An Analysis of the Production Flow at TMI Systems Design Corporation

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AN ANALYSIS OF THE PRODUCTION PROCESS FLOW AT TMI SYSTEMS DESIGN CORPORATION

by

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This study, submitted by Loren J. Zavalney in partial fulfillment of the requirements for the Degree of Master of Science non-thesis from the University of North Dakota, has been read by the Advisor Chairperson under whom the work has been done and is hereby approved.

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PERMISSION

Title	An Analysis of the production process flow at TMI Systems Design Corporation
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ABSTRACT

The purpose of this study was to perform a detailed analysis of the production process flow at TMI Systems Design Corporation that will help improve the overall efficiency of the manufacturing process. The study was sectioned into three phases. Phase one of this study was to collect data on the manufacturing process. Phase two of this study was to incorporate the manufacturing process data into flow process charts and flow diagrams. Phase three of this study was to create an operations process flow chart for the model W2052 wall cabinet.

Phase one was accomplished by collecting data while observing the components of cabinets as they progressed through the various tasks needed to complete a finished cabinet. Data collection for the production process began once the components for the cabinets were cut on the saw and sorted into separate stacks according to individual parts.

Phase two was accomplished by incorporating the manufacturing process data into flow process charts and flow diagrams. The flow process charts gave a graphical representation of the sequence of all operations, transportation, inspections, delays, and storage activities that occurred to the components as they progressed through the production process. The flow diagrams showed the layout of the plant and where the activities in the production process occurred.

Phase three was accomplished by using data from the flow process charts to create an operations process flow chart. The chart assisted in visualizing the operations for each component and the times in which each operation was completed.

Analyzing the data collected from the process flow charts showed that a large percentage of the time that the components were in the plant, they were waiting for an operation to be performed on them. Over 97% of the time that the components are in the plant, they were sitting on the production line having no work performed on them. Taking into consideration material handling and delay time, this percentage increased to 98%. Each of these activities are non-value adding functions and therefore can be considered waste. Only 2% of the entire production time can be considered value adding.

Recommendations for further study are: 1) additional research on TMI's current material handling practices, 2) reduce the amount of time that it takes a job to travel through the factory, 3) automate the entire production process, 4) a detailed analysis of each operation.

CHAPTER I

INTRODUCTION

In today's rapidly changing world, manufacturing companies are faced with global competition and increasingly difficult customer demands. This new environment has challenged companies to seek out new methods and improved processes that will give them the edge to compete and survive in today's global marketplace. Black (1991) stated that "the secret to success in manufacturing is to build a company that can deliver on-time, superior quality products to the customer at the lowest possible cost and still be flexible" (p. 50). This study was designed to investigate the production process flow within TMI Systems Design Corporation in an effort to improve the overall efficiency of the manufacturing process.

TMI Systems Design Corporation located in Dickinson, North Dakota is a manufacturer of institutional laminate casework and storage systems for healthcare, education, laboratory and commercial markets. TMI offers a wide variety of high quality, multi-functional casework to accommodate the needs of virtually any design requirement. This study centers on TMI's ambition to obtain knowledge on improving their customer response time. TMI views this as an opportunity to increase sales, market share, and most of all customer satisfaction.

PROBLEM STATEMENT

The purpose of this study is to perform an analysis of the production process flow at TMI Systems Design Corporation that will help improve the overall efficiency of the manufacturing process.

OBJECTIVES

This study was conducted for the following purposes:

1. Conduct a flow analysis of the current production process flow at TMI Systems Design Corporation for the purpose of providing a benchmark to which alternative facility designs can be evaluated.
2. To aid in identifying areas that may decrease output or increase costs.

ASSUMPTIONS

The following assumptions are made in pursuit of this study:

1. It is assumed that this study will represent an average unit as it progresses through the plant.
2. It is assumed that the plant personnel who collect the data have a working knowledge of the parts and activities involved in the production process.

3. It is assumed that the period of time during which the data are collected is typical with other times of the year.

LIMITATIONS

This study is limited to:

1. The production processes relating to casework and will not include countertops or architectural woodwork.
2. Casework that is most frequently produced.
3. The activities that occur from the time that parts come off the saw and are sorted to the time that the parts get assembled into the final product.

NEED FOR STUDY

It has been estimated that between 20% and 50% of the total operating expenses within manufacturing are attributed to material handling. It is generally agreed that effective facilities layout can reduce these costs by at least 10 to 30%. If effective facilities layout were thus applied, the annual manufacturing productivity in the United States would increase approximately three times more than it has in any year in the last decade (Salvendy, 1992). A good facility layout can minimize the costs of material handling, however, in today's factories, product design changes, different volumes of demand, and changing technology can create problems if the factory is not flexible enough to accommodate these changes. TMI has experienced some of these changes and are faced with a decision to improve their overall performance. In the casework industry, TMI has encountered an increase in demand for a variety of products for various needs. This demand has put TMI in a position to produce various size, shapes and quantities of casework to meet the customers' needs. Most important of all, the technology used in the factory today is not flexible enough to handle large quantities of casework. New technologies have been developed that enable manufacturers to produce more products in less amount of time with fewer costs.

An effective facility layout can provide increased output and shortened manufacturing time. Increased output means greater output with the same or less cost, fewer labor hours, and reduced machine hours. Eliminating idle time and removing unnecessary storage can reduce manufacturing time. Every minute a part is idle on the receiving dock or on the production floor, the lost time is costing the company money in the form of profit.

DEFINITION OF TERMS

Automation - The technique of making an industrial machine, process or system operate without human control or regulation.

Cycle time - The time required to complete one cycle of an operation.

Flow – The progressive achievement of tasks along the value stream so that a product proceeds from design to launch, order to delivery, and raw materials into the hands of the customer with no stoppages, scrap, or backflows.

Flow time - The average amount of time that it takes for one unit to pass through a segment of the production system.

Flow Process Chart - Displays every step a unit follows in the plant, starting with raw material and continuing until the product is completed.

Just-in-Time – A system for producing and delivering the right items at the right time in the right amounts.

Lead time – The total time a customer must wait to receive a product after placing an order.

Non-value-adding - Activities and costs that do not contribute to the usefulness of a product.

Operation – An activity or activities performed on a product by a single machine.

Part - Any piece of material that will be assembled into the unit.

Plant layout - A plan of, or the act of planning, an optimum arrangement of industrial facilities, including personnel, operating equipment, storage space, materials-handling equipment, and all other supporting services, along with the design of the best structure to contain these facilities.

Process – A series of individual operations required to create a design, completed order, or product.

Product - The finished assembly as it is ready to be packaged and shipped to the customer.

Product layout - A facility layout designed to accommodate only a few product and process designs.

Task time - The amount of time required for a well-trained employee to perform a task.

Unit - The main assembly as it progresses through the assembly process until it becomes the product.

Value – A capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer.

Value adding - The activities and costs involved in manufacturing operations that change the product from a pile of materials and components into something useful.

Work station - Physical location where one or more workers perform tasks.

CHAPTER II

REVIEW OF LITERATURE

Introduction

During the economic expansion of recent years, American manufacturers of all sizes have seen their businesses grow. Unfortunately growth alone is no guarantee of future success. The most successful companies today have adopted new strategies, entered new markets and developed new product offerings at an accelerated pace. Suzaki (1993) stated that as the world's business climate changes, it is getting more difficult for companies to remain competitive. Customers demand changes, technology changes, and competitive forces change. The 9th Annual Grant Thornton Survey of American Manufactures Report (1998) found that in 1998 "midsize U.S. manufactures were operating at an average of 75% of total capacity utilization. . . . because of this increase in demand, 53% of midsize manufactures and 68% of larger firms say they expected to add capacity in 1998" (p. 2). Companies are being forced to respond to greater customer demands and cycle times. This is being accomplished by making major investments in advanced technologies and new equipment, revising plant layouts, and expanding facilities. More and more companies are being forced to become more efficient on a continuous basis. By planning in advance for growth, a company can make the best use of its resources to maintain optimal efficiency.

Manufacturing

Manufacturing has gradually progressed to the point where it is today. The earlier days of craftsmanship are long gone and factories that specialize in particular product lines have become the norm. Although the specialization of machines increased productivity, it has also created factories that were inflexible. While companies were seeking out new ways to increase efficiency and volume, they were also creating complex situations within the factory. Kenneth Wantuck (1989) in his book Just in time for America stated how he believed manufacturing progressed to the point where it is today:

> Just about every manufacturing company in America started out as a focused factory. There was only one product family, with few variations, and only one significant market channel. The company was small; people had perspective and communicated with one another. It was a very efficient operation. As time passed, product variety increased, new products were introduced and new markets developed. More equipment was purchased and installed, usually in an available corner. Additions

> were made to the plant. Everything became spread out, disguising the process flow. Looking at the facility today people might well ask, "Who in the world ever designed this place?" The answer, of course, is that nobody did. It just sort of evolved. (p. 122)

Since the operations within the factory became so spread out, large amounts of material were needed on hand to make sure the process flow continued at a steady pace. Efficiency eventually increased because of the larger production runs, but along with more material came the need for more material handling. Salvendy (1992) estimated that:

> Between 20% and 50% of the total operating expenses within manufacturing are attributed to material handling. It is generally agreed that effective facilities layout can reduce these costs by at least 10 to 30%. If effective facilities layout were thus applied, the annual manufacturing productivity in the United States would increase approximately three times more than it has in any year in the last decade. (p. 177)

Continuous Improvement

With the overwhelming number of challenges that face manufactures today, continuous improvement has been the primary philosophy of adapting to these challenges. The term "continuous improvement" means incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance (Suzaki, 1987). A company needs to adapt to changes in order to survive.

Suzaki (1987) summarized the process of continuous improvement:

1. Study the current operation and standardize the work procedure.
2. Find the problem areas.
3. Solve the problems and develop improved methods.
4. Implement the new methods.
5. If the new methods are satisfactory, develop new work standards. Then go back to item 2 and continue the cycle.

Waste

When companies pursue the process of continuous improvement, they will more than likely find inefficiencies throughout the entire manufacturing process. These inefficiencies can be categorized by one word, waste. Waste prevents companies from becoming efficient. Wantuck (1989) defines waste as "anything more than the minimum amount of plant, equipment, materials and workers that are absolutely essential to production." Womack (1996) also defines waste as, "specifically any human activity which absorbs resources but creates no value."

There are many causes of waste, such as imbalances between workers and processes. Changes in scheduling can create excesses or shortages of workers. Too many workers can result in idle production time. Not enough workers creates stoppages in the production flow.

Excess machine capacity is another waste. Wantuck (1989) found that,

> most plants have more capacity than needed, even though it may not look that way at first glance. Many plants are "capacitized," not for today's needs but rather, for tomorrow's hopes. That extra capacity is a waste from a cost standpoint. But, we also do it from a capability standpoint. How many times do we buy a machine intended for a specific application, only to load it with extras, just in case we might need them some day for another undefined application? (p. 23)

Extra machines are often kept on hand because they are expected to break down. Without the proper maintenance, they will eventually break down. Excess machinery also results into excess investment for a company.

Defects and rework are also forms of waste. They consume additional materials but don't add value to the product. Defects not only show up on materials in the plant, but also on raw materials brought into the plant from venders. Another form of waste that is often overlooked is when people perform functions that are often performed better by machines. This is waste, not just from an efficiency standpoint, but because proper use of the workers real talent is not being used. Machines should do the dull, routine jobs, not people.

Productivity

In order to control the actual production process, the performance of the process must be measured. The performance of a process can be measured by knowing the ratio of output to input. When we know this, we can determine how productive the process is.

