

Lean Transformation in Supply Chain, the Autocatalytic Nature of Lean Principles, and Tactics for Implementing Lean Tools

By

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B.S. Mechanical Engineering, Brigham Young University (2003)

Submitted to the MIT Sloan School of Management and the Department of Aeronautics & Astronautics in Partial Fulfillment of the Requirements for the Degrees of

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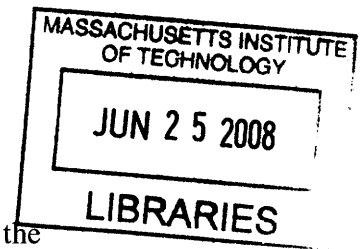
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ABSTRACT

Expanding Lean principles beyond the manufacturing floor, ultimately to entail a comprehensive Lean Enterprise, has gained increasing attention among corporations. This thesis entails a detailed case study of initiating a Lean Transformation in the Supply Chain department of a technology center for engineering, integration and final assembly of directional drilling equipment. This technology center is part of Schlumberger, a global corporation and industry leader in directional drilling and other oilfield technologies and services.

Initiating the Lean Transformation in this Supply Chain department is detailed and used as the central theme throughout the thesis. The rapid, successive applications and results of conventional Lean principles are evaluated. Due to the near relative proximity of the several initiatives undertaken, in both time and within the organization, this case is used to evaluate the Autocatalytic Nature of Lean Principles within the Supply Chain department. Concurrently, the dynamics involved with the interactions of personnel within the department are evaluated. As a Lean Transformation is so heavily dependent upon the personnel participating in the change, tactics for initiating a Lean Transformation are treated in reference to the several initiatives of this case study. These three components, Lean principles, their autocatalytic interaction, and relevant human interactions, are all combined to comprehensively address the most influential aspects of affecting a Lean Transformation in a Supply Chain department.

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1. Thesis Overview

Thesis Overview

This thesis is organized to flow conceptually and chronologically for the reader, presenting things to build upon each other, such that the study undertaken and lessons learned can be understood in context with relevance. It begins with background on the company and the site, moving on to the purpose for this six month project to initiate a Lean Transformation in the Supply Chain. Following this background is a treatment of industry best practices for such Lean transformations. The internal conditions for the Lean Transformation are then given, followed by a chronological overview of the initiatives undertaken. The initiatives are then evaluated individually using a framework allowing a progressive evaluation of the Lean Transformation.

Background

Section 2 begins with Schlumberger Company background and industry, and competitive position in the industry. The background of the Stonehouse Technology Center (SHTC) is then addressed, with growth history and projections, Product Lines, nature of demand and customers.

Supply Chain Department

The Supply Chain department in SHTC is then addressed specifically in section 3, including background on the size, organization, and growth projections. The organic growth path to the initial state of operations and performance at the beginning of this study is illustrated. The roles and organization of the supply chain at the beginning of this study is identified, along with performance metrics. It is identified that the Supply Chain is the bottleneck in SHTC production capacity, and that management is proactively intent upon a Lean transformation.

Lean Transformation; Current Industry Approach

In section 4, an overview of academic materials relevant to this Lean Transformation is evaluated as a benchmark of best practices.

Initiating a Lean Transformation

The initial conditions regarding the business, management, and operating personnel are illustrated in section 5 with respect to this Lean Transformation. Operating personnel and management both shared an internally perceived need for process definition and improvement, and carried a supportive attitude in general, but with rational criticism of the methods and approaches to be undertaken. Three preliminary changes were implemented just before the onset of this study, including implementation of new Forecasting Software, a Clean Kit Policy for Assembly, and a new Supply Chain Manager. The boundaries for what could be changed in this transition are identified.

Chronological Overview

Section 6 provides a chronological overview of the several change initiatives implemented, giving a broad overview of what was done over the duration of the six months. Many initiatives were undertaken in parallel, affecting the observations and implementation of the others. This overview allows the remainder of the initiatives to be treated in reference to the other initiatives simultaneously underway.

DMAIC Framework

The DMAIC recipe is illustrated in section 7 as the framework by which this thesis is organized. DMAIC, as a general process improvement framework, is applied to the Supply Chain department and this Lean Transformation. The acronym stands for *Define, Measure, Analyze, Improve, Control*.

Define

In section 8, the purpose of the Supply Chain within SHTC is clearly defined with respect to relevant stakeholders. The three primary stakeholders are identified as Assembly, Sales, and Suppliers. The Supply Chain department is responsible to ensure delivery of the right parts, in the right condition, to the right place, at the right time, and at minimal cost.

Measure – Identify and Quantify the Current State

Section 9 is where the Thesis begins to delve into the real meat of the Lean Transformation. Measuring consists of quantified measurement of volume, times, and so forth, as well as more operational identification of processes and organization in the form of process flow maps, standard work instructions, and a comprehensive Value Stream Map. This study starts with finding and evaluating what tools were already available, noting that original process definition was nearly non-existent, having organically grown up as operating personnel shared responsibilities according to the needs of the moment. The original performance indicators were sparse, with some misleading measurements, largely resultant from the software tools and the way they were used. After this initial assessment, the section transitions to creating the Value Stream Map (VSM) as the foundational tool for a transformation to a Lean Architecture. The VSM is built following the “need for a part” from the field, through SHTC, until the “need for a part” is fulfilled with a part delivered to the field operators. The incremental steps of building a VSM from scratch are followed, starting with the general overview, and filling in the segments with increasing resolution. Ultimately each step is identified as Value Added, Muda Type 1 or 2, and ready to be quantified. Lessons from meetings with the different Supply Chain groups are evaluated. Methods and considerations for quantifying the Value Stream Map are evaluated.

Analyze – Preliminary

Section 10 presents analysis derived from the initial development of the Value Stream Map, including workflow analysis and quantified data which was first gathered from the MRP database. Expected and unexpected patterns in the data are addressed. Communicating the analysis with operating personnel is discussed, including the nature and evolution of their responses to some of the conclusions.

Improve

Section 11 begins with a discussion of the sources of ideas, and the reinforcing nature of communicating workflow and data analysis with improvement ideas. The several improvement initiatives are then documented, considering development, implementation, and results. Emphasis is given to interactions with personnel in developing and implementing the initiatives. The initiatives evaluated in this section include: Buyer PO Filing, Eliminating PO

Printing, PO Electronic Storage, Action Message Tools, PO Confirmation Policy, Process Improvement Priority Table, Forecast Sharing, MRP Accuracy Improvement, and Standard Work Instructions.

Analyze – Enabled with embedded Lean tools

With the initial round of improvement initiatives, a new depth of analysis became available for process improvement, and is addressed in section 12. This section addresses the most significant of these findings. Beginning with validating MRP software behavior, leading to Rush PO's and Rush Requisitions from MRP instability, and giving special treatment to the participation of operating personnel in developing this deeper analysis.

Control

Section 13 approaches Process Control from the standpoint of sustaining Continuous Improvement. The intent evaluated for Control in this Lean Transformation is institutionalizing continuing process Improvement, including treatment of actions and approaches that may inadvertently short circuit a Lean Transformation. This section also deals with managing a Process Engineer team and Measuring the Performance of a Process Engineer, also evaluating the role of Learning Managers within a Learning Organization.

Future Work

Future work is addressed in section 14, suggesting the next steps to be undertaken in this Lean Transformation, treating both Supply Chain and SHTC wide recommendations. Supply Chain recommendations progress from evaluating MRP settings, to implementing a systematic approach to updating Lead Times with suppliers. SHTC recommendations call for an enterprise wide Value Stream Mapping effort, leading to an SHTC Behavior Measurement System.

2. Background

2.1. Schlumberger Company Background

2.1.1. Industry and Company Facts

Schlumberger is a leading competitor in the Global Oilfield Equipment and Services Industry, with a market cap over \$80B and annual revenues exceeding \$20B, operating in approximately 80 countries with 70,000 employees (Oct. 2007). Schlumberger provides a complete range of oilfield products and services for the entire lifecycle of a well, including formation exploration, drilling and measurement, software solutions, consulting, and oilfield services. Demand for oilfield equipment and services has grown faster than expectations over the past few years, and growth is expected to continue at least through 2010.

2.1.2. Competitive Position

Schlumberger positions itself as the technology leader in the industry, providing the most advanced equipment for drilling, exploration, and processing. Already a global presence, Schlumberger is expanding its manufacturing and engineering locations to include a more globally diverse base. Schlumberger is strategically positioning facilities to leverage the growing capabilities around the globe, and to be better positioned to serve the highest expected growth in demand.

2.2. Stonehouse Technology Center (SHTC) Background

2.2.1. SHTC Site

The SHTC campus consists of five buildings located within walking distance from each other in an industrial business park. One building houses the primary Assembly areas (electronics and mechanical), with Engineering, Research, and Operations sharing this building and two

others. One building is dedicated to Batteries, and another to Shipping and Receiving (Warehouse).

2.2.2. Growth History and Projections

Stonehouse Technology Center (SHTC) houses engineering and production for Directional Drilling (DD) equipment, serving primarily as an integration center for Field Technical Equipment (FTE) and Maintenance and Supply (M&S) equipment for supported products. As a cost center, SHTC is measured in terms of volume produced and spending on production. All transfer pricing is calculated as a percentage above production cost, generating a relatively fixed percentage in annual profit. SHTC 2006 spending on parts for FTE and M&S was approximately \$200M, growing to roughly \$300M for 2007, and expecting similar growth (30%) annually through 2010.

2.2.3. Product Lines

SHTC revenue is primarily driven by sales and production of three Directional Drilling (DD) products, PowerDrive (PWD), Xceed (XCD), and PowerPack (PPK). These are long, thin, highly integrated products, extending to thirty feet in length and up to nine inches in diameter, integrating sensors, electronics, and highly specialized materials. Other product lines in development are not referenced, as they are largely irrelevant to this study.

In addition to Directional Drilling products, SHTC produces unique, mission critical power source products (Batteries - BAT) for DD tools, and a variety of other applications. This product line has experienced explosive growth since 2003, including a transition to a new building for production in 2006. Revenue for this product line has grown to roughly \$30M annually.

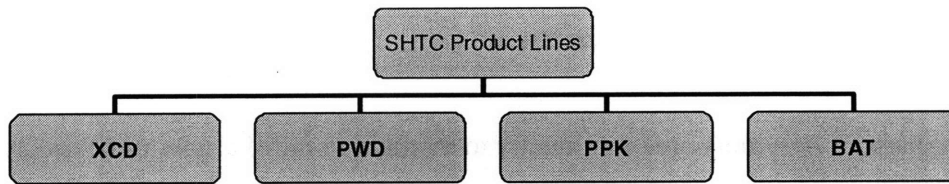


Figure 1: SHTC Product Lines

2.2.4. Nature of Demand and Customers (Value Stream Overview)

Demand for SHTC products is collectively greater than its present ability to produce tools and M&S. The Customer Service Dept (Sales) confirms orders for FTE in balance with the site's ability to deliver on promised orders. Some FTE product line models sell better than others, and M&S demand is variable, so although aggregate demand is greater than production capacity, discretion is still necessary to produce according to actual customer demand.

Every product includes highly complex components, with some requiring over 12 month lead times. While design techniques have been applied to minimize the impact of long lead times for unique parts, a certain amount of production is inherently reliant on forecasted demand.

The general sales flow follows the diagram below (Figure 2). Schlumberger Operations sends direct sales orders for FTE and M&S to the SHTC Customer Service Dept (Sales and Forecasting). Expected future demand for FTE is communicated to SHTC through corporate headquarters. Expected demand for M&S is predicted based on previous sales, forecasted sales, and anticipated replacement rates.

Within SHTC, Sales & Forecasting controls the inputs to the MRP software which drives a production schedule accounting for lead times, yields, and other Planning Parameters. Supply Chain sends orders to Suppliers, and releases internal Work Orders for FTE and M&S according to the MRP software. Suppliers deliver parts to the warehouse to be held in

Inventory. Assembly builds to Work Orders using stock from Inventory. Efforts are made to control the level of inventory in the warehouse.

Completed parts in Assembly are sent directly to the field to fulfill a sales order, or are sent to a global warehouse. SHTC delivers on direct sales orders for both FTE and M&S most often by shipping directly from Stonehouse. When appropriate, sales orders are fulfilled from a global warehouse.

Product Delivery Overview

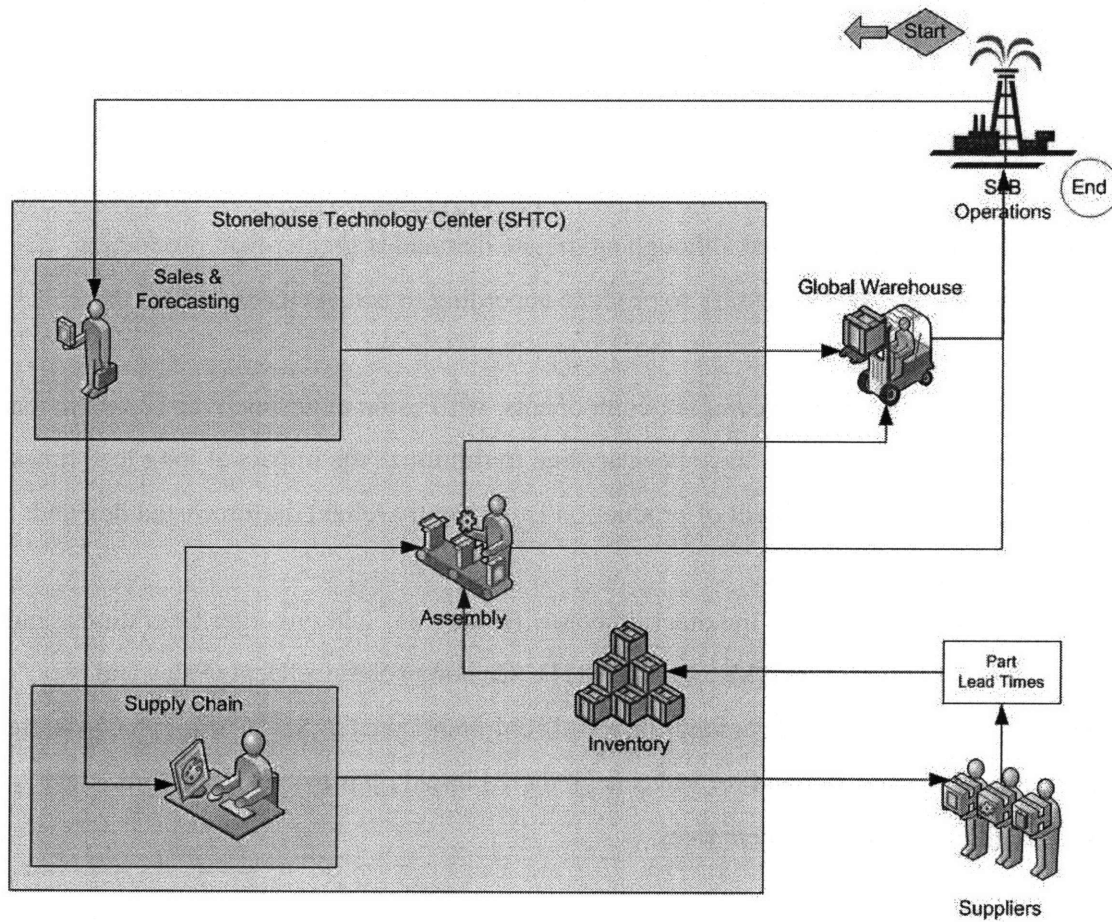


Figure 2: Demand and Product Flow Overview

3. Supply Chain as Organically Grown Roles and Processes

3.1. Growth History and Projections

The Supply Chain department grew up with the site as increasing production demands required more personnel to handle the product lines and volume. Figure 3 shows historical and projected growth in SHTC Spending and Supply Chain Headcount. Over the two years preceding this study, the Supply Chain doubled in headcount, and will double that number again through 2009.

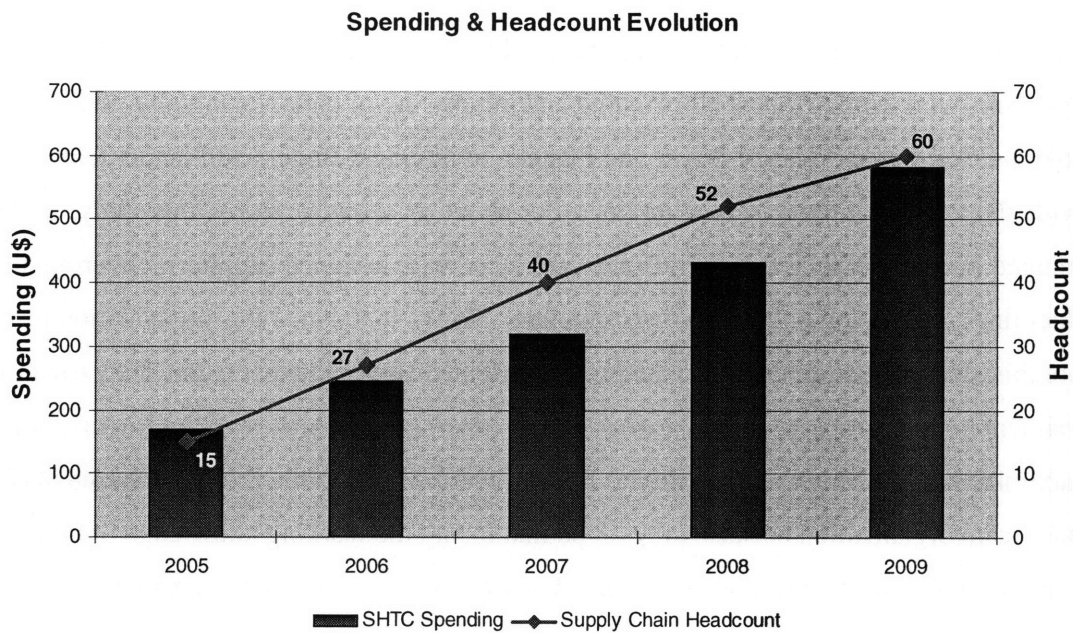


Figure 3: Historical and Projected Growth in SHTC Spending and Supply Chain Headcount

3.2. *Organically Grown Roles and Processes*

3.2.1. Growth to Present State

Initially, the roles in the Supply Chain were generally modeled after other Schlumberger Technology Centers. As shown in Figure 4, this consisted of the Supply Chain Manager, with three fundamental segments reporting to him: Buyers, Planners, and Strategic Sourcing. The role of Global Sourcing was given special emphasis to help augment the corporation's major effort to increase their global presence and supply base. This study deals primarily with the workflow through the Buyer and Planner roles.

The Buyer / Planner role originally was performed by a single individual responsible for a product line, who would control all planning and purchasing of parts. Eventually, SHTC created the two distinct roles of Buyer and Planner, assigning a Buyer and Planner team (two individuals) to each of the four product lines. For about six months prior to this study, SHTC rearranged the Buyers such that each Buyer interfaced with assigned suppliers, covering all product lines purchasing parts from their suppliers. SHTC abandoned this organization just before this study began, returning to the product oriented Buyer Planner team. They tried this experiment hoping to spread the total workload of ordering parts across all the Buyers, hoping to maximize the utilization of each Buyer. SHTC reverted back to the product focused Buyer / Planner team organization because they found that losing the working knowledge of incoming parts associated with their respective product lines was very disruptive to managing the inflow of parts for production needs.

Stonehouse Manufacturing Organization

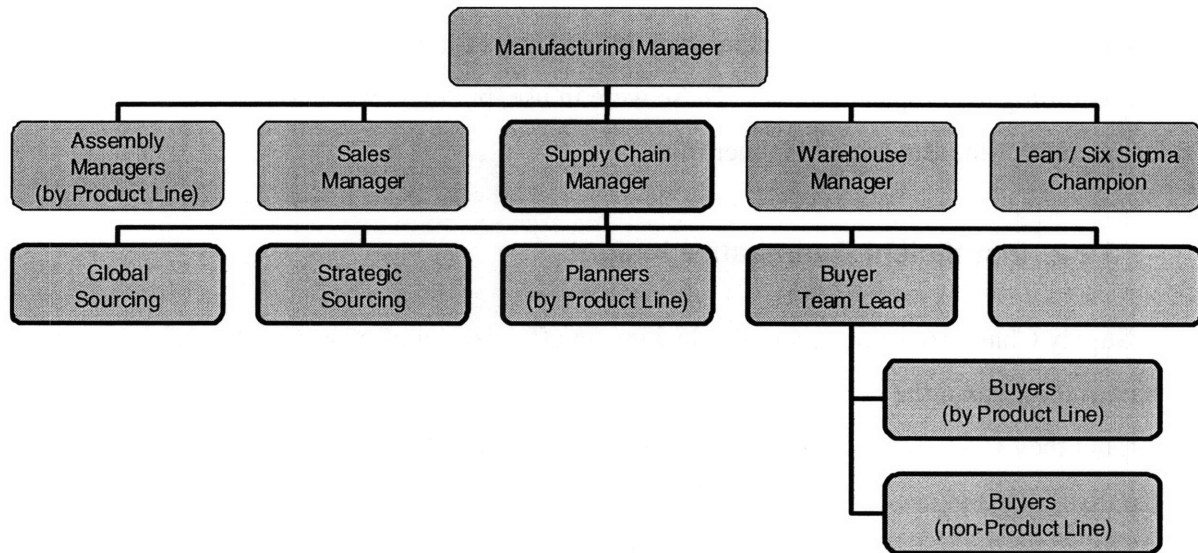


Figure 4: Initial Supply Chain Organization

The initial processes in the SHTC Supply Chain were an organically grown set of roles which had evolved from a small group of people incrementally splitting up responsibilities as demands grew. Consequently, they had a near complete absence of defined processes. There wasn't even an official Job Description for the three primary roles: Buyers, Planners, and Strategic Sourcing. The Buyers and Planners worked closely with each other to keep the right parts coming to the assembly line, each pair operating with very unique processes which they developed on their own.

Coinciding with undefined roles and processes, there were no training procedures. When new employees were added to the team, they were encouraged to “develop their own method” for using the MRP software to accomplish their job. Enough searching on the intranet revealed a web page with a Buyer / Planner manual, but nobody knew of the manual or used it in practice.

The manual didn't show Process Flow or define roles and responsibilities, but was instructions on how to perform various functions with the MRP software.

In the role of Strategic Sourcing, there were defined steps for approving new suppliers and new parts according to company policies. These were in use, but there were no processes documented for the Buyer and Planner roles.

3.2.2. Insufficient Quantitative Insight

The Supply Chain department was also lacking an effective set of measurements of the behavior throughout the system. A few internal indicators had been developed nearly two years prior, but they were aimed at measuring personal performance more than system behavior. The software systems in use provided very little data of any analytical use for workflow, unless custom queries were programmed to access this data from the database. The Supply Chain department did not have any personnel with the training or skill to program such queries, so they were reliant on leftover queries from nearly two years ago.

3.2.3. Supply Chain as the Bottleneck in SHTC Performance

SHTC was facing several challenges that are common to organically grown organizations of this nature. They had production delays from missing parts, customers often had to wait for orders that should have been available, and inventory was growing beyond control. A cursory analysis identified that errors in the Supply Chain were the primary causes of these problems. These problems were the most critical to the health of the site, and are the primary targets of the initiatives in this study.

Additional challenges in the Supply Chain department include expanding the global supply base, managing risk on parts and suppliers, rationalizing the supply base, and negotiating production prices with suppliers. These problems are all strategically important to the Supply Chain department and the SHTC site, and were receiving attention, but they are outside the scope of this study.

3.2.4. Management Desire for a Lean Architecture

In spite of these deficiencies, there were several things that the SHTC Supply Chain had going in their favor. Foremost, they had a talented team of operating personnel who were skilled in their roles, creative in developing solutions to problems, and supportive of improving the methods by which they were working. Leading these personnel was a dedicated Supply Chain Manager and a Manufacturing Manager, both aware of the mounting challenges within the department, and supporting a Lean Transformation.

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4. Lean Transformation – Current Industry Best Practices

4.1. *Lean Philosophy*

Lean, as a Production philosophy centered on creating value for the customer and eliminating waste in the process through continuous improvement, has been around since 1990. As the Lean philosophy has developed and received wider adoption throughout the world, it has been extended beyond the manufacturing floor into all parts of the enterprise, along the entire product value chain, and through the full product lifecycle. Throughout its development, Lean principles have been coupled with other production and management philosophies such as Six Sigma, and Theory of Constraints. While an exhaustive treatment of Lean, its history, principles and tools, requires more than a few pages, a review of literature most relevant to this study is given here.

The foundational concepts of Lean were first characterized in 1990 in the book *The Machine that Changed the World* (Womack, Jones, and Roos, 1990). Built upon extensive research by the MIT International Motor Vehicle Program studying auto makers across the globe, Womack, Jones, and Roos, illustrate the rise of Lean Production through the methods of the Toyota Motor Corporation. While “Lean” is the label Womack, et al attached to the methods embedded in Toyota, Toyota themselves call it the Toyota Production System (TPS), and the guiding philosophy of their company “The Toyota Way.” This work is the foundation from which a plethora of Lean books and articles have followed.

While *The Machine that Changed the World* is very demonstrative of Lean production, subsequent texts delve into more general treatments of the principles in play. In their follow up book in 1996, *Lean Thinking*, Womack and Jones articulate a more conceptual definition of the several components of Lean. Several of the concepts are relevant to this study, in particular the foundation by which they approach the issue. “Value” of a product or service is defined as “a capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer.” (Womack and Jones, 1996, p. 353) The Value Stream is then defined as “The specific activities required to design, order, and provide a specific product, from concept

to launch, order to delivery, and raw materials into the hands of the customer.” (Womack and Jones, 1996, p. 353) From these definitions, it follows that the Supply Chain is an integral part of the Value Stream, and thus a candidate for Lean Principles.

Guiding the design of initiatives implemented in this study, are four rules Toyota operates with, as delineated in the article *Decoding the DNA of the Toyota Production System* by Spear and Bowen.

Rule 1: How People Work. Work should be specified concerning what to do, when to do it, how to do it, and what the result will be. By doing this, workers know exactly what is expected and how they are expected to do it. Such specification reduces variability in workflow, and enables experimentation with the way work is done.

Rule 2: How People Connect. All handoffs, customer-supplier or internal, must be standardized and direct. This creates accountability between operators and suppliers, reducing variability within the value stream.

Rule 3: How the Production Line is constructed. The production line, or line of workflow, must allow work to flow in a simple, direct, and specified path through the plant. Errors must not be allowed to move from one step to the next unnoticed. This reduces variability, ambiguity, and waste from rework.

Rule 4: How to Improve. Improvement must be in accordance with the scientific method, under the guidance of a teacher, and at the lowest level of the company. Improvement ideas are generated and developed through all levels of the company, while controlled through a clear hierarchy.

Also contributing the approach of this Lean Transformation are four lessons presented in the article *Learning to Lead at Toyota* by Steven Spear. In these four lessons, Spear characterizes the approach that operating personnel and managers at Toyota take in designing and improving

their production systems. While these lessons were developed primarily in reference to assembly and manufacturing operations, they equally apply to work in the Supply Chain.

Lesson 1: There's no substitute for direct observation. In application to Supply Chain, this advises detailed observation of how operating personnel actually perform their role, beyond instructions of how they should perform their role.

Lesson 2: Proposed changes should always be structured as experiments. This requires that the current behavior of the system and personnel operating the system is known as a reference, and that changes are then designed and results compared to this known state.

Lesson 3: Workers and managers should experiment as frequently as possible. A one-time system re-design will be insufficient for a truly Lean operation. Lean requires that both operating personnel and managers are both actively engaged in designing experiments to improve the system.

Lesson 4: Managers should coach, not fix. This implies that the operating personnel, who are most familiar with their roles, and the Process Engineer who is most familiar with the systematic behavior of the overall system, should be held directly responsible for improving their roles. The manager is there as a coach and advisor to help these individuals improve their roles.

The foundational tool used to initiate and sustain a Lean Transformation is the Value Stream Map. This tool serves as a basis for measurement, communication, design, and many other uses. In addition, the process of Value Stream Mapping serves to get workers and managers engaged in the Transformation. In *Learning To See*, Shook and Rother provide conceptual guidelines and concrete step-by-step examples for building a Value Stream Map, and applying it to maximize the effectiveness of a Lean Transformation. This book is one of a series of works produced by them, as professional aids to guide managers and process engineers through every step of Value Stream Mapping through the entire value chain.

In *Building Deep Supplier Relationships* by Liker and Chio, they offer guidance particularly applicable to Supply Chain regarding their relationships with suppliers. Among the suggestions in their Supplier-Partnering Hierarchy is guidance to “Share information intensively but selectively.” Intensive sharing of the right information enables Suppliers and Main Partners to quickly respond to changing conditions in the market, in the value stream, and to assist each other in improving the overall performance of their own and joint operations.

