APPLICATION OF DEMAND FLOW TECHNOLOGY TO CABLE ASSEMBLY PRODUCTION LINE

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ABSTRACT

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D.F.T. (Demand Flow Technology) principles were applied to the cable assembly operations. The main objective is to reduce production time with the implementation of a new cable assembly line designed following Demand Flow Technology concepts. The study takes place in a manufacturing company specializing in fall protection equipment that has cable assembly operation as one of the major activities in the production of its finished goods. D.F.T. is a new business strategy based on Demand Flow Manufacturing techniques that help manufacturers to optimize the production system working in all the departments of the company. The final result was a manufacturing cell layout for the cable

assemblies. Improvements compared it with the old way to assemble cables were found in direct labor time. The total implementation of D.F.T. to the company will take years and will touch all departments within the organization.

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I also want to give special thanks to DBI Sala personnel that help me with their manufacturing knowledge and gave me the opportunity to develop this study.

Luis Centeno

DEDICATION

To my wife, my parents, my family, and my friends.

Kike

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Chapter 1

Introduction

1.1. Company background

Sala Group International is one of the world's leading designers and manufacturers of height safety products, engineered safety systems, controlled access systems, rescue equipment, and retrieval equipment. DBI Sala is the most productive United States business unit of Sala Group International.

DBI Sala manufactures and sells personal fall protection and rescue equipment for construction, general industry, climbing and confined space access. Also, DBI Sala provides training, technical assistance and customer service. The company has more than 25 years experience and it is located in Red Wing, Minnesota. The market for the company includes U.S., Canada, Europe, Australia, and some Latin American countries. DBI Sala products are tested and certified to the standards issued by OSHA (Occupational Safety & Health Administration), ANSI (American National Standard Institute), and processes certified to ISO 9001 (International Standards Organization). The most important DBI Sala finished goods are: harnesses, shock absorbing lanyards, self-retracting lifelines, rescue equipment, retrieval equipment, and netting.

The structure of the company includes the following departments: Operations, Engineering, Information Technology, Accounting, Human Resources, Purchasing, Sales, and Marketing. The Operations Department is outlined by the Belt Room Area, the Metal Fabrication Area, the Quality Control Area, the Block Repair Area, the Shipping Area, the Warehouse Area, the Receiving Area, and the Maintenance Area.

All the products are assembled in the Belt Room Division, and in the Metal Fabrication Division. The main function of the other areas is to assist Belt Room and Metal Fabrication areas. Some appropriate examples are the Quality Control Division, responsible for the quality of all the products, the Shipping Division, responsible for shipment of all the products, and the Warehouse Division, responsible for the storage of all the products.

The Belt Room Division assembles products that do not include heavy metal parts, or cables in their fabrication, such as harnesses, belts, and other products assembled with rope. On the other hand, the Metal Fabrication Division assembles those products that have heavy metal parts or cables in their fabrication. Within the Metal Fabrication Division are the SRL (Self Retracting Line) Block, the Web Block, the Winch Block, the Welding Area, the CNC Machinery Block, and the Repairing Block.

1.2. Problem statement

Almost all the Metal Fabrication products have cable as one of their essential parts; therefore, cable assemblies are one of the most important sub-assemblies or feeders on the manufacturing floor. Current problems in cable assembly are: wasting time for the material handler to pick the cable and deliver to next station in the routing for the cable assembly, longer cycle times for final products, less customer satisfaction because of longer cycle times, decrease on sales, high rates on non-value added production times within each product, and higher production costs. The root cause of these problems is that there is no specific production line or location for cable assemblies. Each step included to fabricate cable is situated on a different corner of the shop floor. This procedure creates all of the problems listed above.

The proposed solution is to establish a cable assembly line that supports the SRL Block, the Web Block, and the Winch Block. This line will serve as sub-assembly or feeder for most of the final products on the Metal Fabrication Division.

1.3. Demand Flow Technology

Demand Flow Technology is a managerial tool that helps companies to adjust manufacturing operations in the direction of the actual sales. The main goal is to "take quality products from Design Engineering to the customer as quickly as possible" (Costanza, 1996). DFT not only involve the Operations or Manufacturing Department; it

affects all Departments within a company, including Operations, Purchasing, Sales, Marketing, Human Resources, Research & Development, Engineering, Quality, Estimating, and Accounting, among others.

Demand Flow Manufacturing techniques concentrate in:

- Process design
- Material turn-over
- Minimal over-head support costs
- Quality of the assembled products

DBI Sala started to implement DFT approximately since May 2001. Even though the company is trying to implement DFT in all the departments, this study will focus on the design of a new cable assembly line following DFT concepts but only on the manufacturing point of view.

This is an outline with the steps that DFT recommends to create a new production line, that are applied to set the cable assembly line:

- Determine active cable assembly products.
- Analyze current cable assembly flow.
- Group in families the cable assemblies based on the functional operations.
- Built the mapping process for all the cable assemblies.
- Describe the relationship of processes in a flow to produce a product (product synchronization) for all cable assemblies.

- Define the quantity of resources at a process: operations (labor); machinery and equipment; and parts.
- Determine total product cycle time: the calculated work content through the longest path of the process required to build a product (identify non-value added steps and work to eliminate them).
- Physically place workstations and machines to support the production process.
- Measure and interpret results.

There are some time and space constraints in the design. One limitation was to try to set the line in a place around the area where the cable is cut it. There were a lot of inventory racks in that area and the goal was to set the new cable assembly line taking out as few as possible of those racks. On the other hand, it was the best place to set the line because it is located in the beginning on the production floor, and it will be easier to assist with cables final DFT production lines from this area. Otherwise, the company DFT schedule established approximately four months from the education about DFT to physically situate the new cable assembly line, and it was the pilot for the implementation of DFT in the whole company. With the experience and knowledge obtained with this pilot project, the company assumes that will be easier to implement DFT production lines in the whole DBI Sala manufacturing floor, besides other Sala Group facilities.

Because it is the pilot project for the total DFT implementation on the manufacturing department, the results are not measured in terms of DFT main objectives as: reduce inventory, reduce customer lead times, reduce manufacturing floor space, increase

customer satisfaction, and reduce overhead costs. The company is planning to do that when finished with the implementation of DFT on the whole manufacturing floor, but it assumes it is the first step to get those goals. The measurement of the results are focused on non-value added time saved on each cable assembly with the new line, that is a sub-assembly or feeder for subsequently final assembly products (this time saved it is a direct reduction of the final product cycle time); and on the dollars saved because of the reduction of direct labor hours (workers on the line) needed per cable assembly with the new flow concept implemented.

Chapter 2

Literature Review

2.1. DFT concepts

DFT is a business tool that could be applied to all manufacturing companies regardless of company sizes, kind of products, and quantity of products assembled. Pulling material control techniques are used in the manufacturing process. DFT tries to accomplish the following objectives:

- Increase inventory turns (rotation).
- Reduce customer lead times.
- Easily introduce new products.
- Reduce manufacturing floor space.
- Reduce overhead costs.
- Produce higher quality products.
- Improve cash flow.

"There are three basic elements of product cost:

- Material to make the product.
- Overhead costs for the people and facilities to design, develop and support the product.

- Direct Labor – the employees who typically physically build the product." (Costanza, 1996).

DFT focuses on elements 1 and 2 (90%-97% of the costs). Material Requirement Planning (MRP), another common manufacturing system, focuses on element 3 (3%-10% of the costs).

There are some important DFT concepts regarding to manufacturing (Costanza, 1996); the most relevant are:

"Kanban is a technique of the Demand Flow manufacturing material replenishment system. Using a single-card/container kanban technique, when a kanban container is emptied it is to be refilled. It is replenished from the point of supply listed on the kanban card. The kanban pull process is defined as the points of supply and usage of a particular part. Thus, all the information required to replenish kanbans is listed on the card.

Product synchronization is a technique to show the relationship of the individual flow processes coming together to create the part or product. Once the Product synchronization is defined, each of the individual processes is broken into a TQC (Total Quality Control) Sequence of Events (SOE).

TQC sequence of events (SOE) is the first key elements of a TQC flow process. It is the series of work content steps and quality criteria that need to be completed in order to

manufacture the quality products. Instead of thinking in terms of batches or subassemblies, the thought process should follow the natural flow of the product.

The TQC sequence of events describes the sequential work and, most importantly, the quality criteria for each work step to manufacture the product. Each task in the sequence of events is classified in one of four categories of work. The four categories are:

- Required labor work.
- Required machined work.
- Setup time.
- Move time.

The quality requirements for each step are then identified. Once the TQC sequence of events has been developed and the quality criteria defined, this flow of the product will then dictate the line layout.

Required Labor Time: represent the required steps performed by people for the product to meet your advertised product specifications. While labor time is needed in order for the product to meet these specifications, not all labor time is value-added.

Required machine time also represents the essential steps performed by machines for product to meet your specifications. Required machine time, like required labor time, may or may not add value to the product.

Setup time is work that is performed prior to require machine or labor time, and it, too, is always non-value added. Setup time can range from changing a tool pack and making the

necessary adjustments on a large machine to opening and removing a cable from a package. Once non-value added steps are identified, modification in packaging, line layout, and machine setup procedures can often be made to reduce setup time.

Move time is the time spent in moving products or materials through the process, from the point where they were produced or introduced to the point where they will be consumed. Move time may be either with labor or machine time. It is always non-value added work. Appreciable move time is usually indicative of a poor line layout.

Value added: steps in the production process that increase the worth of a product or service to an external customer or consumer. The part of the product and process specification the customer is expecting and willing to pay to receive.

Non-value added: steps in the production process that may currently be necessary but do not increase the worth of a product or service to a customer.

Process Mapping: a matrix of processes defined by the product synchronizations. A Demand Flow technique used to determine the commonality of manufacturing processes and commonality of products. The objective of process mapping is to develop families of products that share common processes to see which products can be produced in the same mix-model Demand Flow Line."

2.2. Comparison of DFT with other techniques

Even though the cable assembly line follows DFT concepts for its design, there are other managerial tools very similar to DFT that could serve as an excellent point of comparison. The objective is to evaluate some DFT manufacturing concepts versus very popular manufacturing techniques as Lean Manufacturing, Just in Time (JIT), and Enterprise Resource Planning (ERP) to identify some weaknesses and strengths of the DFT implementation.

DFT and ERP are total business strategies, meaning that they involve all units within the organization. On the other hand, Lean Manufacturing and JIT are production systems concentrated in only manufacturing related processes (Costanza, 1996). Focusing on the production process (Costanza, 1996), ERP and JIT need more stock or cushion of materials to keep against an unexpected demand because they are driven by forecast; however, DFT is driven by actual demand and has faster capacity of response.

During last decades, manufacturing companies have been changed by the concept of speed (McIlvane, 1997), "In the 1970's and 1980's speed in manufacturing meant automation: robotics, automated material handling, computer-aided design (CAD). In the 1990's, speed has become a business issue. What matters now is time-to-market, rapid implementation of automation, and quick response to change. That requires speed plus synchronization", focus on flexibility and adaptability to new products. Now, it is important how fast you are, not how big you are (Costanza, 1996). Otherwise, it is

recognized that "many of the principles of DFT can also be found in lean manufacturing, continuous flow, and agile manufacturing ideologies- practiced by an equally growing number of companies and addressed in books by some well known authors" (Greene, 2000).

Some authors (Tully, 1994) establish that DFT follow the same parameters that JIT but goes far broader. With JIT, companies demand daily shipments from suppliers, or ship finished products the hour the customer needs them. However, in terms of efficiency, most of these suppliers simply ship from huge inventories to meet rapid schedules. In contrast, DFT main benefit is zero working capital, and it permanently raises earnings. Working capital consists of raw materials, work-in-process, and finished goods inventories. This is not a realistic situation because if you have no inventory, you have no product to make or sell.