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

Measuring productivity can give a company feedback that allows them to take corrective action that will eventually control the input or process itself better. In a manufacturing facility:

$$\text{Productivity} = \frac{\text{Value Created}}{\text{Values Invested}}$$

The value created by a process can be seen when a high quality product is produced at a low cost and delivered to the customer on time. A safe working environment and high morale among the workers is also value that is created. A highly productive process uses the least amount of input to create the largest amount of output. The input (values invested) of a process can be broken down into five categories: man, machine, material, method, and measurement. Suzaki (1993) stated,

> We should recognize that even 99 percent effectiveness is still unsatisfactory. If we put ourselves in the shoes of the customer who receives that remaining 1 percent, this should be quite obvious. We need to remember that one defect represents a total failure on the part of the organization that provided the good or service to the recipient. (p. 26)

Automation

During the last 10 to 20 years, many companies have pursued automation as a means of increasing productivity. Companies invested large quantities of dollars for new equipment, software, and training just to be able to compete in the global market place. Unfortunately for many of these companies, the dream of being able to compete and possibly becoming leaders in the marketplace never amounted to anything. Instead, companies that had good intentions of increasing productivity fell far short of their intended goals and, in some cases, did not even have adequate payback for the initial investment. The end result was that the productivity in some companies dropped so much that they had no other choice but to convert back to their old system. Rickard (1994) stated that:

> Despite the millions or billions of dollars that have been spent by U.S. companies on automation during the last two decades, average growth of U.S. productivity has only been approximately 1 percent per year for the years from 1979 to 1988. This rate of growth has been among the lowest of any major industrialized nation. (p.28)

The reason many companies are having little if any success at automation is that they lack the basic understanding of the steps that are needed to make it successful. Rickard (1994) suggested that "very few organizations pay adequate attention to these steps is only one symptom of the much larger problem that the training and education on how to automate has not kept pace with the technology itself" (p.28). The first and most important phases in the automation process are data collection and operations analysis. Without these two planning phases, the automation process has little chance of being as effective as the company had intended it to be.

Data Collection

The first step in any automation process is to have good data of the current system. It is good to be familiar with the overall flow of a product as it moves through the plant. Understanding as much as possible about the present condition prepares the company to make improvements on that condition. Too often this initial step is overlooked and the planning process begins with inadequate information. Common data collected includes numerical data on volumes, rates, sizes and other operating variables. Graphical data is also important when it comes to planning for automation. Data should be collected regarding the layout of the plant and show how the product flows through the plant. Some of the more common graphical tools used for data collection are the process flow chart, flow diagram, decision logic diagram and the man-machine chart. These tools help to identify hidden problems that could not be identified by looking at raw numerical data. Each of these tools can be used alone or together to help analyze the different steps in the production process.

The process flow chart is the most useful tool used in analyzing the production process. When completed, it quickly summarizes the various steps of the process by following the sequence of operations needed to produce the product. The chart uses a symbol for each of the different tasks performed on the product. The different symbols are illustrated in Figure 1. From this chart, productive and non-productive elements can be easily identified. The process

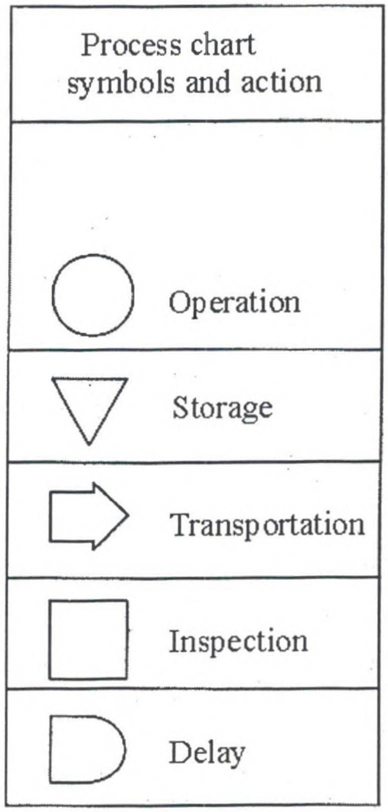


Figure 1. Process flow chart symbols
Note: figure provided by Phillips (1997).

flow chart of the current process also becomes a benchmark by which alternative designs can be evaluated to determine if actual improvements will be accomplished.

A flow diagram provides a pictorial representation of the number of times and the distance a product is moved through the manufacturing process. By using a drawing of the existing plant layout, the path that the product takes through the plant is mapped out. This diagram will help identify processes that have large amounts of material movement. Excessive material movement is a nonproductive activity that should be reduced as much as possible.

Where the process flow chart and flow diagram are primarily used to examine the sequence of operations of a given process, the decision logic diagram and man-machine chart are used to examine one particular operation at a time. The decision logic diagram traces the series of decisions that must be made by an operator to complete a given process such as inspection, material arrangement, filling out paperwork or entering data into the machine. Typically, the more decisions that have to be made by the operator means that there are more opportunities for improving the process.

The man-machine chart shows the relationship of an operator to the machine they are performing a particular operation on. For each cycle of the operation, the operator's actions are compared against the actions of the machine. This chart helps improve machine or operator utilization.

Operations Analysis

Once all of the data is collected about the current production process, re-engineering is done to improve the process. This stage of the automation process is called operations analysis. Value-adding versus non-value-adding processes are identified, and non-value-added processes are reduced if not eliminated. All areas of the process are examined, including the materials, the flow of the information, the flow of the product, the design of the product, and the process itself. According to Skevington (1991):

> Activities which increase the value of a workpiece represent only 5 percent of the total time an order is on the shop floor. If the time from customer order to customer consumption is considered, this percentage drops well below 1 percent. Percentages in excess of 50 percent will be common in the future, reducing lead times by more than a factor of ten. Customers will be able to track their own orders in real time rather than receiving an unknown status over the phone. Just-in-time production will become standard on the shop floor rather than something that is being forced upon suppliers. (p. 240)

The goal of the operations analysis phase is to reduce the complexity of the process as much as possible. Rickard (1994) stated that "when automating anything, the higher the degree of complexity, the higher the cost of successfully automating the process" (p.29). When the operations analysis is done correctly, a company may realize that by improving the old process, the automation would not provide any significant improvement and is therefore not necessary.

Krajewski (1993) described five process characteristics that would benefit the most from operations analysis:

1. The process involves disagreeable or dangerous working conditions.

2. The process results in pollution or large amounts of waste materials.
3. The process is a bottleneck. That is, work piles up waiting to go through this process, and people or machines are idle while waiting for the output of the process.
4. The process consumes a great amount of time.
5. The process requires a great deal of physical movement.

After the initial data collection and attempts at streamlining the process, data should be recollected and reanalyzed. Only after it becomes apparent that further improvements to the current system are no longer likely should the automation process continue onto the next phase.

Lean Manufacturing

In the early 1990s, a new philosophy was developed, its main purpose was to deal with the problems created by waste. Lean manufacturing has become a widely accepted process for companies to become more efficient and responsive. Womack (1996) defined it as a process that "provides a way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively" (p.15). In other words, lean manufacturing provides a way to do more with less human effort, less equipment, less time, and in less space. Companies throughout the United States are developing and implementing lean manufacturing systems to improve the flexibility, reliability, and profitability of their operations. Using these systems, they are reducing setup times, lot sizes, and inventories. They are eliminating non-value-added time from their operations and they are improving process and equipment reliability. Lean manufacturing is founded on five key principles: value, value stream, flow, pull, and perfection.

The operations of a company should provide value in the eyes of the customer. Knowing who the customers are and what they want is very important because value can only be defined by the customer. Providing the wrong product or service the correct way is waste. To avoid this form of waste, a company needs to make sure that everything they do adds value in the eyes of the customer.

The value stream covers all the steps required to transform a product from a raw material to a finished good. Companies need to analyze their supply chain in an attempt to eliminate waste and add value at every step of the operation. To do this, all levels of an organization need to have open lines of communication.

Lean manufacturing gets away from the traditional batch and queue production. These types of production require large inventories. Along with that come large areas to store the inventories and the tasks of handling and tracking them. Flow involves using such methods as just-in-time manufacturing and manufacturing cells that work on one piece at a time. Without the piles of inventory, problems must be quickly resolved. A company can't afford to leave machines broken or poorly maintained. The end result is a company that becomes more responsive to the customer.

Rather than driving production to a schedule, lean manufacturing follows internal and external customer demand. On the shop floor, that means each operation is triggered only when demand is indicated. Doing this involves building pull systems that mechanically or visually signals each operation to make more. This pull then creates a chain reaction on down the line.

Striving for perfection is the final principle in lean manufacturing. It is a goal that never is attained because there is no end to the process of reducing effort, time, space, cost, and mistakes in order to provide the customer with what they want. Eliminating waste reduces the costs of operating while providing the customer with a quality product at the lowest price.

Flow

Flow, being one of the key principles in lean manufacturing, is also a main factor in determining the layout of a plant. In manufacturing, flow refers to the condition of manufacturing smoothness. In order to measure the flow, the average time that it takes to complete a process must be known. To determine if the flow has improved for any portion of the production process, the flow times, before and after the change has been made must be compared. Even though a new layout may seem smoother, if the two flow times are equal, no improvement has been made to the flow. Cedarleaf (1994) explained the significance of flow:

> If improving the production process is one of the goals of the plant layout project, then flow analysis is the first step toward that goal. It is the flow that characterizes all the principles of manufacturing efficiency. It is the flow that encompasses most of the principles of the JIT manufacturing philosophy. It is the flow that can be quantified, justified, and monitored by the project manager. The flow is the most important aspect of the production process that will affect your layout. (p. 15)

Often manufacturing flow is interpreted as involving only the activities taking place in the plant. Manufacturing flow, also referred to as throughput time, is the time required to manufacture a unit, including the parts preparation in the storeroom. The significance of improving the flow is derived from the cost of time, not the labor time. The material idle time can be hidden in every operation. Cedarleaf (1994) listed items that are signals that flow needs improvement:

1. Many units on carts, shelves, or conveyors waiting to be assembled.
2. Parts on the floor in bulk containers waiting to be assembled.
3. Shelving along the walls full of reject parts or other items that have not been disposed of.

4. Numerous rework benches, or a large amount of rework being performed on production benches.
5. Expensive machinery that is idle.
6. People expediting high-priority work orders.
7. Production status meetings being held every day.
8. Trash on the floor.
9. Anything in the aisles except people.
10. Operators making partial assemblies because of a part shortage.
11. Operators inspecting incoming parts to sort out the rejects.

Summary

Plant layout/design and analysis is one of the most interesting and important phases of transition that a company can undertake. It has a direct bearing on quality and profitability because it deals with the arrangement of the physical facilities and the manpower required to operate it profitably and still produce a quality product. The objective in plant layout is to plan the arrangement of facilities and personnel to be the most cost effective by minimizing the movement of both materials and personnel during the manufacturing process. An effective efficiency study, analysis and project management for improved production and profitability could be the most important milestone in a company's future.

Companies that want to be around in the future will take part in making their future happen. The two most predominant happenings in industry today are occurring in the areas of technology and management philosophy. Technology is reshaping the substance of industry and management philosophy is reshaping the spirit of industry in America. With the competitive changes in quality commitment and productivity expansion that have occurred in industry overseas, no longer can American industries be content with the old style management techniques and equipment of the industrial era.

The market is changing therefore industry must change. With the escalation of technology, the market of the American consumer has gone global. Americans are free to choose whatever product from around the globe that provides the best value. American industry competitors are no longer that company down the street or across the country. The American competitors today are worldwide. American manufacturing has to be world-class if they want to compete.

CHAPTER III

METHODOLOGY

The purpose of this study was to perform a detailed analysis of the production process flow at TMI Systems Design Corporation that will help improve the overall efficiency of the manufacturing process. The design of this study is a case study with a combination of descriptive field study analysis and applied manufacturing research.