For future work beyond the immediate scope of this study, *From Lean Production to the Lean Enterprise* (Womack and Jones, 1994) addresses the need for companies to extend beyond their own internal operations, and grow the application of Lean principles across the entire Value Stream. In particular, they identify the conflict of Three Needs that managers must balance; Needs of the Individual, Needs of Functions, and Needs of Companies. All of these must be kept in balance as managers collaborate up and down the Value Stream to become a world class performing enterprise.

4.2. Complimentary Theories and Toolsets

The importance of focusing on the most critical part of the business for bringing value to the customer is illustrated as the Theory of Constraints in *The Goal* (Goldratt, 1984). Goldratt’s Theory of Constraints gives special emphasis to identifying the bottleneck in a production system, and releasing work in pace with the capacity of the bottleneck. Initially applied to the assembly line, Goldratt extends this principle to the rest of the organization, and by implication the entire value stream. Every value stream has a bottle neck, and it may exist in the Assembly Line, Sales, the Supply Chain, or another area. The focus of a company should be on identifying the bottleneck to the system, wherever it may be, and improving that bottleneck until it is operating smooth and regularly enough that another link in the chain becomes the next constraint to receive attention.

One of the complimentary philosophies that has evolved with Lean over the decades has been an increasing development of statistical process control. One of the most prevalent forms of this has been Six Sigma, originally developed by Motorola, and later popularized by General Electric. One of the guiding frameworks to approach problems using the Six Sigma tool pack is

the DMAIC framework: *Define, Measure, Analyze, Improve, Control*. Define the goals of the process. Measure the behavior of the process as it presently performs. Analyze the behavior of the system, looking for causal factors. Improve the existing processes based upon analysis and appropriate modeling. Control the process to eliminate variances and defects. This approach is applicable for everything from highly specific machine functions, to general workflow through a business unit.

This combination of approaches and toolsets collected under a Lean architecture becomes a highly effective approach to improving the operations of any organization, from manufacturing, to design, to services. These concepts which have evolved to become industry best practices have found detailed application throughout this study.

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5. Initiating a Lean Transformation in the Stonehouse Supply Chain

5.1. *Conditions for Implementing Change at SHTC*

We begin the treatment of this Lean Transformation with a look at the conditions within which the transformation was started. Areas of note are the business conditions, management support and familiarity, attitudes among the operating personnel, and finally limitations constraining change options.

5.1.1. Business

As noted in the background section, SHTC was acquired roughly five years prior, and three years prior it was decided to make it a Technology Center for Final Assembly and Integration for Directional Drilling. Since then, the site has experienced 50% growth each year, and anticipates 30% growth for at least the next three years.

This relative newness relieves the site of the burden of history many sites experience when they undertake a Lean Transformation. Some of the people at the site have been around for many years, but the site has experienced so much growth in the near past that everybody is aware of the necessity of change, and has already adapted to a certain level of change.

The anticipated future growth makes management and operating personnel aware that they must develop their organization such that they can handle the continually increasing volume. They are aware that their previous methods will have to be abandoned in order to serve demand.

5.1.2. Management

The management at SHTC are very supportive of initiating a Lean Transformation. They are hopeful of meeting or exceeding projected growth, and recognize that their current operating methods are insufficient. The Manufacturing Manager has over twenty years with Schlumberger, and was transferred to the site six months prior to this study. The Supply Chain

Manager was with the company for about two years, transferring from a management position in China. In addition to acting as Supply Chain Manager for SHTC, he was carrying responsibility for developing the Global Supply Chain base, including China, Singapore, India, Russia, and other such countries. Both managers had previous training in Lean, but did not have experience managing a Lean Supply Chain, or managing a Lean Transformation.

Managers were both supportive of engaging a Process Engineer to drive this Lean Transformation in the Supply Chain. Figure 5 below shows the organization with the newly added Process Improvement role.

Stonehouse Manufacturing Organization

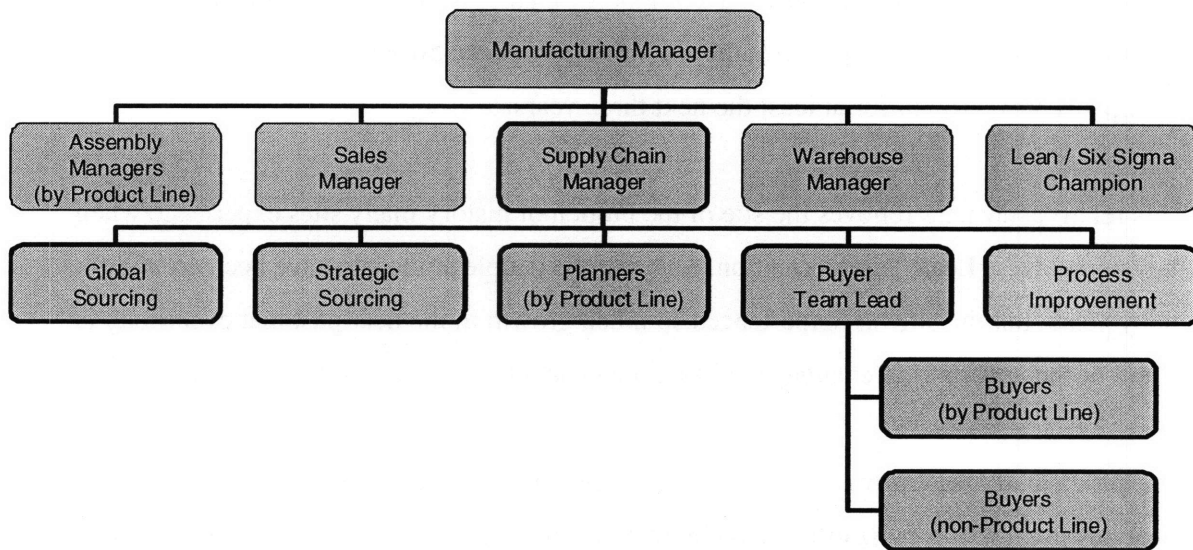


Figure 5: Organization Chart with Process Improvement Role

5.1.3. Operational Personnel – Culture

The operating personnel were relatively young, with a few seasoned personnel, and all new to Lean principles. They were all working using methods they had developed along the way, and were all feeling stretched beyond their ability to effectively fulfill their current and growing responsibilities with their current operating methods. They were supportive of change, and somebody to help them coordinate and design systematic improvements.

5.1.3.1. First Meeting

I joined the Supply Chain department, and the first team meeting I attended illustrated a good representation of the attitudes within the department concerning a Lean Transformation. The Supply Chain Manager introduced the topic of Lean, with our intentions to pursue a Lean Transformation in this Supply Chain. He noted that these principles are what all world class manufacturers design their operations on, and if successful in SHTC, this initiative would be rolled out to Supply Chain departments in the rest of the corporation. Only four of the eighteen present expressed any familiarity with Lean, and Lean Principles. The Stonehouse site had a Lean / Six Sigma Champion, but she hadn't yet set foot in Supply Chain. However unfamiliar they were, all were supportive of this effort to design our operations to get the job done more effectively.

5.1.3.2. Internally Perceived Need

Contrary to popular expectation, there wasn't the slightest hint of resistance, skepticism, or 'flavor of the week' mentality. This was a receptive group. They were part of a company that had been rapidly growing over the last two years, and they had been continually breaking production and sales records.

Along with this continually improving performance, they were growing ever more aware of their limitations to continue scaling up their performance. They were getting stretched to their limits. They believed there were better ways to run things (they were already charged with suggestions of what they'd like to change), and they were looking forward to formally addressing their growing systematic challenges. Working within this type of environment, with

a team which is receptive to new ideas and principles, while almost entirely ignorant of the ideas and principles soon to be introduced, progress was rapid and productive.

5.1.3.3. *Rational Dissent*

At the same time, not everyone in the facility was this positively receptive. Even within the Supply Chain department, it became apparent that a positive attitude breaks down quickly in the face of poorly defined processes and hasty implementation. The absolute necessity of properly defined roles and processes which account for the needs of all stakeholders in all departments is no less critical in a positive environment. However, the positive attitude does assist in the breadth and ease of process design and implementation. The attitude of participants proved to be a highly influential component of the dynamics while orchestrating this Lean Transformation, and this attitude was sensitive to the actions of the Process Engineer in effectively communicating and implementing changes.

5.1.4. Previous Changes Implemented

Just prior to this study, the Manufacturing, Supply Chain, and Customer Service (Sales) managers decided to implement forecasting software to help with forecasting demand for M&S. This software controls forecasting inputs into the MRP Software, calculating expected demand, safety stock, etc, based on projected and historical demand input to the software. This was implemented with little input from the Supply Chain personnel, with Customer Service controlling all of the inputs with which forecasts are calculated.

Another initiative implemented weeks prior to this study was a Clean Kit Policy affecting both Planners and Assembly. Previously, Planners would release Work Orders when Assembly said they were ready to work on them. Kitting would then deliver Kits with the parts necessary for the assembly. Often, the WO's were released and kits delivered with missing parts. Everyone was aware of this, but the thought was that they could make progress on the work until the parts arrived. The Clean Kit policy required that all parts be in stock and available before a WO could be released. Concurrently, Kits would only be delivered having all the parts needed.

5.1.5. Limitations in Change

Entering into this Lean transformation there were several elements that could not be changed, some technological, some organizational, etc.

The MRP software in use was a system called MFG Pro. This MRP software is used all across Schlumberger, and the corporation was promising to “soon” roll out a new version which was still delayed, as it had been over the last two years. This software had an ancient, non-intuitive interface (Figure 6), along with several limitations such as the inability to dual source components from multiple suppliers. There was no option to consider other MRP software.

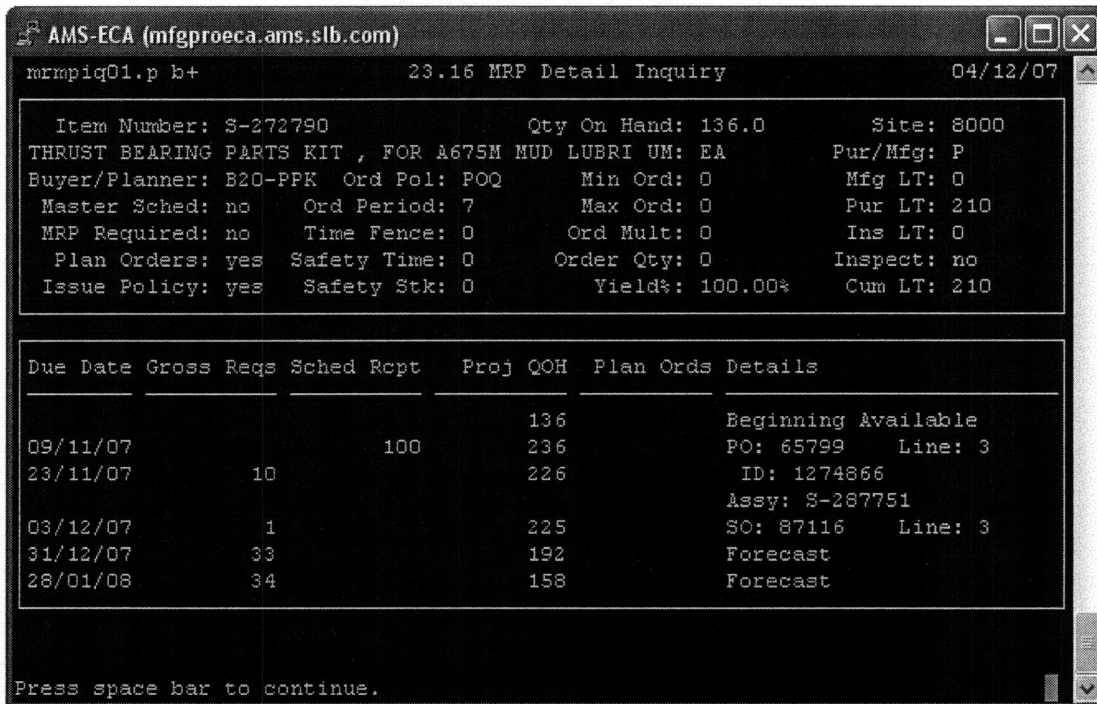


Figure 6: MFG Pro MRP Software Interface

Some positions, such as a Master Scheduler to coordinate the overall forecast across all product lines, and processes in other departments were beyond the power of the process engineer to influence. Some of these boundaries are noted in context.

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6. Chronological Overview of Initiatives and DMAIC Framework

6.1. Chronological Overview

To give context to all the initiatives documented and lessons discussed herein, we will begin with a rapid chronological overview of the project, from the beginning through the end; a concrete description of how this experiment in Lean Transformation was carried out.

I arrived in Stonehouse two weeks after the new Supply Chain Manager started, and immediately set to understanding the existing structure and operating processes. Upon finding an absence of comprehensive or detailed descriptions of the department, roles, and interactions with other departments, I began creating a Value Stream Map (VSM).

While creating the VSM, it quickly became apparent that the system would benefit from immediately implementing two activities: 1) Forecast Sharing with top suppliers, and 2) MRP Accuracy Improvement Process communicating errors upstream to be corrected. In addition, the unnecessary activity of filing paper PO copies (Purchase Orders) was eliminated, and transformed into using printed PO's as visual indicators to reinforce PO Confirmation with Suppliers. Several high level process diagrams and detailed procedures were created and revised throughout the project in order to sustain and improve these initial process changes.

While generating tools to implement these initial three process changes, a suite of performance indicators were produced to give insight into the most relevant steps of the work flow. As indicators were produced, they were collected for meaningful inclusion in monthly reports on the health and performance of the system. Indicators were created for specific users, ranging from specific roles, to management, to overall Supply Chain display.

As insight into system performance increased, additional opportunities for improvement through policy and process changes were identified. A policy for follow-up on PO Confirmation was created, as well as efforts to create a Central PO Database, and eliminate printing paper PO's. Specific job descriptions for each role were created, and standard work

instructions were initiated for key processes in each role. Additional software tools were created to enable users to coherently use the MRP system which had been previously been neglected because of inaccuracy.

A couple of months before I left, a permanent Process Improvement Engineer was hired to carry on the Lean Transformation I had begun. Working in the team brought a new dynamic to the project, in addition to the momentum that had begun to build. We generated a project priority table to manage the proliferation of improvement projects undertaken, and prioritize projects with the greatest potential impact. Projects were handed off and key skills were shared to ensure continuity in the Lean Transformation.

7. DMAIC Framework

7.1. DMAIC as a General Process Improvement Framework

The DMAIC framework for approaching improvements is traditionally applied to specific processes, such as surface finish from a specific manufacturing step. This framework is likewise useful to a broader approach to overall system improvement. In this study, specifically in this thesis, the DMAIC framework is used to present the transformation from the beginning, up through the state of successful implementation at the end of this six month study.

7.2. DMAIC applied to Supply Chain

Applied to a Lean Transformation in Supply Chain, DMAIC follows the same traditional framework of Define, Measure, Analyze, Improve, and finally Control. It is recognized that the framework is intended as a repeating cycle of improvement. As such, the study in this thesis is presented in a slightly modified framework, emphasizing the analysis and improvement cycle, with that the final step of Control intent on ensuring the cycle of improvement is maintained.

Define

First we define the purpose of the Supply Chain department; the value created for the customer, and the relevance of stakeholders.

Measure

Next we set out to measure the behavior of the system. This entails workflow and process flow identification, handoffs between both internal and external roles, and quantifying the behavior where relevant.

Analyze (Preliminary)

Analysis is performed in two respects; process flow, and quantified behavior. Analysis is based upon information drawn from all available sources, including process maps, observations and

perceptions of employees, as well as quantified behavior. Efforts were made such that all data gathered was weighted appropriately for accuracy and reliability.

Improve

The several improvement initiatives undertaken are identified and evaluated. As much as possible, the initiatives are treated in chronological order in which they were undertaken. Ample discussion is given to validate the appropriate application of each principle or tool, and the results. Because the tools and principles applied through each initiative are extensively evaluated in other studies, this study places emphasis on the experiences of the personnel involved with each initiative. A relevant diplomatic principle is illustrated with each initiative.

Analyze (With Embedded Lean Tools)

Following the treatment of the major improvement initiatives undertaken, we will again return to the next level of analysis enabled by the implementation of these early initiatives. This study presents the analysis and improvement segments in alternating sections, which is exemplary of the way a Lean Transformation will continue, perpetually building improvement upon analysis.

Control

This final step of Control is intent on ensuring the cycle of improvement is sustained, making the organization Lean, beyond just a one time change initiative. Therefore, emphasis is given toward the role of the Process Engineer, and the role of Management in supporting the Process Engineer.

Because this study was Initiating the Lean Transformation, this section includes observations from the transformation phase, and the role of management in sustaining the beginning of the Lean Transformation. Some thoughts are extrapolated toward long term support of a Lean environment, but a more complete study would be valuable.

8. Define – Purpose of the Supply Chain Department

At the most fundamental level, the Supply Chain is responsible to ensure: The right parts, in the right condition, are delivered to the right place, in the right quantity, at the right time, at minimal cost.

How the Supply Chain department accomplishes this objective is largely irrelevant to the primary customers; Assembly and Sales. To ensure these objectives are met in a sustainable manner involves the direct activity with the parts, but also consideration of risk throughout the supply base, pricing leverage, and so forth. While these strategic considerations are important, this study focuses primarily on the direct objective of the Supply Chain; workflow involving the parts and primary stakeholders.

In this context, the purpose of the Supply Chain in SHTC is to interface with Suppliers to ensure timely delivery of quality components to Assembly and to Sales, for delivery to customers in the field. All activity in the Supply Chain department should bring value to these three stakeholder groups.

Assembly is the immediate recipient of Supply Chain activities for procuring components for final assembly of FTE, making them a primary customer. Many products required by field customers are manufactured entirely by Suppliers, and procured through the Supply Chain, making the Sales department a primary customer as well. The Supply Chain department acts as the customer to Suppliers, but these relationships are so vital to delivering value to the customer that Suppliers merit treatment as significant as other direct customers. Therefore, Suppliers are counted among the primary stakeholders.

These three primary stakeholder groups are given equal treatment throughout this study. Secondary customers include Engineering, Product Development, Accounting, and other peripheral roles, and are given treatment as merited in each case.

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9. Measure – Identify and Quantify the Current State

9.1. Initial State and Evaluation

Before starting from scratch to build tools for identifying, measuring, and quantifying the workflow, processes, and performance in an organization, it is valuable to see what tools already exist, and how these tools are being used. I began by searching for process flow maps, process definitions, and documented practices. For measurement, I sought out the performance measurements in use, and the nature of the sources of these metrics.

9.1.1. Original Process Definition

When I first began searching for workflow and process definition maps, it quickly became apparent that if any existed, they certainly were not in use. The Strategic Sourcing team had developed one workflow diagram for qualifying a part from a new supplier, but that was the extent of it. I searched the online sources on the company intranet, finding handbooks on using the software to execute certain activities, but there were now process or workflow diagrams defining the roles within the department, and workflow through the department.

9.1.2. Original Performance Indicators

The Supply Chain performance indicators in use were bottom line financial measures, end of stream results of parts delivery, and a few measurements for the Buyers. The internal metrics measured how many PO's were placed by product line, PO Confirmation and On Time Delivery by Suppliers, and Buyer attendance. All these metrics were relevant, but they only addressed downstream effects, as opposed to upstream causes. They offered no insight into the causes of delivery rates to SHTC customers, or from Suppliers. Furthermore, the sources of the data were poorly understood, resulting in misleading interpretations.

An example of one blatantly misleading indicator was in the “SHTC On Time Delivery Rate” to customers. This indicator was consistently above 96%, while SHTC consistently failed to deliver many demanded products on time, and chronically fended off customers demanding

already late products. When scrutinized, this indicator actually measured the on time delivery against the most recently updated delivery date, regardless of the original promised delivery date. Such highly misleading indicators produced confusion among managers, and were entirely discarded by operating personnel.

9.1.3. Evaluating This Initial State

Even though there was no formal process definition, the department operated on systems and shared responsibilities that grew up as the volume and product mix in the site grew. Teams worked together to perform their responsibilities in whatever way seemed best to them. They were reaching a point where they felt unable to handle things in this ad-hoc manner, but didn't have time amongst themselves to formally design the process definition.

As for performance indicators, the metrics they used had originally been developed over a year and a half ago when a programmer set up most of the software systems they were then using. He had since left the site, and a few people within the team were skilled enough to maintain the software systems he had created, but not enough to develop new systems suited to the changing needs of the department. Since the current systems were "working," management was not looking for anybody to develop new systems. Furthermore, the perpetual promise of a new MRP System to be implemented "next quarter" (for the last two years) pacified management to get by with what they already had.

9.2. *Creating the Value Stream Map*

9.2.1. VSM as a foundational tool for a Lean Architecture

The Value Stream Map (VSM) was implemented in SHTC as the foundational tool for transformation to a Lean Architecture. Creating the VSM served for identifying work flow and processes, quantifying behavior, communicating within and across departments, identifying process improvement opportunities, prioritizing initiatives, and spreading general understanding of the systematic interactions within Supply Chain and across departments. The

VSM was intended to provide a concrete tool for discussion about the system, why it displayed its present behavior, and how to most effectively design changes and initiatives.

In line with current industry practice with a VSM, the intent was to initially create a Current State Map, then develop a longer term Future State Map, and create intermediate maps to incrementally progress toward the long term Future State Map.

9.2.2. Supply Chain VSM built following “Need for a Part”

It is acknowledged that a VSM is traditionally focused around a product, and follows that product all the way through the process. In this case, adapting this Lean tool to a service department, the VSM was approached with the “product” defined as a “need for a part.” As such, the VSM begins with the “need for a part” in the field, and traces through each step in organization where that “need” flows, until the actual part arrives to fulfill that “need.”

9.2.3. Outlining the VSM

The earliest forms of the VSM began with a simple block diagram with the final customer, SHTC, the Supply Chain, Assembly, and the major departments. Figure 7 is a fancy version of the initial rough sketches built at the start. This looks simple, but to many people in the Supply Chain, it was novel to see it mapped in this simple logical flow.

Product Delivery Overview

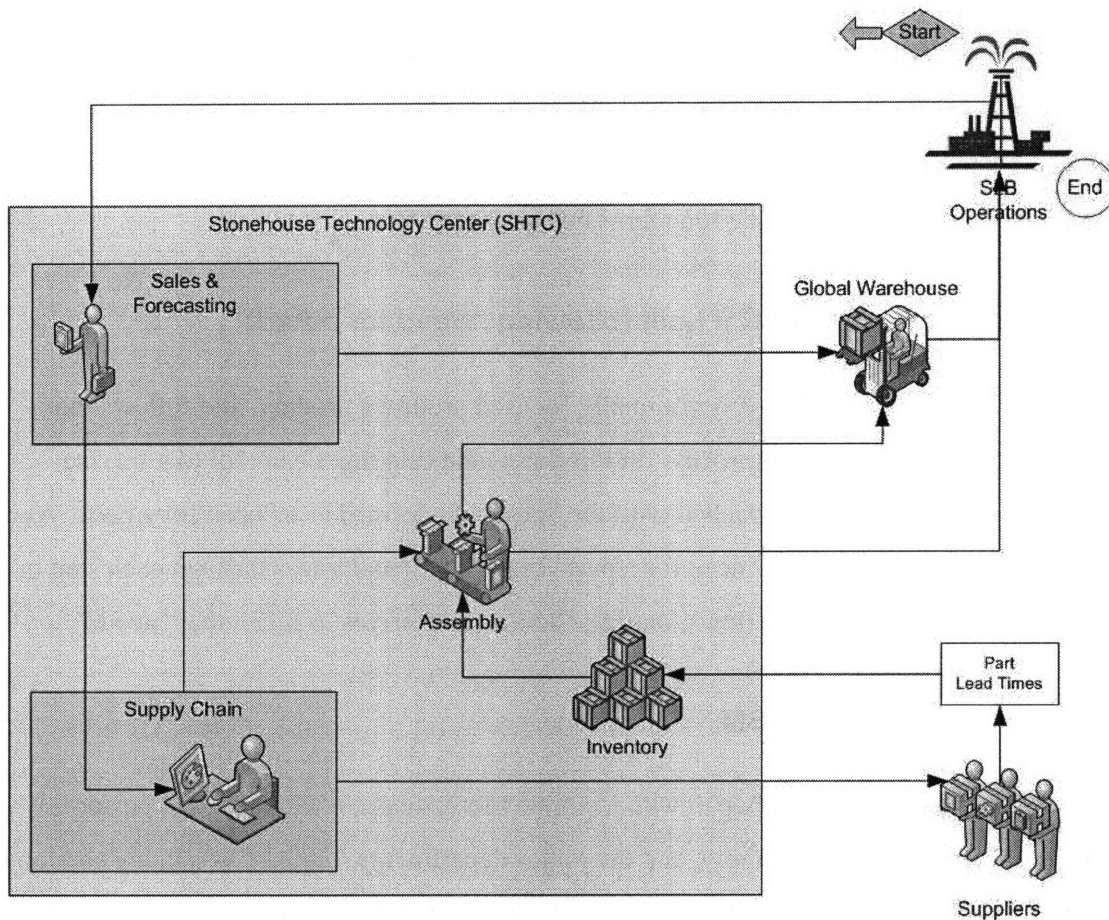


Figure 7: SHTC Product Demand and Delivery Flow Overview

From the general overview, I moved to mapping the Supply Chain VSM. Again, this originated with simple block diagrams identifying the existing roles in the department, with a simple flow of work, or rather, the “need for a part.” Figure 8 shows a cleaned up version of the original sketches. As with the overview VSM, this simple sketch gave a new level of clarity to personnel in the Supply Chain department, and to managers in other departments. Even at this very simple level, this VSM tool helped to increase the understanding of individual roles across departments.

Supply Chain Workflow

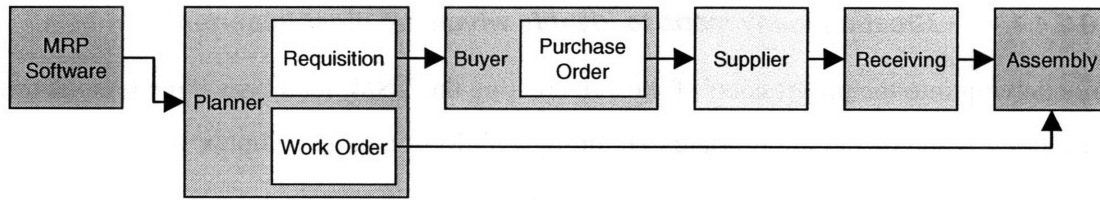


Figure 8: Simple Supply Chain Value Stream Map

Department Organization

The SHTC Supply Chain department was organized into Buyers, Buyer Planners, and Strategic Buyers, each with functional differences, but lacking formal definition. These roles had organically grown from when the organization was in its infancy, when the roles of Purchasing and Planning were carried by a single individual. Consequently, even the titles for the positions revealed these origins. However, even this was a differentiation beyond comparable Schlumberger sites which had large teams of Buyer Planners with each individual performing the same tasks as combined Buyers and Buyer Planners.

For clarification, we began referring to the roles as Buyers, Planners, and Strategic Sourcing, emphasizing the distinct nature of their roles.

Workflow Organization

Workflow definition was in an unspecified state similar to the roles. Essentially, work flowed from MRP (Materials Requirement Planning Software), to Req's (Requisitions), to PO's (Purchase Orders), to Received Parts. Figure 8 provides a clear definition of process flow similar across all product lines, but beyond this level is where each team began diverging into their unique operating methods. Even though each team had their own methods, there were common patterns each followed. The next step was to begin mapping more detailed process flow within each role in this workflow.

9.2.4. Detailing the VSM

9.2.4.1. *Creating many maps to identify which are most important*

Before delving into the progression I followed creating the VSM, let's visit some lessons from this experience and theory appropriate to building a VSM of a large complex system.

Before process flow maps have been created, the outcome that will arise is unknown.

Furthermore, the complete VSM entails too much detail to be undertaken from one end to the other all in a single shot. The details of workflow through individual responsibilities must be understood and identified, in addition to the overall system including workflow handoffs and information flow. But where all these fit together is not obvious from the start.

A useful place to begin is by asking the right questions. Beyond that, a framework is necessary to organize all the answers. All the answers exist. The challenge is they exist in the network of operating personnel performing the work. The initial steps in creating a VSM involve pulling those answers from the network of operating personnel, and organizing them into a continuous flow that represents the systematic interaction.

To effectively build a VSM, work from broad and general, down to specific and detailed. In this study, we began with a very basic diagram of the flow of "need for a product." Then we began filling in the boxes with more detail, each represented by its own local VSM.

In a department with several roles, often there will be several lines of workflow. All these lines of workflow cannot be effectively represented on a single VSM. Naturally, several VSM's will be created to represent the many lines of workflow.

While all workflow paths may be illustrated with a VSM, some workflow paths are more critical than others, or yield more immediate results from initial Value Stream Mapping. The workflow paths which are initially discovered should be prioritized for greatest impact, and approached accordingly.