In DFT, each assembler performs his own quality assurance and inspections of the previous operators because they are trained to do it, based on flow concepts. In contrast, under the batch method (batch manufacturing techniques) it is performed by quality assurance inspectors (Lemley, 1992). Also, in Lean Manufacturing or JIT operators perform their own checking.

The graphic tool called product synchronization by DFT is the operation process chart that has been used in manufacturing from long time ago. The operations process chart "shows the chronological sequence of all operations, inspections, time allowances, and

materials used in a manufacturing or business process- from the arrival of raw material to the packaging of the finished product. It depicts the entrance of all components and subassemblies to the main assembly" (Niebel, 1993). The product synchronization does not synchronize any times; it is just another way to draw an operation process chart.

A work cell concept was developed to establish the cable assembly line. The work cell idea " is to reorganize people and machines that would ordinarily be dispersed in various process departments and temporarily arrange them in a small group so they can focus on making a single product of related products" (Heizer & Render, 1996). Some advantages of work cells are: reduced raw material, work-in-process, and finished good inventory; less floor space; decreased direct labor cost; and increased use of tools and machinery.

Finally, the two main reasons why the company selected to implement DFT within the organization are:

- Top management members success in the implementation of DFT in other companies.
- DFT is implemented in some of the most admired companies in the US, such as: American Standards, General Electric, Dell Computer, Whirlpool, Quaker Oats, and Campbell Soup, among others (Tully, 1994).

Chapter 3

Methodology

The following set of activities was performed on the DBI Sala cable subassemblies:

- Determine active cable assembly products.
    - Extract all cable assembly products.
    - Get all cable assembly routings.
- Analyze current cable assembly flow.
- Group into cable assembly families depending on the functional operations from each routing.
- Describe the relationship of processes in a flow (product synchronization) for all cable assemblies.
- Create the SOE (Sequence of Events) for each cable assembly family.
- Build the mapping process for all the cable assemblies.
- Design the new production line; defining the quantity of resources at a process: operations (labor); machinery and equipment; and parts.
    - Identify the raw materials for all cable assemblies.
    - Set the quantities for each raw material used in all cable assemblies.
    - Establish kanbans for each raw material included in all cable assemblies.
    - Design racks for storage (Kanbans: Materials).
    - Identify all machinery and tools needed to assemble all products.
    - Define machine requirements and utilities.

  - Estimate number of people to work on the new line, based on the experience of the Operations Manager, and Metal Fabrication Supervisor.
- Determine total product cycle time.
  - Identify non-value added steps and work to eliminate them.
- Physically place workstations and machines to support the production process.
  - Make formal requirements for the purchase of new machinery, kanban containers, and materials for new racks, needed on the new cable assembly line.
- Measure and interpret results.
  - Based on the SOE, establish an estimate for the time saved on each cable assembly product.
  - Identify the number of direct labor hours needed to meet the daily demand of cables, and calculate an average of dollars saved per day related to this subject.

Chapter 4

Data Analysis

This is the analysis of the data obtained to create the new cable assembly line. In some cases, it will be a summary because of the extended of the information.

4.1. Process description

DBI Sala produces more than 1,000 cable assembly products. Each product has assigned a routing number to be identified within the company system. Some products could have the same routing number if they have all common assembly activities or steps (functional operations), with different lengths of the products, or different sizes of similar raw material. The routing describes all the assembly activities or steps needed to build a specific product with details. The first step was to identify all cable assembly products and their routings. A sample with five of the most important routings and their products is in Appendix A.

The welding machine is use to weld the cable ends, and prevent fray. The stamp machine is use to stamp the product label with the item number of the product, the company ID (identification number), the manufacturing date, and the length of the cable. The Esco machine is a machine that put a constant pressure around all the cable, and permits to assemble end stops to the cable. Also, the Esco machine can help the cable to hold other

safety elements as pin eyes, and turnbuckles. The vise is a tool, situated in the assembly table, used to hold the cable while the worker is adding him some necessary parts as labels, thimbles, snap hooks, or counterweights. The clincher is a machine, located on the assembly table, used to clinch any kind of ferrules to the cable that helps the cable to keep the hook.

Next DFT steps are to make product synchronization, SOE (Sequence of Events), and process mapping for each product. DBI Sala manufacturing management considered it a waste of time to describe more than 1,000 cable assembly products. Therefore, cable assembly products were grouped in families based on the common functional operations from each routing. Consequently, each family includes products having routings with similar functional operations. Appendix B is a table that includes 48 families identified, and the functional operations or activities that follow each family. Figure 4.1 shows 5 sample families. The table is a summary of the products and routings that belong to each family, following the company codification (product number, description of the product, and routing number). Also, it includes the quantity of products that follow each routings, and each family. The creation of this table took a lot of time because was based on checking all existing routings. The plan was to make product synchronization, and SOE (Sequence of Events), and process mapping for each family, instead of for each cable product, as recommended by DFT. Even for each family, it was a long work to do develop these concepts for the cable assemblies.

Figure 4.1. Five sample families

EXAMPLE OF FIVE FAMILIES OF CABLE PRODUCTS (Based on common assembly activities)

Family	Product	Qty.	Description	Routing	
6	3512010	46	Cab Assy, 3511063, 10' 3511645 Attached	3512010	Cut, Weld, Stamp, Ass. Cable-Twin Base
	3512500		Cab Assy, 3511063, 10' 3511645 Attached	3512500	Clip-Label-Thimble (Vise), Torque
15	3401031	21	Cable Assy, SRL, 33' SS	CAN3400-060	Cut, Weld, Crimp Cable Stops (ESCO)
	3401051		Cable Assy, SRL, 50' Galv 9502324	CAN3400-060	Thimble to Hook (VISE),
	3401053	1	Cable Assy, SRL, 50' SS 9502324	CAN3400-060	Ass. Ferrules-Thimble-Hook (Clincher)
	3401054	1	Cable Assy, SRL, 33' Galv 9502324	3401054	
	3401056	1	Cable Assy, SRL, 85' SS 9502324	M3500-060	
	3401063	1	Cable Assy, SRL, 75' SS 3401215	M3401063	
23	7000010	24	Cab Assy, HLL, 10' Turnbuckle	M06609-10	Cut, Weld, Stamp, *Write Length*, *Grommet Label*,
	7000420		Cab Assy, HLL, 420' Turnbuckle	M06609-410	Ass. Pin Eye-Turnbuckle- Thimble & Swage(ESCO)
					Ass. Cable-Twin Base Clip-Label-Thimble (Vise), *Torque*
37	2105563	1	DPLN Cab 10' 5/16, 9503175, 5900172 Ends	2105563	Cut, Weld, Stamp, Thimble to Snap (Clincher), Ass. Snap Hook-Clip-Label-Thimble-Counterweight (VISE), Torq.
48	2100200	1	Anchor Cable 5.5' 2000524 Ends	M010659	Cut, Weld, Stamp, Grommet Label,
	2100203	1	Anchor Cable 3' 2000524 Ends	M010658	Ass. Ferrule-Cable-Thimble-Snap-Label (Clincher)
	2100310	1	Anchor Cable 10' 9503175 Ends	M4348DDC10	
	2100315	1	Anchor Cable 15' 9503175 Ends	M4348DDC15	
	2100320	1	Anchor Cable 20' 9503175 Ends	M4348DDC20	

Family: one family is compound by products with common activities, or assembly steps, or functional operations
Product: part number for each product,
if more than one follow one routing: we reference from what product number to what product number.
Quantity: the quantity of products that belongs to each family.
Description: the description of each product number
Routing: the rounting number followed by each product,
if more than one product follow one routing: we reference from what product number to what product number.
Common Activities: these are the steps needed to assemble each family,
all products included in a family have common activities.

The product synchronization is a technique to show the relationship of the individual flow processes coming together to create the product. It shows a summary of the principal steps to assembly the product, in an easier way to understand than routings, but without the details of routings or SOE. It will be helpful in the design of multiple final assembly lines because shows all sub-assemblies are included to develop a final product, and the final assembly line for this product. The product synchronization could be valuable for final products or finished goods, and could include information from more than one routing, depending on the number of sub-assemblies for each final product. But, in this case it was a waste of time because the cable assembly line is a sub-assembly for final products, and all cables will be assembled in only one production line. The cable assembly line does not have sub-assemblies or feeders that support it. The product synchronization was defined for each cable assembly family, and was based on the functional operations included on the routings. There is one example of product synchronization for a cable family in Appendix C.

TQC Sequence of Events (SOE) is a table that contains all work content steps or functional operations and quality criteria that need to be completed in order to manufacture a product. DFT recommend one SOE for each product. SOE includes: the product description; the item number (company code); the date of creation of the SOE; the time unit, the quantity of unique; the functional operations number (#); the functional operations description with sub-divisions; the time to make each functional operation sub-division and classify it: if it is value or non-value added time, if it is setup time, required time, move time, machine time and labor time (defined in the Literature

Review); the quality information; and an estimate of the total time to assembly one unit of a product. Each time was taken on the manufacturing floor and each one is an average of five or more samples. Setup time listed is per unit, it is equal to the total setup time divided by the average order size. Move time listed is per unit, it is equal to total move time divided by the average order size. The meaning of the SOE is to get a result of the non-value steps that could be eliminated or reduced from the cable assemblies; if exist, find the opportunity to increase production times by the automation of some processes (change some labor time to machine time); and apply this to the new production line. 48 SOE (Sequence of Events) were created, one for each cable assembly family. Appendix D presents five SOE from five different cable families. Figure 4.2 shows one example. SOE was very helpful for the implementation of the new cable assembly line because it was created in order to identify non-value added time (move, setup or inspection times) reflected by this SOE. Also, gave DBI Sala people an idea of the time that could be saved training operators to perform the quality assurance procedures. The SOE have more details (including times) in the description of the functional operations than the product synchronization, and the process mapping. Finally, Appendix D-6 include a summary with most repeated non-value added activities took it from the SOE, and their approximate duration times. This summary illustrates in a clear way the non-value steps to eliminate or reduce on the design of the new cable line.

The process mapping is a matrix of processes defined by the product synchronization. It does not include the functional operations on details. It is simple to create, and includes each product and their functional operations. Like the product synchronization, the

Figure 4.2. SOE for a cable family

PRODUCT: Family 6 (130')		TIME UNIT: *MINUTES*
ITEM #: 3512130	DATE: Nov 30, 2001	QUANTITY: *1*

DEMAND FLOW TECHNOLOGY (S.O.E.)

SEQ. #	FUNCTIONAL OPERATION	V. A.	Setup		REQUIRED		Move		QUALITY INFO.
			M	L	MACH.	LAB.	M	L	
1	**REVISION TO ROUTING**								
A.	Revision to Routing	NO				0.03			
2	**CABLE PULLER**								
A.	Setup	NO	1.08						
B.	Pull & Cut Cable	YES				3.23			
C.	Bring the Material to the Inspection Area	NO						0.10	
3	**INSPECTION-METAL FAB**								
A.	Inspect Check Cable Length 10%	NO				0.01			Inspect Cable Length
B.	Bring Material to the Welding Area	NO						0.283	
4	**WELDING TIG**								
A.	Setup	NO		0.169					
B.	Weld Cable Ends	YES				0.78			Welding Procedure Specification
C.	Bring Material to Next Work Table	NO						0.177	
5	**STAMP MANUAL**								
A.	Setup the Machine	NO		0.057					
B.	Stamp Label with Item, ID #, Manuf. Date, Lenght	YES				0.42			
C.	Bring Material to Next Work Table	NO						0.16	
6	**ASSEMBLE**								
A.	Setup	NO		0.175					
B.	Mark Cable 4" from End	YES				0.08			
C.	Assemble (VISE)	YES				3.92			
	Twin Base Clip (Torque to 30 FT-LBS)								Torque to 30 FT-LBS
	Label								
	Thimble								
D.	Bring Material to Inspection	NO						0.06	
7	**INSPECTION-METAL FAB**								
A.	Inspect per Print and/or Guidelines	NO				0.90			Inspect per Print and/or Guidelines
B.	Put it on the System	NO				0.02			
8	**SHIP TO STOCK-METAL FAB**								
A.	Ship to Stock Metal-Fab	NO						0.07	
			1.08	0.40	0.00	9.38	0.00	0.84	

Total Time: 11.70

Seq.#: number of activity
V.A.: if the activity is value added, or non-value added (see the concept in the literature review)
M: machine time (see the concept in the literature review)
L: labor time (see the concept in the literature review)
MACH.: machine time (see the concept in the literature review)
LAB.: labor time (see the concept in the literature review)
Setup: setup time (see the concept in the literature review)
Required: activity necessary to assembly the product
Move: move time (see the concept in the literature review)
Total Time: the duration of all the activities to assemble the product. The sum of all setup, required, and move times

process mapping will be valuable in the design of more than one final assembly line because shows a map with the products and the functional operations in a way easy to group depending on the common functional operations and design different production lines based on the commonality of the processes. The mapping process could be valuable for final products or finished goods, and could include information from more than one routing, depending on the number of sub-assemblies for each final product. But, in this case do this was a waste of time because the cable assembly line is a sub-assembly for final products, and all cables will be assembled in only one production line. So, DBI Sala manufacturing management skipped this step for the design of the new cable assembly line.