Descriptive field study research, as Leedy (1989) described, is "a type of research method when the analyst does two things: First they observe with close scrutiny the population bounded by research parameters; second they make careful record of what they observe so that when an aggregate record is made, the researchers can then return to the record to study the observations described there" (p. 141).

Applied manufacturing analysis as referred to by Tersine (1980) is, "Concerned almost entirely with practical applications and the solution of practical problems. It's directed toward improvement of manufacturing processes and reduction of cost."

Objectives of the study were:

1. Conduct a flow analysis of the current production process flow at TMI Systems Design Corporation for the purpose of providing a benchmark to which alternative facility designs can be evaluated.
2. To aid in identifying areas that may decrease output or increase cost.

The procedure to support the purpose of this study and satisfy the listed objectives was accomplished in three phases.

Phase one of this study was to collect data on the manufacturing process. Information was collected by observing the components of a selected cabinet as they progressed through the various tasks needed to complete a finished cabinet. The unit from which information was collected from was a model W2052 wall cabinet. The reason this cabinet was chosen on which to perform the analysis was because it represented 12% of the total number of cabinets produced at TMI Systems Design Corporation. This percentage was the largest for any one single cabinet produced. The project from which the wall cabinet was chosen contained a lot size of 14 identical W2052 wall cabinets. Data collection for the production process began once the components for the cabinets were cut on the saw and sorted into separate stacks according to individual parts. The data (time and distance) compiled for the study was gathered through personal observation and measurement of the process by the researcher and plant personnel.

Phase two of this study was to incorporate the manufacturing process data into flow process charts and flow diagrams. A flow process chart is a graphic representation of the sequence of all operations, transportation, inspections, delays, and storage activities that occur to one part, or groups of parts, as they move from being a raw material to a finished product. Flow diagrams were created from the information on the flow process charts. The flow diagram is a sketch of the layout of floors and buildings, which shows the location of all activities on the flow process chart. The path of the components that have been flow process charted is traced on the flow diagram by lines. Each activity is located and identified on the flow diagram by symbol and number corresponding to the flow process chart

Phase three of this study was to create an operations process flow chart for the model W2052 wall cabinet. The chart will help assist personnel in visualizing the different operations needed to complete a finished product. An operation is described as physical activity in which work is performed on a part of a product. The chart also shows the days on which each of the operations was performed in comparison to each other. Bottleneck areas can easily be identified on the chart by locating areas that have a long delay between operations. Data for the chart were collected from information from the production process chart.

CHAPTER IV

FINDINGS

This study was designed to perform an analysis of the production process flow at TMI Systems Design Corporation in an effort to improve the overall efficiency of the manufacturing process. The objectives were to conduct a flow analysis of the current production process flow, establish a benchmark to which alternative facility designs can be evaluated, and aid in identifying areas that may decrease output or increase costs.

Phase one of this study was to collect data on the manufacturing process and record the information on a flow process chart. Since TMI manufactures a variety of sizes, shapes, and quantities of cabinets, it was impossible to analyze every cabinet as it progressed through the factory. Because of this, one specific cabinet was chosen to be observed as it progressed through the manufacturing process. The unit chosen was a model W2052 wall cabinet. The reason this cabinet was chosen to perform the analysis was because it represented 12% of the total number of cabinets produced at TMI. This percentage was the largest for any one single cabinet produced. TMI produces cabinets on a per job basis, meaning that each job contains various cabinets with different manufacturing specifications. Although there are differences between the cabinets, problem areas within the process flow will remain the same for all cabinets. In other words, it does not matter which type of cabinet is observed, the same inefficiencies in the process flow will be seen with all cabinets. Before data could be collected, the wall cabinet was broken down into its individual components. The components for the W2052 wall cabinet are:

1. Left side panel
2. Right side panel
3. Top
4. Bottom
5. Shelf
6. Doors
7. Back

All activities required to complete a component were recorded and listed in sequential order on a chart. A chart was then attached to each group of components as they progressed through the factory. When an activity was performed, the worker would record the start time and end time for that activity. From these two times, the total time for that activity could then be calculated. Process time per component was then calculated by dividing the total time by the number of components. Data collection began after the particleboard panels were laid up with plastic laminate, cut on the saw and separated into stacks of individual components. This point was chosen as the starting point because it was a time in which all components were easily accounted for. Data collection ended after all of the cabinets were assembled. The job from which the wall cabinets were sampled from contained 14 identical cabinets. The data collected from each component can be seen in Tables 1 – 7.

Data collected from the components were then incorporated into the flow process charts. A flow process chart is a graphic representation of the sequence of all operations, transportation, inspections, delays, and storage activities that occur to one part, or groups of parts, as they move from being raw material to a finished product. The flow process charts generated from this study can be used as benchmarks that represent the present method used to manufacture this type of cabinet. The distance in which the components moved from one operation to the next was also measured and incorporated into the charts.

Flow diagrams were created from the information on the flow process charts. The flow diagram is a sketch of the layout of floors and buildings, which shows the location of all activities on the flow process chart. The path of the components that have been flow process charted is traced on the flow diagram by lines. Each activity is located and identified on the flow diagram by symbol and number corresponding to the flow process chart. The flow diagram becomes a necessary addition to the flow process chart wherever movement is an important factor. Figures 2 – 15 show the flow process charts and flow diagrams for each component as they progressed through the plant.

DESCRIPTION OF TASKS	START DATE	START TIME	END DATE	END TIME	TOTAL TIME (MIN.)	# COMPONENTS	AVG.TIME/COMP.
Sorting			9/30/1996	7:30 AM		14	
Waiting for machining	9/30/1996	7:30 AM	9/30/1996	5:30 PM	600	14	42.86
Moved to machining	9/30/1996	5:30 PM	9/30/1996	5:32 PM	2	14	0.14
Waiting to be machined	9/30/1996	5:32 PM	9/30/1996	6:15 PM	48	14	3.43
5mm line bore	9/30/1996	6:20 PM	9/30/1996	6:25 PM	5	14	0.36
Waiting to be moved	9/30/1996	6:25 PM	9/30/1996	6:27 PM	2	14	0.14
Moved to 1mm bander	9/30/1996	6:27 PM	9/30/1996	6:32 PM	5	14	0.36
Waiting for 1mm edge	9/30/1996	6:32 PM	9/30/1996	7:58 PM	86	14	6.14
1mm edge applied	9/30/1996	7:58 PM	9/30/1996	8:07 PM	9	14	0.64
Waiting to be moved	9/30/1996	8:07 PM	9/30/1996	8:13 PM	6	14	0.43
Moved to 3mm bander	9/30/1996	8:13 PM	9/30/1996	8:18 PM	5	14	0.36
Waiting for 3mm edge	9/30/1996	8:18 PM	9/30/1996	10:30 PM	132	14	9.43
3mm edge applied	9/30/1996	10:30 PM	9/30/1996	10:32 PM	2	14	0.14
Waiting to be moved	9/30/1996	10:32 PM	9/30/1996	10:40 PM	8	14	0.57
Moved to point-to-point	9/30/1996	10:40 PM	9/30/1996	10:45 PM	5	14	0.36
Waiting at point-to-point	9/30/1996	10:45 PM	10/1/1996	1:05 PM	860	14	61.43
Boring point-to-point	10/1/1996	1:05 PM	10/1/1996	1:30 PM	25	14	1.79
Waiting to be moved	10/1/1996	1:30 PM	10/1/1996	2:00 PM	30	14	2.14
Moved to sorting	10/1/1996	2:00 PM	10/1/1996	2:05 PM	5	14	0.36
Waiting to be sorted	10/1/1996	2:05 PM	10/4/1996	7:45 AM	3940	14	281.43
Sorted	10/4/1996	7:45 AM	10/4/1996	8:30 AM	45	14	3.21
Waiting to be assembled	10/4/1996	8:30 AM	10/4/1996	2:00 PM	330	14	23.57
Assembled	10/4/1996	2:00 PM	10/4/1996	3:00 PM	60	14	4.29
				Minutes	6210		
				Hours	103.50		
				Days	4.31		
		Activities	Minutes	Hours	Days		
		Operation	146	2.43	0.10		
		Transportation	22	0.37	0.02		
		Delay	6042	100.70	4.20		
		TOTALS	6210	103.50	4.31		

Table 1. Right side panel data

DESCRIPTION OF TASKS	START DATE	START TIME	END DATE	END TIME	TOTAL TIME (MIN.)	# COMPONENTS	AVG.TIME/COMP.
Sorting			9/30/1996	7:30 AM		14	
Waiting for machining	9/30/1996	7:30 AM	9/30/1996	5:30 PM	600	14	42.86
Moved to machining	9/30/1996	5:30 PM	9/30/1996	5:32 PM	2	14	0.14
Waiting to be machined	9/30/1996	5:32 PM	9/30/1996	6:15 PM	48	14	3.43
5mm line bore	9/30/1996	6:20 PM	9/30/1996	6:25 PM	5	14	0.36
Waiting to be moved	9/30/1996	6:25 PM	9/30/1996	6:27 PM	2	14	0.14
Moved to 1mm bander	9/30/1996	6:27 PM	9/30/1996	6:32 PM	5	14	0.36
Waiting for 1mm edge	9/30/1996	6:32 PM	9/30/1996	7:58 PM	86	14	6.14
1mm edge applied	9/30/1996	7:58 PM	9/30/1996	8:07 PM	9	14	0.64
Waiting to be moved	9/30/1996	8:07 PM	9/30/1996	8:13 PM	6	14	0.43
Moved to 3mm bander	9/30/1996	8:13 PM	9/30/1996	8:18 PM	5	14	0.36
Waiting for 3mm edge	9/30/1996	8:18 PM	9/30/1996	10:30 PM	132	14	9.43
3mm edge applied	9/30/1996	10:30 PM	9/30/1996	10:32 PM	2	14	0.14
Waiting to be moved	9/30/1996	10:32 PM	9/30/1996	10:40 PM	8	14	0.57
Moved to point-to-point	9/30/1996	10:40 PM	9/30/1996	10:45 PM	5	14	0.36
Waiting at point-to-point	9/30/1996	10:45 PM	10/1/1996	1:05 PM	860	14	61.43
Boring point-to-point	10/1/1996	1:05 PM	10/1/1996	1:30 PM	25	14	1.79
Waiting to be moved	10/1/1996	1:30 PM	10/1/1996	2:00 PM	30	14	2.14
Moved to sorting	10/1/1996	2:00 PM	10/1/1996	2:05 PM	5	14	0.36
Waiting to be sorted	10/1/1996	2:05 PM	10/4/1996	7:45 AM	3940	14	281.43
				Minutes	5775		
				Hours	96.25		
				Days	4.01		
		Activities	Minutes	Hours	Days		
		Operation	41	0.68	0.03		
		Transportation	22	0.37	0.02		
		Delay	5712	95.20	3.97		
		TOTALS	5775	96.25	4.01		

Table 2. Left side panel data

DESCRIPTION OF TASKS	START DATE	START TIME	END DATE	END TIME	TOTAL TIME (MIN.)	# COMP.	AVG.TIME/COMP.
Sorting			9/30/1996	9:50 AM		14	
Waiting to be moved	9/30/1996	9:50 AM	9/30/1996	10:20 PM	750	14	53.57
Moved to 3mm bander	9/30/1996	10:20 PM	9/30/1996	10:25 PM	5	14	0.36
Waiting for 3mm edge	9/30/1996	10:25 PM	9/30/1996	10:33 PM	8	14	0.57
3mm edge applied	9/30/1996	10:33 PM	9/30/1996	10:40 PM	7	14	0.50
Waiting to be moved	9/30/1996	10:40 PM	9/30/1996	11:38 PM	58	14	4.14
Moved to boring area	9/30/1996	11:38 PM	9/30/1996	11:43 PM	5	14	0.36
Waiting for boring	9/30/1996	11:43 PM	10/2/1996	9:25 AM	2022	14	144.43
Boring and doweled	10/2/1996	9:25 AM	10/2/1996	9:30 AM	5	14	0.36
Waiting to be moved	10/2/1996	9:30 AM	10/2/1996	9:40 AM	10	14	0.71
Moved to sorting	10/2/1996	9:40 AM	10/2/1996	9:45 AM	5	14	0.36
Waiting to be sorted	10/2/1996	9:45 AM	10/4/1996	7:45 AM	2760	14	197.14
				Minutes	5635		
				Hours	93.92		
				Days	3.91		
		Activities	Minutes	Hours	Days		
		Operation	12	0.20	0.01		
		Transportation	15	0.25	0.01		
		Delay	5608	93.47	3.89		
		TOTALS	5635	93.92	3.91		