In this study, the workflow given highest priority was the flow followed from the MRP Software through the Supply Chain ordering and receiving parts for Assembly. This is the path on which the majority of Supply Chain time is spent, and which appeared to present the greatest potential for improvement in overall SHTC production and sales. VSM's could be created for the Supplier Approval Process, and other aspects of the sites Global Sourcing and Supply Base Rationalization initiatives, but these were set aside for this study. I elected to narrow the immediate scope of the project to procurement workflow to generate effective results in the six months allowed.

9.3. Meetings with Each Functional Group (Buyers, Planners, Strategic)

9.3.1. Buyers

To diagram the detailed workflow through the Supply Chain and customer departments, meetings were held with each of the Supply Chain groups, in order to map and understand the roles they presently performed. These meetings were held early on, but could have been held in the first week of the project with equal effectiveness. Because these initial meetings are followed up with subsequent meetings, it can be more effective to hold the earlier the first meetings as soon as appropriate.

The existing personnel in the department usually have different ideas about the general workflow through the department, and through the company, such that a Process Engineer can get their input to create an initial overview of the overall system in the first few minutes of a meeting, or through informal discussions. Beginning each meeting with a draft of the overall system is an effective way of getting the group to see the big picture, and begin thinking of how their role impacts the entire system. In addition, it makes it easier for them to identify the interactions they have with other roles and responsibilities. Often, these interactions and handoffs are highly critical sections for analyzing and engineering improvements in the process. Finally, beginning with a general overview helps the Process Engineer to identify the several interactions and complexities of the system which are often overlooked during discussions with individuals. This enables an accurate diagram to gradually evolve, which comprehensively reflects all the players and factors in the organization.

Following this approach from general to detailed, the first meeting with the Buyers was very effective. We started with several large pages stuck to the wall, and began with post-it notes representing each of the major groups in the process flow; Customer, MRP Software, Planners, Buyers, Suppliers, Receiving, and Assembly. We discussed what we wanted to accomplish, and how their input was critical. Then I planted the post-it notes where it looked like they belonged, and opened up the floor for input.

Initially I asked the Buyers to start drawing lines and sticking post-it notes. Quickly though, I discovered it was better for the hosting Process Engineer to facilitate the meeting by asking questions, guessing what belongs on the map (often guessing wrong and getting corrected), and leading the diagram process. While beginning the draft, leave enough space to add details between steps as they are written. More detail will fill in incrementally. Try to focus on documenting each step that is applicable to the common workflow for the operating personnel. This is crucial for later identifying where the system can be measured most effectively. Eventually, this will be the foundation from which Standard Work Instructions are developed, but this isn't yet developing Standard Work Instructions, so that level of detail is not yet necessary. The result from the meeting was the sketch shown in Figure 9.

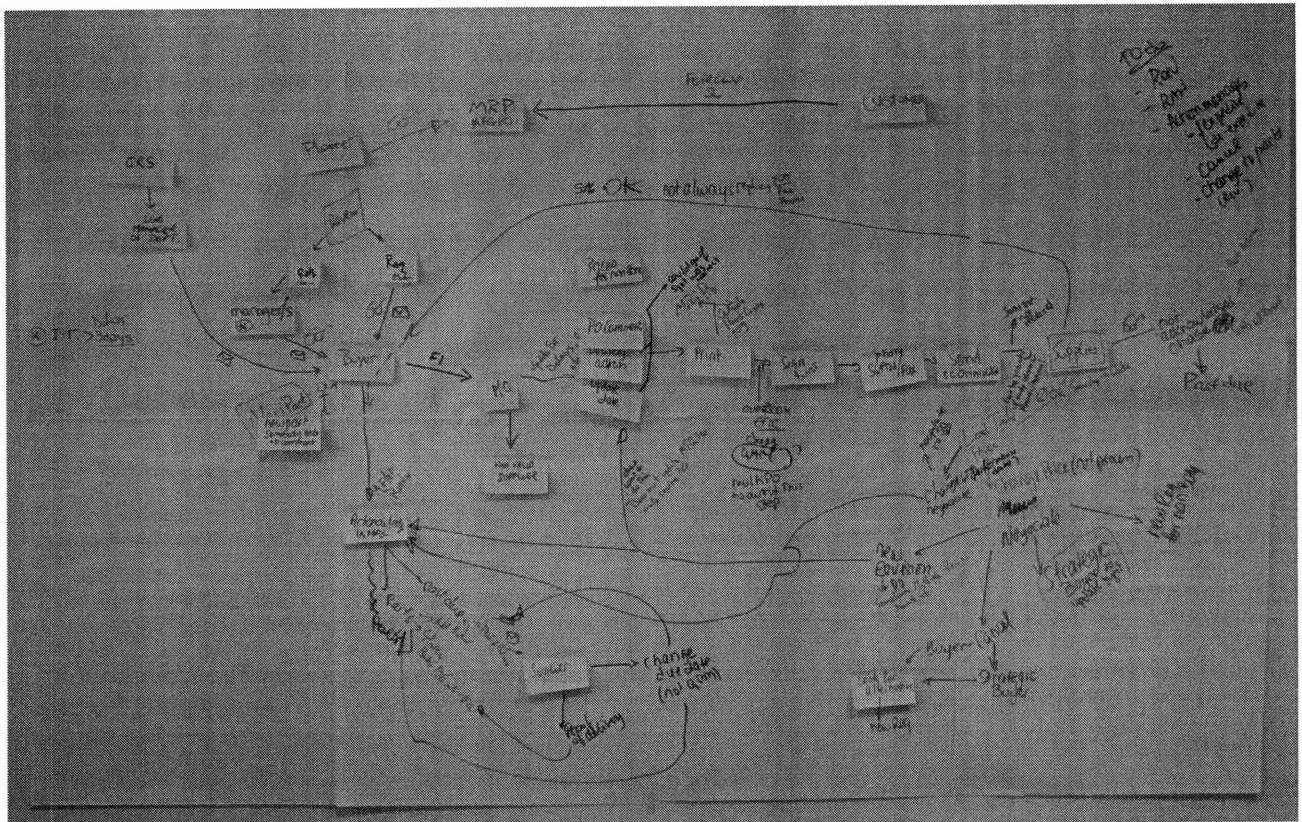


Figure 9: Buyer Workflow Sketch from the Initial Meeting

9.3.1.1. Mapping “What is” instead of “What should be”

When first developing the Value Stream Maps, it is important to emphasize that the map is for identifying “what is” instead of “what should be.” While developing the VSM in this study, the initial reflex of members in the Supply Chain was to offer input on how they believe the Supply Chain “should” be running. This input for change becomes valuable later on, but it is essential to first identify the actual current state.

9.3.1.2. Learn the Current State before trying to define a Future State.

Another thing to keep in mind is the difference between “what should be” and the Future State that will eventually be designed. There was a tendency during these meetings to refer to the present theoretical flow as the Future State toward which we are working. In all probability, the reason the current state (“what is”) doesn’t match the present theoretical flow (“what should be”) is because the present theoretical flow is not sustainable.

It is critical to understand the Current State before trying to define a Future State. The nature of a Lean Transition is to change the organization from a present state to an ever evolving Future State. The Future State will always be evolving in reference to the behavior of the Current State. The real process engineering that needs to take place is not in composing an ideal End State, but in composing how to transition from the Current State to become an organization ever progressing toward a better way of operating. First learn how the organization is presently operating and behaving. Only with that foundation, an existing knowledge of present operations and behavior, can an organization predictably modify their behavior to achieve their desired results.

For the VSM, the Current State must be understood, but it only needs to be identified to a relevant level of precision. As the organization becomes increasingly understood, detailed Work Instructions will be developed. The VSM will serve to identify levels of priority by which Work Instructions will be developed. Understanding this synergy between the VSM and Work Instructions, the nature of a Future State Map becomes apparent. Much of the Future State will be defined in terms of reduced variability, waiting time, and so forth.

9.3.1.3. *Focus on Current State to Avoid Inspiring Resistance*

An additional, and essential, benefit gained from focusing on the Current State instead of a Future State, is avoiding making any premature decisions about process changes that may inspire resistance. As a process engineer, it is essential to understand the system, and communicate that understanding, before attempting to design and implement any changes. Attempting to make changes that will inadvertently harm the system or stakeholders will quickly inspire resistance to the change initiatives. The support necessary to design and implement effective changes in both the near and long term will diminish. This is addressed in greater detail in the later section on How to Sabotage Lean.

9.3.1.4. *Digitize the Workflow Map*

As the Process Engineer, be sure to schedule the meeting room for an hour beyond what will be necessary for the meeting with the team. This extra span will be time to document the map,

and take notes on what was discussed and learned. Take a picture of the map while it's on the wall to reference it later if necessary. Then begin translating the map into a cleaner workflow diagram using software that can easily be changed in the future. Visio was effective for this.

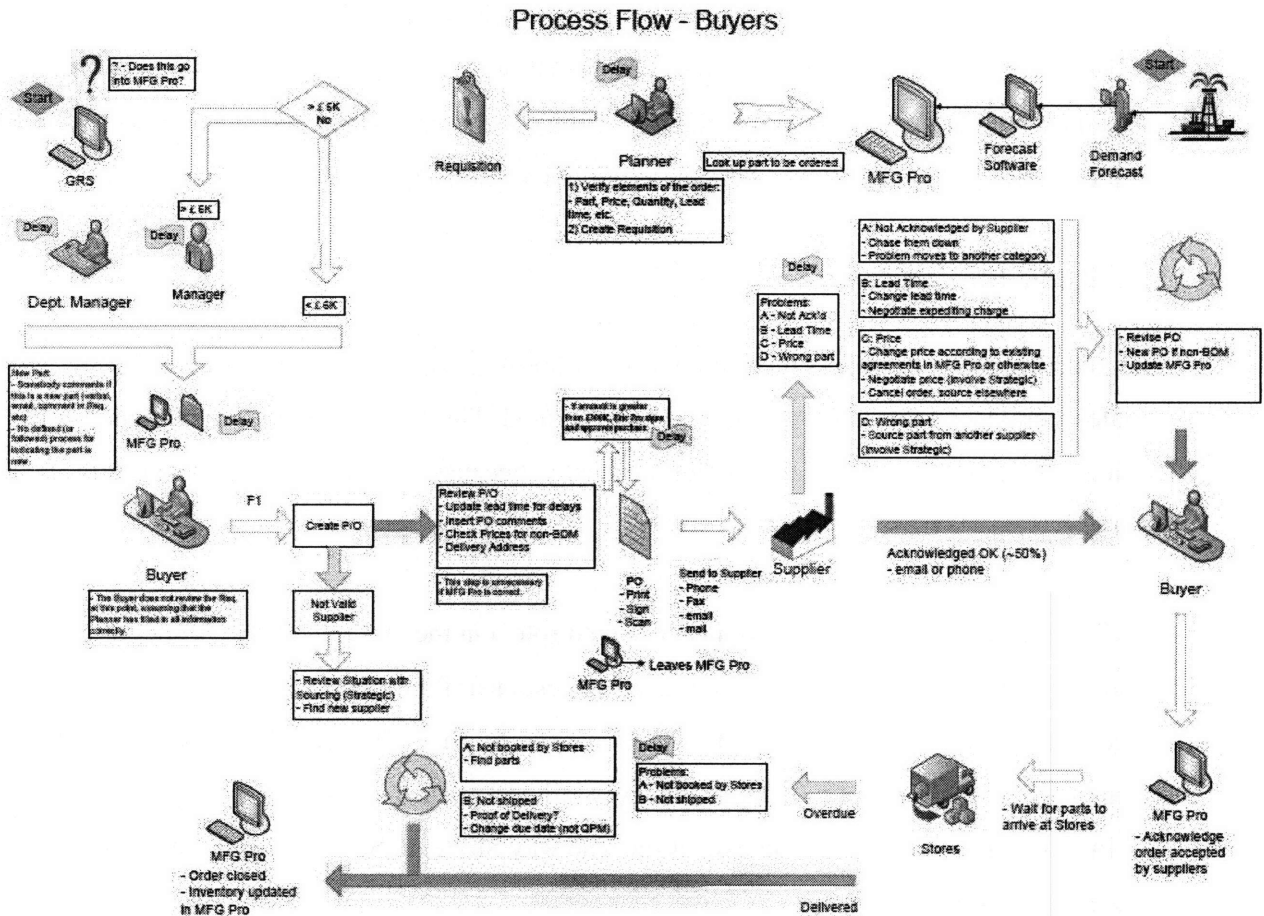


Figure 10: Initial Workflow Diagram for Buyers

Figure 10 shows the initial electronic workflow diagram generated after the meeting with the buyers. Note that by following an S curve instead of a linear progression, the diagram is less intuitive to understand. In general, the more linear the diagrams (horizontal or vertical), were more intuitive for others to understand. Also recognize the notes placed at each step in the workflow. These notes were helpful for generating an understanding of how the system behaves, particularly regarding the causes of errors found, and the work-around methods used

to correct or adapt to these errors at each step. It would have been easy to forget these many details if they are not written down immediately following the meeting.

A lesson I didn't expect to learn was the power of cartoon symbols. I was initially concerned I was wasting time using the cartoon figures in Visio to represent people, computers, documents, etc. However, when it came time to share the workflow map with others, these symbols made it instantly intuitive what was in the diagram. Boxes with text would have taken more time for them to study, and made it more difficult to get quick and frequent input for corrections.

9.3.2. Strategic

This meeting with the Buyers turned out as a textbook example of how a mapping session should operate, and the result that should be generated. The experience with the Planners was similar. However, not all cases work out this easily, because not all roles can be so easily defined.

The Buyer role is a very sequential, task oriented role. On the other hand, the Strategic Sourcing role is more nebulous, involving a few responsibilities that can be mapped in a process, but much of it is dealing with situations case by case. The workflow they follow takes place over six weeks to six months, is uniquely tailored to each supplier, product line, or part, and involves more judgment than execution. The way Strategic Sourcing deal with processing a "need for a product" is more a network of associated responsibilities, than a process execution. While discussing all these responsibilities and processes they follow, one of the Strategic Sourcing personnel individually drafted this network of responsibilities shown in Figure 11, which seems to effectively illustrate all the paths their responsibilities flow through.

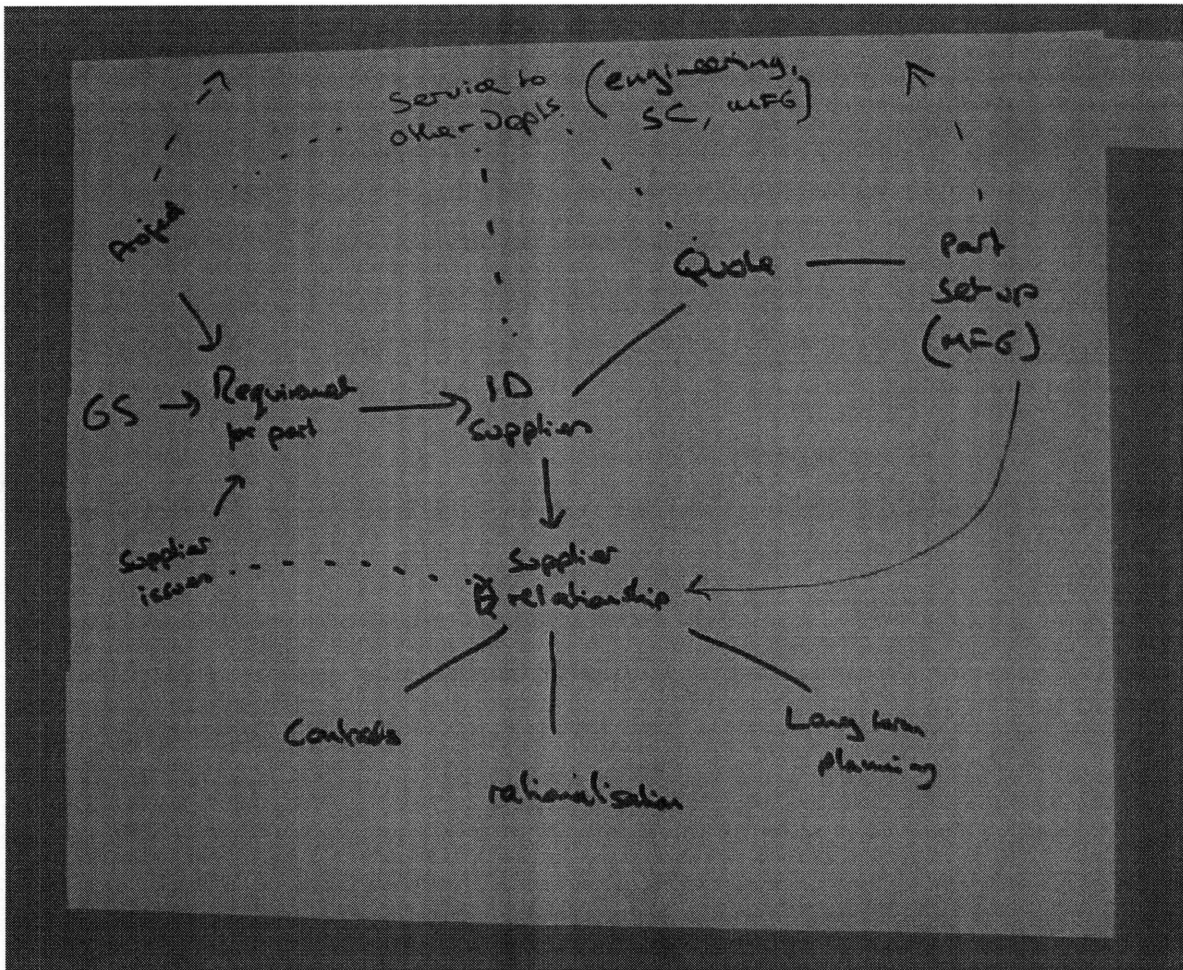


Figure 11: Strategic Sourcing Responsibility Diagram Sketch

There are certainly areas within this Strategic Sourcing role which can benefit from inclusion in the VSM. In this case, this represents the point at which the Law of Diminishing Returns begins to set in. The purpose in the VSM is to bring “value” to the process, not to map every activity undertaken. In every VSM, there will come a point to exclude peripheral processes.

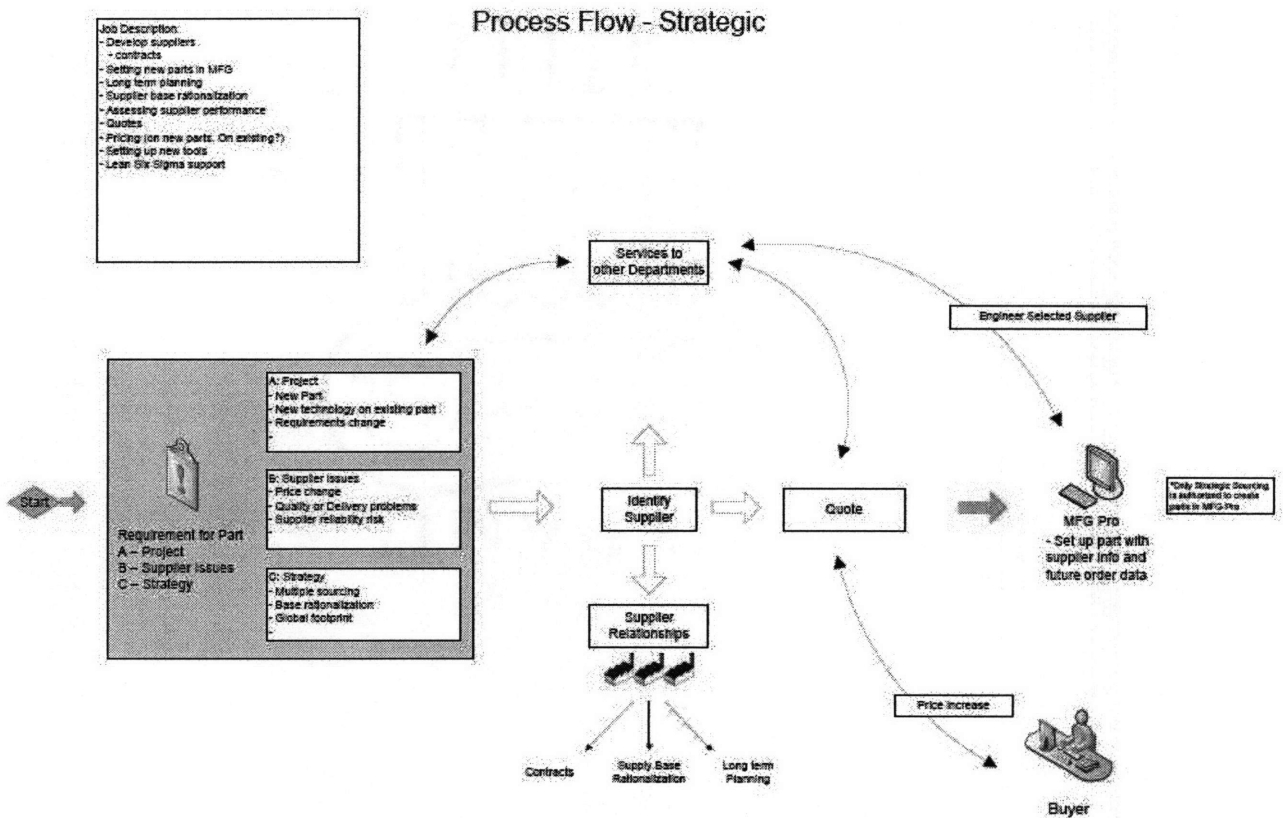


Figure 12: Strategic Sourcing Responsibility Diagram

9.3.3. Planners

Drafting the workflow with Planners involved a mix of the nature of work with both Buyers and Strategic Sourcing. Significant aspects of the Planners role is to manage Supplier Relationships, working with different engineering groups etc. These nebulous responsibilities don't fit into a workflow diagram so well. However, given the VSM objective of mapping the flow of "need for a part," a significant portion of the Planners role fits easily into this workflow. Namely, workflow for Work Orders (WO's) and Requisitions (Reqs).

Mapping the Planner Workflow for WO's and Reqs followed a similar process to the Buyers. However, the Planners had greater diversity in the way they each approached their product lines. As a Process Engineer, it was necessary to note each of these methods, and collaborate

with the Planners to generalize the workflow in a way that common steps and activities could be noted for comparative reference.

At the level of the VSM, while defining the Current State, there will be occasions such as this where accommodations for ambiguity must be made. As noted in later sections on Value Stream Mapping, the intent it is not to map a Future State. However, the next phase will be Quantifying the VSM, and to effectively do this requires common measurement points relevant to the behavior of the overall system.

When it came time to develop Standard Work Instructions, this preliminary effort to identify common steps and activities relevant to all product lines provided a sound foundation for developing a standard process which, ultimately, all the Planners could use for all product lines.

9.3.4. Defining Roles of Other Departments (Assembly, Kitting, Customer Service)

In addition to workflow within the Supply Chain Department, an effective VSM needs to identify the interfaces and handoffs with other departments. In this case, the most relevant departments were Sales, Warehouse (Shipping / Receiving), Kitting, and Assembly. With each of these departments, it is necessary to understand their needs relevant to Supply Chain, and how the Supply Chain influences their operations. A detailed VSM of workflow through each is unnecessary.

When these external departments are represented on the VSM, it is likely they will have very little detail, only meriting very general representation. As a Process Engineer, it is still essential to have a functional understanding of their activities in order to judge how their behavior and other department's behavior will influence each other. At a minimum, it is essential to know who in each department can be contacted with more detailed questions.

9.3.4.1. *Gathering External Contacts for Future Initiatives*

One of the peripheral benefits from visiting the other departments is developing a network for information and support when it becomes time to begin the variety of Lean initiatives. The changes to be made in the Supply Chain are bound to impact external departments. Ideally these will be positive impacts, but in some instances it may require changes in roles and responsibilities from people outside the Supply Chain.

As will be discussed later, this study found significant interaction with the Sales department was necessary. Having initially established a relationship with the Sales Manager, on terms of understanding their role and needs, it made it far easier to collaborate with the department later on. Even before changes were initiated, it was essential to understand the role of Sales in influencing the upstream workflow through the Supply Chain department.

When changes were being developed and implemented, the support of Sales was indispensable, as they were directly involved. Because they felt involved and aware of the Lean Transformation effort from the very beginning, they were very cooperative when it came time to implement changes. By the end of this six month project, the Sales Manager had gone from neutral on the Lean Transformation, to requesting a Process Engineer team to VSM and initiate a Lean Transformation in his department.

Preliminary meetings with personnel from external departments also had a significant impact on the overall enterprise Lean Transformation effort in several respects. Most notable, is the sharing of Lean principles and transformation efforts with operating personnel. Countless studies have shown that effective learning requires repeated exposure. In this case, visiting the operating personnel in the Kitting department helped them to understand the Lean principles applied in the recently implemented Clean Kit Policy, and thereby work more supportively of the effort. This also helped to improve their attitude toward this and future change initiatives, by understanding how it is working, and seeing that they would be informed and involved in the process.

9.4. Combine Local Workflow Diagrams into an Overall Value Stream Map

When the local workflow diagrams are detailed, it becomes time to compile them into a comprehensive VSM. This enables the Process Engineer, Managers, and concerned operating personnel to intuitively view the entire system, and how each role can have greater or lesser impact in achieving their collective objectives. Figure 13 shows the initial complete Supply Chain VSM that was developed.

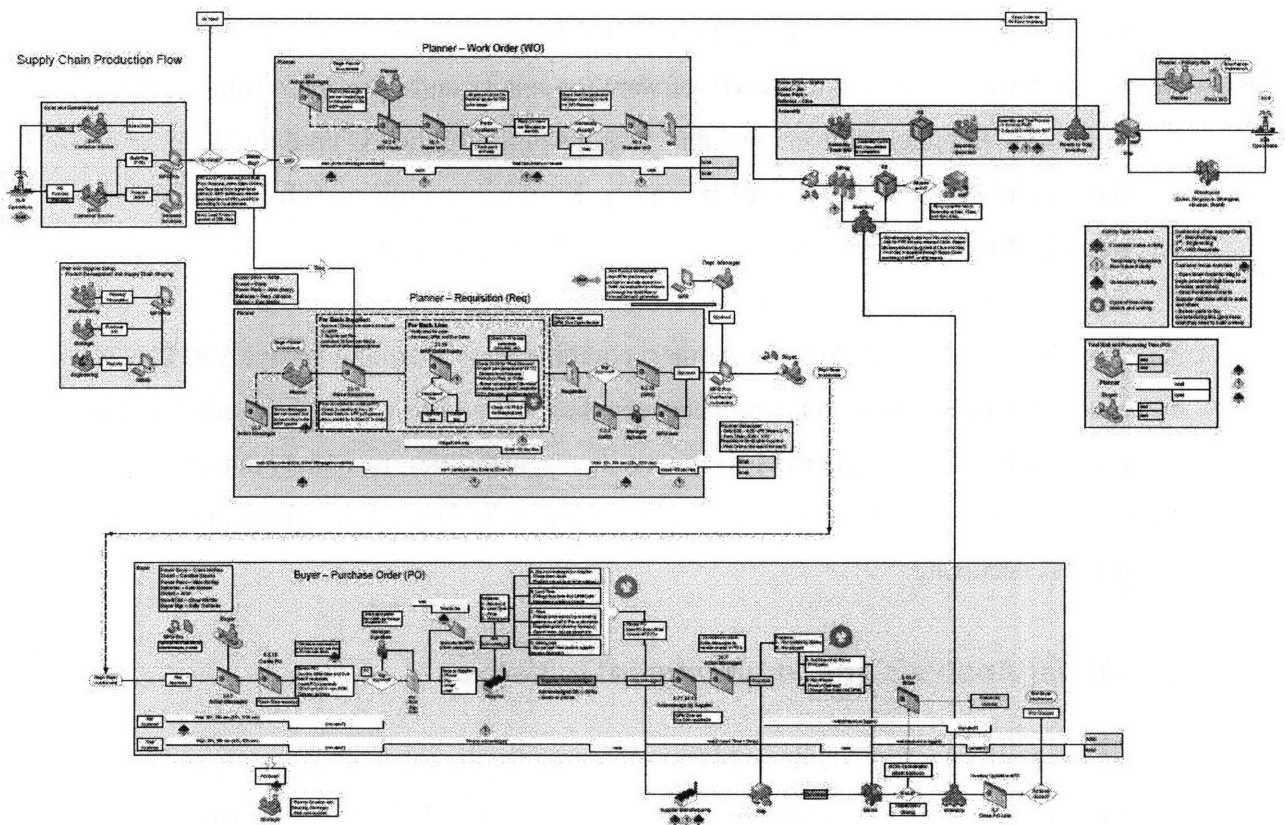


Figure 13: Current State Supply Chain Value Stream Map

This VSM flows left to right, with an S detour along the bottom for Reqs. Activities are grouped according to which roles perform them with a color coded block underlying the sequence of activities. Other details are explained in the following text where most relevant.

Overall, this VSM starts in the upper left corner with SLB Operations, the customer who initiates the “Need for a Part.” This “need for a part” flows through Sales (Customer Service) into the MRP Software. The Planners then check the MRP software for WO’s to release (top green box), and for Req’s to release for parts (middle green box).