4.2. Storage area design

The table in Appendix E includes the 76 raw materials, and the quantity used per day over the last three months (this information was obtained from the company manufacturing system). This quantity was divided by three to obtain the monthly use, shown in the Appendix E (20 working days). Three months are equivalent to 60 working days, then if you divide that quantity by 60 the result is an average of how many parts are used in a working day. Also, the manufacturing management decided to start setting kanbans for one day on each container, working with 2 containers of materials on the line racks. The fraction numbers were round up to be more secure. There were designed two different storage racks on the production line: one located beside the Esco machine for parts used in that machine, and another storage rack located on the final table assembly

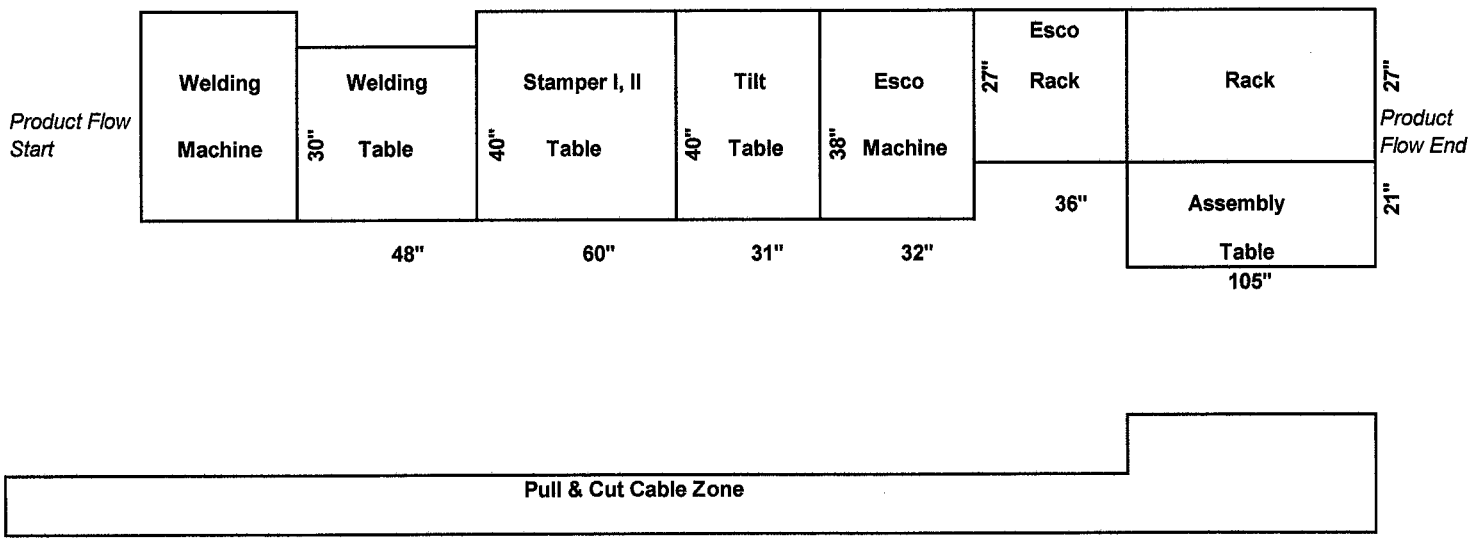
for parts to be worked with tools from this table. To give one day to the material handler to replenish an empty container, kanbans were set for one day; and due to space constraints on the line, the racks are designed to have two containers for each part. The space constraints came with the idea to establish the line close to the original cut & pull cable area and in this area were placed some big storage racks; so, another objective was to move as few as possible of these old racks. In addition, each part was observed and classified by its size as: small, medium or big; based on the measurements of the containers already establish by the container company supplier. The container size for each part also was based on the number of parts set for each container (kanban). Then, the racks were designed focus on the number of containers and the size of them. Rack design and containers specifications are included in Appendix F. Most used parts were placed closest to the machines where they are used.

4.3. Line layout

Based on the product synchronization and the SOE of each family, it was easy to determine the machines that will be included in the line layout. All products use the machines in the same order. Some products may skip some of the operations, but no product uses the operations in a different order. After measuring each machine, calculating the space required on the floor for the line, and determining the table assembly size; came the design of the whole layout. The new cable assembly layout is shown in Figure 4.3, and it goes left to right. The machinery requirements and utilities necessary to establish the new line were determined, and included in Appendix G.

Figure 4.3. New cable line layout

NEW CABLE ASSY LINE (Top View)



Drawing with No Scale

People that will work in the new cable assembly line, received a training in quality assurance by the quality supervisor to performs their own quality process and inspections on the line, and eliminate move, setup and queue times originated by a separate quality assurance area.

4.4. Economic analysis

The approximate time saved on each cable assembly product family was calculated (see Appendix H) ranging from 0 to 1 minute. The numbers come from times took it on the floor while the old method to assemble cables was running. Setup times were reduced and move times were eliminated with the implementation of the new cable assembly line because machines are next to each other and these machines are dedicated to one type of products.

An economic study determined the number of direct labor hours needed to meet the daily demand of cables once established the new line, and the money saved (see appendix I). The study shows the reduction of 12 daily labor hours in the cable assemblies to meet the same daily demand of 150 cables per day, resulting in $1.60 per cable, or $240 per day. Consequently, the study reflects the improvement of efficiency obtained with the implementation of the new production line.

Chapter 5

Conclusions

The implementation of the new cable assembly line was successful and it started to save money for DBI Sala since the first day of implementation. However, the improvements are due to the implementation of flow production concept in the assembly of cables. Similar results could be obtained following Lean Manufacturing/ Just in Time scheme, or ERP ideas, from a manufacturing point of view. DFT is another flow manufacturing technique where John Costanza changed some common manufacturing terms and followed some concepts already established in the market. As a point against DFT, people on the floor seem to be confused because the change of some standard manufacturing terms, such as: sub-assemblies for feeders, or warehouses for raw in process area. On the other hand, referring to the DFT book "The Quantum Leap" (Costanza, 1996) the steps to follow DFT implementation are very clear; even clearer that other manufacturing techniques books, such as: "ERP: Making it Happen" (Wallace & Kremzar, 2001).

The entire DFT implementation in companies varies, and they have to be very careful. Information about DFT is hard to find and expensive to obtain compared with other techniques like ERP, Lean Manufacturing or Just in Time. There are examples of companies in financial problems because of the expense of DFT education and implementation (Rutledge, 1993).

The zero working capital (no inventory) DFT concept is not a realistic situation because if you have no inventory, you have no product to make or sell. At this point, DBI Sala has not worked with inventory reduction. This result could be analyzed after the total implementation of DFT in the manufacturing floor, remembering that the new cable assembly line is only a feeder or sub-assembly in the floor, and next steps are the design of new final assembly lines on the metal fabrication area. Also, there could be a reduction of time spent if companies design production lines based on the experience of the manufacturing staff instead of follow step-by-step some DFT concepts (mapping process, SOE, product synchronization), that took a lot of time for all cables. Even the next step if you follow DFT techniques is the creation of operational sheets, which will take a lot of time by the engineering department. Operational sheet is a DFT tool used on the floor to guide workers on the line, which includes the drawing of the product parts and how to assemble these parts, all this information in a sheet of paper (letter size).

One next step is to implement a method where vendors directly replace parts on the production line storage racks. However, because this is a process planned after set all new production lines on the floor, there are not improvements on raw material inventory (reductions) at this time. Currently, the cable assembly line gets inventory from the warehouse. Another next step is to estimate WIP (Work in Process) inventory reduction, and throughput time reduction.

Kanbans sizing may bring problems depending on the variability of demand. If daily demand for a part is one (kanban size), and there is an order for three, it will stop the

process. The Toyota kanban equation could be an alternative to solve this problem because it provides a safety stock level for every part used on the line.

Finally, as a conclusion the problems were solved. The work done in the design of the new cable assembly line could be applied in the design of new production lines in DBI Sala, and in other similar business units of Sala Group International. At this point, we can not prove that DBI Sala achieved DFT main objectives as: reduce inventory, reduce customer lead times, reduce manufacturing floor space, and increase customer satisfaction. The company is planning to measure that when finished with the implementation of DFT on the whole manufacturing floor. But, it is true that the company began to reduce overhead costs, and reduce the production time of cable assemblies. DBI Sala is trying to involve all departments within the organization, because DFT is a total business strategy; but this study is only focus in the manufacturing point of view.

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Appendix A. Routings

Routing: 3512130
CAB ASSY, 3511063, 130' 3511645 ATTACHED

1 *REVISE REVISION TO ROUTING.*

2 *CUT 1/4" CABLE X 130'.*
MARK AT 23 1/2" FROM END.

3 *INSPECT CABLE LENGTH 10%.*

4 *WELD CABLE ENDS TO PREVENT FRAY.*

5 *STAMP I.D. LABEL WITH ITEM, DATE, I.D. NUMBER AND LENGTH. MARK DIAMETER AND MATERIAL.*
USE FIXTURE T1871.

ITEM	LENGTH	DIAMETER	MATERIAL
3512130	130	1/4	WIRE

6 *ASSEMBLE CABLE, TWIN BASE CLIPS, LABEL, THIMBLE, & 3511645. (TORQUE TO 30 FT-LBS*

7 *INSPECT PER PRINT AND/OR GUIDELINES.*

8 *SHIP TO STOCK-METAL FAB.*

Routing: CAN3400-060

1 *REVISE REVISION TO ROUTING.*

2 *CUT 3/16" CABLE X 50'*

ITEM NUMBER	CABLE
3401039	9501479
3401041	9501613
3401042	9501613
3401051	9501479
3401053	9501613
3401064	9501479
3401380	9501613

3 *INSPECT CHECK CABLE LENGTH 10%.*

4 *WELD CABLE ENDS.*

5 *ASSEMBLE AND CRIMP CABLE STOPS.*
USE FIXTURE T2878.

6 *ASSEMBLE THIMBLE TO SWIVEL HOOK IF PRESENT.*

7 *ASSEMBLE FERRULES, SWIVEL HOOK ASSEMBLY, BUMPER, & CABLE GUIDE ASSEMBLY TO CABLE & CRIMP FERRULES.*

8 *INSPECT-CHECK SWAGE & ASSEMBLY PER PRINT.*

9 *SHIP TO STOCK-METAL FAB.*

Routing: M06609-10

1 *REVISE REVISION TO ROUTING.*

2 *STAMP (9500065) LABEL WITH ITEM, DATE & I.D. NUMBER.*
USE FIXTURE T1855.

