll Forming										
30	Lettering										
40	Stamp 1										
50	Stamp 2										
60	Stamp 3										
70	Stamp 4										
80	Stamp 5										
90	Trim										
100	Chamfer 1										
110A	Chamfer 2A										
110B	Chamfer 2B										
111	Chamfer 3										
112	Chamfer 4										
120A	Deburr 1A										
120B	Deburr 1B										
130A	Deburr/Plate 1A										
130B	Deburr/Plate 1B										

Factory: F4		Member: Intermediate				Date:			Time:		
Process #	Process	# of operators	batch size	# of pieces	waiting time	cycle time	cycle time	cycle time	cycle time	cycle time	cycle time
20	Roll Forming										
30	Lettering 1										
40	Stamping 1										
50	Stamping 2										
60	Stamping 3										
70	Trim 1										
80	Trim 2										
90	Chamfer 1										
91A	Deburr 1A										
91B	Deburr 1B										
92A	Deburr 2A										
92B	Deburr 2B										
100	Stamping 4										
110	Stamping 5										
120	Lettering 2										
121A	Deburr 3A										
121B	Deburr 3B										
130	Stamping 6										
140	Trim 3										
150A	Chamfer 2A										
150B	Chamfer 2B										
151	Chamfer 3										
152	Chamfer 4										
153	Deburr 4										
154	Deburr 5										

Appendix C: Interview Questions Asked to CIS Employees

Shipping supervisor

1. How far is the DHL warehouse from F6?
2. What are the DHL pick up dates and times? (data sheet)
3. How many products can one DHL truck hold?
4. When are the containers booked?
5. How many are booked at one time?
6. Can DHL store excess inventory at a DHL warehouse to reduce CIS inventory?
 - a. Will also allow DHL to ship those products first (constant supply to ship) as opposed to having to come to F6 to pick up products
7. What are the possible reasons for excess inventory being placed on F6 work floor space?
8. Why aren't containers combined of different parts of the same company as opposed to just being one product? (1000 Berlin + 500 London vs. 1500 Berlin)
9. Why doesn't CIS ship products for IBM and HP on days when DHL doesn't come since those products can be shipped daily?

Production Planner

1. Whenever there is excess inventory, why isn't information sent back to Singapore saying there is excess inventory and to place a smaller order?
2. How many kits of each Dell product are produced per shift? (9G, Dagger, Pony)
3. How long does it take to produce one DHL truck worth of products?

Warehouse manager

1. When there is excess inventory whom do you notify?

Global logistics manager

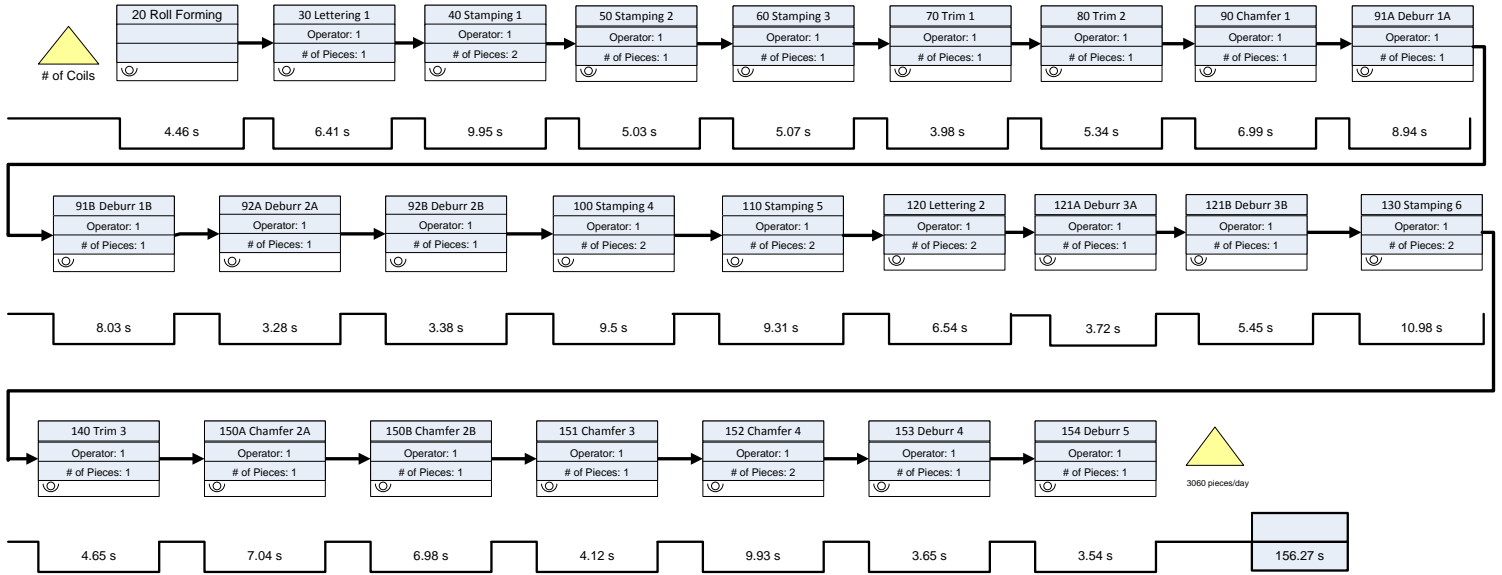
1. Why is there poor upstream information flow between factories and Singapore?

Global inventory manager

1. Why are orders made by individual products (1500 Berlin) as opposed to being mixed (1500 Berlin, 1500 London, and 1000 Montreal)?

Appendix D: Current State Maps

Intermediate Member



Chasis Member