WO’s are processed by the Planner, and then handed off to Kitting and Assembly. When Assembly has completed the WO, it is shipped to the customer, and the Planner closes the WO.

Reqs are processed by the Planner, approved by a Manager if necessary, and then handed off to the Buyers. Buyers look into the MRP software (or email), and raise a PO from the Req, and send that to the Suppliers. Buyers maintain responsibility for the PO until the Supplier delivers it to the warehouse where it goes into inventory. Kitting then pulls parts from inventory according to WO’s sent by Planners, and delivers them to Assembly.

Analytically, it is essential that everything is combined into a comprehensive VSM because this makes the interfaces and handoffs between the local groups receive attention. With an organization that already operates in segmented responsibilities, it is likely that the handoffs have received the least attention. In this study, it was at these handoffs where the greatest waiting was occurring.

9.5. Initial Analysis and Improvement Initiatives

Having generated the Value Stream Map, accounting for the roles of all groups and departments influencing and effected by the workflow through the Supply Chain, you have developed a tool that can already be used to analyze the system with a certain degree of intelligence. From that analysis, process improvements of a certain nature can be confidently undertaken.

In this study, three process improvement initiatives were undertaken at this point: Buyer PO Filing, MRP Accuracy Improvement, and Forecast Sharing. The analysis leading to these initiatives, and the initiatives themselves, are discussed in the relevant sections.

9.5.1. Identify Processing and Waiting Points

Once the VSM has been compiled, the first step toward making it a quantifiable analytical tool is identifying processing and waiting times. This is simple enough, using standard notation of a timeline with a raised line during wait times, and a lowered line during processing. Figure 14 shows the WO waiting to be raised in the MRP software, and then the Planner visiting the interface to raise the WO.

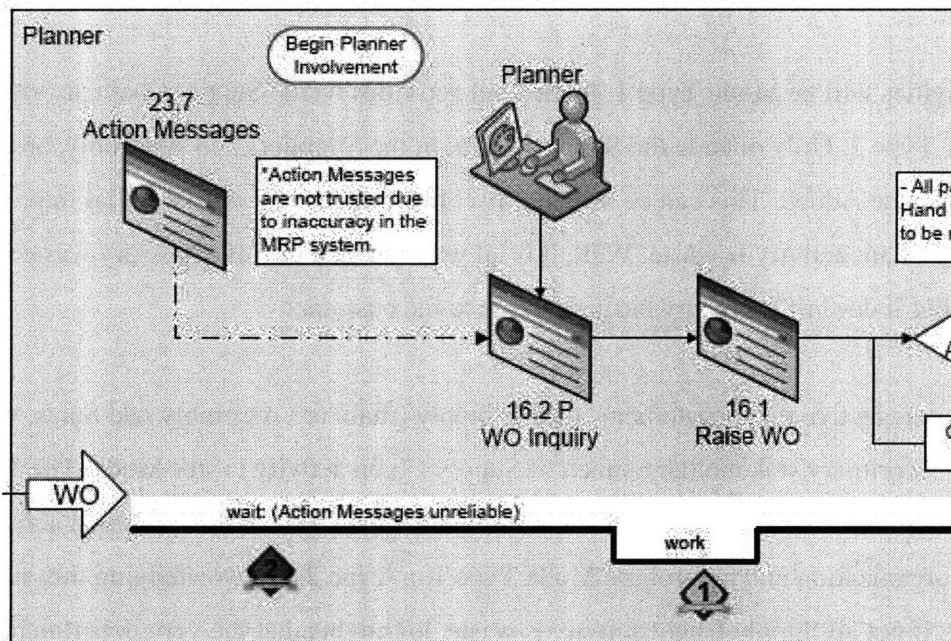


Figure 14: Waiting and Processing Activities for Planners with Work Orders

This is a preliminary step. Eventually, these timelines may be quantified with wait time, processing time, etc, as discussed in the section on Quantifying the VSM. The important thing in this step is to begin identifying what will be most effective to quantify.

9.5.2. Identify Value Added, Muda Type I, and Type II Activities

After identifying where “Need for a Part” is waiting and where it is processing, it is then valuable to identify each of the activities as Value Added, Muda Type 1, and Muda Type 2. Muda Type 1 is wasted activity which, given current constraints, is necessary. An example of

Muda Type 1 is Planners manually raising Requisitions; this doesn't bring value to the customer, but is necessary for processing orders to suppliers. Muda Type 2 is wasted activity which is unnecessary under current conditions. An example of Muda Type 2 is waiting for Buyers to process PO's after the Planner has raised the Req; this doesn't bring value to the customer, and isn't necessary for processing orders to suppliers. Naturally, waiting brings no value to anybody and should be removed as soon as possible. Simply waiting to remove waiting is Muda Type 2². Figure 14 shows waiting for WO's to be raised as Muda Type 2, and Raising the WO as Muda Type 1.

Most activities will be Muda Type 1. Indeed, all activities inside Supply Chain are either Muda Type 1 or Type 2. Only outside the Supply Chain, in the Suppliers and Assembly, are any activities Value Added. This can be initially disconcerting, as it gives the initial impression that all Supply Chain activity is waste. Well, it is all waste. Much of it is necessary waste (Muda Type 1), but it doesn't bring any intrinsic value to the customer.

From the perspective that "customers" of the Supply Chain are Assembly and Sales, with Suppliers as primary stakeholders, much of Supply Chain activity is still Muda. The WO or PO with instructions of what to build by when is valuable, but the rest of the internal activity and tools for organization and control are Muda Type 1 or Type 2. Acknowledging this simple fact that most, if not all Supply Chain activity is waste, highlights that the very department is flush with opportunity to design out waste from the process.

9.6. Quantifying the Value Stream Map

Creating the value Stream Map as a workflow diagram is useful in itself, but quantifying the several activities represented in the VSM brings it to a whole new level of usefulness. Data is incredibly important, because people believe data. People don't always believe theory, but data is convincing. Even at that, selecting the right data and organizing it appropriately has a significant impact on the usefulness of the data, both for analysis and for communication.

9.6.1. Comprehensive Behavior Indicators – Flashlight Analogy

One of the trends floating around business management practice is choosing a select few Key Performance Indicators (KPI's), and managing to those measurements. This study has found that, while focusing on a small set of indicators may be effective from a managerial standpoint, that same small set of data points is inadequate for effective process improvement. To be effective, a Process Engineer requires an array of detailed performance measurements, as well as the liberty to investigate whatever aspect of the system may hold interest.

9.6.1.1. Flashlight Analogy, and Turning on the Lights

Evaluating the performance of the Supply Chain Department is like walking onto a production line, turning off the lights, and then evaluating the performance of the line. You may hear more noise in one area, and less in another. You may see material coming in and finished goods leaving from the shipping dock. You can listen, feel around, and see the end result, but you're helpless to make improvement without seeing what is happening internally.

Following this analogy, most of the Supply Chain workflow happens in the software system. Inventories and WIP are piled up in the MRP database. You can't easily see where WIP is piled, and what the piles consist of. Unless you can "turn the lights on" to see workflow, WIP, etc. any changes proposed are nothing more than theoretically based guessing. You may get lucky with a good guess, but you're only shooting in the dark.

"Turning on the Lights" in the Supply Chain first requires "Installing the Lights." This is predominantly done through the software system; finding what data is available, and learning to generate the most relevant data to give useful insight into the system's behavior.

Following the analogy, gaining numerical insight into a step in a the workflow is comparable to shining a flashlight on that step. It allows you to see what is actually happening. A Process Engineer needs a flashlight to investigate specific aspects of the system. Furthermore, effective system analysis requires that the Process Engineer set up an array of flashlights whereby they can see many steps at once, and observe the effects of systematic changes. Since "installing a

lot of lights,” or generating data for a lot of activities, can be time consuming, it is prudent to discriminately select which data is most important, and prioritize the order in which it is generated.

Again, from the standpoint of the manager, a select set of KPI’s may be appropriate. However, the manager cannot overlook the Process Engineer’s need for a more detailed set of performance measurements. A set of KPI’s may be selected for regular review with management, but management must understand that this limited data is insufficient for the process engineer to effectively measure, understand, design and communicate the necessary changes to improve the system.

9.6.2. Identify Desired Measurements

The first step to measuring a system is identifying what it is you want to measure. Through building the Value Stream Map, a concrete tool to identify the activities and handoffs between roles and departments has been generated. This will become the foundational tool for choosing what to measure, and communicating the meaning and nature of the activities and behavior measured.

9.6.3. Identify Information Available, Unavailable, and What Can be Generated

One of the initial factors in deciding what to measure is the simple criteria of what is already available. If the existing software system already provides useful data, then find what that is, and go ahead and integrate it. This is free data! No engineer in their right mind turns down free data!

Less straight forward is data which is unavailable, or must be generated independently using tools such as MS Access, Excel, etc. It isn’t always clear what is unavailable, and what can be generated. These will be investigated according to the usefulness of information desired.

Talking with the operating personnel is possibly the fastest way to find what is readily available. This brings another advantage, in that if operating personnel are already aware of certain data, they're probably already accustomed to what it means, and may be comfortable with using it. This becomes a valuable reference point for communicating the rest of the measurements that will be implemented.

9.6.4. Analysis Data vs. Operational Data

At this point, it's worth differentiating between Operational Data and Analysis Data. As a Process Engineer there will be cases where both of these types of data will be valuable.

In this context, Operational Data is information used to execute the needs of the Supply Chain, such as which PO's are outstanding, when parts are due to arrive, and so forth. Operational Data is usually used in terms of specific instances, seldom aggregated. Generally, Process Improvements involving data will entail making some sort of Operational Data available to the personnel; data which helps them make decisions about what to do with the workflow. This is data about the current state of things (e.g. how many open PO's, how many are late, etc).

Analysis Data is useful for understanding the behavior of the Supply Chain, often aggregated, to observe trends in wait time for processing, percentage of corrections, and so forth. Analysis Data is useful to understanding the behavior of the system, but often lacks the resolution necessary for operational personnel to execute their responsibilities. This will be worthwhile to the Process Engineer and Management more than to the operating personnel. This will help to design systematic process improvements, and prioritize where to develop operational tools as process improvements.

When quantifying the VSM, it is likely that Analysis Data will be more relevant for understanding the system behavior, as opposed to Operational Data more appropriate to running the system. In this study, the data provided through the MRP software was very operationally oriented. It's still hard to believe, but I never found a single report the MRP system could automatically generate which provided any sort of analytical data. All the analysis data used in this study was generated using MS Access to query the database upon

which the MRP Software was running. This nature of the MRP software's intended use was probably very influential in why the Supply Chain had so few aggregated performance indicators at the beginning of this study.

9.6.5. Leveraging Expertise from Operating Personnel

This is one situation where it is immensely valuable to involve the operating personnel. They are familiar with the software system, and many of the quirks that aren't immediately apparent to a new user. More important, this keeps them in the loop while measurements and metrics are under development, and invites their suggestions for analysis, and ultimately improvements. This helps them to feel involved in the process improvement, and in the criteria by which future process improvement decisions will be made. This makes them more inclined to support the data that will be generated, whatever that data may indicate. In this study, some personnel were more involved in this process than others, and there was a notable difference in their receptivity later on when improvements based upon this analysis was presented. At a minimum, communicating the meaning of the data was far easier with those who participated in the development.

9.6.6. Behavior Metrics vs. Performance Metrics

A useful tactic for enlisting the input of operating personnel is to approach the analysis as System Analysis, instead of Performance Analysis. Or in terms of metrics, labeling them Behavior Metrics, instead of Performance Metrics. Throughout this study, I watched personal attitudes change from opposing the "imposition" of Performance Metrics, to supporting the development of Behavior Metrics. Furthermore, the Process Engineer's intent is not to drive improved performance on whatever metrics may exist, but to understand the behavior of the system, and design systematic changes which will ultimately increase productivity. The terminology of Behavior Metrics helps to reinforce this approach.

When I was developing the initial set of metrics, one of the first responses I received on the Received PO data was "That's not fair to measure us on that. We can nag the suppliers, but ultimately we can't control when they deliver. And what if Stores books it in a few days late?"

We can't be penalized for that." Nothing had been said about measuring them personally with the data, but that was their reflexive response from all metrics generated in the past. To the Buyers and Planners, quantified metrics were the enemy.

By approaching metrics to analyze the system instead of analyzing the personnel, a Process Engineer can more readily leverage the expertise of the operating personnel to accurately quantify what is happening in the system.

By the end of this study, with consistently developing metrics for the purpose of improving the system, instead of measuring personnel, their attitude had changed. Discussing another approach to measuring Rush Reqs, a Planner commented "...But this isn't to measure our performance anyway. This is to show what we're working with. You know what might help, is if we looked into..." The more detailed evaluation of the development of Req Rush measurement illustrates this change even more dramatically in the relevant section.

In addition, when it is understood that metrics are being developed to evaluate the behavior of the system instead of personal performance, personnel became more favorable toward developing and using Standard Practices coinciding with the metrics.

People despise being measured upon things which are not under their control. Trying to impose such performance metrics on people incites resentment of the measurement system as a whole. However, they do generally want to improve the performance of the system within which they are working, and they are happy to offer suggestions. When they see that analysis is aimed at measuring the right things, they were inviting and supportive of the analysis. They naturally want their domain in the system to improve in what the metrics are measuring. When the metrics are used to analyze the system, personnel looked to see how they could improve the overall system. This is very different from working to improve a performance metric.

The other advantage of this approach is personnel perceive the analysis as a tool assist them. It is offered as a contribution to their efforts, as opposed to a regulator of their efforts.

When the measurement is offered as a tool to assist them in their role, they invite it, and try to use it appropriately. In this contributing case, they have something to gain from the metric. People are naturally inclined to use things wherein they gain from them.

When the metric is applied to quantify their performance, they seek out ways to game the system. In this regulatory case, they have something to lose from the metric. This encourages ways to unfairly manipulate the metric, because the metric is being unfairly applied. In this second regulatory case, the metric is a tool only for the manager to use. The personnel don't see it as a tool for them to use, since the applied intent is irrelevant. However, when the metric is a tool for operating personnel to use, then they invite it. The manager doesn't need the tools as much as the personnel executing the role.

For the comprehensive consideration, it is important to note that fair metrics for personal performance are accepted when they are clearly fair metrics. The Buyers never once complained about using the metric of Wait Time for conversion to PO as a personal performance metric. While extraneous conditions may hinder their ability to raise PO's in a timely manner, they acknowledge that this metric is largely under their personal control.

9.7. Organizing the Data – Data File Map

The VSM is important for understanding and communicating the system, but much of the data gathered while initiating the Lean Transformation will not need such a detailed map. Eventually the Lean Transformation will progress to quantify enough steps that it will be appropriate to fill out each step on the VSM, this that's overkill for this early phase.

In order to effectively communicate analysis from the data being gathered, and planned to be gathered, it can be useful to create a smaller map specifically identifying the activities and steps represented by the data. In this study this was called the Data File Map (Figure 15).

MAP Data File Map – SHTC Supply Chain, 2007

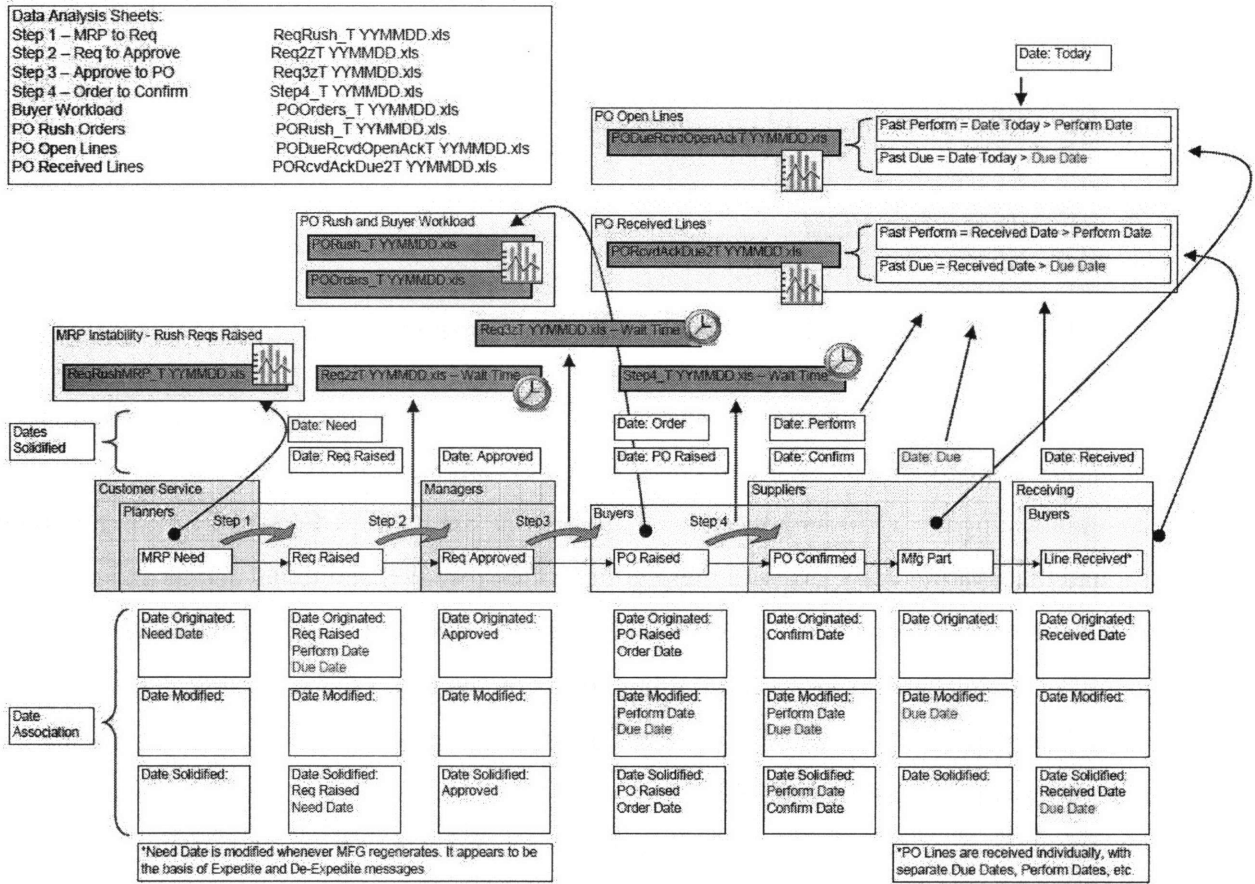


Figure 15: Data File Map

This Data File Map was composed for ease of identifying files with analysis relevant to specific steps, and discussing the implications and correlations of analysis from each step. The details of the analysis will be discussed in the associated sections.

The top left box correlates the activity analysis to the file name. The block diagram flowing across the middle represents the workflow through Supply Chain, with roles and responsibilities as overlapping colored boxes. The white boxes represent the steps off workflow progression. The green boxes have the file name, and arrows referencing them from their correlating position in the workflow. These green boxes also hyperlink to the analysis files for easy navigation. Each file has a chart or clock associated, indicating the nature of the

data as wait time or volume. The columns of boxes below the workflow present the properties of specific dates in the MRP System. Easy reference to proper terminology for what dates mean became painfully necessary for discussing the behavior of the system. Details such as these require extra attention for preparing graphical representations.

9.8. Evolving the VSM

9.8.1. Communicate the Draft with Everyone Involved

This VSM now identifying the Current State is the first version that will be made. The first step to be taken in evolving the VSM and progressing toward creating a Future State is, again, communicating the VSM with the several groups who are identified on the VSM. In this study, I found that sharing the VSM with these groups often revealed additional details and nuances in how the groups interacted. During the initial conversations, it's difficult for individuals to identify certain characteristics, and for the process engineer to accurately understand them. With the compiled VSM to use as a discussion mechanism, it makes it easier to clarify and document exactly how the handoffs and interactions between groups occur. This is very important, because these details make a significant difference later on when designing process changes.

9.8.2. Implementing Improvements

As process changes are introduced, this Current State will change, and will be updated appropriately. Most often, the incremental Future State maps created will then become the next Current State.

10. Analyze – Preliminary Patterns and Conclusions

10.1. Analysis and Conclusions That Don't Require Quantified Illustration

With the workflow component of the VSM completed, a concrete tool for analyzing the system has been created. Without the steps and behavior quantified it is still too early to draw many conclusions, but this is sufficient for conclusions which are not dependent upon the quantified performance.

Discussing the VSM with each of the groups involved is an effective method for generating a preliminary understanding of the behavior that is occurring. In addition to inviting clarification on any errors that may have been made, it helps people get a feel for what is happening at each step. In this study, I narrowed in on which sections each group spent the most time reworking errors, and what appeared to be the cause of the errors they were reworking. I narrowed down three areas with significant rework or firefighting, marking them with orange looping arrows.

10.1.1. Planners – MRP Errors

Planners spent a significant portion of their time reviewing the orders MRP suggested they raise. Figure 16 shows a sub loop within the workflow where Planners would compare the MRP requested order with forecasted demand, actual demand, parts on hand, and so forth. Using this process, the Planners frequently corrected orders for obsolete parts, and parts obviously far in excess of actual demand. In addition to comparing the actual parts to be ordered, they frequently modified the dates MRP suggested. The need date given by MRP was frequently far shorter than the agreed lead time, and shorter than suppliers could rush orders through. They continually balanced the urgency and criticality of the demands they placed upon their suppliers.

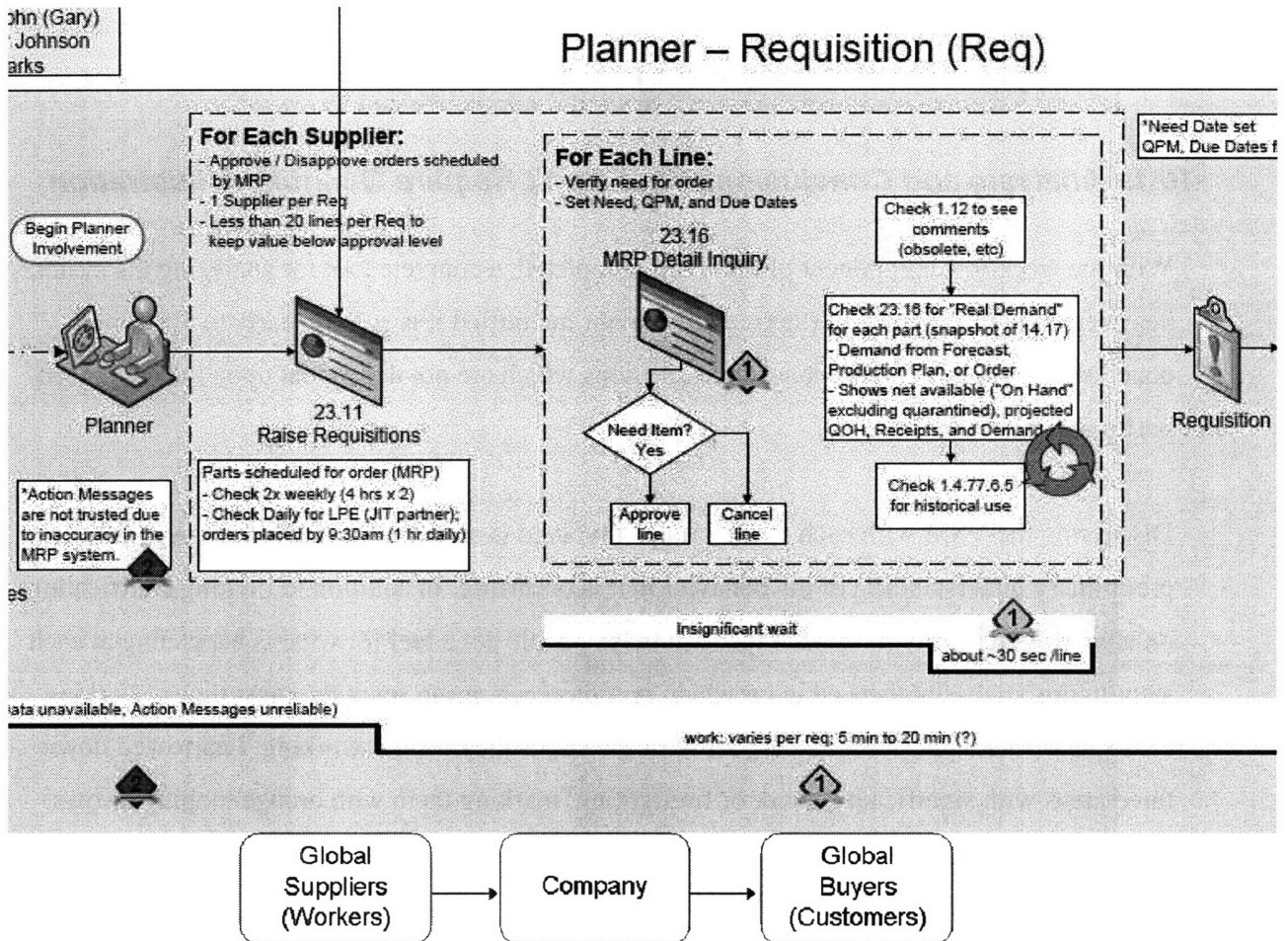


Figure 16: Planner Req Workflow, Order Verification and Modification

If the MRP software inputs were correct, and correctly adhered to, this cycle of rework would be unnecessary. At a minimum, it would just be a practice of validation, and finding occasional errors overlooked at the inputs.

It is tempting to criticize this method of adjusting the orders and delivery dates, arguing that the adjustments cause instability in the MRP system. However, sitting with the Planners and observing the nature of errors they were correcting brings a very different judgment. In one case, MRP was prompting a Req of 100 parts, in addition to the 56 parts already in inventory. The annual demand was about 20 parts. The Planner pointed to this saying “I had to cancel this same order last month. The forecast is all screwed up, and even where it’s right, it still gives us

schedules like this. Customer Service (Sales) controls the forecast, so to change it I have to go argue with them. And even after I do argue with them, it doesn't always get changed." Clearly errors like this are not induced by improper adherence to the MRP system, but errors in the MRP system.

This systematic reworking of planned Reqs is, unfortunately only Muda Type 1. With the inaccuracy of the MRP system, it is temporarily necessary waste. Furthermore, while this method enables Planners to prevent ordering excess parts, it doesn't enable them to systematically gain insight into what orders MRP is failing to schedule. Consequently, WO's were frequently waiting on one or two parts before they could be released to Kitting and Assembly.

At this point, we had no means for quantifying the magnitude of the problem. However, the occurrences were frequent enough that the example above just happened to occur with the daily routine of Reqs that Planner released each day. There were a couple more corrections he made while validating the next several Reqs he raised, and this was typical for a standard day.

With observable behavior like this, quantifying the problem is still important, but the behavior and probable cause is obvious enough to immediately begin working on a systematic, process based solution. The initial approach to this manifest problem is discussed in other sections after quantifying the magnitude and narrowing onto the nature of the problem.

10.1.2. Buyers – Chasing Wrong and Overdue Orders

The Buyers spent most their firefighting time dealing with overdue orders, and modifying order due dates, and other details. The overdue orders were identified to have two causes. The supplier may simply be late, and often the warehouse (Stores on the VSM) was late in booking the part into the system. Figure 17 shows these segments in the workflow.