3 *WRITE LENGTH IN FT. ON 9500065 LABEL.*

4 *CUT 9500098 CABLE X*

ITEM	LENGTH
7000010	15'
7000020	25'
7000025	30'

5 *WELD EACH END OF CABLE TO PREVENT FRAY.*

6 *MARK CABLE 2 1/2" FROM END.*
ASSEMBLE PARTS & SWAGE. USE TOOL T2875. TORQUE CABLE CLIPS TO 45 FT-LBS.

7 *INSPCT-M INSPECT PER PRINT AND/OR GUIDELINES.*

8 *PREPACK ON INSTRUCTION SHEET*
CHECK PART NUMBER, WRITE PART NUMBER IN BLANK SPACE OR PLACE LABEL IN 2 X 4" SPACE PROVIDED.

9 *PACKAGE REMAING PARTS.*

10 *SHIP TO STOCK-METAL FAB.*

Routing: 2105563
DPLN CAB 10' 5/16 9503175, 5900172 ENDS

1 REVISE REVISION TO ROUTING.

2 STAMP I.D. LABEL WITH ITEM, DATE & I.D. NUMBERS. MARK LENGTH, MATERIAL, & DIAMETER..
USE FIXTURE T1871.

3 CUT 9501591 CABLE X 10' 8".

4 WELD EACH END OF CABLE TO PREVENT FRAY.

5 ASSEMBLE THIMBLE TO SNAP.

6 ASSEMBLE PARTS & TORQUE CABLE TO 30 FT-LBS.

7 INSPECT PER PRINT AND/OR GUIDELINES.

8 SHIP TO STOCK-METAL FAB.

Routing: M4348DDC20

1 *REVISE REVISION TO ROUTING.*

2 *CUT 3/8 GALV. CABLE X 20'5".*

3 *WELDTIG WELD EACH END OF CABLE TO PREVENT FRAY.*

4 *GROMMET LABELS.*

5 *STAMP I.D. LABEL WITH ITEM, DATE, I.D. NUMBER & LENGTH. MARK MATERIAL & DIAMETER.*

USE FIXTURE T1871.

ITEM	LENGTH	MATERIAL	DIAMETER
2100320	20	WIRE	3/8

6 *ASSEMBLE CABLE, FERRULES, LABEL, THIMBLES AND SNAP HOOKS AND CRIMP PER PRINT.*

7 *INSPECT PER PRINT AND/OR GUIDELINES.*

8 *SHIP TO STOCK-METAL FAB.*

Appendix B. Cable assembly families

Family	Product	Qty.	Description	Routing	Common Activities
1	7260060	1	Cable, 8 mm. x60' 7x7, 316SS, USA	M2371-51	Cut Cable
	7230002	109	Cable, Sayf, 12 mm.x2.33', 7x7, 316SS, USA	M2372	Final Inspection
	7231620		Cable, Sayf, 12 mm.x1620', 7x7, 316SS, USA	M2372-1611	
	6110007	382	Cable, Flex, 3/8x7', 1x7 Galv.	M396	
	6116000		Cable, Flex, 3/8x6000', 1x7 Galv.	M396-5991	
	6120010	105	Cable, Flex, 3/8x10', 1x7 SS	M397	
	6121750		Cable, Flex, 3/8x1750', 1x7 SS	M397-1731	
	7240000	11	Cable, Sayf, 1/2x105', 1x19, Galv.	M4245-91	
	7240010		Cable, Sayf, 1/2x20', 1x19, Galv.	M4245-11	
2	6130004	67	Cable, Flex, 3/8x4', 7x19 Galv.	M98-11	Cut Cable
	6133200		Cable, Flex, 3/8x6000', 1x7 Galv.	M98-3191	Weld End of Cable
	6140007	106	Cable, Flex, 3/8x7', 7x19, SS	M99	Final Inspection
	6142800		Cable, Flex, 3/8x2800', 7x19, SS	M99-2791	
	3511000		Cable, SSB63, 3/16x150' 7x19, 302SS	3511000	
	3511001		Cable, SSB63, 3/16x160 7x19, 302SS	3511001	
	3511002		Cable, SSB63, 3/16x300 7x19, 302SS	3511002	
	3511003	9	Cable, 1/4x350', 7x19, Galv.	3511003	
	3511011		Cable, 1/4x50', 7x19, Galv.	3511011	
	3401000	1	Cable, 3/16x175', 7x19', Galv.	3401000	
	6126023	6	Cable, Flex, 5/16x23, 7x19, Galv.	M1591-11	
	6126175		Cable, Flex, 5/16x175, 7x19, Galv.	M1591-171	
3	6152009	145	Cable, Flex, 3/8 x 9, Assy 1x7, SS	M126-11	Cut Cable, Mark Cable
	6155000		Cable, Flex, 3/8 x 1050, Assy 1x7, SS		Assemble Parts & Swage, Insp.
4	6151030	46	Cable, Flex, 3/8 x 30, Assy 1x7, Galv.	M5888-30	Cut, Stamp End of Carrier Lug
	6151250		Cable, Flex, 3/8 x 30, Assy 1x7, Galv.	M5888-250	Mark, Ass. Parts & Swage, Insp.
5	3510008	36	Cab Assy, 3511063, 8'	M1160	Cut, Stamp, Ass. Cable-Twin Base Clip
	3510600		Cab Assy, 3511063, 600'	M1160-600	Clip-Label-Thimble (Vise), Torque
6	3512010	46	Cab Assy, 3511063, 10' 3511645 Attached	3512010	Cut, Weld, Stamp, Ass. Cable-Twin Base
	3512500		Cab Assy, 3511063, 10' 3511645 Attached	3512500	Clip-Label-Thimble (Vise), Torque
7	5901000	1	DPLN Cab 20' 3/8 Galv 9503175, 5900172 Ends	M009778	Cut, Weld, Stamp, Ass. Cable-Twin Base
	5901001	1	DPLN Cab 22' 3/8 Galv 9503175, 5900172 Ends	M010339	Clip-Label-Thimble (Vise), Torque
	5901008	1	DPLN Cab 85' 3/8 Galv 9503175, 5900172 Ends	M010212	
	5901002	13	DPLN Cab 28' 3/8 Galv 9503175, 5900172 Ends	M1176-11	
	5901020		DPLN Cab 40' 3/8 Galv 9503175, 5900172 Ends	M1176-31	

Family	Product	Qty.	Description	Routing	Common Activities
	5901013	1	DPLN Cab 150' 3/8 Galv 9503175, 5900172 Ends	M4391	
	5901014	1	DPLN Cab 160' 3/8 Galv 9503175, 5900172 Ends	M4391	
	5901015	1	DPLN Cab 45' 3/8 SS 9503175 & 5900172 Ends	5901015	
	5901016	1	DPLN Cab 45' 3/8 SS 9503175 & 5900172 Ends	5901016	
	5901021	1	DPLN Cab 45' 3/8 SS 9503175 & 5900172 Ends	5901021	
8	3900520	10	Cab Assy, 3000057, Galv, 9500100 End	3900520	Cut, Weld, Ass. End Stops(ESCO),
	3900530		Cab Assy, 3700500, Galv	3900530	Ass. Crimp Snap, Tear Drop Thimble & Ferr. (Clincher)
9	2100107	1	Cab Assy, 7' 3/16" O-Ring One End	M3809	Cut, Weld, Stamp, Ass. Thimble-
	2100109	1	Cab Assy, 3/16" O-Ring One End x 20'		Snap-O-Ring-ID Tag (Clincher)
	2100125	1	Cab Assy, 3/16" O-Ring One End x 25'		
10	8100040	7	Cab Assy, Winch 50' 1/4 Galv.	M1850-003	Cut, Weld, Ass. Ferrules-Thimble
	8100047		Cab Assy, Winch 140' 1/4 Galv.	8100047	Hook (Clincher)
11	3302100	1	Cab Assy, 115' Galv 9503175, Control Descent	M3302100	Cut, Weld, Ass. Thimble (Clincher),
	3302103	1	Cab Assy, 115' SS 9503175, Control Descent	M3302100	Crimp Cable Stops (ESCO),
	3302106	1	Cab Assy, 200' Galv 9503175, Control Descent	M3302100	Ass. Parts-Snap-Ferrule-Thimble (Clincher).
	3302107	1	Cab Assy, 200' SS 9503175, Control Descent	M3302100	
12	3520012	12	Cab Assy, 3504430, 5' Galv 9502324 End	CAN02321	Cut, Weld, Thimble to Hook (VISE),
	3520027		Cab Assy, 3506001, 11' SS 2102325 End	CAN02321	Crimp Cable Stops (ESCO), Ass. Heat Shrink (Gun),
					Ass. Snap Hook-Ferrule-Eyelet-Thimble (Clincher)
13	3520070	6	Cab Assy, 3504430, 20' Galv Repairs	3520070	Cut, Weld, Crimp Cable Stops (ESCO)
	3520075		Cab Assy, 3504430, 50' SS Repairs	3520075	Ass. Heat Shrink (Gun)
14	3911603	1	Cable, Cable Stops, Galv 175' SRL	3911603	Cut, Weld, Crimp Cable Stops (ESCO)
	3401340	6	Cable, Cable Stops, Galv 50' SRL	M3400-065	
	3401345		Cable, Cable Stops, SS 130' SRL	M3600-065	
	3401346		Cable, Cable Stops, SS 175' SRL	3911603	
15	3401031	21	Cable Assy, SRL, 33' SS	CAN3400-060	Cut, Weld, Crimp Cable Stops (ESCO)
	3401051		Cable Assy, SRL, 50' Galv 9502324	CAN3400-060	Thimble to Hook (VISE),
	3401053	1	Cable Assy, SRL, 50' SS 9502324	CAN3400-060	Ass. Ferrules-Thimble-Hook (Clincher)
	3401054	1	Cable Assy, SRL, 33' Galv 9502324	3401054	
	3401056	1	Cable Assy, SRL, 85' SS 9502324	M3500-060	
	3401063	1	Cable Assy, SRL, 75' SS 3401215	M3401063	
16	6153124	1	Cable, Flex, 3/8x124, Assy 7x19, Galv	M5889-111	Cut, Weld,
	6153150	1	Cable, Flex, 3/8x150, Assy 7x19, Galv	M5889-131	Ass. Carrier Lug & Shock Absorver (ESCO)
	6153180	1	Cable, Flex, 3/8x180, Assy 7x19, Galv	M5889-171	
	6154002	40	Cable, Flex, 3/8x2, Assy 7x19, SS	M5890	
	6154140		Cable, Flex, 3/8x140, Assy 7x19, SS	M5890-131	