Table 3. Top data

DESCRIPTION OF TASKS	START DATE	START TIME	END DATE	END TIME	TOTAL TIME (MIN.)	# COMPONENTS	AVG.TIME/COMP.
Sorting			9/30/1996	9:50 AM		14	
Waiting to be moved	9/30/1996	9:50 AM	9/30/1996	10:20 PM	750	14	53.57
Moved to 3mm bander	9/30/1996	10:20 PM	9/30/1996	10:25 PM	5	14	0.36
Waiting for 3mm edge	9/30/1996	10:25 PM	9/30/1996	10:33 PM	8	14	0.57
3mm edge applied	9/30/1996	10:33 PM	9/30/1996	10:40 PM	7	14	0.50
Waiting to be moved	9/30/1996	10:40 PM	9/30/1996	11:38 PM	58	14	4.14
Moved to boring area	9/30/1996	11:38 PM	9/30/1996	11:43 PM	5	14	0.36
Waiting for boring	9/30/1996	11:43 PM	10/2/1996	9:25 AM	2022	14	144.43
Boring and doweled	10/2/1996	9:25 AM	10/2/1996	9:30 AM	5	14	0.36
Waiting to be moved	10/2/1996	9:30 AM	10/2/1996	9:40 AM	10	14	0.71
Moved to sorting	10/2/1996	9:40 AM	10/2/1996	9:45 AM	5	14	0.36
Waiting to be sorted	10/2/1996	9:45 AM	10/4/1996	7:45 AM	2760	14	197.14
				Minutes	5635		
				Hours	93.92		
				Days	3.91		
		Activities	Minutes	Hours	Days		
		Operation	12	0.20	0.01		
		Transportation	15	0.25	0.01		
		Delay	5608	93.47	3.89		
		TOTALS	5635	93.92	3.91		

Figure 4. Bottom data

DESCRIPTION OF TASKS	START DATE	START TIME	END DATE	END TIME	TOTAL TIME (MIN.)	# COMP.	AVG.TIME/COMP.
Sorting			9/30/1996	8:45 AM		28	
Waiting to be moved	9/30/1996	8:45 AM	9/30/1996	5:00 PM	495	28	17.68
Moved to 3mm bander	9/30/1996	5:00 PM	9/30/1996	5:05 PM	5	28	0.18
Waiting for 3mm edge	9/30/1996	5:05 PM	10/1/1996	8:27 AM	922	28	32.93
3mm edge applied	10/1/1996	8:27 AM	10/1/1996	8:55 AM	28	28	1.00
Waiting to be moved	10/1/1996	8:55 AM	10/2/1996	10:30 PM	2255	28	80.54
Moved to machining	10/2/1996	10:30 PM	10/2/1996	10:35 PM	5	28	0.18
Waiting to be machined	10/2/1996	10:35 PM	10/3/1996	8:10 AM	575	28	20.54
Machined	10/3/1996	8:10 AM	10/3/1996	9:06 AM	56	28	2.00
Waiting to be moved	10/3/1996	9:06 AM	10/3/1996	9:21 AM	15	28	0.54
Moved to sorting	10/3/1996	9:21 AM	10/3/1996	9:26 AM	5	28	0.18
Waiting to be sorted	10/3/1996	9:26 AM	10/4/1996	7:45 AM	1339	28	47.82
				Minutes	5700		
				Hours	95.00		
				Days	3.96		
		Activities	Minutes	Hours	Days		
		Operation	84	1.40	0.06		
		Transportation	15	0.25	0.01		
		Delay	5601	93.35	3.89		
		TOTALS	5700	95.00	3.96		

Table 5. Doors data

DESCRIPTION OF TASKS	START DATE	START TIME	END DATE	END TIME	TOTAL TIME (MIN.)	# COMP.	AVG.TIME/COMP.
Sorting			9/30/1996	11:17 AM		14	
Waiting to be moved	9/30/1996	11:17 AM	9/30/1996	5:30 PM	373	14	26.64
Moved to 3mm bander	9/30/1996	5:30 PM	9/30/1996	5:35 PM	5	14	0.36
Waiting for 3mm edge	9/30/1996	5:35 PM	9/30/1996	8:40 PM	185	14	13.21
3mm edge applied	9/30/1996	8:40 PM	9/30/1996	8:45 PM	5	14	0.36
Waiting to be moved	9/30/1996	8:45 PM	10/2/1996	1:15 PM	2430	14	173.57
Moved to shelving	10/2/1996	1:15 PM	10/2/1996	1:30 PM	15	14	1.07
Waiting to be cleaned	10/2/1996	1:30 PM	10/3/1996	7:30 AM	1080	14	77.14
Cleaned	10/3/1996	7:30 AM	10/3/1996	8:45 AM	75	14	5.36
Waiting to be moved to assembly	10/3/1996	8:50 AM	10/3/1996	9:00 AM	10	14	0.71
Moved to assembly	10/3/1996	9:00 AM	10/3/1996	9:05 AM	5	14	0.36
Waiting to be assembled	10/3/1996	9:05 AM	10/4/1996	2:50 PM	1785	14	127.50
				Minutes	5968		
				Hours	99.47		
				Days	4.14		
		Activities	Minutes	Hours	Days		
		Operation	80	1.33	0.06		
		Transportation	25	0.42	0.02		
		Delay	5863	97.72	4.07		
		TOTALS	5968	99.47	4.14		

Table 6. Shelf data

DESCRIPTION OF TASKS	START DATE	START TIME	END DATE	END TIME	TOTAL TIME (MIN.)	# COMP.	AVG.TIME/COMP.
Finished cutting job			10/2/1996	10:04 PM		14	
Waiting to be moved	10/2/1996	10:04 PM	10/4/1996	7:40 AM	2016	14	144.00
Moved to assembly	10/4/1996	7:40 AM	10/4/1996	7:45 AM	5	14	0.36
Waiting to be assembled	10/4/1996	7:45 AM	10/4/1996	2:00 PM	375	14	26.79
				Minutes	2396		
				Hours	39.93		
				Days	1.66		
		Activities	Minutes	Hours	Days		
		Operation	0	0.00	0.00		
		Transportation	5	0.08	0.00		
		Delay	2391	39.85	1.66		
		TOTALS	2396	39.93	1.66		

Table 7. Back data

TMI SYSTEMS DESIGN CORPORATION

☒ Present Method	☐ Proposed Method	Date:9/30/96
Part Description: Right Side Panel		
Operation Description: From sorting to assembly		

SUMMARY	PRESENT No.	PRESENT Time	PROPOSED No.	PROPOSED Time	DIFF. No.	DIFF. Time
Operation	6	146				
Transport	5	22				
Delay	11	6042				
Inspections						
Distance Traveled	913 ft.					

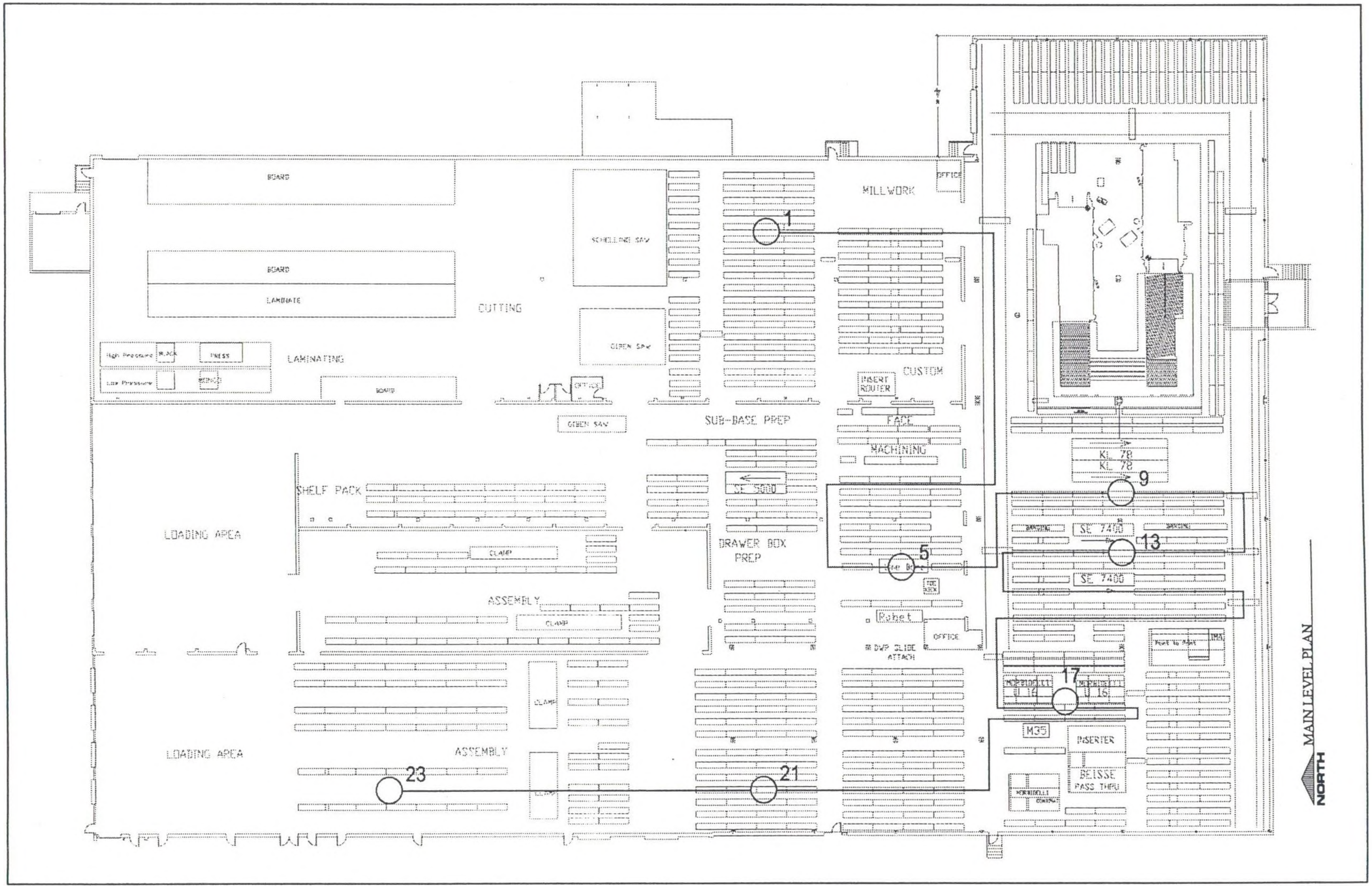
ANALYSIS: WHY, WHAT, WHERE, WHEN, WHO, HOW

Flow Diagram on following page

Studied By: Loren Zavalney

Description of Task	Operation / Transport / Delay / Inspection	Distance in feet	Quantity	Time (min.)	Comments
1. Sorting	Operation				
2. Waiting for machining	Delay		14	600	
3. Moved to machining	Transport	257 ft.	14	2	
4. Waiting to be machined	Delay		14	48	
5. 5mm Line bore	Operation		14	5	
6. Waiting to be moved	Delay		14	2	
7. Moved to 1mm bander	Transport	89 ft.	14	5	
8. Waiting for 1mm edge	Delay		14	86	
9. 1mm edge applied	Operation		14	9	
10. Waiting to be moved	Delay		14	6	
11. Moved to 3mm bander	Transport	182 ft.	14	5	
12. Waiting for 3mm edge	Delay		14	132	
13. 3mm edge applied	Operation		14	2	
14. Waiting to be moved	Delay		14	8	
15. Moved to point-to-point	Transport	175 ft.	14	5	
16. Waiting at point-to-point	Delay		14	860	
17. Boring point-to-point	Operation		14	25	
18. Waiting to be moved	Delay		14	30	
19. Moved to sorting	Transport	94 ft.	14	5	
20. Waiting to be sorted	Delay		14	3940	
21. Sorted	Operation		14	45	all components of cabinet are sorted
22. Waiting to be assembled	Delay		14	330	
23. Assembled	Operation		14	60	

Figure 2. Flow process chart (right side panel)



<u>Figure 3</u>. Flow diagram (right side panel)

TMI SYSTEMS DESIGN CORPORATION

☒ Present Method	☐ Proposed Method	Date: 9/30/96

Part Description: Left Side Panel

Operation Description: From sorting to sorting

SUMMARY	PRESENT No.	PRESENT Time	PROPOSED No.	PROPOSED Time	DIFF. No.	DIFF. Time
Operation	4	41				
Transport	5	22				
Delay	11	5712				
Inspections						
Distance Traveled	797 ft.					