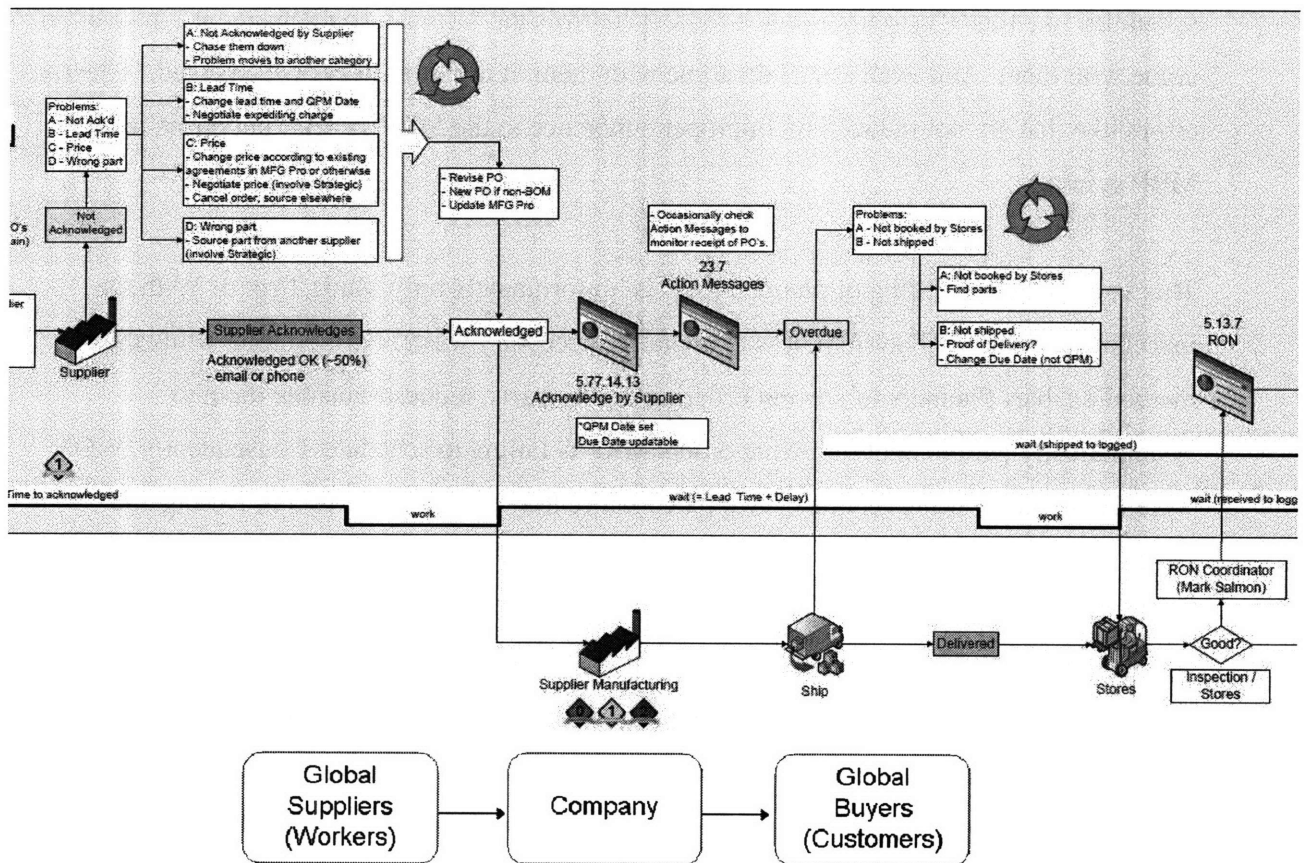


Figure 17: Buyer Activities with Wrong Orders and Overdue Orders

Identifying why a supplier may be late could range from lead time being ignored initially, or just poor supplier performance. Previous data was available showing that little more than half of the orders every were confirmed, so this showed improving Confirmation rates as a possible avenue to improve on time delivery, but quantified analysis would be necessary for more specific recommendations.

The second component regarding overdue orders, the warehouse failing to promptly book in received parts, is something within range of influence of this process. However, discussions with the process engineer intern for that department, and with others who had been involved with trying to draw attention to this step in the system, it became clear that this was a very charged issue in that department. Nobody had quantified the magnitude of this problem, and there was staunch resistance to every recent recommendation to change the problem. Without

data to quantify the magnitude of this specific problem, it was clear that entering that battleground would only incite resistance that may be detrimental to other efforts.

It became clear that addressing overdue orders, without quantified behavior at particular steps, would not be feasible at this early stage in the Lean Transformation.

Modifying orders that Buyers placed with suppliers was frequently concerning dates parts were requested. Almost all the parts had agreed lead times with the suppliers, but these were frequently overridden when a part was urgently needed. If MRP indicated urgent need for a part, and the Planner agreed with the urgency, then they would send the urgency forward to the Buyers. The Buyers would then negotiate a feasible date with the supplier, and any accompanying fee for rushing the order. Clearly, improving MRP to reduce the quantity of rush orders would reduce the time Buyers spend negotiating date changes. Arguably, ordering according to consistent lead times would also improve the predictability of on time delivery from suppliers.

These postulates on the cause of and correction for modified orders could not yet be quantified, but they reinforced the value to arise from improving the accuracy and effective use of the MRP system.

10.1.3. Buyers – PO Filing

One of the few Muda Type 2 activities identified in the workflow (aside from waiting) was the activity of Buyers filing paper PO's. For every PO, the Buyers would print, sign, scan, and fax or email a PDF of the signed PO to the supplier. The Buyers maintained a copy of every PO in their email folders on their computers. Once a week, or whenever they took the time, Buyers would file the paper PO's into thick binders stacked in log rows on long cabinets. They didn't feel any value came from the activity, even though they'd been doing it for years. In a meeting, they all chimed in saying "I don't see why we do this. It's nothing but a hassle and a waste of time." Buyers estimated they spend 1 to 2 hours a week filing PO's. Figure 18 shows the step in the workflow.

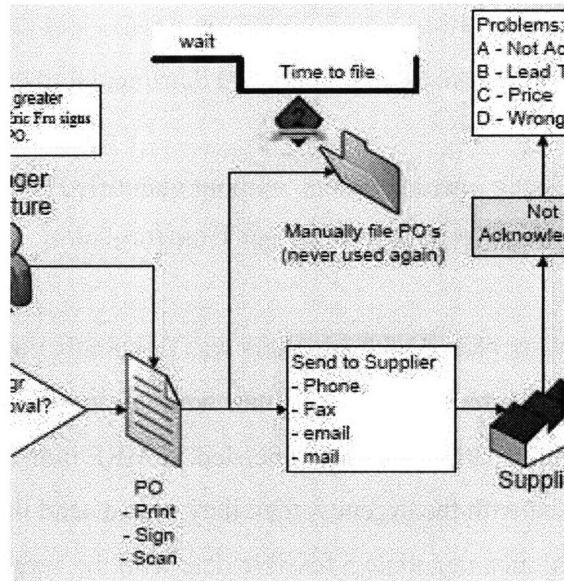


Figure 18: PO Filing Activity

While there is no point in quantifying this activity, there was the probability that the PO's were kept all these years because of taxation, auditing, or other purposes. I contacted a chain of people, including the site financial controller, the corporate head of auditing, and the accounting department, to inquire if and how this activity was necessary for their requirements. Without exception, each of the external departments accounted for their needs through other means, such as invoices and data already stored on the database. Talking with a Buyer who has been at this site for the last four years, it appeared that they used to file the PO's because they were uncertain of the reliability of the previous software system. The need that this activity served at that time had now expired.

Implementing a change based on this analysis was much more involved, and much more interesting than initially anticipated. Efforts to implement changes often bring to surface additional factors that can't be found in a cursory analysis. This change effort and the lessons from it are discussed in later sections.

10.1.4. Forecast Sharing

The third initiative undertaken around this time was Forecast Sharing with main suppliers. Recognizing the need for this initiative was not derived from the VSM itself, but from the process of creating the VSM. While one of the Planners was showing me her process for raising Reqs, we came across an order for which we had enough stock on hand and on order to comfortably fulfill our needs. The two previous orders were late for delivery, so she approved this order and sent it on to the Buyer, saying: “We don’t really need this right now. Normally I’d order it in a month, but they’re late on the last two orders, so I’m going to send this as well, just to let them know that we really do need these parts.”

Upon hearing this justification, I almost fell out of my seat in shock. This behavior is a precise illustration of why The Beer Game developed at MIT, illustrating how the Bull Whip effect finds its way into organizations. Demand for these parts was very consistent throughout the year, but sending signals like this make it appear as though there was a temporary surge in demand, which will then appear to abate when the late shipments finally arrive.

This Planner and I discussed the Bull Whip effect, and once she thought about it, it made good sense to her. However, before she thought about it, she was operating on the auto-pilot that so many people naturally operate on, which is why the Bull Whip effect so readily occurs throughout every industry.

An understanding of the Bull Whip effect needed to be shared with the Planners, but this revealed a missing gap in communicating long term material needs with suppliers. Most of the suppliers were capable of accommodating varying demand, but guidelines as to the expected annual stability can be expected the help them plan their production more accurately, and even reduce prices by producing closer to actual needs in both time and volume.

Developing and implementing Forecast Sharing is evaluated in the later section.

10.2. Implement Lean Initiatives Where Preliminary Analysis is Sufficient

Understanding the reality of how a system is operating, or mis-operating, is essential before undertaking certain kinds of change initiatives. At the same time, some behaviors can be identified based on a preliminary analysis, and intelligent solutions proposed and implemented. This was the case with the first three initiatives undertaken with this study: MRP Improvement, PO Filing, and Forecast Sharing. Implementing each of these initiatives is discussed in their respective sections under the Improve segment.

10.3. Quantify Relevant Steps

While extensive analysis went into each step of the Value Stream through the Supply Chain department, this section will only discuss the nature of each form of analysis applied, using selected examples. Specific analysis is given treatment where it is relevant to a particular initiative, lesson or principle.

All the quantified analysis discussed in this section is relevant to the Data File Map originally shown as Figure 15, and duplicated below as Figure 19 for reference convenience.

MAP Data File Map – SHTC Supply Chain, 2007

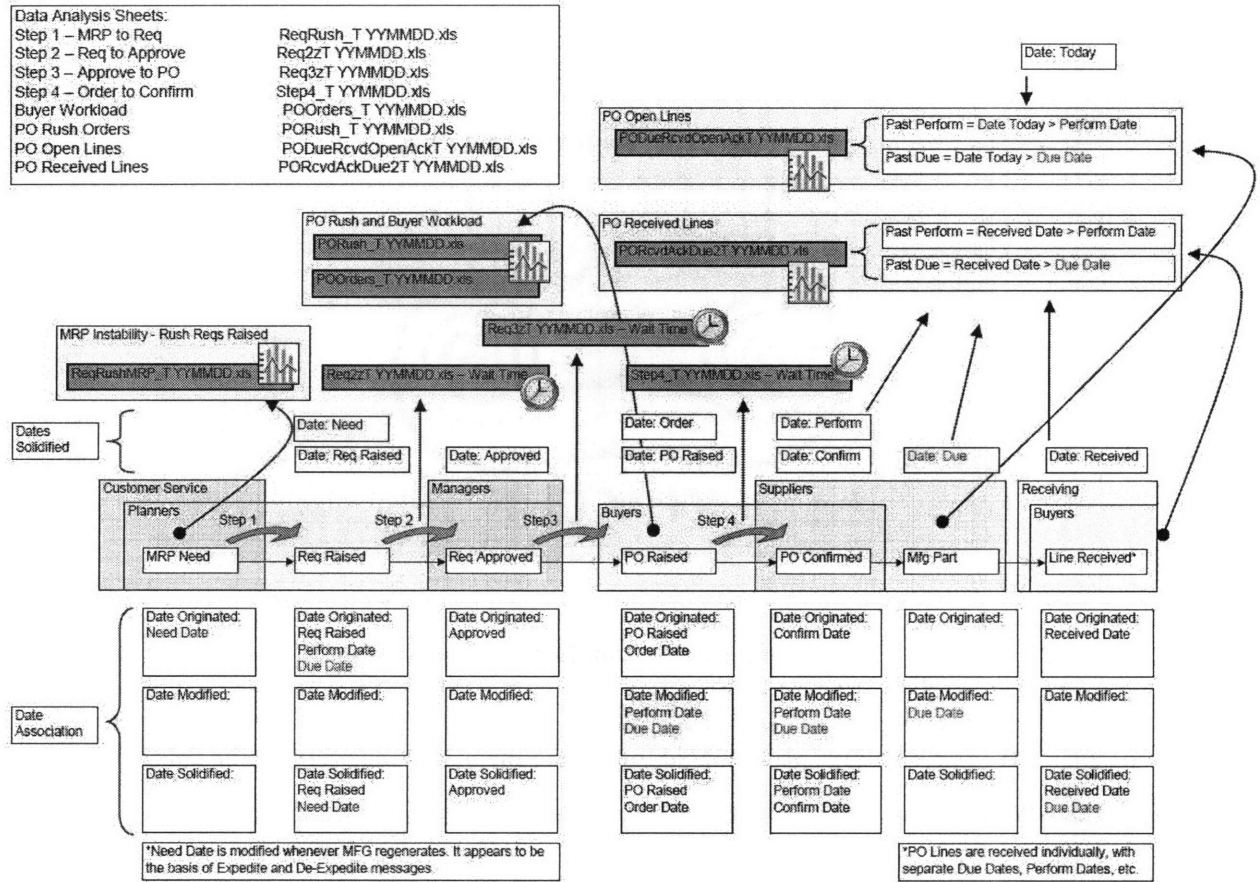


Figure 19: Data File Map

The first steps quantified were wait times at handoffs between personnel. The MRP software carried all Reqs within the system, from when the Req was raised, to waiting for managerial approval if necessary, to when the Buyer raised a PO from the Req, to receiving Confirmation of the order, and ultimately receiving the order. Some of the internal steps had timestamps associated, and downstream steps only had dates. This was adequate for our analytical needs.

Figure 20 shown below is drawn from Step 2, wait time for manager approval after a Req is raised. This data was shown in the aggregate, as well as individually for the four managers who approved Reqs at different financial levels. Figure 20 is an individual chart for one of the

mangers. Each chart was accompanied with a table indicating the actual numbers on the chart (Figure 21).

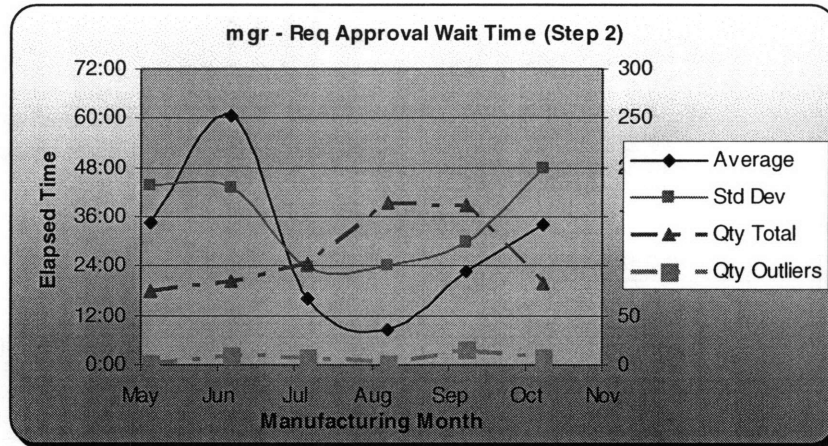


Figure 20: Wait Time for Manager Approval

All charts are accompanied with a table indicating the actual numbers on the chart (Figure 21). For brevity, only this table is shown accompanying its chart.

| mgr | | | | |
|-----|---------|---------|-----------|----------|
| | Average | Std Dev | Qty Total | Outliers |
| | hh:mm | hh:mm | | |
| Jan | | | | |
| Feb | | | | |
| Mar | | | | |
| Apr | | | | |
| May | 34:42 | 43:46 | 75 | 2 |
| Jun | 60:44 | 43:14 | 85 | 9 |
| Jul | 15:52 | 23:31 | 103 | 8 |
| Aug | 8:43 | 24:13 | 164 | 1 |
| Sep | 22:56 | 29:52 | 162 | 15 |
| Oct | 34:14 | 47:56 | 82 | 8 |
| Nov | | | | |
| Dec | | | | |

Figure 21: Table of Wait Time for Manager Approval

In this chart, covering the time period from May through October '07, the diamonds represent the average wait time of approvals that were approved in under 7 days. The squares represent

the standard deviation of those in the average. The triangles represent the total number of Reqs approved. The squares represent the number of Outliers approved, defined as Reqs approved after a seven day time span. Outliers were removed from the average and standard deviation so these latter measurements could give more reliable insight into the routine behavior of the personnel. Managers agreed that Reqs taking longer than 7 days were due to unique circumstances.

It is noteworthy how behavior changed for July, when the VSM was created, and managers were informed that their time response was going to be measured. All managers (except the new Supply Chain manager), showed similar dramatic response to the emphasis placed on time response, and the ability to measure it. Likewise, managers generally drifted away from this quick time response as the months moved on, cycling up and down as lagging performance induced a reminder.

Histograms were generated for relevant charts to give more insight into the pattern of behavior. Figure 22 shows the histogram for the aggregate manager approval wait time in September. This insight into the patterns enables insight for designing coordination of steps by the different roles.

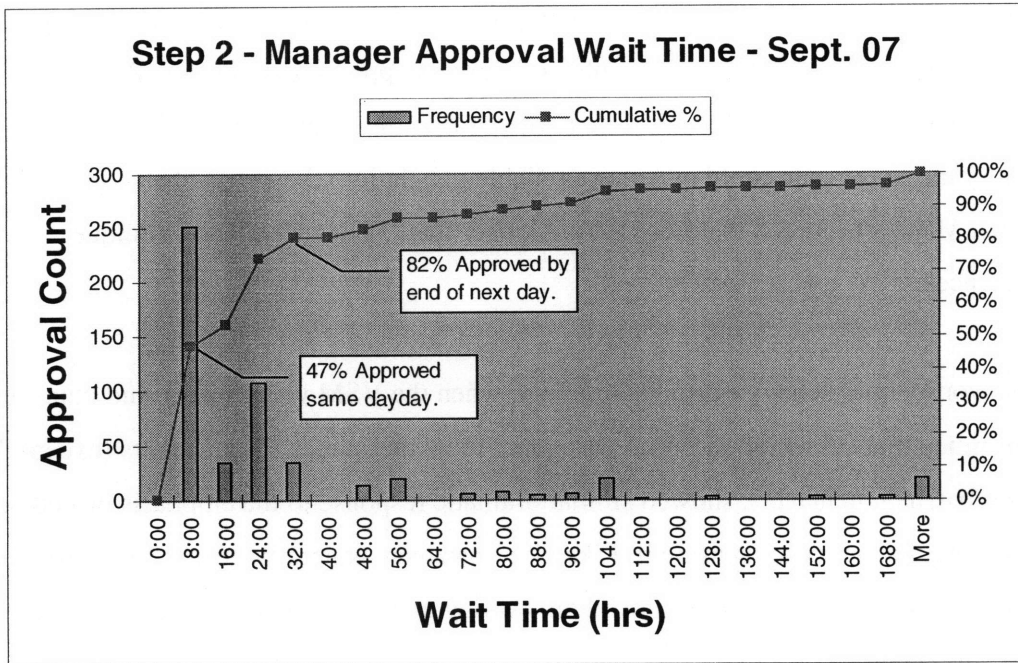


Figure 22: Histogram for Manager Approval Wait Time in September

10.3.1.1. Team Behavior Revealed

A capability enabled with this analysis was the unique behavior patterns of Buyer / Planner teams. The behavior shown in Figure 23, with the tightly coupled average and standard deviation is resultant from the coordinated way in which this Buyer / Planner team coordinated releasing their Reqs and PO's.

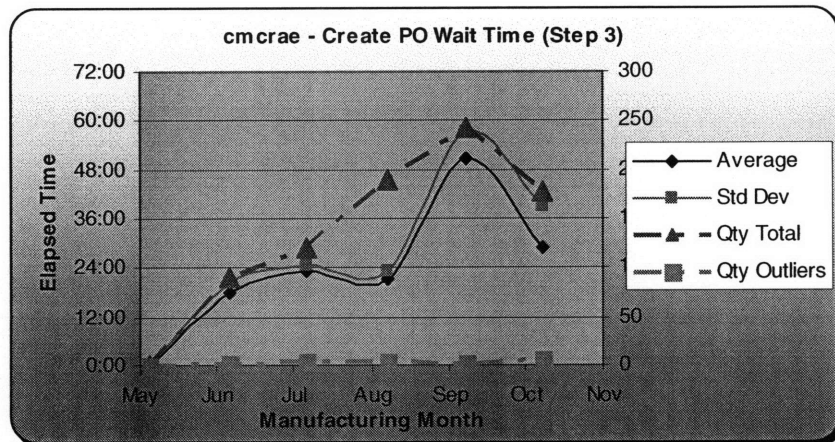


Figure 23: Behavior Unique to Specific Buyer / Planner Team Behavior

Such behavior patterns weren't immediately useful to this study, but after Standard Work Instructions are developed on an individual level, this offers insight for designing coordinated processes for Buyer / Planner teams. Studying, designing, and implementing process changes of this nature will be worthwhile future work for the process engineer.

10.3.1.2. Historical Volume and Ratios

Historical Volume of workload, delivery rates, etc, were quantified where applicable. Figure 24 shows the received PO lines for the combined Supply Chain, also indicating volume received before Due Date, and before Perform Date. Giving Resolution between these different dates gives added insight into the performance of the Buyers tracking the status of expected orders. Appropriate buffers were calculated into the data to allow for the warehouse to check in late, and other such factors outside the influence of Buyers whose behavior these numbers were used to evaluate. As with all charts, these measurements were broken down by product line or Personnel, as appropriate.

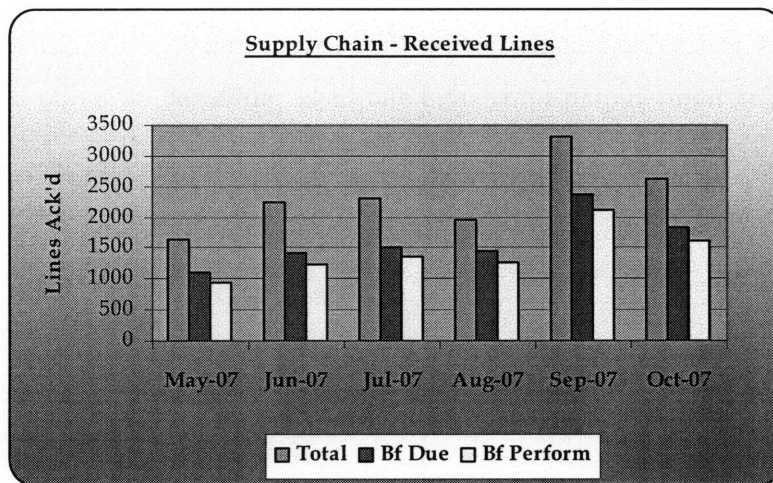


Figure 24: Received PO Lines for Total Supply Chain

Most charts indicating historical volume were also valuable represented in ratios and percentages. Figure 25 shows delivery rates by individual Buyers, according to Due Date.

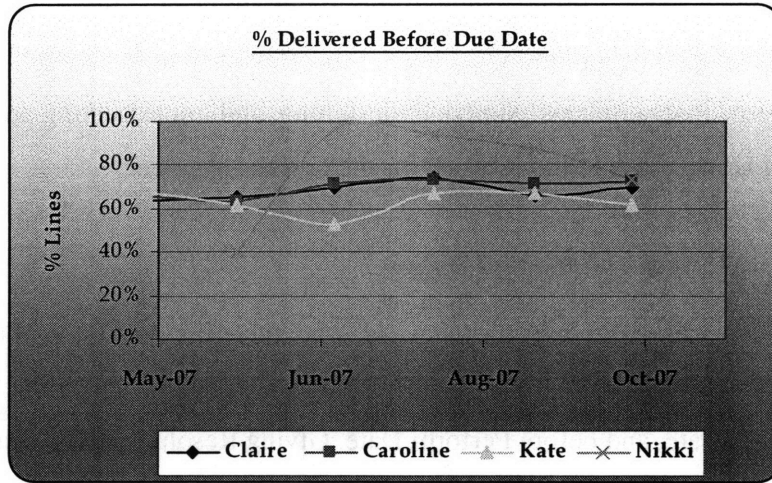


Figure 25: PO Lines Received Before Due Date by Buyers

To give insight beyond the binary state of On Time or Late, histograms were developed and evaluated. This particular analysis shown in Figure 26 prompted an effort to encourage suppliers to not only deliver parts on time, but not deliver excessively early. Warehouse space and inventory had been a dilemma throughout the summer, and the efforts following this began to have an impact in improving this inventory and space problems.

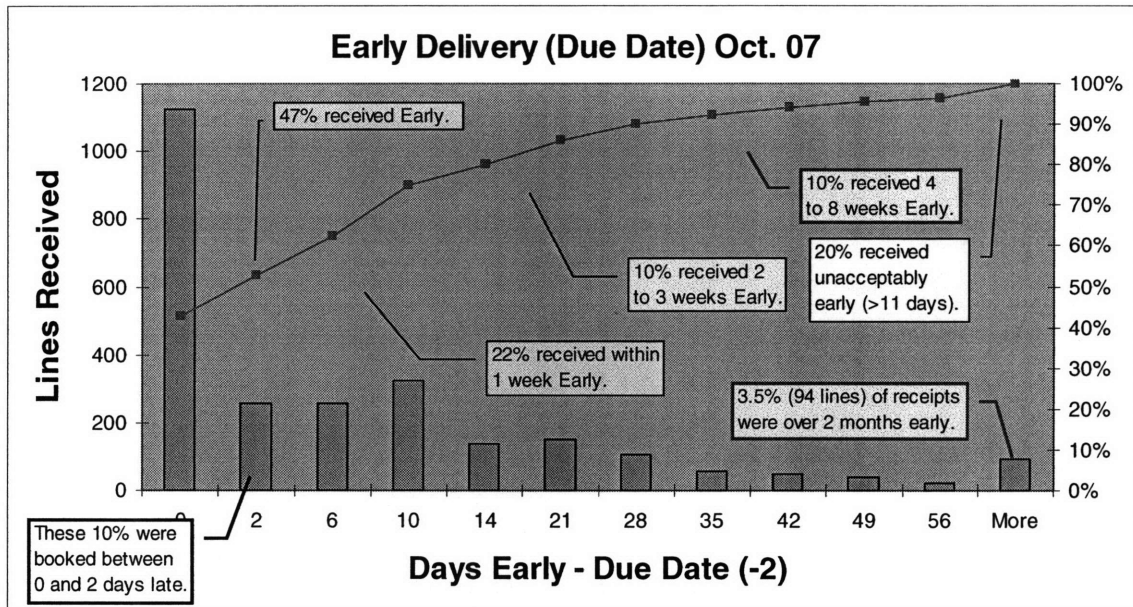


Figure 26: Histogram of Early Deliveries in October

This histogram of early deliveries that 10% of all deliveries in October were delivered between 4 and 8 weeks early, with 22% delivered over a week early. Also implied by this chart is that nearly half of the orders delivered more than 2 days late. The Supply Chain Manager asked for this analysis to be performed when he became curious about the impact early deliveries had on the system. Because the raw data was already routinely gathered, generating a histogram to quantify the answer to his question allowed him to take quick and decisive action on this issue.

10.3.1.3. Snapshot Volume and Ratios (Operational)

Some data is most effectively taken as a snapshot in time. This tends to be Operational data as opposed to Analytical data, and can be worthwhile in appropriate use.

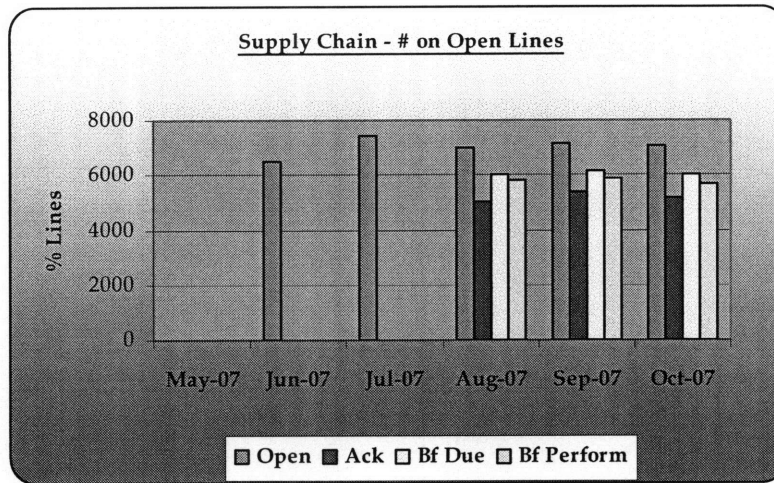


Figure 27: Open PO Lines for Total Supply Chain

Figure 27 shows open PO lines and their on time status for the total Supply Chain at the given dates that the data was queried from the database. Since this data is a snapshot in time, there was no way to gather historical data.

10.3.1.4. Combined Volume and Ratio

Some analysis is best represented with a mixed assortment of data on the same chart. At first glance, a chart like this can appear too cluttered, but for understanding a complex problem, and observing the different factors involved, it is worth the time for a process engineer, manager, and involved personnel to learn the chart, whereby they can gain greater insight faster.

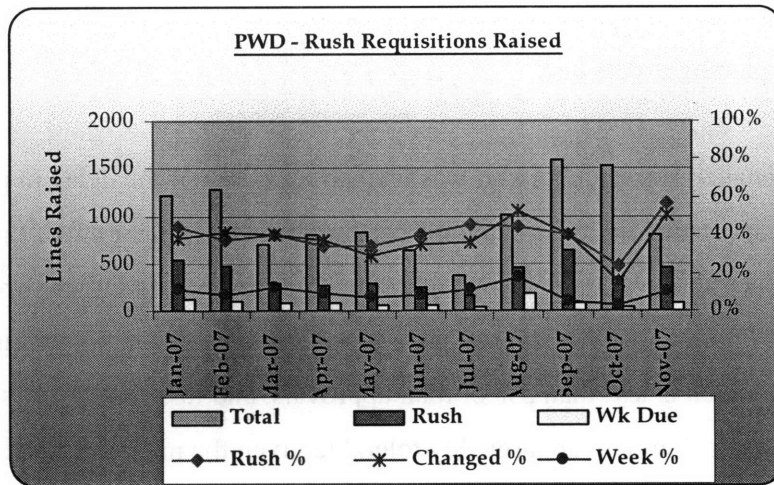


Figure 28: Rush Requisitions Raised for the Largest Product Line

Figure 28 shows Rush Reqs raised for PowerDrive, the largest product line. Indicated are total lines raised, the number raised in rush, the number raised and needed that same week, the associated percentages, and the % of Reqs wherein the Planner or Buyer changed the due date to accommodate real need, or feasibility of delivery from the supplier. (And for the record, it gets pretty complex to sort out the sequence of equations to derive all this from the raw data.)