Family	Product	Qty.	Description	Routing	Common Activities
17	7001010	25	Cable, HLL, 10', Swage Fitting	M066-10	Cut, Weld, Ass. Pin Eye (ESCO)
	7001450		Cable, HLL, 450', Swage Fitting	M066-450	
18	7008560	1	Cable, Assy, 60', 7008501	M7008560	Cut, Weld, Ass. Ferrule-Carabiner-Turnbuckle-
	7008561	1	Cable, Assy, 60', 7008502	M7008561	Energy Absorver-Thimble (Clincher)
19	6147002	25	Climbing Extension 2'	M171	Cut, Weld, Ass. Carrier Lug (ESCO)- Counterweight
	6147120		Climbing Extension 120'	M171-120	
20	7004010	1	Cab Assy, Single Span, 10' Zorbit	M7004010	Cut, Weld, Stamp, *Write Length*, *Grommet Label*,
	7004020	1	Cab Assy, Single Span, 20' Zorbit	M7004020	Ass. Ferrule-Turnbuckle-Energy Abs.-
	7004030	1	Cab Assy, Single Span, 30' Zorbit	M7004030	Thimble-Shackle (Clincher)
	7004040	1	Cab Assy, Single Span, 40' Zorbit	M7004040	
	7004050	1	Cab Assy, Single Span, 50' Zorbit	M7004050	
	7004060	1	Cab Assy, Single Span, 60' Zorbit	M7004060	
	7402510	1	Cab Assy, Beamsafe, 10' Zorbit	M7402510	
	7402520	1	Cab Assy, Beamsafe, 20' Zorbit	M7402520	
	7402530	1	Cab Assy, Beamsafe, 30' Zorbit	M7402530	
	7402540	1	Cab Assy, Beamsafe, 40' Zorbit	M7402540	
	7402550	1	Cab Assy, Beamsafe, 50' Zorbit	M7402550	
	7402560	1	Cab Assy, Beamsafe, 60' Zorbit	M7402560	
21	7004070	1	Cab Assy, Multi Span, 70' 2 Zorbit	7004070	Cut, Weld, Stamp, *Write Length*, *Grommet Label*,
	7004120	1	Cab Assy, Multi Span, 120' 2 Zorbit	7004120	Swage Thimble End (ESCO)
	7004150	1	Cab Assy, Multi Span, 150' 2 Zorbit	7004150	Ass. Ferrule-Turnbuckle-Energy Abs.-
	7004300	1	Cab Assy, Multi Span, 300' 2 Zorbit	7004300	Thimble-Shackle (Clincher)
22	7402020	1	Cab Assy, Beamsafe, 20'	7402020	Cut, Weld,
	7402030	1	Cab Assy, Beamsafe, 30'	7402030	Ass. Cable-Hardware & Torque (VISE)
	7402040	1	Cab Assy, Beamsafe, 40'	7402040	Ass. Cable-Thimble-Ferrules (Clincher)
	7402050	1	Cab Assy, Beamsafe, 50'	7402050	
	7402060	1	Cab Assy, Beamsafe, 60'	7402060	
23	7000010	24	Cab Assy, HLL, 10' Turnbuckle	M06609-10	Cut, Weld, Stamp, *Write Length*, *Grommet Label*,
	7000420		Cab Assy, HLL, 420' Turnbuckle	M06609-410	Ass. Pin Eye-Turnbuckle- Thimble & Swage(ESCO)
					Ass. Cable-Twin Base Clip-Label-Thimble (Vise), *Torque*
24	5900205	1	DPLN Cab 4' 3/8 Galv 9503175 Ends	M010254	Cut, Weld, Stamp, Thimble to Hardware (VISE)
	5900210	1	DPLN Cab 2.17' 3/8 Galv 2000524 Ends	M010254	Ass. Ferrule-Carabiner-Thimble & Swage(ESCO)
	5900211	1	DPLN Cab 2.92' 3/8 Galv 2000524 Ends	M010254	
	5900212	1	DPLN Cab 6.17' 3/8 Galv 2000524 Ends	M010254	
	5900213	1	DPLN Cab 8.92' 3/8 Galv 2000524 Ends	M010254	
	5900222	1	DPLN Cab 5' 3/8 Galv 9503175 Ends	M010254	

Family	Product	Qty.	Description	Routing	Common Activities
	5900206	1	DPLN Cab 10' 3/8 SS 9503175, 9503880 Ends	M010412	
	5900209	1	DPLN Cab 3.5' 3/8 SS 9503175, 9503880 Ends	M010412	
	5900214	1	DPLN Cab 6' 3/8 SS 9503175, 9503880 Ends	M010412	
	5900225	1	DPLN Cab 8' 3/8 SS 9503175, 9503880 Ends	M010412	
	5900207	1	DPLN Cab 4' 3/8 SS 2100000 Ends	M010427	
	5900220	1	DPLN Cab 5' 3/8 SS 2100000 Ends	M010427	
	5900200	1	DPLN Cab 8' 3/8 SS 9503175 Ends	M009651	
	5900201	1	DPLN Cab 10' 3/8 SS 9503175 Ends	M009651	
	5900202	1	DPLN Cab 12' 3/8 SS 9503175 Ends	M009651	
	5900203	1	DPLN Cab 38.5' 3/8 SS 9503175 Ends	M009991	
	5900204	1	DPLN Cab 21' 3/8 SS 9503175 Ends	M009991	
	5900215	1	DPLN Cab 2' 3/8 SS 9503175, 2007153 Ends	M5900215	
	5900224	1	DPLN Cab 3.83' 3/8 SS 9503175, 2007153 Ends	M5900215	
	5900216	1	DPLN Cab 2' 3/8 SS 9503175 Ends	M5900216	
	5900217	1	DPLN Cab 2.5' 3/8 SS 9503175 Ends	M5900216	
	5900218	1	DPLN Cab 3.3' 3/8 SS 9503175 Ends	M5900216	
	5900219	1	DPLN Cab 3.67' 3/8 SS 9503175 Ends	M5900216	
	5900223	1	DPLN Cab 3.83' 3/8 SS 9503175 Ends	M5900216	
25	5900208	1	DPLN Cab 28' 3/8 SS 9506596 Ends	M010448	Cut, Weld, Stamp, Grommet Label, Thimble to Hardware
	5900221		DPLN Cab 180' 3/8 SS Thimble, Cut Ends	M5900221	(VISE), Ass. Ferrule-Carabiner-Thimble & Swage(ESCO)
26	5900226	14	DPLN Cab 140' 3/8 SS Thimble, Cut Ends	5900226	Cut, Weld, Stamp, Grommet Label,
	5900239		DPLN Cab 135' 3/8 SS Thimble, 9503880 Ends	M5900238	Ass. Ferrule-Thimble & Swage(ESCO)
	5900270	8	DPLN Cab 140' 3/8 SS Thimble, 9503880 Ends	M5900238	
	5900277		DPLN Cab 150' 3/8 SS Thimble, 9503880 Ends	M5900228	
27	5900110	13	DPLN Cab 52' 3/8 Galv 9503714, 9503879 Ends	M010996	Cut, Weld, Stamp,
	5900122		DPLN Cab 6' 3/8 Galv 9503175 Ends	5900122	Ass. Cable & Hardware-D-Ring-Thimble (VISE), Torque
	5900124	5	DPLN Cab 66.5' 3/8 Galv 9503175 Ends	M1176-A10	
	5900129		DPLN Cab 70' 3/8 Galv 9503714, 9503879 Ends	M5900126	
28	5900123	1	DPLN Cab 30' 3/8 Galv 9503175 & 2000108 Ends	5900123	Cut, Weld, Stamp,
					Ass. Cable & Hardware-Carabiner-Thimble (VISE), Torque
29	5900150	6	DPLN Cab 10' 3/8 Galv 2000108, 9501404 Ends	M011017	Cut, Weld, Stamp, Grommet Label, Ass. Thimble & O-Ring
	5900155		DPLN Cab 11' 3/8 Galv 2000108, 9501404 Ends	M011017	(Clincher), Ass. Cable & Hardware-Carabiner-
					Thimble- O-Ring (VISE), Torque
30	3900531	1	Cab Assy, DBU, Galv 9500100 End	3900531	Cut, Weld, Swedge Ferrules and End Stops (ESCO)
					Ass. Thimble-Ferrule-Rubber Balls-Snap Hook
					& Grommet into Cable (Clincher)

Family	Product	Qty.	Description	Routing	Common Activities
31	8100055	4	Cab Assy, Winch, 90' 3/16, Galv, Salalift II	8100055	Cut, Weld, Ass.Hook-Ferrules-Thimble-Bushing (Clincher)
	8100058		Cab Assy, Winch, 120' 3/16, SS, Salalift II	8100058	
32	8100100	1	Cab Assy, Winch, 120' 3/16, Galv, 9507668, Salalift	8100100	Cut, Weld, Swage Button Stop (ESCO) Ass.Hook-Ferrules-Thimble-Bushing (Clincher)
33	8103000	1	Winch Mat'l only 9500100, MTG Brkt	8103000	Cut, Weld, Ass.Hook-Ferrules-Thimble-Bushing (Clincher)
	8103001		Winch Mat'l only SS 9500100, MTG Brkt	8103000	
34	8100090	1	Cab Assy, Winch, Tagline 50', 3/16, SS, 8102100	M8100090	Cut, Weld, Crimp Cable Stops (ESCO) Ass. Thimble-Ferrule-Rubber Balls-Clip (Clincher)
35	3401165	1	Cab Assy, Winch, 60' 1/4 Galv, Salalift II	3401165	Cut, Weld, Thimble to Hook (VISE),
	3401166	1	Cab Assy, L7400, 60' SS	3401166	Ass. Cable-Hook-Ferrules (Clincher)
	3401167	1	Cab Assy, Winch, 60' 1/4 SS, Salalift II	3401165	
36	3514072	1	Rung Belt Hook Assy 3511063	3514072	Cut, Weld, Stamp, Ass. & Crimp: Thimble-Ferrules-Hook-Label (Clincher)
37	2105563	1	DPLN Cab 10' 5/16, 9503175, 5900172 Ends	2105563	Cut, Weld, Stamp, Thimble to Snap (Clincher), Ass. Snap Hook-Clip-Label-Thimble-Counterweight (VISE), Torq.
38	5000800	1	RG (5001011) System 30' 1 5001011, Zorbit	M5000800	Cut, Weld, Stamp,
	5000801	1	RG (5001011) System 30' 2 5001011, Zorbit	M5000800	Ass. & Swage: Label-Turnbuckle-Energy Absorver-
	5000802	1	RG (5001011) System 30' 4 5001011, Zorbit	M5000800	Thimble-Ferrules (Clincher)
39	2105564	1	DPLN Cab 80' 5/16, 9503175 Ends	2105564	Cut, Weld, Stamp, Ass. Thimble to Snap (Clincher),
	2105565	1	DPLN Cab 100' 5/16, 9503175 Ends	2105565	Ass. Snap-Clip-Label-Cable (VISE)
40	3520000	1	Brake Lever Counterweight	3520000	Cut, Weld, Ass. Cable-Thimble-Ferrules (Clincher)
41	5900021	1	Positioning Cable 3' 9503175 Ends	M011874	Cut, Weld, Stamp,
	5900022	1	Positioning Cable 3.5' 9503175 Ends	M011875	Erase " Meets OSHA and ANSI A10.14-1991 Type II
	5900023	1	Positioning Cable 10' 9503177 Ends	M970DDC10	Requirements"
	5900024	1	Positioning Cable 4' End Wyatt	M970DDC4	Ass. Cable-Thimble-Label-Ferrules-Snap (Clincher)
	5900105	1	Positioning Cable 6' 9503177 Ends	M970DDC4	
42	5900025	1	Positioning Cable 4' 2100001 Ends-Trailer	M970T4	Cut, Weld, Ass. Thimble to Snap (Clincher),
	5900026	1	Positioning Cable 6' 2100001 Ends-Trailer	M970T6	Ass. Cable-Thimble-Label-Snap (Clincher)
43	3401052	1	Cable Assy, SRL, 25' Galv 9502324	3401052	Cut, Weld, Ass. & Crimp Cable Stops (ESCO), Ass. Cable-Ferrules-Hook (Clincher)
44	3302104	1	Cab Assy, 115' Galv 9503175, Control Descent	M3302101	Cut, Weld, Ass. Thimble (Clincher),
	3302105	1	Cab Assy, 115' SS 9503175, Control Descent	M3302101	Crimp Cable Stops (ESCO),
					Ass. Parts-Snap-Standoff-Swivels-Ferrule-Thimble (Clincher).
45	4100000	1	Net Demo Kit	4100000	On the Shipping Area
46	3401230	1	Retrieval Handle Grip	3401230	Cut, Strip of Plastic Covering on Ends, Ass. & Crimp: Cable-Grip-Ferrule (ESCO)

Family	Product	Qty.	Description	Routing	Common Activities
47	5901579	1	Tagline 20' Loop End 1/16 Galv	5901579	Cut, Remove Plastic Cover, Crimp Ferrules (Clincher)
48	2100200	1	Anchor Cable 5.5' 2000524 Ends	M010659	Cut, Weld, Stamp, Grommet Label,
	2100203	1	Anchor Cable 3' 2000524 Ends	M010658	Ass. Ferrule-Cable-Thimble-Snap-Label (Clincher)
	2100310	1	Anchor Cable 10' 9503175 Ends	M4348DDC10	
	2100315	1	Anchor Cable 15' 9503175 Ends	M4348DDC15	
	2100320	1	Anchor Cable 20' 9503175 Ends	M4348DDC20	

Family: one family is compound by products with common activities, or assembly steps, or functional operations
Product: part number for each product,
if more than one follow one routing: we reference from what product number to what product number.
Quantity: the quantity of products that belongs to each family.
Description: the description of each product number
Routing: the rounting number followed by each product,
if more than one product follow one routing: we reference from what product number to what product number.
Common Activities: these are the steps needed to assemble each family,
all products included in a family have common activities.