ANALYSIS

WHY WHEN
WHAT WHO
WHERE HOW

Studied By: Loren Zavalney

Flow Diagram on following page

Description of Task	Operation	Transport	Delay	Inspection	Distance in feet	Quantity	Time (min.)	Comments
1. Sorting	X							
2. Waiting for machining			X			14	600	
3. Moved to machining		X			257 ft.	14	2	
4. Waiting to be machined			X			14	48	
5. 5mm Line bore	X					14	5	
6. Waiting to be moved			X			14	2	
7. Moved to 1mm bander		X			89 ft.	14	5	
8. Waiting for 1mm edge			X			14	86	
9. 1mm edge applied	X					14	9	
10. Waiting to be moved			X			14	6	
11. Moved to 3mm bander		X			182 ft.	14	5	
12. Waiting for 3mm edge			X			14	132	
13. 3mm edge applied	X					14	2	
14. Waiting to be moved			X			14	8	
15. Moved to point-to-point		X			175 ft.	14	5	
16. Waiting at point-to-point			X			14	860	
17. Boring point-to-point	X					14	25	
18. Waiting to be moved			X			14	30	
19. Moved to sorting		X			94 ft.	14	5	
20. Waiting to be sorted			X			14	3940	
21. Sorting	X							

Figure 4. Flow process chart (left side panel)

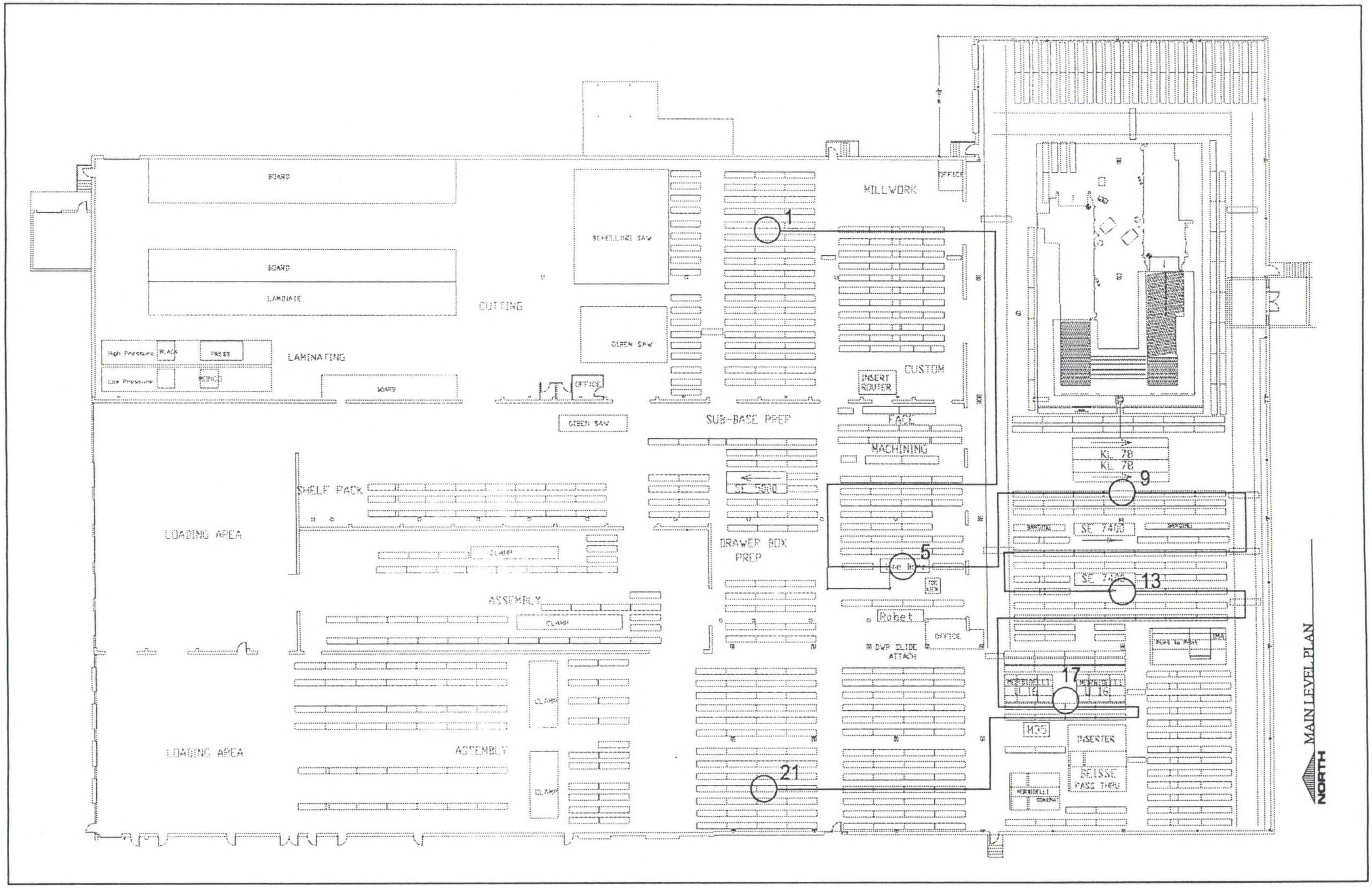


Figure 5. Flow diagram (left side panel)

TMI SYSTEMS DESIGN CORPORATION

☒ Present Method ☐ Proposed Method | Date: 9/30/96

Part Description: Top

Operation Description: From sorting to sorting

SUMMARY	PRESENT No.	PRESENT Time	PROPOSED No.	PROPOSED Time	DIFF. No.	DIFF. Time
Operation	2	12				
Transport	3	15				
Delay	6	5608				
Inspections						
Distance Traveled	515 ft.					

ANALYSIS

WHY WHEN
WHAT WHO
WHERE HOW

Flow Diagram on following page

Studied By: Loren Zavalney

Description of Task	Operation	Transport	Delay	Inspection	Distance in feet	Quantity	Time (min.)	Comments
1. Sorting	X							
2. Waiting to be moved			X			14	750	
3. Moved to 3mm bander		X			226 ft.	14	5	
4. Waiting for 3mm edge			X			14	8	
5. 3mm edge applied	X					14	7	
6. Waiting to be moved			X			14	58	
7. Moved to boring area		X			195 ft.	14	5	
8. Waiting for boring			X			14	2022	
9. Boring and doweled	X					14	5	
10. Waiting to be moved			X			14	10	
11. Moved to sorting		X			94 ft.	14	5	
12. Waiting to be sorted			X			14	2760	
13. Sorting	X							

Figure 6. Process flow chart (top)

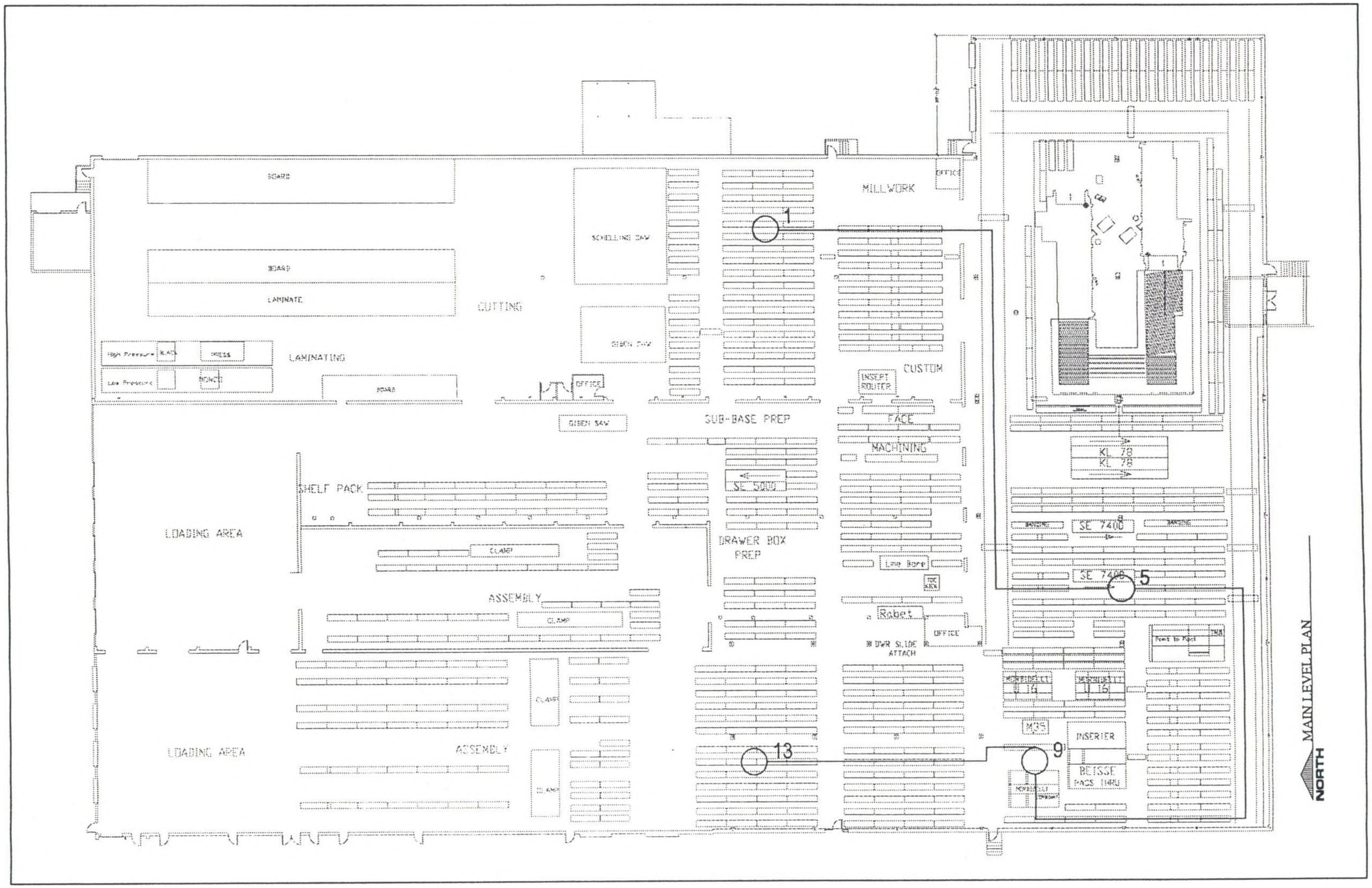


Figure 7. Flow diagram (top)

TMI SYSTEMS DESIGN CORPORATION

☒ Present Method	☐ Proposed Method	Date: 9/30/96
Part Description: Bottom		
Operation Description: From sorting to sorting		

SUMMARY	PRESENT No.	PRESENT Time	PROPOSED No.	PROPOSED Time	DIFF. No.	DIFF. Time
Operation	2	12				
Transport	3	15				
Delay	6	5608				
Inspections						
Distance Traveled	515 ft.					