10.4. Expected and Unexpected patterns

10.4.1. Bill of Health – More Productive Thought Processes

Validating the performance of segments in the workflow frees up the creativity and analytical resources of personnel. People only have so much time to analyze scenarios, and to dream up ideas for improvements. By confirming the behavior of suspect workflow segments, it frees their minds from considering potential problem states. For generating ideas, it helps them see where improvement ideas are of greater or lesser value.

There is value in confirming a clean bill of health. Ideally, as a team continuously implements improvements throughout the Supply Chain, most of the behavior will look healthy most of the time. In this case, the Wait Time data, indicating time response of personnel, largely

exonerated the Managers and Buyers from the perception that they may be a major cause of late deliveries by placing orders late.

There was one manager in particular who was blamed for much of the delay in processing orders. When the data came in, it indicated his performance was on par with others, but the relatively miniscule volume of orders flowing through him made him largely irrelevant to overall workflow. Figure 29 shows this manager's performance, indicating volume below twenty approvals, which is less than 5% of total approvals, and less than 2% of total PO's. The two or three outliers each month are arguably tolerable given the nature of what he approved.

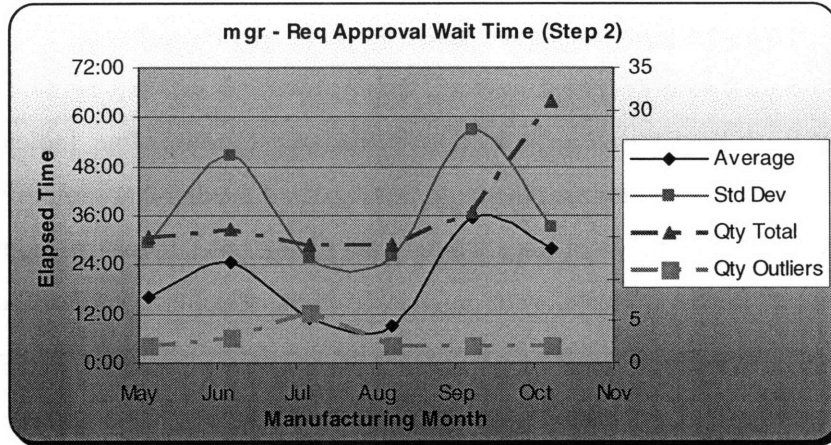


Figure 29: Time Response for a Manager

By collecting this data and validating the performance, it allowed all personnel and managers to turn their attention to ideas that would benefit the Supply Chain, instead of making and defending accusations against vaguely perceived possibilities for breakdowns in performance.

Much of the data gathered for the VSM may simply reveal behavior as expected, but verifying this has hidden value. With this data, you are creating a quantitative foundation by which to comparatively reference all components of the workflow. It serves as a reference by which to judge acceptable and poor performance, and the data that simply validates expected behavior is useful to confirm expectations, and allow more pointed investigation elsewhere.

10.4.2. Believing Results May Take Time

The advantage of quantified analysis is that it helps us to see and believe things that we otherwise might not believe. Sometimes, even quantified data is too far off from expectations for us to believe. These cases require time and analysis for associated people to begin believing the reality shown by the data. That was the case with the initial analysis of the behavior of the MRP System prompting Reqs to be raised in a Rush status.

Having developed the VSM, and seeing that the MRP system was the primary cause of late orders and rework on orders, I began looking for data that would quantify this. I searched the database to gather data quantifying how many Reqs were raised in a Rush (i.e. not allowing the agreed Lead Time before the Due Date).

I was just learning how to use MS Access and how to navigate the database, so I wasn't confident in my data, or exactly what the data meant. The results that I gathered consistently showed between half and two thirds of the Reqs as raised in this Rush status. I didn't believe that, and when I discussed it with the Planners, they didn't believe it either. At length, I dismissed the data as erroneous due to my unfamiliarity with MS Access and the database. I moved on to measure wait times at appropriate steps in the workflow.

A few months later when I was more familiar with MS Access, and I could validate the meaning of specific data in the database with various methods, I returned to this analysis for measuring Rush Requisitions. This time, I knew I was querying the data correctly, and I knew what it meant. In addition, we had developed Standard Work Instructions which allowed us to run daily experiments with the Planners and the MRP system. These concrete experiments locally verified the data I was generating in aggregate.

The Rush Req data now was in similar proportion to the earlier analysis, but this time we believed it. Around half of the Reqs raised were raised in a Rush status. It was a highly unexpected pattern, and it took the other Planners and Managers some time and scrutiny to believe it themselves. For further treatment of this analysis, see the section Rush Reqs.

The lesson from this is that data may reveal an entirely unexpected pattern, but that doesn't mean that it's wrong. However, for people to believe such unexpected results, they may need to see quantified analysis of the surrounding elements of the system first. Change in how a system operates requires time. At the same time, change in how people believe a system operates likewise takes time.

10.5. *Communicating the Analysis*

Analysis isn't effective in a vacuum. Other people need to understand the analysis from their position of expertise. Especially as a process engineer, where the accuracy and relevance of your analysis relies on the expertise of operating personnel, and initiatives justified by the analysis needs the support of others, it is important relevant personnel are aware of and understand the analysis you produce.

Communicating this analysis is far easier if effective communication tools are developed. Spending sixty minutes as a process engineer to make analysis intuitively understandable, may save other personnel ten minutes each in understanding it themselves, while producing better understanding, and more willing cooperation in the analysis and associated initiatives. The latter two results are invaluable, and likewise save more time down the road. The time required to develop effective communication tools is easily justified when considering the time saved for other personnel to understand, and time savings derived from their increased support.

Beyond the communication tool, the effort must finally be made to share the results, either casually or formally, with affected personnel. In this case, many suggestions came as a result of personnel being aware of data, in independently introducing the ideas days later.

10.5.1. Supply Chain Dashboard

One initiative undertaken that assists in communicating the behavior of the system was the development of a Supply Chain Dashboard. This was intended to serve as display to the Supply Chain and people from visiting departments, showing the behavior of the Supply Chain in relevant indicators. The planned medium for this Dashboard was a large LCD monitor posted

within easy view, set to cycle through select indicators and metrics. While this will be effective when implemented, a lower cost method using a simple display board along a common wall, updated weekly or monthly, has merits to be argued for as well. The important concept is thing is that an appropriate format is chosen to share relevant data with the group generally.

10.6. Begin Implementing Lean Initiatives to Enable More Productive Analysis

Due to the autocatalytic nature of Lean tools and principles, implementing appropriate Lean initiatives will bring greater system insight, and enable further analysis of greater relevance. After a preliminary analysis on this level, there will be elements of uncertainty in behavioral patterns, and the causes of this behavior. However, as initiatives are undertaken based upon the most relevant conclusions that can already be drawn, clarity will be given to the uncertain areas. In this expectation, a process engineer can avoid “paralysis by analysis.” Furthermore, management generally prefers to see action taken in a timely manner. By undertaking early initiatives when ready, the benefits of the Lean Transformation will become apparent more readily.

Most fundamental to early initiatives, a Lean Transformation is fundamentally geared at creating an environment of continuous improvement. There is never an expectation that any analysis will lead to the final permanent improved method of operation. By undertaking sound initiatives at the start, and then building upon those initiatives, it demonstrates the continuously improving nature of the Lean Transformation; starting the momentum of analysis and intelligent implementation, repeated throughout the organization, always building upon measured behavior and designed improvement.

Preliminary Analysis Conclusion

This concludes the treatment of the preliminary analysis in this Supply Chain Lean Transformation. Following the treatment of the major improvement initiatives undertaken, we will again return to the next level of analysis enabled by the implementation of these early initiatives.

11. Improve – Initiatives for Immediate Execution

Each of the initiatives undertaken is useful for illustrating several tactics, methodologies, and principles valuable for initiating a Lean Transformation. While many lessons could be derived from each initiative, this study will present each initiative in reference to the tactic, method, or principle most relevant to it in content, or for the flow of concepts from the reader. Many of the initiatives evolved with each other in parallel as well as in series, so they will generally be addressed chronologically where relevant.

11.1. Sources of Improvement Ideas

Before looking into individual initiatives that were implemented, it is worthwhile to observe where the ideas for the initiatives arose. Knowing where ideas come from helps process engineers and managers to more effectively support activities that will invite the most effective ideas to circulate and receive attention.

At the beginning of each initiative addressed, we will go through the origination and evolution of the specific idea. For the moment, we'll look generally at behavior observed throughout all the initiatives. Overall, the operating personnel were the most effective source of improvement ideas. However, the Value Stream Map was an indispensable tool for organizing and bringing these ideas to fruition. Following these two tools in significance are the data analysis, and the Process Engineer.

The Value Stream Map was the by far the most used tool for generating, documenting, and communicating improvement ideas. Just generating the VSM got operating personnel thinking about improvement ideas. Then having their roles visually drafted on paper, it became easy for them to see and identify where there was the greatest room for improvement. Finally, the ideas that were proposed could be documented on the VSM, and communicated to others.

The quantitative analysis of performance at each step in the workflow was highly influential. The data is just data, inherently void of "ideas." However, when the data is rationally collected

and displayed, it becomes obvious where problem areas lie. Easily overlooked is the value of the quantified data in identifying what not to work on. It's easy to identify improvement ideas, but knowing which ideas promise greater return is valuable. The quantified allowed people to quickly see and agree where it was most effective to develop improvement initiatives.

I have listed the Process Engineer as the last significant contributor of ideas, not because I didn't have many of the same ideas as operating personnel, but because the operating personnel didn't need me there to generate the ideas. Serving as a process engineer, it was more critical that I was able to facilitate the development of ideas, communicate these ideas, and offer supporting services in detailing and implementing the initiatives.

From these examples, it becomes clear that a process engineer will always have plenty of effective ideas if they simply remain in regular communication with operating personnel throughout the implementation of initiatives. The combination of Lean initiatives, quantitative analysis, and operating personnel have an autocatalytic tendency to identify and prioritize the next most important initiative. All a Process Engineer needs to do is maintain the momentum of the initiatives as they arise.

11.2. PO Filing by Buyers – Communication Tools

11.2.1. Communication Tools

When a process change or implementation is simple and obvious, it can be very tempting to implement the change on a verbal basis, and move on to “more worthwhile” tasks. From a change management perspective, quick and deliberate action is often preferred to excessive communication clarity. While a balance between rapid change and deliberate definition merits consideration, this study contains numerous examples of benefit derived from developing communication tools which may have otherwise seemed unimportant. Two examples are illustrated here, one simple, and one spread over five months, wherein the system was significantly improved through the process of creating communication tools for implementing the change.

11.2.2. PO Filing Elimination to Visual Indicators for Confirmation

A simple but striking example of Process Evolution gained through developing communication tools arrived through eliminating the waste activity of filing and storing paper PO's. While developing the VSM, it was identified that the Buyers spent an hour or two each week filing paper PO's which were never again used. This was clearly muda waiting to be removed. A discussion with the site Financial Controller, and an email to the person in charge of auditing at headquarters, confirmed that filing paper PO's was unnecessary for tax, auditing, and other purposes.

Instead of simply making a verbal announcement that paper PO filing will be terminated, time was taken to draft the new Future State workflow for Buyers with this simple step deleted, and generate a schedule for cleaning out the old unnecessary PO's already filed and sitting on the shelves.

The first evolution came from stopping for sixty seconds to draft a simple Current and Future State process flow. The initial intent was to show the wasted step, and then show the wasted step missing. While hurrying through this step, it became apparent that this existing paper PO could feed back into the process, acting as a visual indicator for PO Confirmation (see Figure 30).

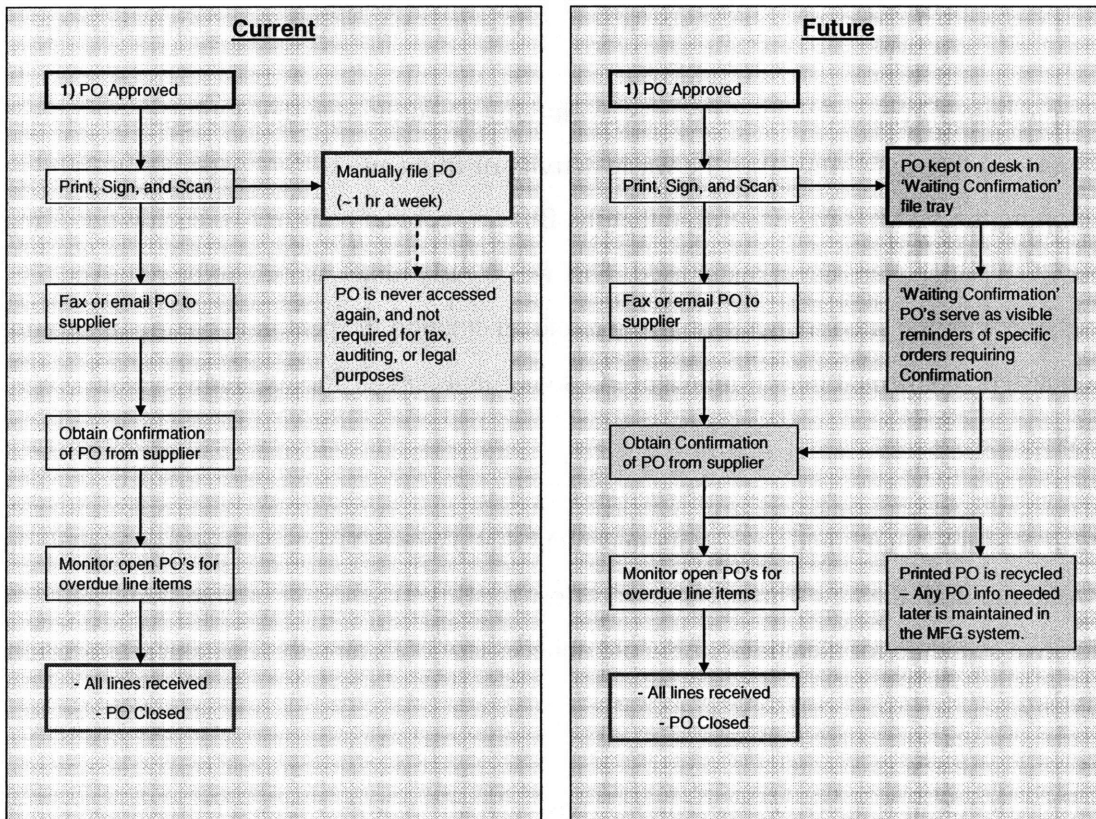


Figure 30: PO Filing Previous and Future State

At this early stage in the transformation, PO Confirmation appeared to be a high potential area for increasing On Time delivery from suppliers (see Figure 31).

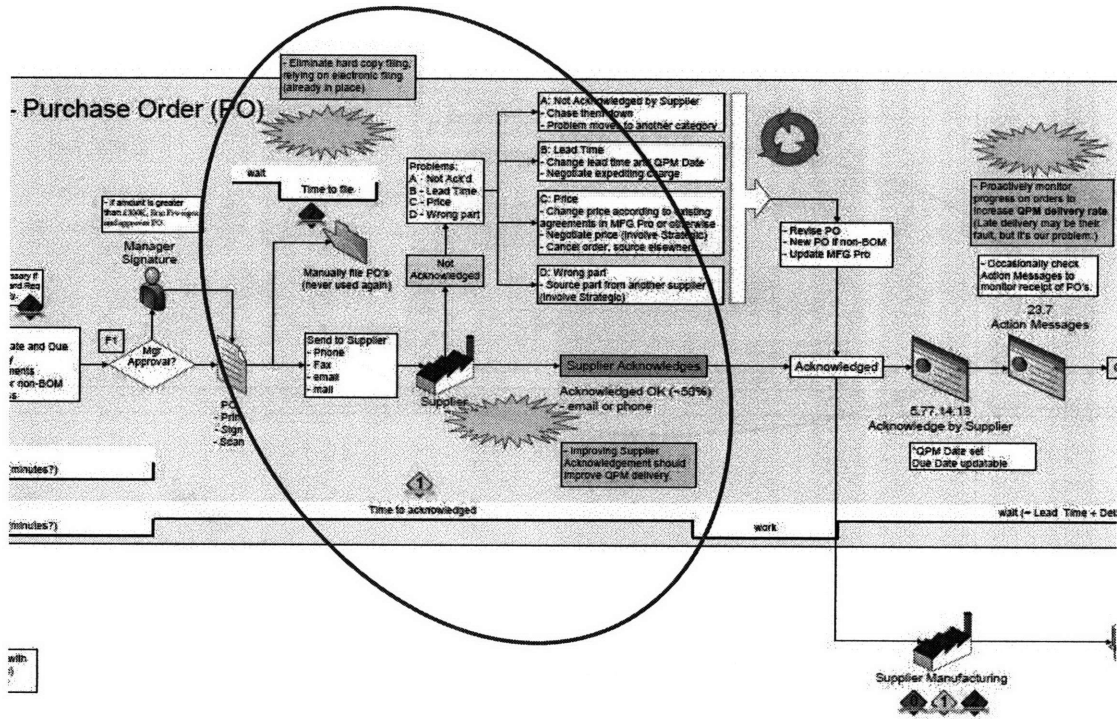


Figure 31: PO Filing and Storage as Wasted Activity

The result was taking what was previously muda, and turning it into a process improvement tool (see Figure 32).

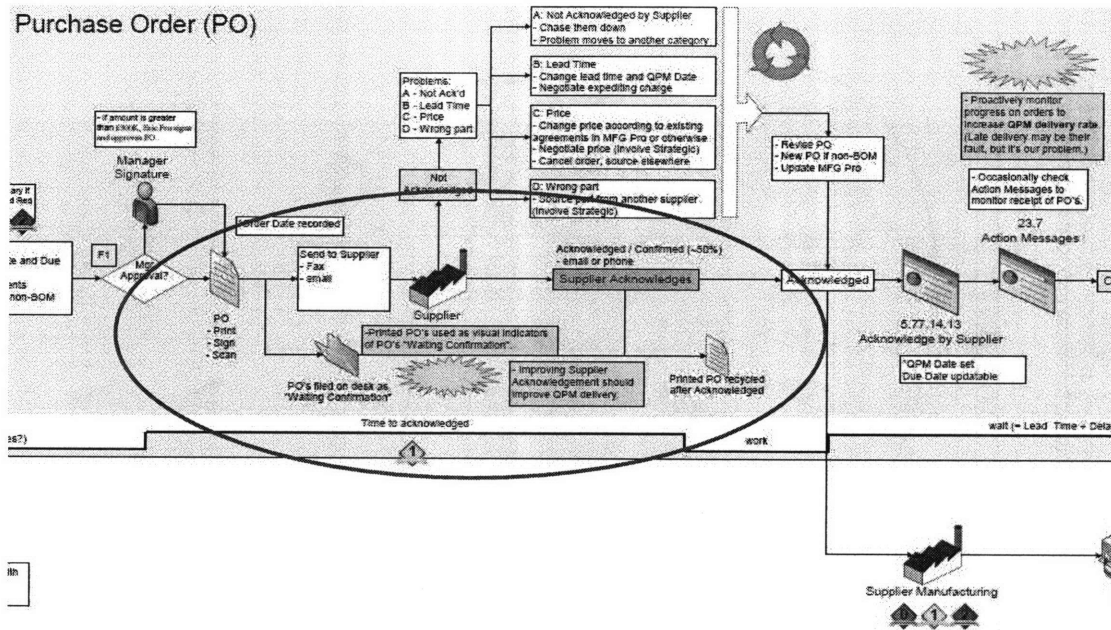


Figure 32: PO's now used as visual indicators for confirmation follow up

The next insight came from drafting a simple schedule for implementation. This time, the seemingly irrelevant housekeeping step of cleaning out the old filed PO's became apparent. Housekeeping aspects of a change management can be easy to neglect, even though they're very simple to execute. Taking thirty seconds to think about the schedule for implementation was enough to bring out this important but inconspicuous housekeeping step.

11.3. Eliminating PO Printing

The natural step after eliminating PO Filing was eliminating the printing of paper PO's all together. The reasons for this are obvious. The PDF image is the only part of the process that actually makes the workflow easier for anybody. A digital signature replacing the ink signature would be sufficient for Buyers and Managers to have the validation they wanted.

The MRP Software was such that it could only send an image to a printer, so it would take some IT finagling to trick the system into creating a PDF instead of printing a hard copy. This is easier said than done. We contacted a series of personnel who made attempts. Eventually, shortly after the conclusion of this study, a solution was finally developed. This initiative

received regular attention and support from upper management, but it was put on hold for a while due to an additional need the Buyers had.

11.4. Buyer PO Electronic Storage

Combined with this series of improvements, the Buyers requested creating an electronic central PO storage location. This initiative turned out to be a preliminary requirement for eliminating printing of paper PO's, but this was not immediately realized. The section on the value of follow-up discusses this matter in greater detail.

With Buyers occasionally substituting for each other, and especially when Buyers would leave the department or company, other Buyers needed access to the PO's. They needed a tool where any Buyer could access a PO raised by any other Buyer, and view any notes made on the PO, or emailed comments about the PO.

A simple solution was developed and proposed for this, shown in Figure 33, enabling Buyers to cc emails to the storage location without any changes in their current operating methods.

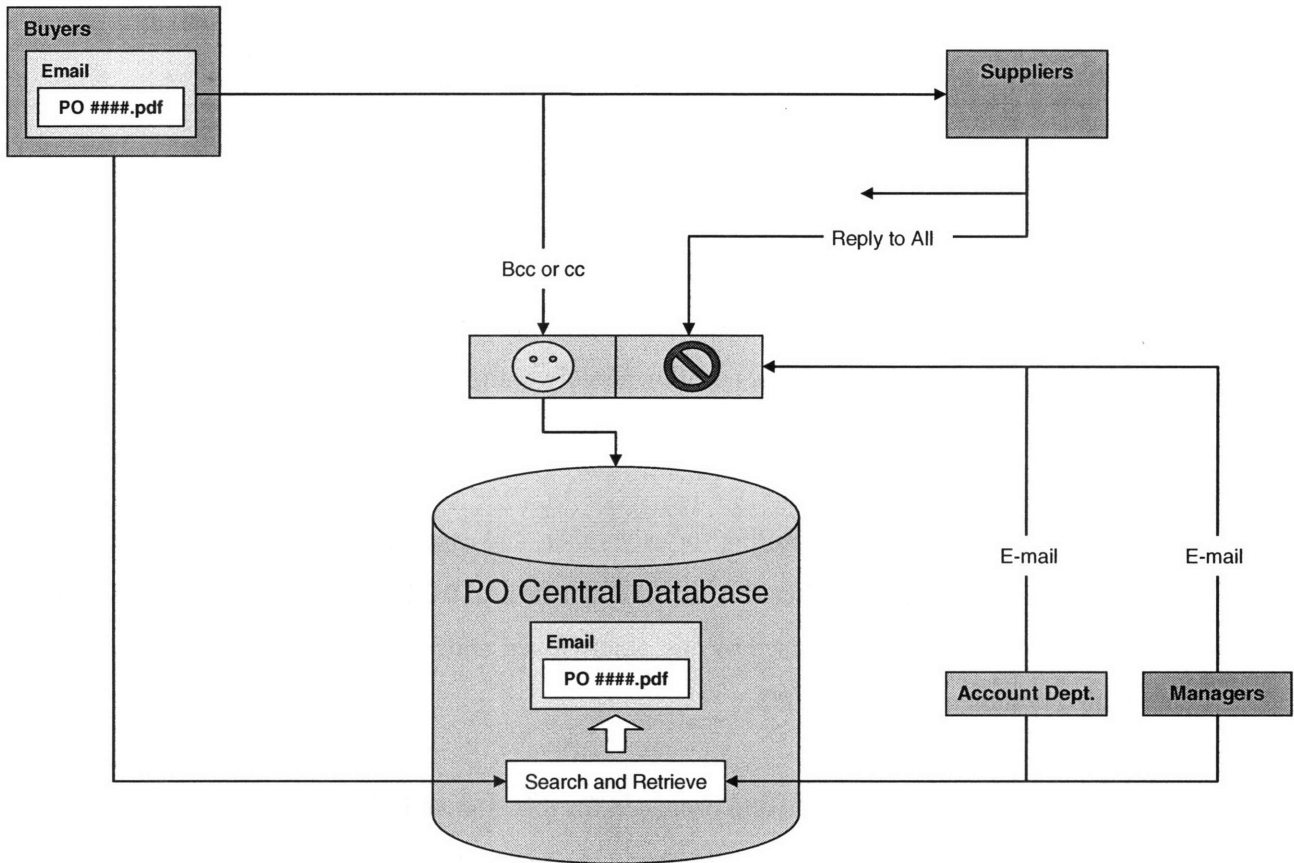


Figure 33: Buyer PO Central Database

While the solution was simple, both conceptually and technically, it required a drawn out series of discussions, meetings, and follow up, before it finally got implemented at the conclusion of this study. The personnel in Supply Chain didn't have the expertise to implement this solution themselves. Discussion with a series of four IT personnel easily grew into discussions about very lengthy, corporation wide solutions to problems of this nature. Even though the Process Engineer and Supply Chain Manager sought a simple, local solution, every IT person that got involved continually looked at the tool in terms of a complex database system requiring frequent maintenance and support. Seeing this through to implementation required patience and persistence. Seeing this through to implementation required patience and persistence.

There were two factors that enabled this to finally be implemented. First, It turns out that the language used in communicating this initiative with IT was one of the biggest impediments to

helping them realize the simplicity of the solution desired. To an IT person, a “Database” must be designed, with many rules and interfaces for use. However, a “Storage Location” is something easy for them to configure.

Second, the IT personnel needed to feel they had explored all possible options. While the Supply Chain personnel spend their life in their roles, and an IT solution like this seems simple, IT personnel spend their lives dealing with large information systems, and patching up hasty work people left behind from initiatives like these. They needed time to consider how this fits into their overall IT system for which they are responsible. They must also allow the IT personnel to explore all the possible solutions they could devise, so they are likewise confident that the solution implemented is adequate. This may require patience on the part of the process engineer to wait (and follow up), until the IT personnel feel comfortable.

While this initiative was more valuable to the Buyers than was eliminating printing paper PO's, this initiative received little attention from upper management. The benefits of this change were less obvious to those outside the operational position, while the benefits of eliminating paper PO's were readily apparent. This is a clear case where priorities for operational personnel are different than perceived by management. This case reiterates why it is important for the process engineer to set priorities with an accurate understanding of how initiatives will actually help operating personnel, as well as a systematic outlook on the process.

11.5. Action Message Tools – Hidden Expertise

Two additional tools were developed from a Planner who happened to have strong expertise in data mining, and creating user interfaces for databases. These tools were MS Access interfaces which allowed Buyers and Planners to access Action Messages from the MRP System giving instructions for changes in due dates for parts, and other such changes. The nature of these tools is beyond the scope of this study, but it is relevant to the autocatalytic nature of Lean tools to evaluate how these came about.

When the Planner with this software expertise was hired, he was positioned to pick up responsibility for a product line left by a previous Planner. As the Process Engineer was using MS Access and VBA in Excel to generate tools and analysis for the system, this Planner took an interest in the work. It soon became apparent that this Planner had greater expertise than the Process Engineer, so they frequently consulted on how to get the data desired, and eventually this Planner undertook several analysis tasks on his own. Once his expertise became apparent, he was given more leeway to further pursue more analysis, and develop tools enabling greater operational capabilities for the Buyers and other Planners.

When a Lean Transformation is initiated, personnel are naturally invited to apply their insight and expertise to improving the system. When initiatives are undertaken on many different levels, and these initiatives are generally communicated throughout the department, it enables people with hidden expertise to offer their expertise. In this case, this Planner had software skills. His skills could just as easily have been applied were they in some other discipline. However, it was the environment of the Lean Transformation that enabled this Planner to offer and apply his hidden expertise.

11.6. PO Confirmation Policy - Follow Up

11.6.1. Follow up

The importance of Follow Up was clearly in play with each of the initiatives. With some initiatives, Follow Up was appropriately carried through with positive results. In other cases, Follow Up was neglected, much to the detriment of the momentum and progress of this Lean Transition. We will evaluate the present situation in detail, identifying the systematic impact of neglecting follow up. The following section on Forecast Sharing illustrates the dynamics of effective and ineffective follow up as well, although the emphasis in that section is on Communication Tools.

11.6.2. Following up on Buyer PO Filing

When we formally eliminated filing the paper PO's from the Buyers work process, they were all so happy about it that it didn't seem any follow-up would be necessary. We expected to see the PO Confirmation Rate increase over the next couple months, but the flat line over the next three months was disappointing (Figure 34).