Appendix C. Product synchronization

PRODUCT SYNCHRONIZATION: CABLE ASSY

Product: 3512130 (130')

Family: 6

CUT	INSPECT	WELD	STAMP	ASSEMBLE	INSPECT	SHIP
4.41 min.	0.29 min.	1.13 min.	0.64 min.	4.23 min.	0.92 min.	0.07 min.

Assemble Thimble to Hook (VISE)

Appendix D-1. SOE for a cable family

PRODUCT: Family 6 (130')									TIME UNIT: *MINUTES*
ITEM #: 3512130				DATE: Nov 30, 2001					QUANTITY: *1*

DEMAND FLOW TECHNOLOGY (S.O.E.)

SEQ. #	FUNCTIONAL OPERATION	V. A.	Setup		REQUIRED		Move		QUALITY INFO.
			M	L	MACH.	LAB.	M	L	
1	**REVISION TO ROUTING**								
A.	Revision to Routing	NO				0.03			
2	**CABLE PULLER**								
A.	Setup	NO	1.08						
B.	Pull & Cut Cable	YES				3.23			
C.	Bring the Material to the Inspection Area	NO						0.10	
3	**INSPECTION-METAL FAB**								
A.	Inspect Check Cable Length 10%	NO				0.01			Inspect Cable Length
B.	Bring Material to the Welding Area	NO						0.283	
4	**WELDING TIG**								
A.	Setup	NO		0.169					
B.	Weld Cable Ends	YES				0.78			Welding Procedure Specification
C.	Bring Material to Next Work Table	NO						0.177	
5	**STAMP MANUAL**								
A.	Setup the Machine	NO		0.057					
B.	Stamp Label with Item, ID #, Manuf. Date, Lenght	YES				0.42			
C.	Bring Material to Next Work Table	NO						0.16	
6	**ASSEMBLE**								
A.	Setup	NO		0.175					
B.	Mark Cable 4" from End	YES				0.08			
C.	Assemble (VISE)	YES				3.92			
	Twin Base Clip (Torque to 30 FT-LBS)								Torque to 30 FT-LBS
	Label								
	Thimble								
D.	Bring Material to Inspection	NO						0.06	
7	**INSPECTION-METAL FAB**								
A.	Inspect per Print and/or Guidelines	NO				0.90			Inspect per Print and/or Guidelines
B.	Put it on the System	NO				0.02			
8	**SHIP TO STOCK-METAL FAB**								
A.	Ship to Stock Metal-Fab	NO						0.07	
			1.08	0.40	0.00	9.38	0.00	0.84	

Total Time: 11.70

Seq.#: number of activity
V.A.: if the activity is value added, or non-value added (see the concept in the literature review)
M: machine time (see the concept in the literature review)
L: labor time (see the concept in the literature review)
MACH.: machine time (see the concept in the literature review)
LAB.: labor time (see the concept in the literature review)
Setup: setup time (see the concept in the literature review)
Required: activity necessary to assembly the product
Move: move time (see the concept in the literature review)
Total Time: the duration of all the activities to assemble the product. The sum of all setup, required, and move times

Appendix D-2. SOE for a cable family

PRODUCT: Family 15 (50')								TIME UNIT: *MINUTES*
ITEM #: 3401041			DATE: Nov 30, 2001					QUANTITY: *1*

DEMAND FLOW TECHNOLOGY (S.O.E.)

SEQ. #	FUNCTIONAL OPERATION	V. A.	Setup		REQUIRED		Move		QUALITY INFO.
			M	L	MACH.	LAB.	M	L	
1	**REVISION TO ROUTING**								
A.	Revision to Routing	NO				0.03			
2	**CABLE PULLER**								
A.	Setup (Including Cut Tape, and Pick Holders Up)	NO	0.09						
B.	Cut Cable	YES				1.07			
C.	Bring the Material to the Inspection Area	NO						0.10	
3	**INSPECTION-METAL FAB**								
A.	Inspect Check Cable Length 10%	NO				0.01			Inspect Cable Length
B.	Bring Material to the Welding Area	NO						0.283	
4	**WELDING TIG**								
A.	Setup	NO		0.17					
B.	Weld Cable Ends	YES				0.78			Welding Procedure Specification
C.	Bring Material to Next Work Table	NO						0.177	
5	**ASSEMBLE**								
A.	Setup	NO		0.07					
B.	Assemble End Stops, Crimp in Press (ESCO)	YES			1.02				
C.	Bring Material to Next Work Table	NO						0.10	
6	**ASSEMBLE**								
A.	Setup	NO		0.08					
B.	Assemble Thimble to Hook (VISE)	YES				0.53			
C.	Bring Material to Next Work Table	NO						0.08	
7	**ASSEMBLE**								
A.	Setup	NO		0.08					
B.	Assemble (Clincher) Hook Thimble & Ferrules	YES				2.08			
C.	Bring Material to Inspection	NO						0.06	
8	**INSPECTION-METAL FAB**								
A.	Inspect per Print and/or Guidelines	NO				0.90			Inspect per Print and/or Guidelines
B.	Put it on the System	NO				0.02			
9	**SHIP TO STOCK-METAL FAB**								
A.	Ship to Stock Metal-Fab	NO						0.07	
			0.09	0.40	1.02	5.43	0.00	0.86	

Total Time: 7.80

Seq.#: number of activity
V.A.: if the activity is value added, or non-value added (see the concept in the literature review)
M: machine time (see the concept in the literature review)
L: labor time (see the concept in the literature review)
MACH.: machine time (see the concept in the literature review)
LAB.: labor time (see the concept in the literature review)
Setup: setup time (see the concept in the literature review)
Required: activity necessary to assembly the product
Move: move time (see the concept in the literature review)
Total Time: the duration of all the activities to assemble the product. The sum of all setup, required, and move times

Appendix D-3. SOE for a cable family

PRODUCT: Family 23 (50')									TIME UNIT: *MINUTES*
ITEM #: 7000050				DATE: Dec 7, 2001					QUANTITY: *1*

DEMAND FLOW TECHNOLOGY (S.O.E.)

			Setup		REQUIRED		Move		
SEQ. #	FUNCTIONAL OPERATION	V. A.	M	L	MACH.	LAB.	M	L	QUALITY INFO.
1	**REVISION TO ROUTING**								
A.	Revision to Routing	NO				0.03			
2	**CABLE PULLER**								
A.	Setup	NO	1.08						
B.	Pull & Cut Cable	YES				1.24			
C.	Bring the Material to the Inspection Area	NO						0.10	
3	**INSPECTION-METAL FAB**								
A.	Inspect Check Cable Length 10%	NO				0.01			Inspect Cable Length
B.	Bring Material to the Welding Area	NO						0.28	
4	**WELDING TIG**								
A.	Setup	NO		0.17					
B.	Weld Cable Ends	YES				0.78			Welding Procedure Specification
C.	Bring Material to Next Work Table	NO						0.18	
5	**STAMP MANUAL**								
A.	Setup the Machine	NO		0.06					
B.	Stamp Label with Item, ID #, Manuf. Date, Lenght	YES				0.42			
C.	Bring Material to Next Work Table	NO						0.16	
6	**ASSEMBLE**								
A.	Write Length on Label (HAND)	YES				0.15			
7	**ASSEMBLE**								
A.	Grommet Label	YES				0.17			
8	**ASSEMBLE**								
A.	Setup	NO		0.07					
B.	Mark Cable 2.5" from End	YES				0.08			
C.	Assemble (ESCO)	YES			2.17				
	Pin Eye								
	Turnbuckle								
	Thimble								
9	**ASSEMBLE**								
A.	Setup	NO		0.08					
B.	Assemble (VISE)	YES				3.92			
	Twin Base Clip (Torque to 45 FT-LBS)								Torque to 45 FT-LBS
	Label								
	Thimble								
C.	Bring Material to Inspection	NO						0.06	

40 INSPCT-M	**INSPECTION-METAL FAB**								
A.	Inspect per Print and/or Guidelines	NO				0.90			Inspect per Print and/or Guidelines
B.	Put it on the System	NO				0.02			
999 SHIPM	**SHIP TO STOCK-METAL FAB**								
A.	Ship to Stock Metal-Fab	NO						0.07	
			1.08	0.38	2.17	7.71	0.00	0.84	

Total Time: 12.17

Seq.#: number of activity
V.A.: if the activity is value added, or non-value added (see the concept in the literature review)
M: machine time (see the concept in the literature review)
L: labor time (see the concept in the literature review)
MACH.: machine time (see the concept in the literature review)
LAB.: labor time (see the concept in the literature review)
Setup: setup time (see the concept in the literature review)
Required: activity necessary to assembly the product
Move: move time (see the concept in the literature review)
Total Time: the duration of all the activities to assemble the product. The sum of all setup, required, and move times

Appendix D-4. SOE for a cable family

PRODUCT: Family 37 (10')									TIME UNIT: *MINUTES*
ITEM #: 2105563					DATE: Dec 7, 2001				QUANTITY: *1*

DEMAND FLOW TECHNOLOGY (S.O.E.)

SEQ. #	FUNCTIONAL OPERATION	V. A.	Setup		REQUIRED		Move		QUALITY INFO.
			M	L	MACH.	LAB.	M	L	
1	**REVISION TO ROUTING**								
A.	Revision to Routing	NO				0.03			
2	**CABLE PULLER**								
A.	Setup	NO	1.08						
B.	Pull & Cut Cable	YES				0.25			
C.	Bring the Material to the Inspection Area	NO						0.10	
3	**INSPECTION-METAL FAB**								
A.	Inspect Check Cable Length 10%	NO				0.01			Inspect Cable Length
B.	Bring Material to the Welding Area	NO						0.28	
4	**WELDING TIG**								
A.	Setup	NO		0.17					
B.	Weld Cable Ends	YES				0.78			Welding Procedure Specification
C.	Bring Material to Next Work Table	NO						0.18	
5	**ASSEMBLE**								
A.	Setup	NO		0.09					
B.	Assemble Thimble to Snap (Clincher)	YES				1.07			
6	**ASSEMBLE**								
A.	Setup	NO		0.08					
B.	Assemble (VISE)	YES				3.92			
	Twin Base Clip (Torque to 30 FT-LBS)								Torque to 30 FT-LBS
	Snap Hook								
	Label								
	Thimble								
	Counterweight								
C.	Bring Material to Inspection	NO						0.06	
7	**INSPECTION-METAL FAB**								
A.	Inspect per Print and/or Guidelines	NO				0.90			Inspect per Print and/or Guidelines
B.	Put it on the System	NO				0.02			
8	**SHIP TO STOCK-METAL FAB**								
A.	Ship to Stock Metal-Fab	NO						0.07	
			1.08	0.33	0.00	6.98	0.00	0.68	

Total Time: 9.07

Seq.#: number of activity
V.A.: if the activity is value added, or non-value added (see the concept in the literature review)
M: machine time (see the concept in the literature review)
L: labor time (see the concept in the literature review)
MACH.: machine time (see the concept in the literature review)
LAB.: labor time (see the concept in the literature review)
Setup: setup time (see the concept in the literature review)
Required: activity necessary to assembly the product
Move: move time (see the concept in the literature review)
Total Time: the duration of all the activities to assemble the product. The sum of all setup, required, and move times

Appendix D-5. SOE for a cable family

PRODUCT: Family 48 (20')								TIME UNIT: *MINUTES*
ITEM #: 2100320			DATE: Dec 14, 2001					QUANTITY: *1*

DEMAND FLOW TECHNOLOGY (S.O.E.)