ANALYSIS: WHY, WHAT, WHERE, WHEN, WHO, HOW

Flow Diagram on following page

Studied By: Loren Zavalney

Description of Task	Operation / Transport / Delay / Inspection	Distance in feet	Quantity	Time (min.)	Comments
1. Sorting	Operation				
2. Waiting to be moved	Delay		14	750	
3. Moved to 3mm bander	Transport	226 ft.	14	5	
4. Waiting for 3mm edge	Delay		14	8	
5. 3mm edge applied	Operation		14	7	
6. Waiting to be moved	Delay		14	58	
7. Moved to boring area	Transport	195 ft.	14	5	
8. Waiting for boring	Delay		14	2022	
9. Boring and doweled	Operation		14	5	
10. Waiting to be moved	Delay		14	10	
11. Moved to sorting	Transport	94 ft.	14	5	
12. Waiting to be sorted	Delay		14	2760	
13. Sorted	Operation				

Figure 8. Process flow chart (bottom)

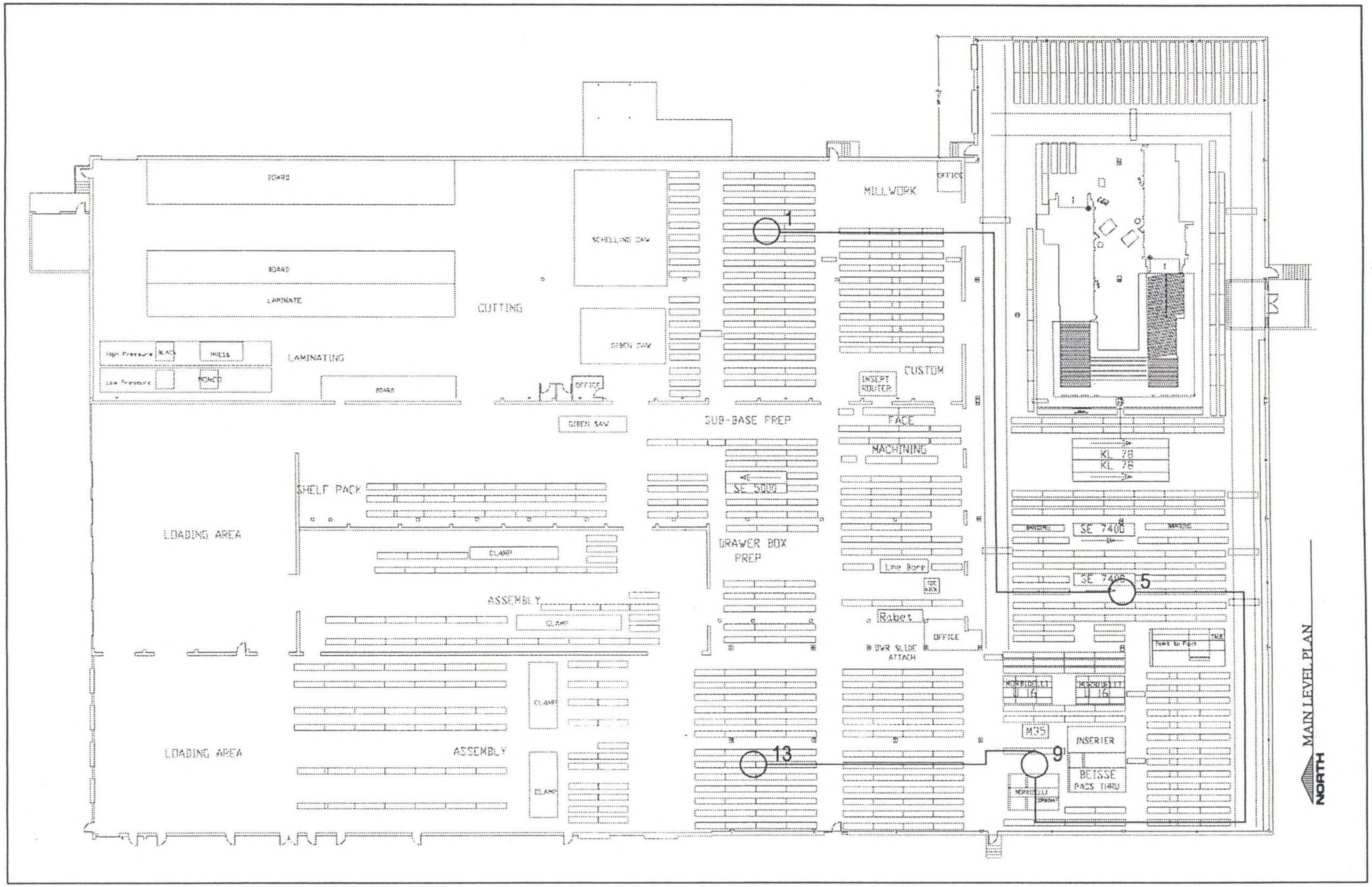


Figure 9. Flow diagram (bottom)

TMI SYSTEMS DESIGN CORPORATION

☒ Present Method ☐ Proposed Method Date: 9/30/96

Part Description: Doors

Operation Description: From sorting to sorting

SUMMARY	PRESENT No.	PRESENT Time	PROPOSED No.	PROPOSED Time	DIFF. No.	DIFF. Time
Operation	2	84				
Transport	3	15				
Delay	6	5601				
Inspections						
Distance Traveled	603 ft.					

ANALYSIS

WHY WHEN
WHAT WHO
WHERE HOW

Flow Diagram on following page

Studied By: Loren Zavalney

Description of Task	Operation	Transport	Delay	Inspection	Distance in feet	Quantity	Time (min.)	Comments
1. Sorting								
2. Waiting to be moved						28	495	
3. Moved to 3mm bander					226 ft.	28	5	
4. Waiting for 3mm edge						28	922	
5. 3mm edge applied						28	28	
6. Waiting to be moved						28	2255	
7. Moved to machining					207 ft.	28	5	
8. Waiting to be machined						28	575	
9. Machined						28	56	
10.Waiting to be moved						28	15	
11.Moved to sorting					170 ft.	28	5	
12.Waiting to be sorted						28	1339	
13. Sorted								
14.								
15.								
16.								
17.								
18.								
19.								
20.								
21.								
22.								
23.								
24.								
25.								

Figure 10. Process flow chart (doors)

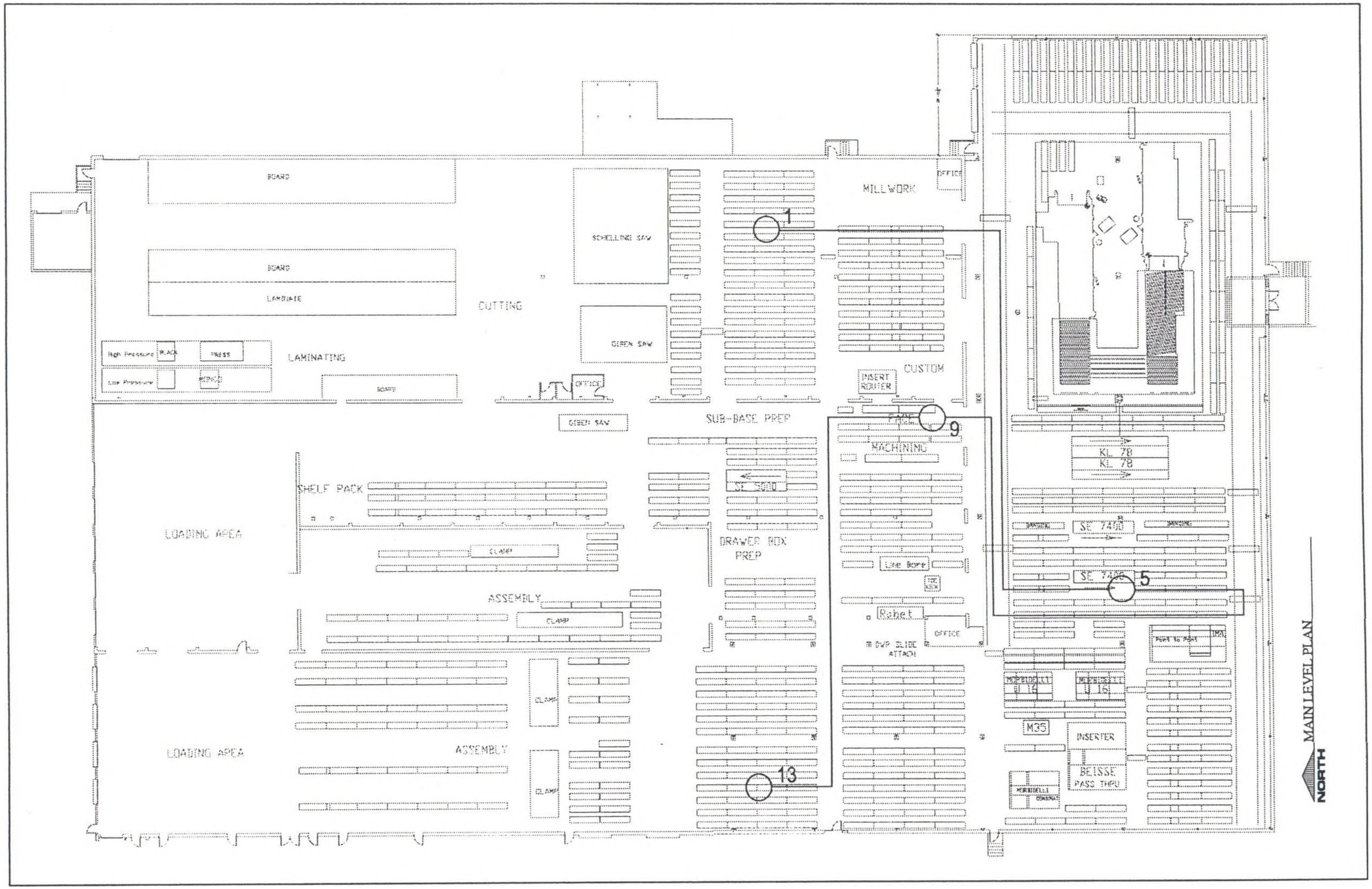


Figure 11. Flow diagram (doors)

TMI SYSTEMS DESIGN CORPORATION

☒ Present Method ☐ Proposed Method Date: 9/30/96

Part Description: Shelf

Operation Description: From sorting to assembly

SUMMARY	PRESENT No.	PRESENT Time	PROPOSED No.	PROPOSED Time	DIFF. No.	DIFF. Time
Operation	2	80				
Transport	3	25				
Delay	6	5863				
Inspections						
Distance Traveled	878 ft.					