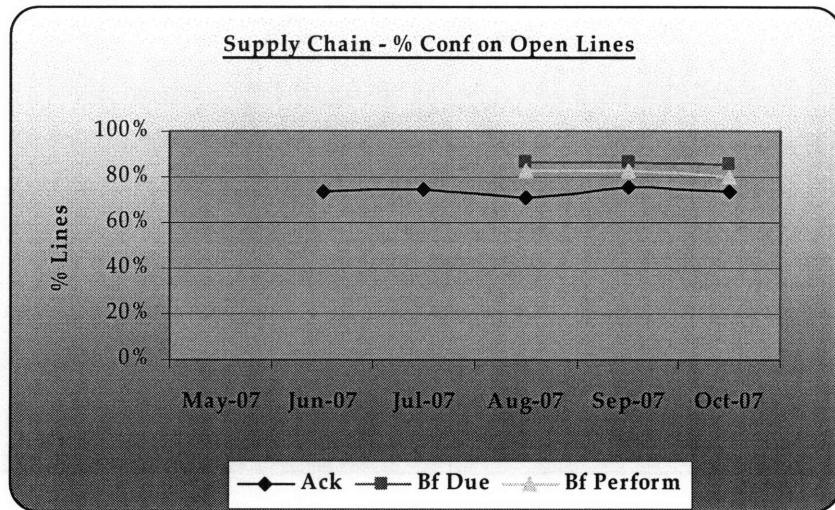


Figure 34: PO Confirmation Percent on Open Lines

Two months after the change, we analyzed histograms of how long PO's waited before Confirmation, shown in Figure 35 for the month of October. These histograms revealed that most PO's were confirmed the same day of placement, with over 50% confirmed within 1 week. It was recommended to implement a policy to follow up on unconfirmed PO's after one week, expecting this activity would increase on time delivery, and decrease firefighting to chase down undelivered parts or incorrect shipments. The SC Manager was reasonably hesitant to place more demands on the already overextended Buyers, preferring to keep their attention focused on relationships with key suppliers.

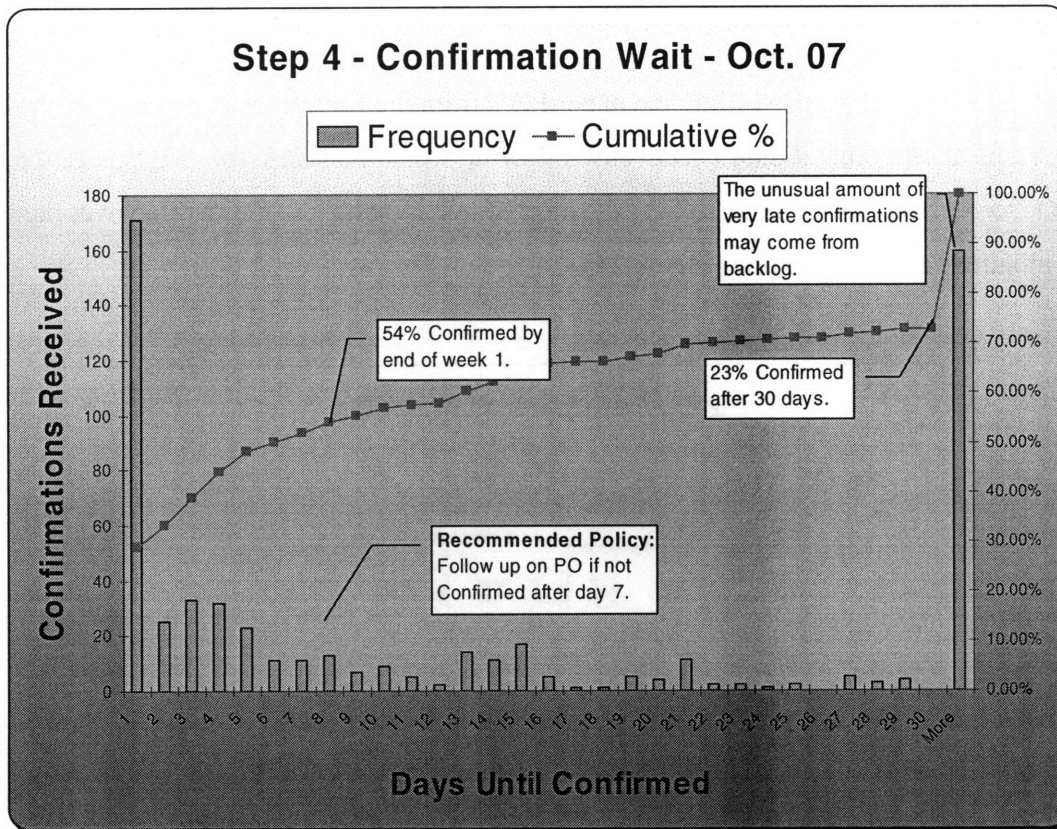


Figure 35: PO Confirmation Wait Time, Histogram for October

The mind boggling thing in all this is, while doing this analysis, we didn't ask the Buyers what they were doing with the PO's and Confirmations, specifically regarding this new process. In November, three months after terminating PO Filing, I finally took the time to ask specifically about following up on PO's with the paper copies as visual indicators.

Much to my surprise, the Buyers had stopped filing the PO's, but weren't discarding the paper copies when confirmed or received. The printed PO's had been stacking up on their desks. The Buyers said they had been afraid to discard them because 1) They don't have an email specifically approving for them to throw the PO's away, and 2) They were afraid to throw the PO's away in case another Buyer or someone needed reference to the PO, and they weren't around personally to look up the PO on their computer.

This situation clearly illustrates multiple reasons for follow-up on even the most simple process changes. Two lessons most applicable to general cases will be addressed with this example. First, the message may not have been communicated as intended, even though it seems obvious. Follow-up is necessary to ensure the message was clear. Second, the personnel executing the process may have additional needs or concerns that weren't apparent when the process change was designed. Follow-up is necessary to ensure needs are addressed as they were intended.

11.6.3. Follow-up to Ensure the Message was Communicated

There are four ways in which a simple message is likely to fall through, which can be overcome through quick follow up. These include the message itself, a natural hesitance to change, a personal change in operating process, and concern about liability for unexpected problems that may arise.

According to the understanding of the SC Manager and the Process Engineer, instruction to discard the PO's had been given directly. The Process Change was discussed in a group meeting, and sent in an email clearly indicating paper PO's would be discarded after the PO was confirmed. This may be the case, but the result is what ultimately matters, not the effort made. If the Buyers collectively didn't get the message, it is indicative of a failure in communication. An early follow-up on this initiative would have reinforced the official efficacy of the policy to discard paper copies of Confirmed PO's.

Even if the message were clearly understood in the meeting and the email, it is natural for personnel to be hesitant to change practices which have been in place for as long as they've performed the job. It is reasonable that they would need direct reinforcement to initiate such process changes. When the Lean Transformation has been making progress, and changing and improving working procedures has become commonplace, workers can be expected to more readily change their working patterns. However, the first change is a very significant change for any group, and can appropriately be expected to require additional reinforcement.

Even after the first execution of the new process, it is likely follow-up will still be necessary. A new method doesn't become "Process" until it has been executed multiple times. In the eyes of the employee, the first time is a "New Activity." The second time is a "Repeat." The third time it becomes "Process." Follow-through must be carried out to change old habits, and to reinforce a new culture responsive to continual process improvement.

The fourth component of ensuring the message is communicated deals with liability for the process change. The first concern expressed by the Buyers addressed their aversion to being blamed for discarding the PO's. The release of liability for the specific process change needs to be explicitly communicated, and provided in documented form sufficient that the personnel involved in the change can prove they are absolved from liability for departing from the old procedure. They may believe the change is a good idea, but the historical conditions in which they've been working is likely very risk averse. A history of reinforcing certain behaviors is difficult to change. At the same time, it must be explicitly stated what the personnel are responsible for performing. While management assumes responsibility for the defined process change, the personnel still hold responsibility for operating as intelligent individuals. If they find failures in the new system, it is still their responsibility to communicate this. It is natural for people in a risk averse environment to require documented confirmation of the process change.

11.6.4. Follow-up to Ensure all Personnel Needs are Addressed

When designing a process change, even with extensive participation by the personnel executing the process, it is possible to overlook new conditions created by the change. In this case, the Buyers discovered how important it is for them to have their PO's available for other people to access in their absence. They had considered this when helping to design the process change, but didn't realize the full impact it would have until they were there ready to discard the paper PO's. Similar discoveries could occur in almost any process change. The discovery can be a shift in perceived priority as was this, an emergent behavior from the new process, or any number of unexpected outcomes. Immediate and frequent follow-up early on is essential to ensure these discoveries are addressed.

Furthermore, immediate and frequent follow-up enables the Process Engineer to benefit from the autocatalytic nature of implementing Lean Principles. Opportunities to improve a process are often most apparent during the initial implementation, and they are easiest to change during the initial implementation. Follow on initiatives can be readily identified. Follow on initiatives previously identified can be reevaluated in terms of design, efficacy, and priority.

In this study, two follow on initiatives were already under consideration. Following up immediately would have helped to identify the relative priority of each initiative. The two initiatives undertaken immediately after terminating filing paper PO's, were efforts to 1) create a Central PO Storage location on a server where everyone could access historical PO's, and 2) configure the software to directly create PDF's instead of printing PO's.

The second of these initiatives, directly creating PO PDF's, received high attention from the SC Manager and higher managers because of the obvious savings in time and materials. However, to the Buyers responsible for their role, the first initiative, creating an electronic Central PO Storage location was essential for them to perform their responsibilities if paper copies were eliminated. Without this electronic PO storage, they didn't even feel safe discarding their printed PO's, let alone transitioning directly to PDF's without a hard copy at all.

Had there been timely follow-up on the first change initiative, the priorities for each of the follow on initiatives would have been realigned to reflect the real benefit they bring to the Supply Chain. Three months later, instead of having more insight into what wasn't working, and zero process improvement realized, we would likely be two steps further along the process improvement path.

11.6.5. Diplomatic Follow-up: Inquire About Implementation vs. Command Implementation

Before concluding this discussion of follow-up, it is worth noting the appropriate balance of approaches with which to follow up on process changes. Follow-up is predominantly the role

of the Process Engineer, with the Manager coordinating and supporting Process Engineer efforts.

Follow-up can be approached in a Support nature, and in a Command nature. The Support nature is ideally the most frequent form of follow-up. In a Supporting nature, the Process Engineer interacts with personnel on a basis of inquiring about their adherence to the process change, and their observations, needs, etc. The Process Engineer should be readily available to answer any questions at the onset of the process change, and evaluate changes in needs and priorities as discussed above. With a cooperative team, as participated in this study, following up in a Supportive nature is optimal for maintaining good relations, and positive moral about process improvement, and the role of the Process Engineer. The perception of the Process Engineer is reinforced as an individual intent on improving the system in a way that benefits the operating personnel.

The Command nature of follow-up can be necessary with uncooperative employees. Through sincere efforts to understand the needs of personnel executing the processes, design the processes accordingly, and effectively communicate with personnel, the need for a Command nature of follow up can often be avoided. Effective communication tools and diagrams, tailored to the specific thought processes and concerns of those involved, can be thought intensive to design and create, but the consensus they can generate is often worth the time it saves by preventing or overcoming conflicting relationships between departments and personnel (also reference the section on MRP Improvement). Furthermore, if an employee is adamantly resistant to a process change, it is probably because implementing the proposed process will hinder productivity in some way. Before commanding adherence, the Process Engineer and Manager must ensure that appropriate measures have been taken to understand and account for the criticisms of the resistant employee (also reference the section on Forecast Sharing and Planner 5). Even though there was pointed resistance during development of processes, these criticisms were integrated into the processes designed, and consensus was achieved when the procedures were ready for implementation. This study did not encounter any circumstances wherein a Command nature of follow up was necessary or appropriate.

11.6.6. Other examples: Clean Kit, Demand Solutions, Forecast Sharing, MRP Improvement

Several other components of this study reinforce the follow-up principles identified with this PO Filing example. These are briefly identified to substantiate the general relevance of these principles.

The initial conditions for this study include the Clean Kit Policy addressing Planners releasing WO's, and Kitting bringing parts to Assembly. When this policy was implemented, the policy was clearly defined, and liability for the results of this policy was clearly communicated and understood across all involved departments. Regular follow-up with the Planners at the source of the workflow ensured the policy was adhered to. Supportive follow-up with personnel for their observation and questions was neglected, resulting in a slightly demoralizing effect with the implementation. When follow-up with the personnel provided answers to their concerns later on, their attitude regarding the policy changed, enabling them to consciously work such that they assisted the purpose of the policy.

Another initial condition was the implementation of new forecasting software for M&S. This initiative was implemented in a Command style, igniting a resistant response. Initial follow-up was neglected, resulting in the software being ignored, and Planners working around the influence it had on the system. When Supportive Follow-up was offered, addressing the needs identified by the Planners, adherence to the software and policy began to improve incrementally.

Follow-up was initially neglected for the Forecast Sharing initiative resulting in policy failure and systematic problems remaining hidden (see the section on implementing Forecast Sharing). When Supportive Follow-up was offered, the process was intelligently designed, enabling successful and efficient execution.

The MRP Improvement meetings received appropriate Supportive Follow-up, resulting in development of tools and processes necessary to facilitate the ease of the initiative, and support from both departments involved.

11.7. Process Improvement Priority Table – Organized Process Improvement

With the momentum that begins during a Lean transformation, and the importance of maintaining momentum and following up on initiatives that have begun, it is essential that a Process Engineer develop an effective method for organizing and prioritizing the several initiatives that are undertaken, and that are to be undertaken in the future. It is beyond the scope of this study to evaluate organizational methods, but in this study a systematic method was developed, called a Process Improvement Priority Table. This enabled the Process Engineer, and later the team, to collaborate on initiatives and responsibilities, track progress, prioritize initiatives, follow up, and evaluate the success of projects with management. This organization system was essential to keep a handle on the several projects simultaneously underway, and to discuss realistic objectives with the Supply Chain Manager.

11.8. Forecast Sharing – Importance of Process Definition

Forecast Sharing is the policy of sending monthly demand forecasts for specific parts to the ten largest suppliers of each product line (ranked by spending). Naturally, the intent of this is to help suppliers plan their production to better serve the needs of SHTC.

11.8.1. Forecast Sharing Idea

The idea and tools for Forecast Sharing came about from two experiences while creating the Value Stream Map. The first was seeing the Bull Whip effect blatantly evident in the thought processes of a Planner during the regular Req release routine, discussed in more detail in the associated section.

The next came while talking with another Planner about the method he used for comprehensively managing his product line. The MRP software could automatically create a forecast report for any supplier the Planner selected. The report came as a text file, and was very tedious to format so that it made sense. However, every other month or so, this Planner would export this report for his most critical suppliers, to make sure the planned orders looked

consistent. It was tedious, but he felt it was worth the three or four hours to validate the forecast and system. Seeing such a forecast was available in the MRP software, we discussed sharing that report with suppliers, and what would be most helpful.

11.8.2. Forecast Sharing Macro (Enabling Tools)

As the process engineer, I had experience programming with VBA in Excel, and was confident I could easily create a macro to automatically format the report this Planner used to validate critical forecasts. Even if I didn't personally have the necessary programming skills, such skills are not uncommon, and another person in the department could have been called upon who had similar expertise. In this case, it wasn't having the programming skill that made the critical link (although it helped). The critical link was recognizing that a tool could be easily programmed to format the annual forecast on a regular basis.

I spent four hours one morning to write a first draft of this macro, and evaluate it with the Planner who was already using the forecast reports. For reasons discussed in the section on *Managing a Process Engineer*, this macro wasn't written until two weeks after learning of the forecast report, and it was not shared with the Supply Chain Manager for another two weeks. Because the SC Manager was dictating other priorities, he remained ignorant of this opportunity. Once it was introduced to him, he gave the initiative his full support for further development and implementation to proceed rapidly.

The Forecast Macro was developed as user friendly as possible, and the process engineer met with Planners individually to instruct them on how to use it, and verify they understood how to use the tool. This covers the development of the idea and the enabling tools. Next, more relevant to this study, we will address the evolution of the procedure.

11.8.3. Forecast Sharing Procedure Evolution

The evolution of the Forecast Sharing Initiative over five months offers a concrete perspective from several angles on the relationship between process improvement, process definition, and process communication. Each aspect of the change initiative is reinforcing of the others, and

necessary for success in the whole initiative. In this section, three phases in the evolution of this procedure will be addressed, identifying the assumptions, intent, and results of each step in the progression.

The first phase of the Forecast Sharing Process entails a generally defined objective with clearly developed tools, but only a vaguely suggested process for reaching the stated objective, and little personal discussion. The second phase includes an explicitly defined process, with improvements derived in the process definition. This was implemented with cumbersome communication tools, which evolved into a more effective process flow diagram, and process for developing and correcting the objective. Finally, the third phase matures into clear and concise work instructions, again with process improvements arising while defining the instructions.

11.8.4. Phase One: Clear Objective with No Process Definition

The first round for Forecast Sharing was initiated decisively. The idea was proposed by the PI Engineer and a Planner, and immediately supported by the Supply Chain Manager. An Excel macro was rapidly developed over the next couple days to enable automatic formatting of the forecast report generated by the MRP software. The macro was distributed to Planners with instructions for exporting the MRP forecast report and running the macro. Finally, the SC Manager stipulated that forecasts were to be shared with the top ten suppliers on each product line. The deadline was set to send the reports by the first Friday of each calendar month.

As the PI Engineer, I had not personally defined a process for this initiative, other than instructions for using the macro. The SC Manager put one of the Planners in charge of answering questions about Forecast Sharing, and I was directed to continue pursuing analysis of other aspects of the Supply Chain.

The SC manager's expectation was that this first iteration would be a bit rocky, and the group would figure out a process naturally. This attitude is typical of traditional change management for initiatives of this small scale. The idea is to avoid micro-managing, empowering employees to decide how to do the job. As expected, it was rocky.

For the first month, the Planners attempted to work through the reports, running into many questions which were fed to the lead Planner, and some relayed to the SC Manager. The SC Manager addressed concerns accordingly, producing a spreadsheet sorting suppliers by spending per product line, and designating Buyers to send reports to Suppliers. The reports drug on past a week late. Ultimately, sharing the forecast was abandoned for the first month.

With the second iteration the next month, the Planners and Buyers stumbled through the reports, completing and sending the reports one week later than expected.

The process that organically grew out of these conditions resulted in duplication of work, ambiguity of responsibility, unnecessary work at the end of the line, and uncertainty of completeness. With several suppliers shared across produce lines, the Planners exported the MRP forecast report, separated it for their own product line, and validated the forecast. The multiple forecasts had to be compiled into a single report for each Supplier, so Planners and Buyers discussed amongst themselves to decide which Buyer would compile the reports and send them. The Buyer included this report with other monthly performance reports for the Suppliers, and relied on their own familiarity to judge when they had received all reports.

This ambiguity was expected for the first couple iterations, so everyone worked through it without complaining. However, repeating this decision process the third month (with a Planner and the SC Manager out of the office for the week), the outcome was very frustrating, especially for the Buyers at the end of the process. When the frustration finally boiled over, the need for process definition became painfully apparent.

11.8.5. Traditional Change Management

It is significant to note the application of traditional change management practices in this instance, the results that occurred, and the conditions that were likely to evolve by continuing with these traditional policies. Then the differences between this traditional approach and a Lean approach will be compared, followed by the experience of transitioning to a Lean implementation process.

Applied

Within the traditional change management method, the end objective was defined, and personnel were assigned responsibility for reaching this objective. The flow of authority was specified, and personnel were empowered to do what was necessary to get results. Support was given from the top manager when necessary. The employees were trusted to act intelligently, instead of micro-managed.

Results

The results under this approach had the first attempt at implementation failing, and the second attempt concluding a week late. The process that evolved showed ambiguity of responsibility and compounded work. The process was not robust to unexpected (but routine) absence of personnel. The objective was achieved, but it required more effort and stress than is sustainable.

Expected Evolution

If Forecast Sharing was to continue under this framework, it can be expected that the Planners and Buyers would have adapted by developing a process shared as “tribal knowledge” by which the reports would usually be completed on time. Just as they have adapted organically to their other responsibilities, they would have found their personal routine for accomplishing their part of this new responsibility. The process would have kept its systematic inefficiency of compounding work, but the workers would develop an unwritten set of expectations of responsibility for each step. The Buyers and Planners would adapt, and the Supply Chain would limp along.

11.8.6. Lean Change Management

11.8.6.1. Difference between Traditional and Lean

The difference between the Lean approach to change management and the Traditional approach lies in how the Process the workers use evolves.

In the Traditional approach, the Process evolves by *chance* and *localized tactical intelligence*. Workers adapt by tactical intelligence, using whatever process seems best in their immediate sphere when initially confronted with the responsibility. Work procedures are determined and maintained by habit. The habits are almost purely influenced by each workers first impression of the best way to deal with a problem. Empowering employees to find solutions only empowers them to work by their own habits, whether they are efficient or not.

In a Lean approach, the Process evolves by *design* in light of *systematic intelligence*. A Process Engineer develops a process with participation from workers, accounting for the systematic considerations in the process sphere, as well as the tactical considerations in the sphere of the workers. Work processes are designed, modified, and improved. Empowering employees, and involving a Process Engineer to coordinate work flow, empowers them to intelligently develop efficient workflow, always capable of being improved.

11.8.7. Phase Two: Detailed but Cluttered Process Definition

The Traditional change management approach to Forecast Sharing took place over three production month ends. Process improvement progressed from incapable of achieving the objective, to achieving it late, to flagrant frustration with systematic inability to meet the objective.

The second phase of Forecast Sharing took a Lean approach to the objective, beginning with talking to the personnel responsible for generating and sending the Forecast Reports (while they were at the height of frustration with the organically developing process). After working with the personnel to put out the fire that flared up around the original process, the Process

Engineer immediately set to defining an intelligent and unambiguous procedure for Forecast Sharing.

The Procedure initially developed was detailed and comprehensive (Figure 36), including the complete workflow from SC Manager responsibilities through sending the validated forecasts to Suppliers. In addition to Forecast Sharing workflow, the procedure included steps for documenting errors discovered while validating the forecast, and reporting these through the defined channels to correct the system.

Forecast Sharing Process (Review for Supplier)

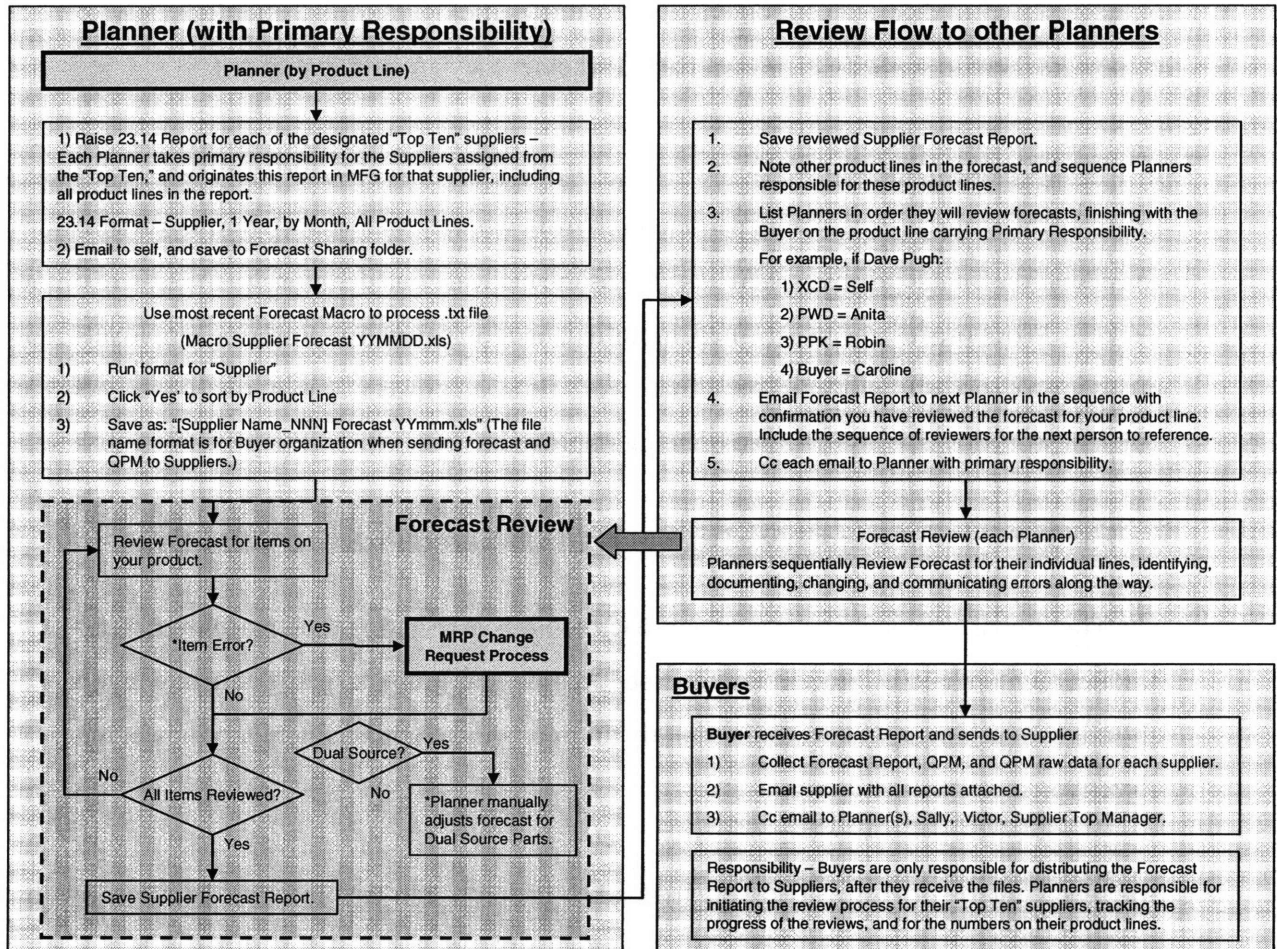


Figure 36: Forecast Sharing Procedure, First Version

While defining the procedure, the principles of Single Line Flow, and Flow Processing were applied. Single Line Flow was applied to create clear responsibility for each step in the process, avoid duplicate work, and assure each step was complete when the work was passed on. This application began with each Supplier assigned to a single Planner responsible for generating the forecast report from the MRP Software. This Planner would validate the forecast for his / her product line, and define routing for subsequent Planners to validate the forecast for their lines, and pass it to the next in the routing. When the forecast reaches the final person in the routing (the Buyer), the forecast has been fully validated, and is ready to send to the Supplier without any further questions.

Serial Processing was applied by specifying that Planners export, validate, and route one forecast at a time, before exporting the next forecast. This allows forecasts to circulate for validation sooner, instead of waiting in batch for all reports to be exported and validated before other Planners can review them.

Both of these concepts are easy to understand and design into processes, but unless the process is considered from a systematic standpoint, it is highly unlikely that they will spontaneously occur as an organically grown process. From the perspective of a Planner responsible for a product line, it seems natural to take care of your product line, and let others take care of theirs. This was the natural thought pattern that led to the organically grown process. The possibility of Single Line Flow originating from one Planner, and the coordination necessary to facilitate it, do not become available unless the process is viewed from a systematic level. The practice of Flow Processing in this application could spontaneously occur, but the batch mentality carried over from Mass Production counters this practice. It only requires a suggestion to start people on the more efficient Flow path, and the result can be the difference between completing reports late or on time.

Because the detailed procedure is not intuitive to understand, implementing this procedure would require an intuitive flow diagram, both for demonstrating the concept to personnel, as well as the SC Manager.