SEQ. #	FUNCTIONAL OPERATION	V. A.	Setup M	Setup L	REQUIRED MACH.	REQUIRED LAB.	Move M	Move L	QUALITY INFO.
1	**REVISION TO ROUTING**								
A.	Revision to Routing	NO				0.03			
2	**CABLE PULLER**								
A.	Setup (Including Cut Tape, and Pick Holders Up)	NO	0.09						
B.	Cut Cable	YES				0.66			
C.	Bring the Material to the Inspection Area	NO						0.10	
3	**INSPECTION-METAL FAB**								
A.	Inspect Check Cable Length 10%	NO				0.01			Inspect Cable Length
B.	Bring Material to the Welding Area	NO						0.28	
4	**WELDING TIG**								
A.	Setup	NO		0.17					
B.	Weld Cable Ends	YES				0.78			Welding Procedure Specification
C.	Bring Material to Next Work Table	NO						0.18	
5	**STAMP MANUAL**								
A.	Setup the Machine	NO		0.1					
B.	Stamp Label with Item, ID #, Manuf. Date, Lenght	YES				0.42			
C.	Bring Material to Next Work Table	NO						0.16	
6	**ASSEMBLE**								
A.	Grommet Label	YES				0.17			
7	**ASSEMBLE**								
A.	Setup	NO		0.09					
B.	Assemble (Clincher)	YES				2.08			
	Ferrule								
	Cable								
	Thimble								
	Label								
	Snap								
C.	Bring Material to Inspection	NO						0.06	
8	**INSPECTION-METAL FAB**								
A.	Inspect per Print and/or Guidelines	NO				0.90			Inspect per Print and/or Guidelines
B.	Put it on the System	NO				0.02			
9	**SHIP TO STOCK-METAL FAB**								
A.	Ship to Stock Metal-Fab	NO						0.07	
			0.09	0.31	0.00	5.06	0.00	0.84	

Total Time: 6.30

Seq.#: number of activity
V.A.: if the activity is value added, or non-value added (see the concept in the literature review)
M: machine time (see the concept in the literature review)
L: labor time (see the concept in the literature review)
MACH.: machine time (see the concept in the literature review)
LAB.: labor time (see the concept in the literature review)
Setup: setup time (see the concept in the literature review)
Required: activity necessary to assembly the product
Move: move time (see the concept in the literature review)
Total Time: the duration of all the activities to assemble the product. The sum of all setup, required, and move times

Appendix D-6
CABLE ASSY (NON-VALUE ADDED ACTIVITIES)

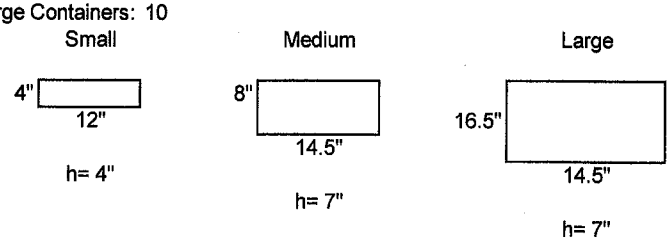
Cable Puller:	
Put each Cable on the Container:	3.89 sec.
Go to the Inspection Table:	10.16 sec.
Inspector:	
Take each Cable from the Container to Inspect:	5.72 sec.
Put each Cable on the Container after Inspected:	3.05 sec.
Go to the Welding Area:	2.11 sec.
Welder:	
Bring the Cable Container near the Welding Table:	14.88 sec.
Take each Cable from the Container to Weld:	3.85 sec.
Put each Cable on the Container after Welded:	3.85 sec.
Go to the ESCO Machine:	2.92 sec.
ESCO:	
Take each Cable to Crimp Stops:	4.38 sec.
Put each Cable on the Container after Crimped:	4.38 sec.
Go to VISE Machine:	1.66 sec.
VISE:	
Take each Cable to Assemble Thimble	4.69 sec.
Put each Cable on the Container after Assemble Thimble	4.69 sec.
CRIMP:	
Take each Cable to Crimp Ferrules	4.75 sec.
Put each Cable on the Container after Crimp Ferrules	4.75 sec.
Go to the Inspection Table:	3.31 sec.

Appendix E- Cable Assembly Raw Materials Summary (Based on the Used of Last Three Months: Company System)

#	ITEM (Pat Number and Description)	Estimated Used for 20 Days	Part Size	Used for 1 Day	Used for 2 Days	Container Size	Location Rack on Line
1	1010100 (Swivel, 5/16, Jaw&Jaw, SS, Drilled)	20.00	Small	1	2	Small	Table
2	2000108 (Carabiner,2 3/16 Throat)	33.00	Medium	2	3	Small	Table
3	2000524 (Carabiner,11/16" Throat ZP with Pin)	98.00	Medium	5	10	Small	Table
4	2100000 (Snap Hook, Locking, Swivel)	14.00	Medium	1	1	Small	Table
5	2102324 (Hook, Impact Indicator, PL Brass Ferrule, L7400)	150.00	Small	8	15	Small	Table
6	2102325 (Hook, Impact Indicator, SS Brass Ferrule)	15.00	Small	1	2	Small	Table
7	3302990 (Cable Guide, 3303015)	3.00	Medium	0	0	Small	Table
8	3401215 (Swivel Hook W/Impact Ind)	647.00	Medium	32	65	Medium	Table
9	3401216 (Swivel Hook W/Impact SS)	84.00	Medium	4	8	Medium	Table
10	3401365 (Cable Guide Assy)	195.00	Medium	10	20	Medium	Table
11	3401366 (Cable Guide Assy W/ Nylon Sleeve)	344.00	Medium	17	34	Medium	Table
12	3511645 (Rung/Belt Hook Assy 3511063)	20.00	Large	1	2	Large	Table
13	3908149 (Button Stop, 3/4, Alum 3000057)	291.00	X-Small	15	29	Small	Esco
14	3908151 (Ferrule, Duplex, Alum 3/16 3000057)	1778.00	Small	89	178	Small	Table
15	3908152 (Ferrule, Copper, Dup, 3/16 3000057)	1327.00	Small	66	133	Small	Table
16	3908468 (Bushing, Cable, Plastic 3006050 3700500)	0.00	Small	0	0		
17	3908807 (Ferrule,1/16, Alum, Duplex)	444.00	X-Small	22	44	Small	Table
18	7002050 (Turnbuckle,Jaw&Jaw,5/8x12,Galv,Modified)	107.00	Medium	5	11	Medium	Table
19	7006597 (Turnbuckle, Jaw&Jaw,3/4x12,Galv,Modified)	10.00	Large	1	1	Large	Table
20	9500083 (Eyelet, Guide, Nylon, 3504430, 3504450)	124.00	X-Small	6	12	Small	Table
21	9500100 (Snap Hook, Locking, Swivel)	190.00	Medium	10	19	Medium	Table
22	9500265 (Quick Link, 1/4, 316SS)	1.00	Small	0	0	Small	Table
23	9500398 (Carrier Lug, SS, 3/8 Cable)	88.00	Medium	4	9	Medium	Esco
24	9500743 (Quick Link, 3/8, ZP 7/16 Opening, 8800 Tensl)	9.00	Small	0	1	Small	Table
25	9500942 (Thimble, 1/2, TD, Galv)	14.00	Small	1	1	Small	Table
26	9501162 (Ferrule,1/4, Alum Duplex)	562.00	Small	28	56	Small	Table
27	9501163 (Ferrule,7/32, Alum Duplex)	675.00	Small	34	68	Small	Table
28	9501164 (Thimble, 1/4, TD, Galv)	302.00	Small	15	30	Small	Table
29	9501404 (O-Ring, 1/2x3, Chromate)	6.00	Medium	0	1	Small	Table
30	9501419 (Adjuster, Oval, CP, Forged)	724.00	Small	36	72	Small	Table
31	9501563 (Clip, Cable, 3/8, Twin Base Galv Forged)	280.00	Small	14	28	Small	Table
32	9501743 (Clip, Cable, 3/16, Galv)	0.00	Small	0	0		
33	9502016 (Ferrule, Duplex, 1/4, CU)	137.00	Small	7	14	Small	Table
34	9502320 (Tubing, Shrink, .400x.500 Polyolefin)	453.00	X-Small	23	45	Small	Table
35	9502324 (Hook, Impact Indicator, PL Brass Ferrule)	487.00	Medium	24	49	Medium	Table
36	9503000 (Ferrule, Duplex, 3/8, Alum)	236.00	Small	12	24	Small	Table
37	9503016 (Clip, Cable, 1/4, Twin Base Galv)	52.00	Small	3	5	Small	Table
38	9503175 (Snap Hook, Self Locking)	92.00	Medium	5	9	Medium	Table
39	9503285 (Cable Tie, 8, Black Nylon)	13333.00	X-Small	667	1333	Small	Table
40	9503366 (Bumper, Cable Guide, 3403400)	1481.00	Medium	74	148	Medium	Table
41	9503442 (Cable Stop, .19x.5, 304SS 3403400)	355.00	Small	18	36	Small	Esco