ANALYSIS

WHY WHEN
WHAT WHO
WHERE HOW

Studied By: Loren Zavalney

Flow Diagram on following page

Description of Task	Operation / Transport / Delay / Inspection	Distance in feet	Quantity	Time (min.)	Comments
1. Sorting	Operation				
2. Waiting to be moved	Delay		14	373	
3. Moved to 3mm bander	Transport	226 ft.	14	5	
4. Waiting for 3mm edge	Delay		14	185	
5. 3mm edge applied	Operation		14	5	
6. Waiting to be moved	Delay		14	2430	
7. Moved to shelving	Transport	382 ft.	14	15	
8. Waiting to be cleaned	Delay		14	1080	
9. Cleaned	Operation		14	75	
10. Waiting to move to assembly	Delay		14	10	
11. Moved to assembly	Transport	270 ft.	14	5	
12. Waiting to be assembled	Delay		14	1785	
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					

Figure 12. Process flow chart (shelf)

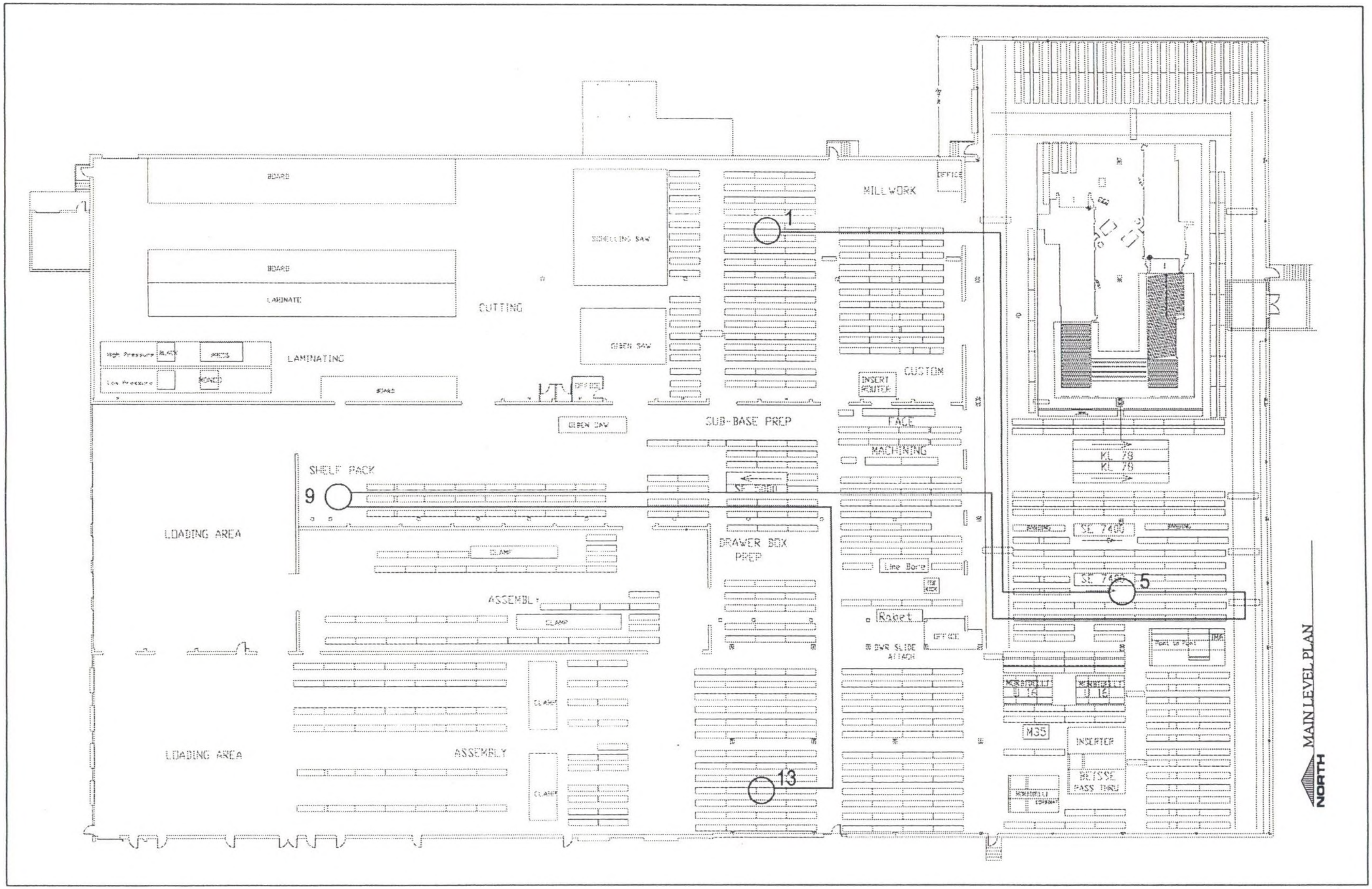


Figure 13. Flow diagram (shelf)

TMI SYSTEMS DESIGN CORPORATION

☒ Present Method	☐ Proposed Method	Date: 9/30/96
Part Description: Back		
Operation Description: Cutting to Assembly		

SUMMARY	PRESENT No.	PRESENT Time	PROPOSED No.	PROPOSED Time	DIFF. No.	DIFF. Time
Operation	0	0				
Transport	1	5				
Delay	2	2391				
Inspections						
Distance Traveled	161 ft.					

ANALYSIS

WHY WHEN
WHAT WHO
WHERE HOW

Flow Diagram on following page

Studied By: Loren Zavalney

Description of Task	Operation / Transport / Delay / Inspection	Distance in feet	Quantity	Time (min.)	Comments
1. Finished cutting	Operation				
2. Waiting to be moved	Delay		14	2016	
3. Moved to assembly	Transport	161 ft.	14	5	
4. Waiting to be assembled	Delay		14	375	
5. Assembly	Operation				
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
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22.					
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25.					

Figure 14. Process flow chart (back)

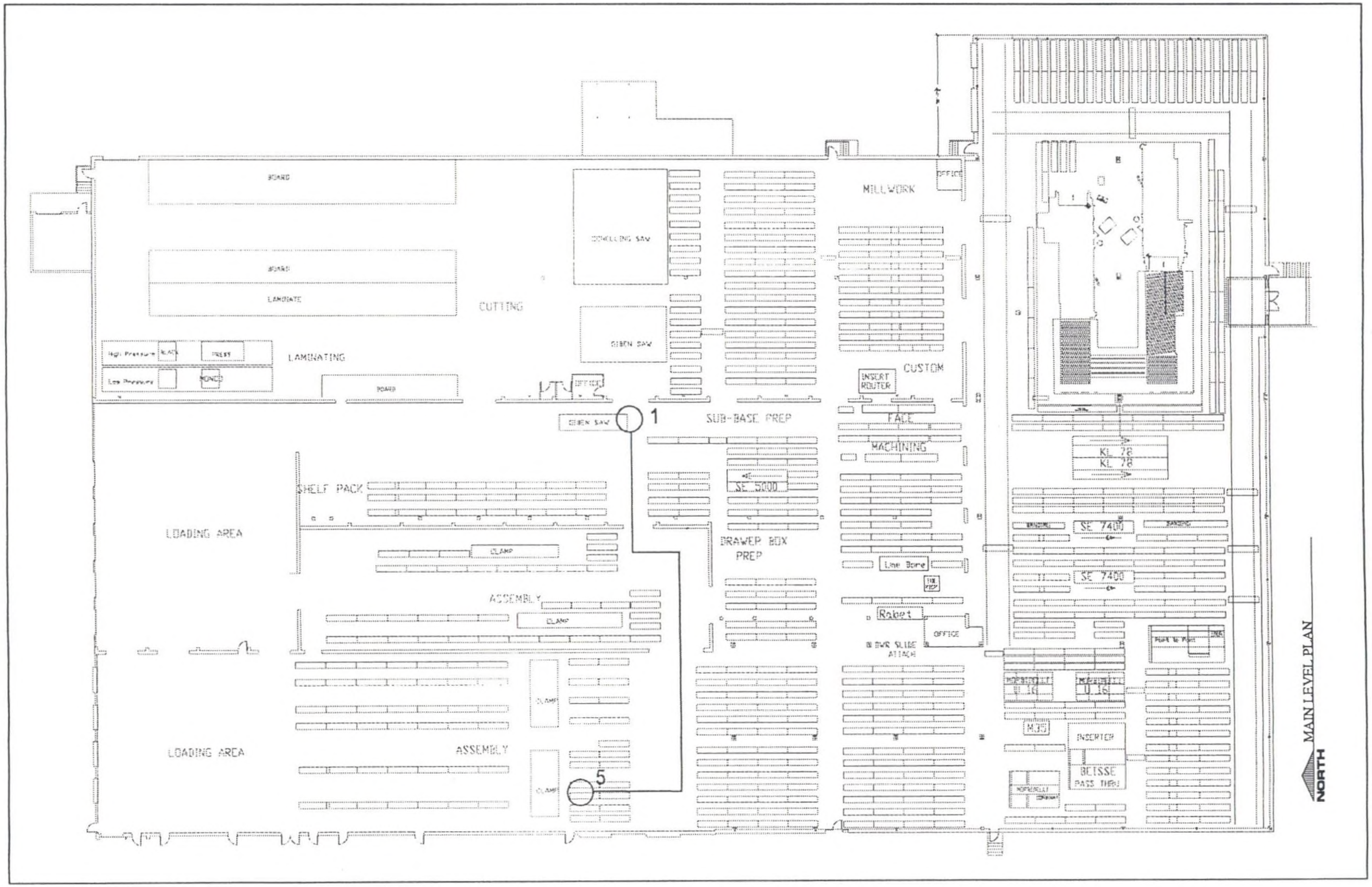

Figure 15. Flow diagram (back)

TMI manufactures all of their cabinets using the 32mm system. The system was designed to make the best use of natural materials and labor. The system has several benefits that increase the overall efficiency of manufacturing large quantities of cabinets. Some of these benefits are:

1. Using hinge locations that are equal distances from the top and bottom of the door. Balanced hinge referencing allows the operator to bore holes with no consideration for top or bottom of the door. All the operator needs to know is on which side of the door that the hinge is located.
2. All drawers are made with equal bottom referencing. This means that the distance from the bottom of the drawer front to the bottom of the drawer bottom is the same for all cabinets. Doing this eliminates the special setups for boring and thus eliminating the opportunity for mistakes.
3. Line bored holes on the side panels of the cabinet are located 37mm back from the front edge of the cabinet. Doing this allows hinges to be located accurately offering little opportunity for mistakes.

The 32mm system is designed to eliminate several inefficiencies in the construction of the cabinets. The basic construction of the cabinets manufactured by TMI does not change very much from cabinet to cabinet. Although, there may be differences between the edging, hinges, and pulls used on a cabinet, the operation to apply each of them is basically the same. All of the operations performed on a cabinet are essential and therefore none of them can be eliminated. Patterns of the components for all the cabinets on a job are prepared by using computer software to optimize board utilization. On any job, the doors for a wall cabinet may be the same dimension as the doors on a base cabinet. The same goes for cabinet sides and shelves. This type of construction increases efficiency by allowing up to four board patterns to be cut at on time.

Once all of the components are cut, they are then sorted into groups of components of identical cabinets on the job. Grouping these components together allows TMI to provide one shop order for a group of cabinets. Once the components are sorted, they proceed through the different manufacturing processes. The amount of time it takes from this point to final assembly may vary from a couple of days to several days. This all depends on the size of the job, whether or not materials are available, and what time of the year the job is going through the plant.

The next operation is sorting. At this stage, components are separated out of their component groups into groups of parts that make up one cabinet. This operation allows cabinets to progress through assembly on a continuous basis. A large portion of TMI's facility is used for sorting. The sorting operation is very labor intensive and time consuming. Large quantities of work-in-progress can be seen at each of these locations. Figure 16 is an operation process chart showing each of the operations performed on all of the components of a cabinet. It identifies what time during the production process each operation takes place

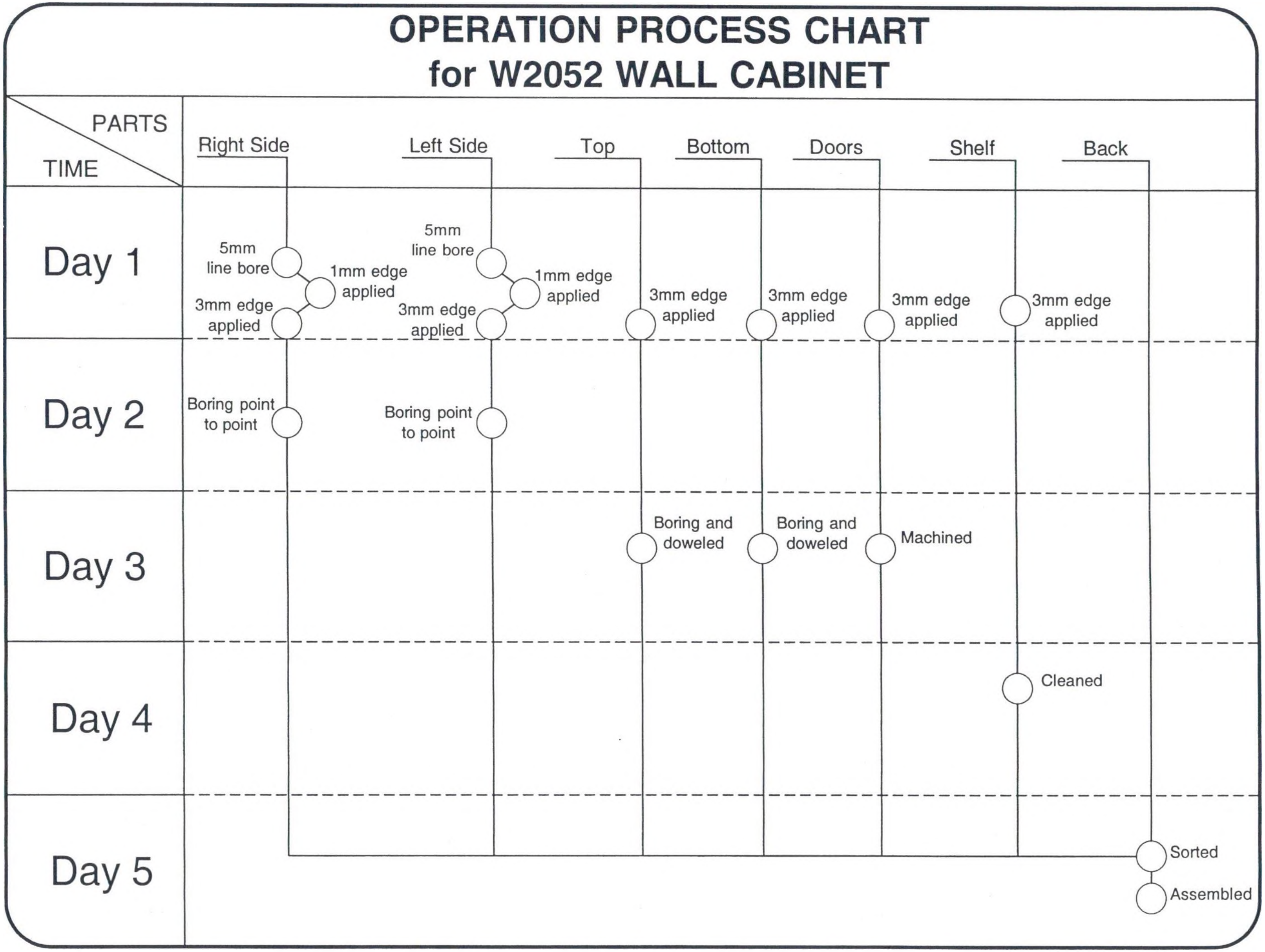

Figure 16. Operation process chart

in comparison to all of the components. For this job, production took place over a five day span.

Summary of Data

In observing the manufacturing processes used to produce a cabinet, several efficiencies were noticed in the basic construction of the cabinet. These practices greatly improve the construction process and add value to each cabinet. However, several inefficiencies exist in the production process flow. Analyzing the data collected from the process flow charts shows that a large percentage of the time that the components are in the plant, they are having no worked performed on them. Figure 17 shows that over 97% of the time that the components are in the plant, they are sitting on the production line having no work performed on them. Taking into consideration material handling and delay time, this percentage increases to 98%. Each of these activities is considered non-value adding functions and therefore can be considered waste. Only 2% of the entire production time can be considered value adding.

What was found in this study is something that TMI has learned to adapt to and work around. It is commonly agreed upon that the future holds great

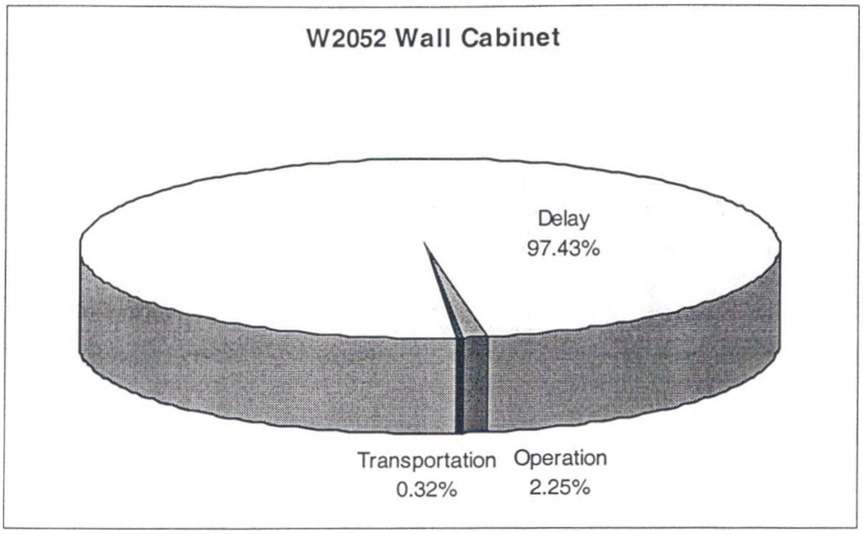

Figure 17. Pie chart of task percentages

opportunities for change at TMI. With advancements being made in technology and management practices, TMI will be able to improve the production process flow of its manufacturing facility.

CHAPTER V

SUMMARY, CONCLUSIONS, & RECOMMENDATIONS

Restatement of the Problem

This study was instituted to perform an analysis of the production process flow at TMI Systems Design Corporation that would help improve the overall efficiency of its manufacturing process.

The objectives of the study were:

1. Conduct a flow analysis of the current production process flow at TMI Systems Design Corporation for the purpose of providing a benchmark to which alternative facility designs can be evaluated.
2. To aid in identifying areas that may decrease output or increase costs.

Summary

TMI Systems Design Corporation is a manufacturer of plastic laminate casework, countertops and architectural woodwork for education and healthcare markets. TMI's goals and objectives in 1999 are designed to support its basic business strategy of building a people-focused, market-driven, technologically-current, financially-strong, "World Class" organization. TMI currently has been in business for 30 years and the pace of change within the company continues to accelerate.

This study was performed in the area where TMI manufactures its plastic laminate casework. In this area, TMI produces cabinets of various size, shape and design. Cabinets are produced on a per job bases and vary in quantities and dollar amounts from job to job. Specifications on the cabinet construction also vary from job to job. On any given day, there will be numerous jobs simultaneously going through TMI's 130,000 square foot facility. Production levels vary from being high in the summer months to being low in the winter months. On average, it will take a job 6 – 8 days to progress through the factory during high production levels and 3 –4 days during low production levels. Although there are many differences between the cabinets and production levels at TMI, the same inefficiencies exist within the plant for all cabinets and at any time of the year.

Plant layout/design is one of the most important improvements that a company can focus on to have a competitive cost advantage over others. The objective in plant layout/design is to plan the arrangement of facilities and personnel to be the most cost effective by minimizing the movement of both materials and personnel during the manufacturing process. It has a direct impact on quality and profitability because it deals with the arrangement of physical facilities and the manpower required to operate it profitably. All of this is done while still producing a quality product. The result is a new method of manufacturing that is much more efficient and has a lower product cost.

An effective plant layout will eventually improve productivity. This is possible because steps have been taken to eliminate portions of the production process that do not add value to the final product. These nonvalue-adding processes are no longer needed to produce the same or even higher levels of output. Eliminating large quantities of work-in-progress will eventually improve quality because when problems occur they will be noticed immediately. Workers will also be closer together allowing better and more frequent communication. All of these lead to greater output for less input which translates into more profit dollars for the company. Black (1991) stated that "the secret to success in manufacturing is to build a company that can deliver on-time (short throughput time), superior quality products to the customer at the lowest possible cost (least waste) and still be flexible".

This study was significant in the fact that change in customer demand is challenging manufactures to deliver a superior quality product on time at the lowest possible cost and still be flexible. Improving the plant flow leads to improvements in customer responsiveness, greater efficiencies, lower inventory, and lower operating costs. Companies that want to compete in a world-class, global economy can no longer ignore the ongoing cost of poor plant layout.

Companies need to constantly review and improve their manufacturing methods in order to compete.

Conclusions

The following conclusions were based on the review of literature and the results of analyzing the production process flow at TMI. The area of greatest concern in the plant is the percentage of time work is in material handling. Large amounts of work in progress are spread throughout the plant adding additional cost to the entire system. Materials in-flow consume time, and at the very least, they generate cost because of the interest on the money they represent. In addition they require space, equipment, handling labor, insurance, and in many instances incur damage to the parts. Changes in material handling operations do not affect the design, function, or marketability of the product. If the market price is stable, the cost reduction increases the gross margin and is therefore all profit. The cost reductions can also benefit the company by allowing competitive pricing on jobs. Material handling also has a direct effect on the machine utilization at TMI. Machine utilization decreases when the operator takes time to find the components that need to be processed. Even more time is lost when the operator has to move the components to the next operation.

The sorting operations that take place at the beginning and end of the manufacturing process consume more time than any other operation except final assembly. This additional time is very labor intensive and requires components to handled quite often. The excessive material handling increases the possibility of components being damaged. The additional time and cost associated with rework is something every company would like to avoid.

To increase the overall efficiency of the manufacturing process, TMI must make the most of their existing facilities. To do this, they must make optimum use of the building space, while maintaining flexibility of operations. The distance between operations is very large. This area is mainly occupied by a large amounts of work-in-progress. Moving the work areas closer together would reduce a good portion of the material handling while improving the flow of communication between workers.

When inventory reduction results in shorter lead-times, it makes the company more responsive to the customer needs. With shorter throughput time in the factory, TMI can react faster to changes, especially change orders and special rushes. When inventory levels are lowered, problem areas within the process flow will be exposed. Solving these problems will improve the production process flow and minimize the lead-time in the factory. The first step towards making improvements at TMI is recognizing the potential. Reducing the lead-time of a job creates enormous benefits for the company and more important the customer.

Recommendations

Upon completion of this study the author makes the following recommendations.

1. Additional research needs to be done on TMI's current material handling practices. Reducing the amount of material handling would increase productivity by eliminating several activities that do not add value to the final product.
2. Reduce the amount of time that it takes a job to travel through the factory. By smoothing out the flow of materials and information, days can be eliminated from an entire manufacturing process. Customer service is the key to success today, and in order to improve service, process time must be cut to meet increasingly demanding customer requirements.
3. Automate the entire production process. Automating the production process would allow materials to flow through the plant smoother by eliminating the large amounts of work-in-progress. Bar coding would

allow TMI to track individual components and know where they are located within the production process at any time.

4. Additional research is recommended in performing a detailed analysis of each operation. Knowing the decisions and actions that must be made by an operator while help improve machine and operator utilization.

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