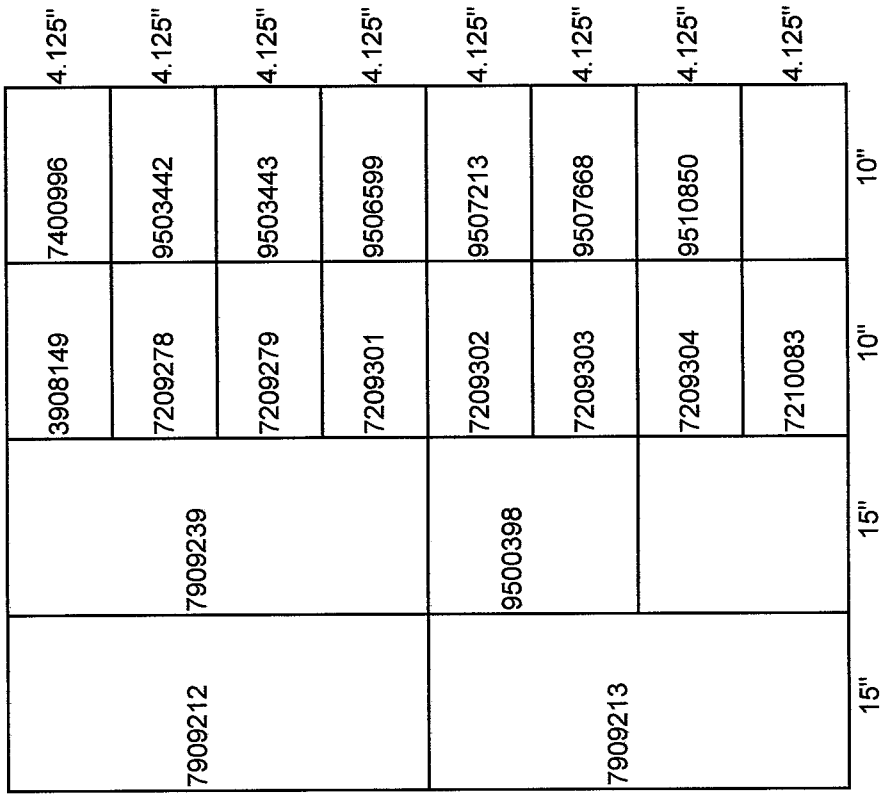
42	9503443 (Cable Stop,Tapered, 304SS 3403400)	1041.00	Small	52	104	Small	Esco
43	9503627 (Rope Guide, L3405)	4.00	Small	0	0	Small	Table
44	9503713 (Clip, Cable, 5/16, Twin Base Galv)	0.00	Small	0	0		
45	9503714 (Thimble, 3/8, TD, Galv)	6.00	Small	0	1	Small	Table
46	9503747 (Thimble, 1/4, TD, HD)	337.00	Small	17	34	Small	Table
47	9504047 (Thimble, 3/16, TD, SS)	1955.00	Small	98	196	Small	Table
48	9504440 (Eyelet, Guide, 3504430, 3504450)	339.00	Small	17	34	Small	Table
49	9505566 (Thimble, 5/16, TD, Galv)	0.00	-	0	0		
50	9506595 (Shackle, Chain,1/2, Galv, No Pin)	407.00	Medium	20	41	Medium	Table
51	9506596 (Thimble, 3/8, TD, HD, Galv)	172.00	Small	9	17	Small	Table
52	9506599 (Pin Eye Terminal, 3/8 SA154)	12.00	Medium	1	1	Small	Esco
53	9507213 (Button Stop, .281x.563x.845, SS)	96.00	Small	5	10	Small	Esco
54	9507668 (Button Stop, .203x.568x.737 304SS)	30.00	Small	2	3	Small	Esco
55	9508299 (Tubing, Shrink, 1x5 SD100)	141.00	X-Small	7	14	Small	Table
56	9509297 (Pin, Coil, 2.75mmx18.25mm SS)	55.00	X-Small	3	6	Small	Table
57	9509654 (Ferrule, 3/8, SS, Duplex)	24.00	Small	1	2	Small	Table
58	9510099 (Thread Locking Compound Removable Blue)	0.00	Liquid	0	0		
59	9510759 (Cable Grip 3/16-1/2)	2.00	Medium	0	0	Small	Table
60	9510850 (Button Stop, Copper)	1.00	Small	0	0	Small	Esco
61	9511914 (Ferrule, 5/16, SS, Duplex)	0.00	Small	0	0		
62	7209213 (Tensioner, Toggle- Toggle)	6.00	Large	0	1	Large	Esco
63	7209212 (Tensioner Toggle Swage Assembly)	94.00	Large	5	9	Large	Esco
64	7209239 (End Termination Toggle/Swage)	52.00	Large	3	5	Large	Esco
65	7209278 (Entry/Exit Unit RH Toggle)	13.00	Medium	1	1	Small	Esco
66	7209279 (Entry/Exit Unit LH Toggle)	2.00	Medium	0	0	Small	Esco
67	7209301 (Swage, Left Hand, B3000281)	18.00	Medium	1	2	Small	Esco
68	7209302 (Swage, Right Hand, B3000280)	16.00	Medium	1	2	Small	Esco
69	7209303 (Toggle, Threaded, Right Hand)	7.00	Medium	0	1	Small	Esco
70	7209304 (Toggle, Threaded, Left Hand B4000273)	4.00	Medium	0	0	Small	Esco
71	7209305 (Mid Entry Point Body SS351)	12.00	Medium	1	1	Small	Table
72	7210083 (Link, Tensioner, Sayfglida)	5.00	Small	0	1	Small	Esco
73	7210888 (Stud, Swage, Tensioner)	0.00	-	0	0		
74	7400995 (Thimble Clamp, 3/8)	69.00	Medium	3	7	Medium	Table
75	7400996 (Button Stop,.437x.875x1.313)	70.00	Small	4	7	Small	Esco
76	7401034 (Shackle Assy)	150.00	Small	8	15	Small	Table

Small Containers: 104
Medium Containers: 24
Large Containers: 10



Appendix F- Rack design and container specifications

ESCO MACHINE RACK (with parts numbers included per container)
Front View



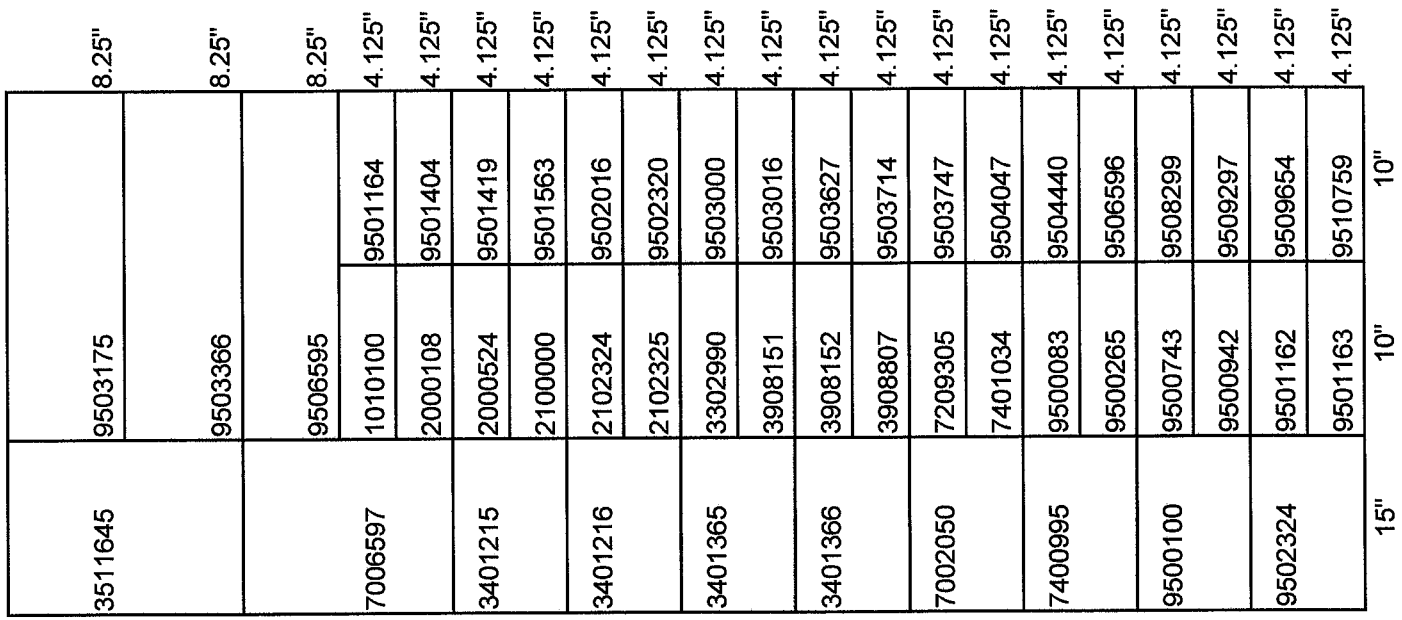
15 Small Container Parts
1 Medium Container Parts
3 Big Container Parts

W	D	H	
4"	11 5/8"	4"	Small Container
8 1/4"	14 3/4"	7"	Medium Container
16 1/2"	14 3/4"	7"	Big Container

Drawing with No Scale

Appendix F- Rack design and container specifications

TABLE ASSEMBLY RACK (with parts numbers included per container)
Front View



W	D	H	
4"	11 5/8"	4"	Small Container
8 1/4"	14 3/4"	7"	Medium Container
16 1/2"	14 3/4"	7"	Big Container

36 Small Container Parts
11 Medium Container Parts
2 Big Container Parts

Drawing with No Scale

Appendix G. Machinery requirements and utilities

Machine	Operator	Operator Status	Power
Cut & Pull Machine	I	Stand	No power needed
Welding Machine	II	Sit	208 Volts, 3 Phases
Stamper	II	Stand	110 Volts
Esco (Tilt Table)	II	Stand	208 Volts, 3 Phases
Assembly Table	III	Sit	110 Volts

Appendix H. Approximate time saved on each cable assembly product family

Family	Move Mat. to Welding Area	Setup for Weld	Move Mat. to Stamper (Belt Room)	Mat. to ESCO Machine	Setup ESCO Machine	Move Mat. to Table Metal Fab.	**Total Time Saved per Item (Min.)**
1							**0.00**
2	0.094	0.169					**0.26**
3				0.10	0.03		**0.13**
4				0.10	0.03	0.03	**0.16**
5			0.62			0.03	**0.64**
6	0.094	0.169	0.62			0.03	**0.91**
7	0.094	0.169	0.62			0.03	**0.91**
8	0.094	0.169		0.10	0.03	0.03	**0.42**
9	0.094	0.169	0.62			0.03	**0.91**
10	0.094	0.169				0.03	**0.29**
11	0.094	0.169		0.10	0.03	0.06	**0.45**
12	0.094	0.169		0.10	0.03	0.03	**0.42**
13	0.094	0.169		0.10	0.03	0.03	**0.42**
14	0.094	0.169		0.10	0.03		**0.40**
15	0.094	0.169		0.10	0.03	0.03	**0.42**
16	0.094	0.169		0.10	0.03		**0.40**
17	0.094	0.169		0.10	0.03		**0.40**
18	0.094	0.169				0.03	**0.29**
19	0.094	0.169		0.10	0.03		**0.40**
20	0.094	0.169	0.62			0.03	**0.91**
21	0.094	0.169	0.62	0.10	0.03	0.03	**1.04**
22	0.094	0.169				0.03	**0.29**
23	0.094	0.169	0.62	0.10	0.03	0.03	**1.04**
24	0.094	0.169	0.62	0.10	0.03	0.03	**1.04**
25	0.094	0.169	0.62	0.10	0.03	0.03	**1.04**
26	0.094	0.169	0.62	0.10	0.03		**1.01**
27	0.094	0.169	0.62			0.03	**0.91**
28	0.094	0.169	0.62			0.03	**0.91**
29	0.094	0.169	0.62			0.03	**0.91**
30	0.094	0.169		0.10	0.03	0.03	**0.42**
31	0.094	0.169				0.03	**0.29**
32	0.094	0.169		0.10	0.03	0.03	**0.42**
33	0.094	0.169				0.03	**0.29**
34	0.094	0.169		0.10	0.03	0.03	**0.42**
35	0.094	0.169				0.03	**0.29**
36	0.094	0.169	0.62			0.03	**0.91**

Family	Move Mat. to Welding Area	Setup for Weld	Move Mat. to Stamper (Belt Room)	Mat. to ESCO Machine	Setup ESCO Machine	Move Mat. to Table Metal Fab.	**Total Time Saved per Item (Min.)**
37	0.094	0.169	0.62			0.03	**0.91**
38	0.094	0.169	0.62			0.03	**0.91**
39	0.094	0.169	0.62			0.03	**0.91**
40	0.094	0.169				0.03	**0.29**
41	0.094	0.169	0.62			0.03	**0.91**
42	0.094	0.169				0.03	**0.29**
43	0.094	0.169		0.10	0.03	0.03	**0.42**
44	0.094	0.169		0.10	0.03	0.06	**0.45**
45							
46				0.10	0.03		**0.13**
47						0.03	**0.03**
48	0.094	0.169	0.62			0.03	**0.91**

Appendix I. Economic study

- **Old system for assemble cables:**

    - Daily demand: 150 Cables
    - Direct labor people: 4.5 people working full time.
    - One day: 8 working hours
    - Cost per hour per worker (approximately): $20/ hour
    - Total direct labor cost per day assembling cables:
        - 4.5 x 8 hours/day x $20/ hour = $720 per day
    - Cost for each cable (direct labor):
        - $720 per day/ 150 cables per day = $4.8 per cable

- **New system for assemble cables:**

    - Daily demand: 150 Cables
    - Direct labor people: 3 people working full time.
    - One day: 8 working hours
    - Cost per hour per worker (approximately): $20/ hour
    - Total direct labor cost per day assembling cables:
        - 3 x 8 hours/day x $20/ hour = $480 per day
    - Cost for each cable (direct labor):
        - $480 per day/ 150 cables per day = $3.2 per cable

- **Dollars saved:**

    - **Per cable assembly:**

        - **$4.8 - $3.2 = $1.60 per cable**

    - **Per day (150 cables):**

        - **$720 – $480 = $240 per day, or**

        - **$1.60/ cable x 150 cables/day = $240 per day**

    - **Per month (20 working days in a month):**

        - **$240 x 20 days/month = $4,800 per month**