It was discovered that a sequence of flow charts of incremental complexity are most effective for communicating concepts. The following Flow Diagrams in, Figure 37, Figure 38, and Figure 39 were used in sequence to communicate first, Single Line Flow (Figure 37), then more detail of the steps to validate and forward the same document (Figure 38), and finally illustrating the inclusion of MRP Improvement feedback steps (Figure 39)

Forecast Sharing – Simple Process Flow

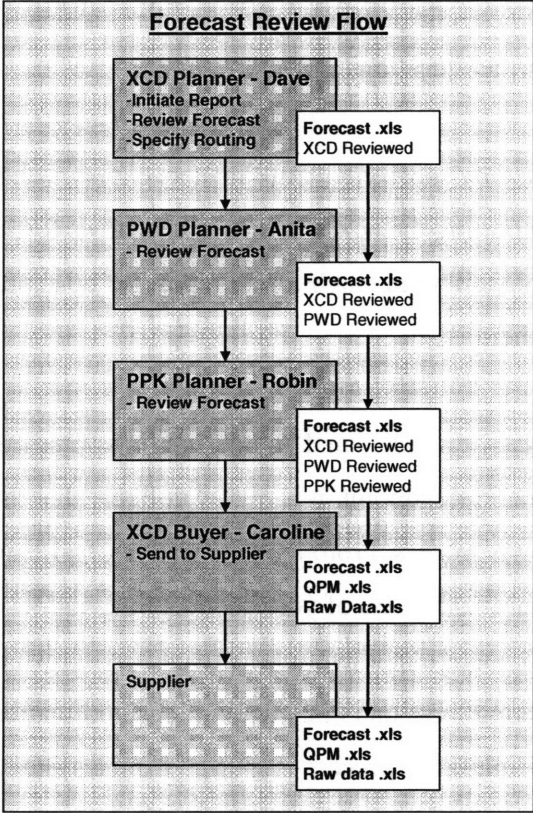


Figure 37: Forecast Sharing Process Flow, Single Line Flow

Flow Overview (Sample)

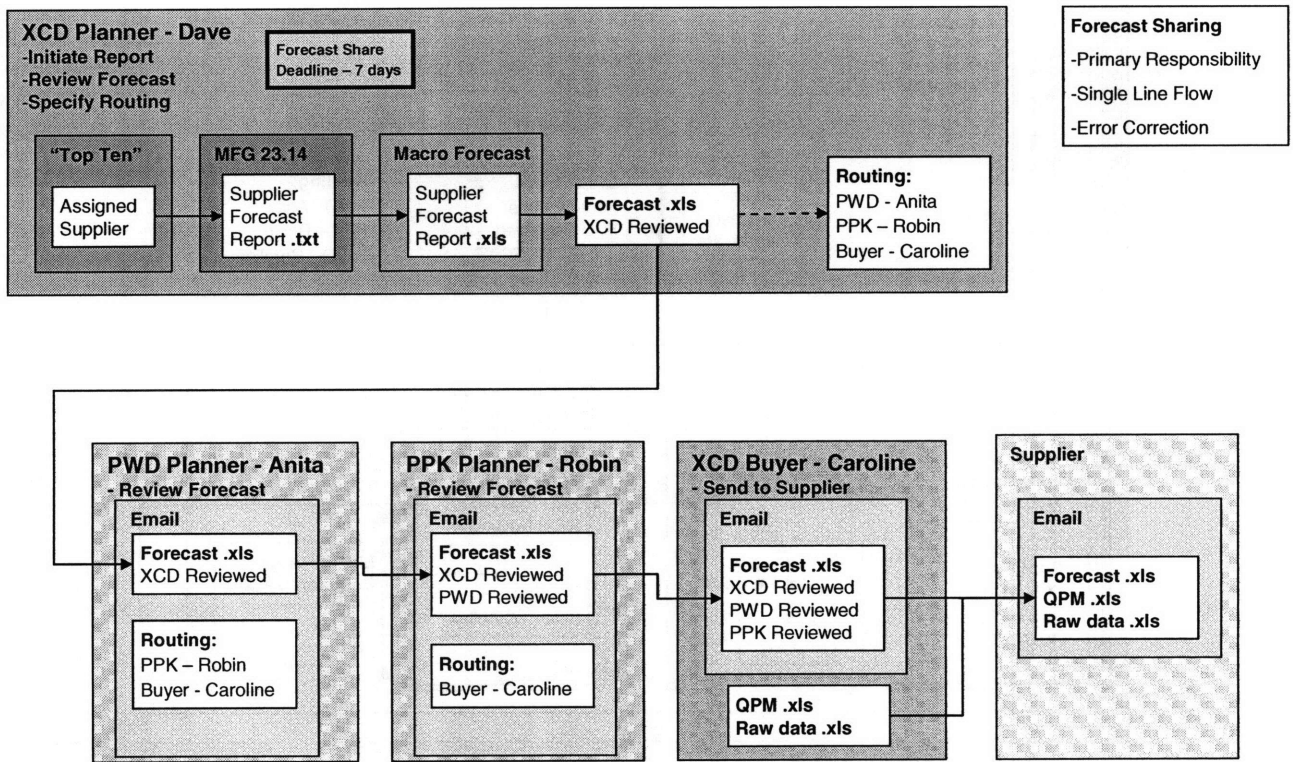


Figure 38: Forecast Sharing Process Flow, Document Flow and Routing

Flow Overview (Sample – with MRP Change Requests)

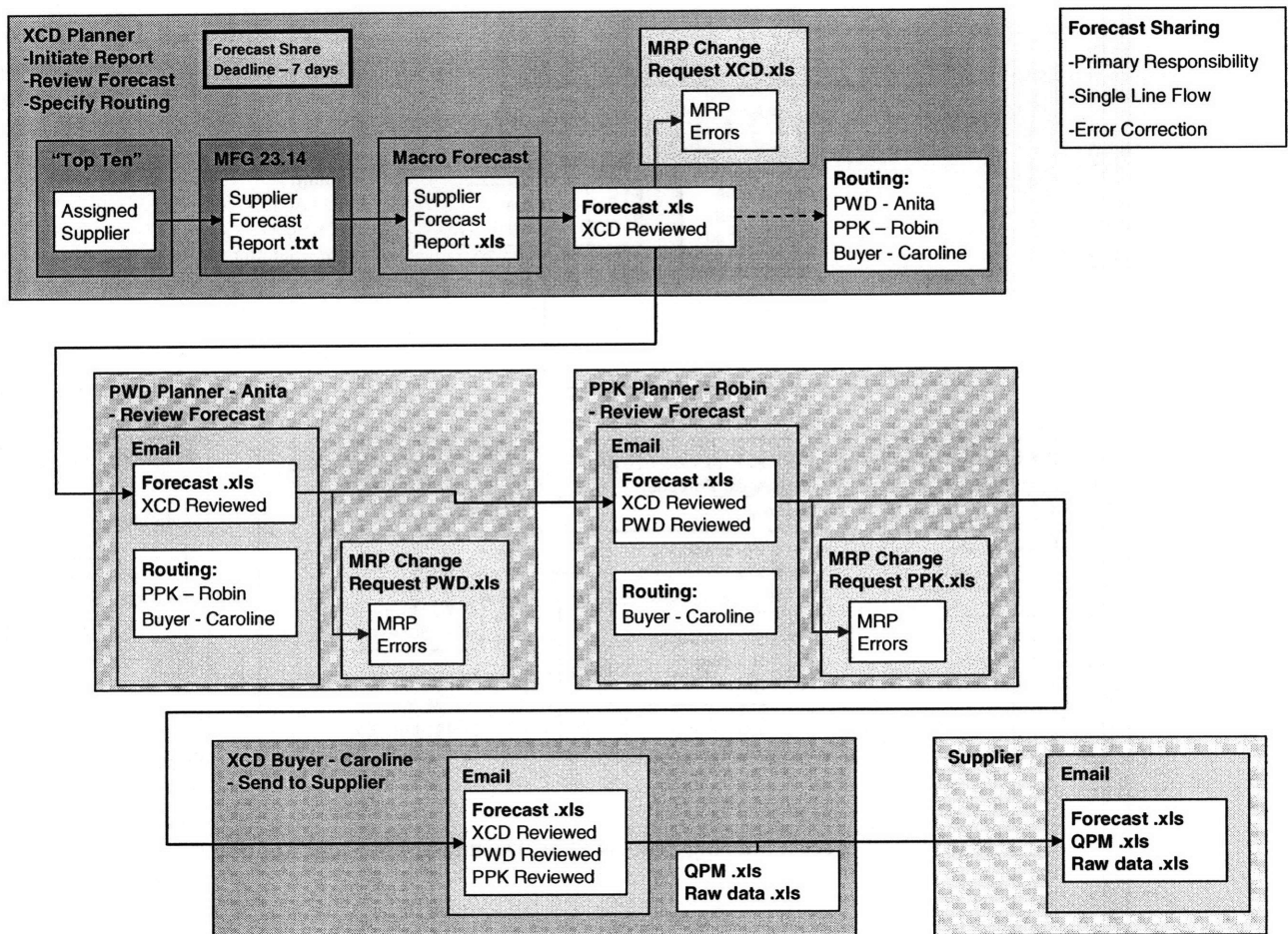


Figure 39: Forecast Sharing Process Flow, Procedure with MRP Improvement

The first Flow Diagram presented, Figure 37, was the last diagram created. In brief discussions with co-workers, it was apparent that the flow of the more complex diagrams didn't make sense at first glance (Figure 37, Figure 38, and Figure 39). Later on, after the first diagram was used to illustrate the concept of Single Line Flow, Buyers, Planners, and the SC Manager were able to easily build upon that understanding with the more complex, but more accurate diagrams.

Another significant observation from the use of these communications tools came forth illustrating the different ways in which people individually think and understand systems.

Within this small group of fifteen Planners, Buyers, Process Engineer, and Manager, it became obvious that some people thought predominantly in Pictorial terms, while others thought in terms of Lists. All personnel quickly grasped the concept illustrated in Figure 37, illustrating a simple Single Line Flow in a hybrid Pictorial format with a List flow. Beyond that diagram, it was striking how obviously some personnel gravitated to Figure 36 to understand the process with a List emphasis, while the others gravitated to Figure 38, and Figure 39 with the pictorial emphasis. While commenting and questioning for clarification, personnel consistently referenced the diagram which they personally understood best, while laughing at the “confusing” nature of the other diagram style.

Assuming most working teams consist of a similar mix of Picture and List oriented personnel, for communication tools to be optimal, they will ideally appeal to both groups. It can be difficult to create process flow charts that fulfill both these thought styles. The anticipated presentation forums (personal discussion, group meeting, training material, etc), and criticality of the communication should be considered when deciding how much time to invest in creating one type, or two diagrams in both styles, to communicate a particular process.

It was also observed that personnel tended to identify more readily with the use of concrete examples of specific people and product lines. The abstract use of figures such as “Planner A, Planner B, Buyer A, etc” made sense after the concept was initially illustrated with concrete people such as “Dave, Anita, Caroline, etc.” While the process definition must be detailed in the abstract form, the concept was more effectively communicated with the concrete form.

In addition to the Flow Diagrams, it was necessary to define Responsibilities and Roles for those involved, shown in Figure 40. While the process flow was unambiguously defined with the flow charts, it was necessary to unambiguously articulate who was responsible for which outcomes.

Responsibilities and Roles

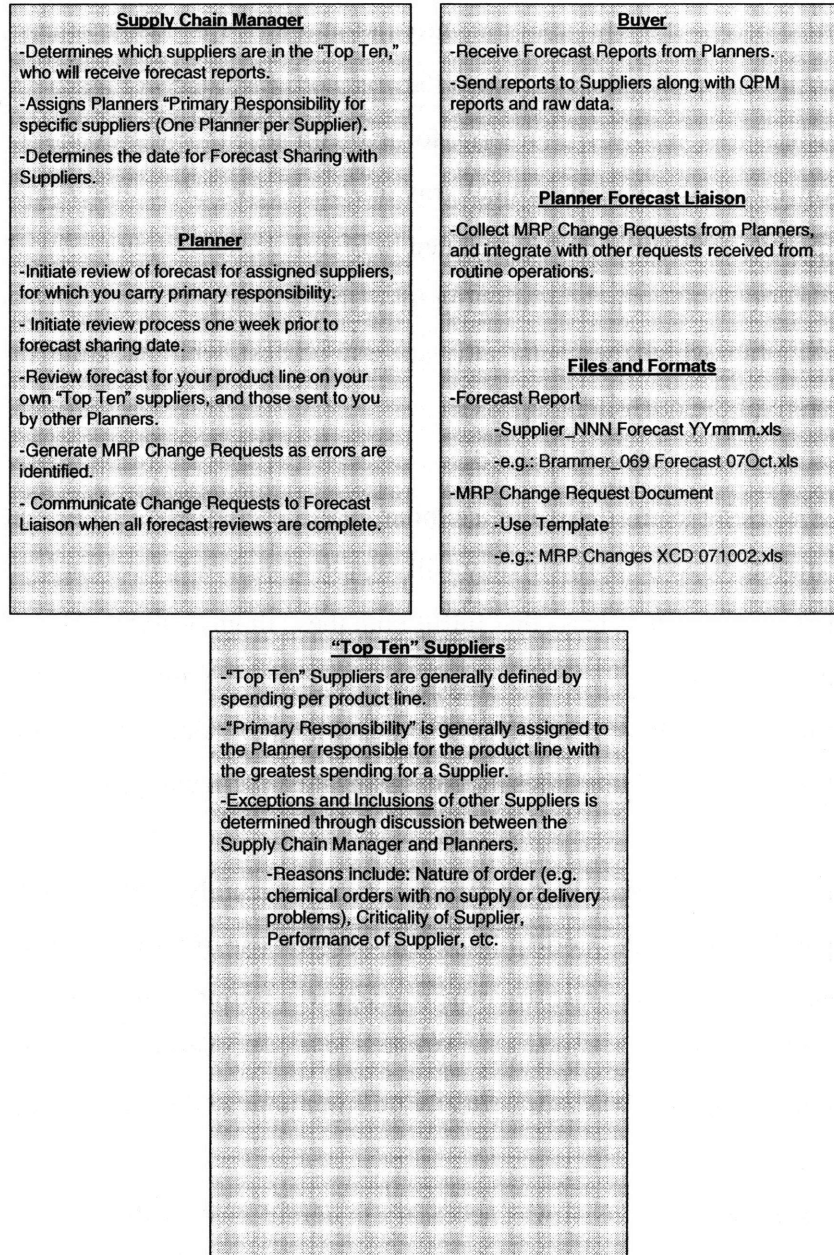


Figure 40: Forecast Sharing Responsibilities and Roles

This procedure was designed immediately after the need became apparent from the frustration with the organically grown process. The concept was communicated with the Buyers and Planners in general during development, and then communicated in detail just prior to the Forecast Sharing round for the next month. There was some discussion at the start concerning

which “Top Ten” suppliers to include for certain product lines, and these were modified according to agreed criteria. From there, this round went through on time, without any problems from anyone involved.

11.9. Phase Three: Detailed Work Instructions

To the experienced eye, it will be apparent that the process diagrams in Figure 36 through Figure 39 are not in conformance with the format of typical Standard Work Instructions. This is partially due to their intended use as communication tools, and partially to an emphasis on speed and function instead of form. While custom adapted communication tools will always be appropriate for individual initiatives in a Lean Transformation, the Transformation cannot be considered complete until appropriate Standard Work Instructions have been developed.

Figure 41 shows the Standard Work Instructions developed for Forecast Sharing. Standard Work Instructions are discussed in greater detail in a later section, so here we will address the autocatalytic impact this had on MRP Improvement.

As with other Standard Work Instructions, instructions for this process were developed in a few iterations.

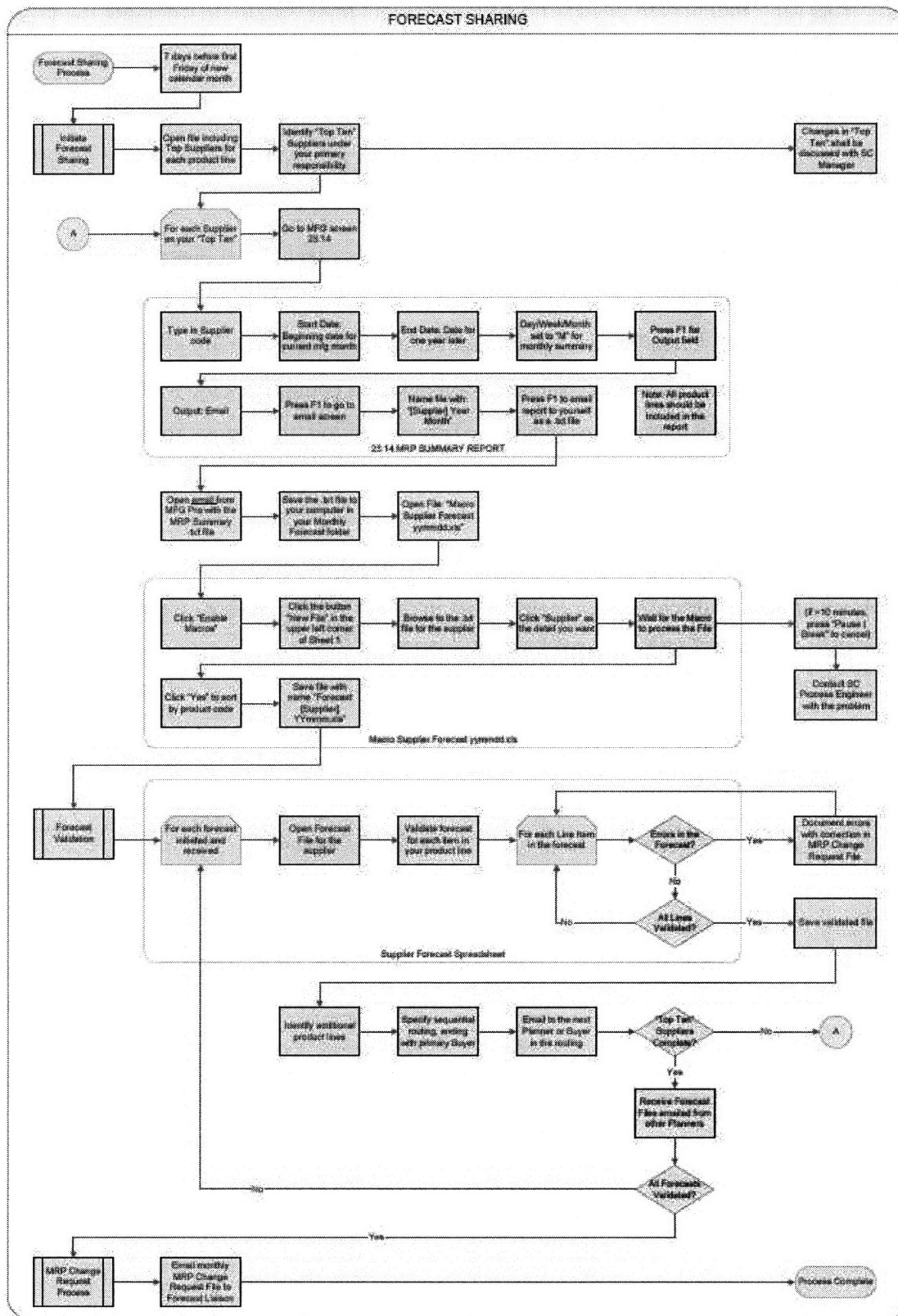


Figure 41: Standard Work Instructions for Forecast Sharing

11.9.1. MRP Improvement Tool

One of the most valuable results from implementing this process immediately came into play regarding the autocatalytic interaction with the MRP Improvement initiative discussed in the relevant section. The MRP Improvement initiative concurrently implemented with Forecast Sharing was originally intended to derive improvements from the regular process of raising Reqs. Introducing this process now gave the Planners a tool and monthly process to evaluate the aggregate forecast for all major suppliers. Right away, the Planners found several errors which were promptly communicated to the Sales department to be corrected. When this exercise was repeated in following months, Planners continued to find errors which they had missed previously, or had not been corrected.

One forecast error in particular was a shortfall for a critical part with a nine month lead time. This forecast shortfall had been in the system for three months already, and had not been discovered. Had this error not been found and corrected through Forecast Sharing, SHTC would have lost approximately \$14 million in sales until more parts could be ordered and received.

Another instance was regarding a forecast for an obsolete part that was persistently stuck in the MRP system. All the settings in the MRP software said these parts were removed from forecasted ordering. However, when the forecast came through it continued to show orders for \$300 thousand worth of this part. With cases like these, Forecast Sharing proved to go beyond helping the suppliers it was initially intended to assist, and gave SHTC Planners insight which helped them to more effectively perform their responsibilities.

11.10. MRP Accuracy Improvement – Preparatory Communication

While constructing the Value Stream Map, it became apparent that most of the things Planners and Buyers spent their time reworking on the Reqs could be avoided if the MRP software were more accurate. At this early stage we didn't have any idea that the MRP system was behaving in the way identified in the later section on Rush Reqs, but it was clear where the source of this wasted effort was coming from.

In the first VSM including recommendations for change initiatives, areas to insert feedback processes were identified and highlighted (see Figure 42).

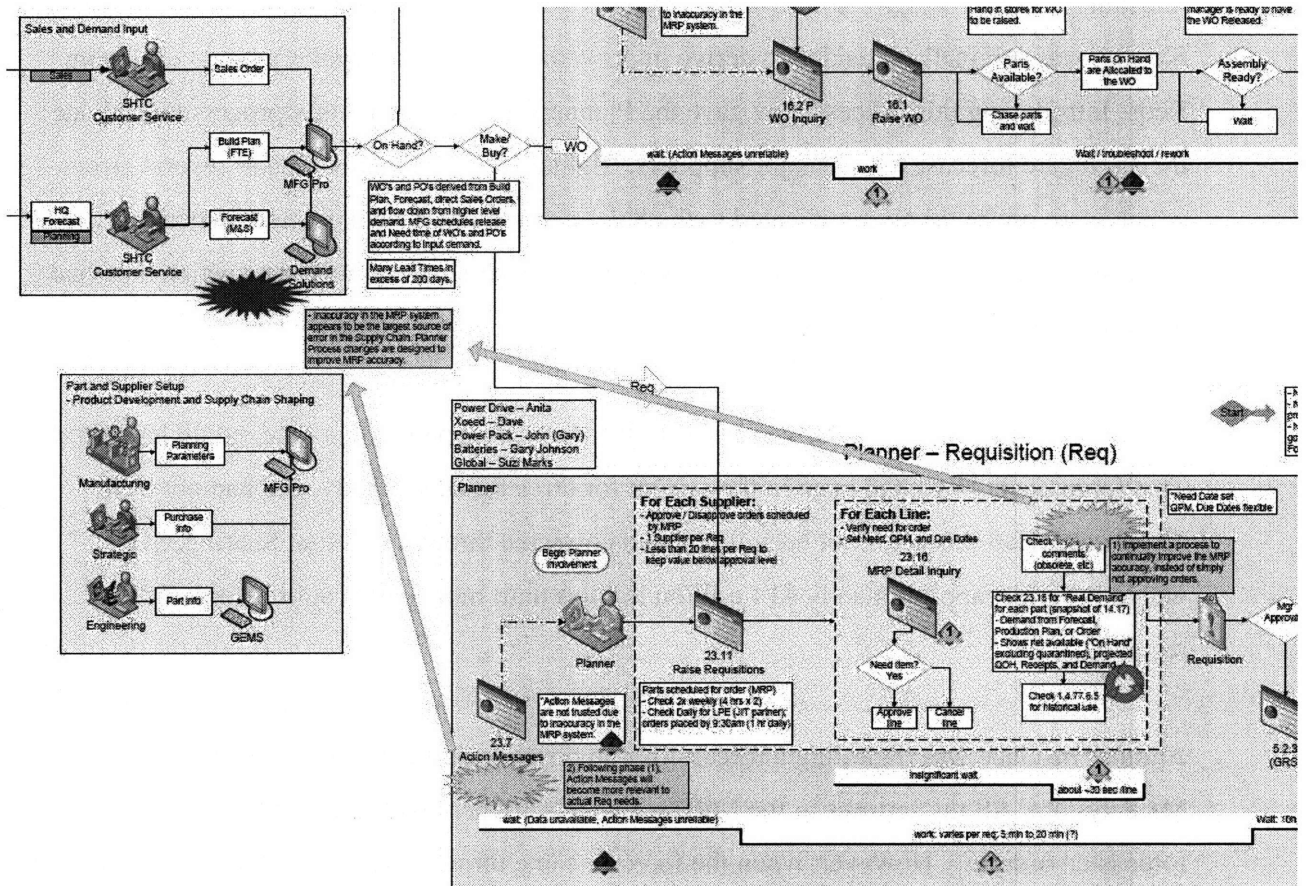


Figure 42: VSM with MRP System as Source of Req Rework

From this analysis identifying the source of the problem, a process was developed to begin addressing it. Even though the exact nature and magnitude of the problem hadn't been identified, it was clear that attention needed to be drawn to this area from both Sales and Supply Chain. Due to the split responsibility for inputs to the MRP system, it was essential that a regular communication line be opened up between these two departments. The remainder of this section addresses the evolution of this initiative.

11.10.1. Forecast Liaison

The critical importance of communication tools for implementing a Lean Transformation cannot be overstated. Under traditional structures, communication loops are often left open because attempts to communicate result in arguments between personnel in different departments. A typical illustration of this was the relationship at SHTC between the Supply Chain and Sales departments. Specifically, the Planners responsible for executing requisitions and work orders through the MRP system wanted input to the forecasting for M&S (spares), while Sales currently controlled these inputs due to their close communication with the customer and their needs. Discussions to change inputs to this system frequently became heated, and often left both sides unsatisfied with agreed upon actions, and complaining about unfulfilled obligations. This disagreement had become the expected mode of interaction for meetings addressing Forecasting issues.

One of the first initiatives undertaken for the Lean Transformation was to implement a process to close the loop on communicating forecast errors discovered downstream by the Planners. It was necessary that these errors were corrected upstream at the Forecast inputs controlled by Sales. A monthly Forecast Liaison Meeting was proposed, with a single Planner designated to organize and represent the collected requests of all Planners across all product lines (designated the Forecast Liaison). Before this first meeting was to be held, I became aware of the tensions in this relationship.

While collecting understanding to generate the VSM, I had learned the needs of both roles, Planners and Sales, and where their responsibilities overlapped with each other. Time was taken to understand how decisions made in Sales influenced the tools the Planners worked with, as well as why control over Forecast inputs was given to Sales. The cause of the tension was apparent, and it was clear that a simple monthly meeting would be insufficient to overcome the conflict of priorities systematically present. In addition to proposing a regular meeting, it was necessary to define a very specific flow of responsibility. Only explicitly defined responsibilities and process flow would enable communication where needs from both sides were met, and cooperation could be relied upon for specific tasks.

11.10.2. MFG Pro / Demand Solutions Information Flow

In preparation for the first Forecast Liaison Meeting, I prepared documents illustrating unambiguous flow of responsibility and information, as well as explicit process flow for identifying and communicating errors.

Figure 43 shows the then Current State of information flow and responsibility between Sales (Customer Service) and Planners. Both parties appreciated the humorous representation of a fight ensuing at the end of the process, exclaiming “That’s exactly what happens!”

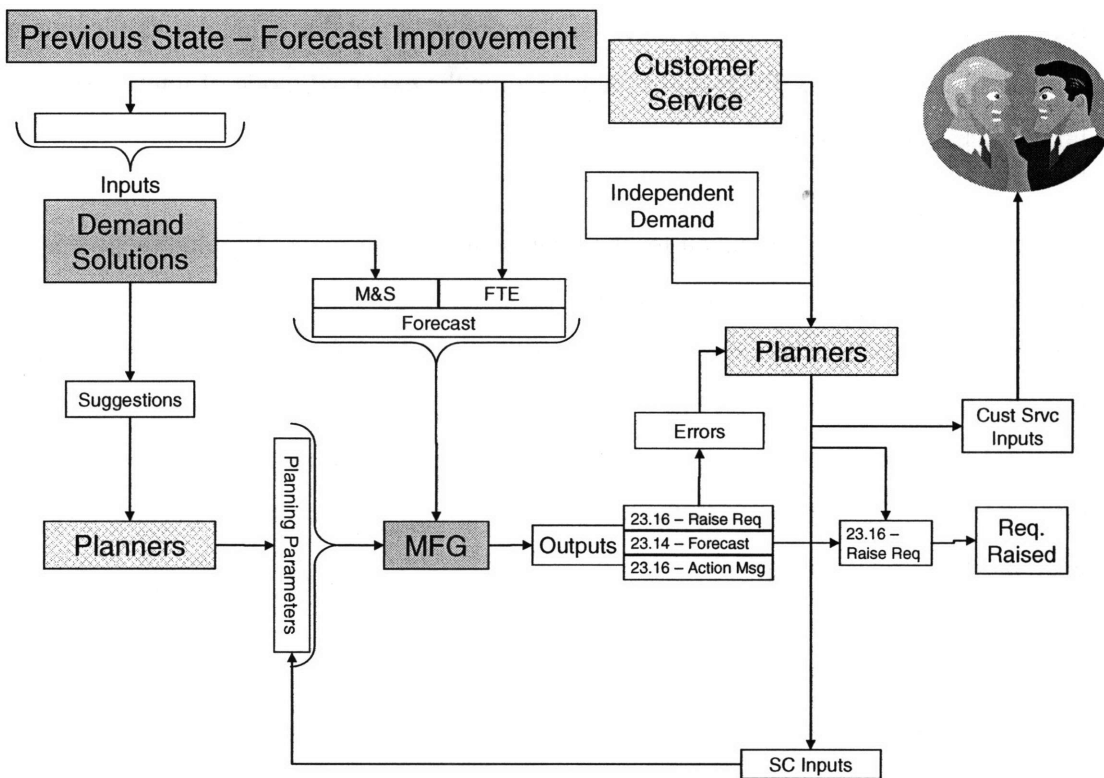


Figure 43: Previous State of MRP Errors not being communicated and fixed

Figure 44 shows the designed Future State identifying an unambiguous path of responsibility and communication.

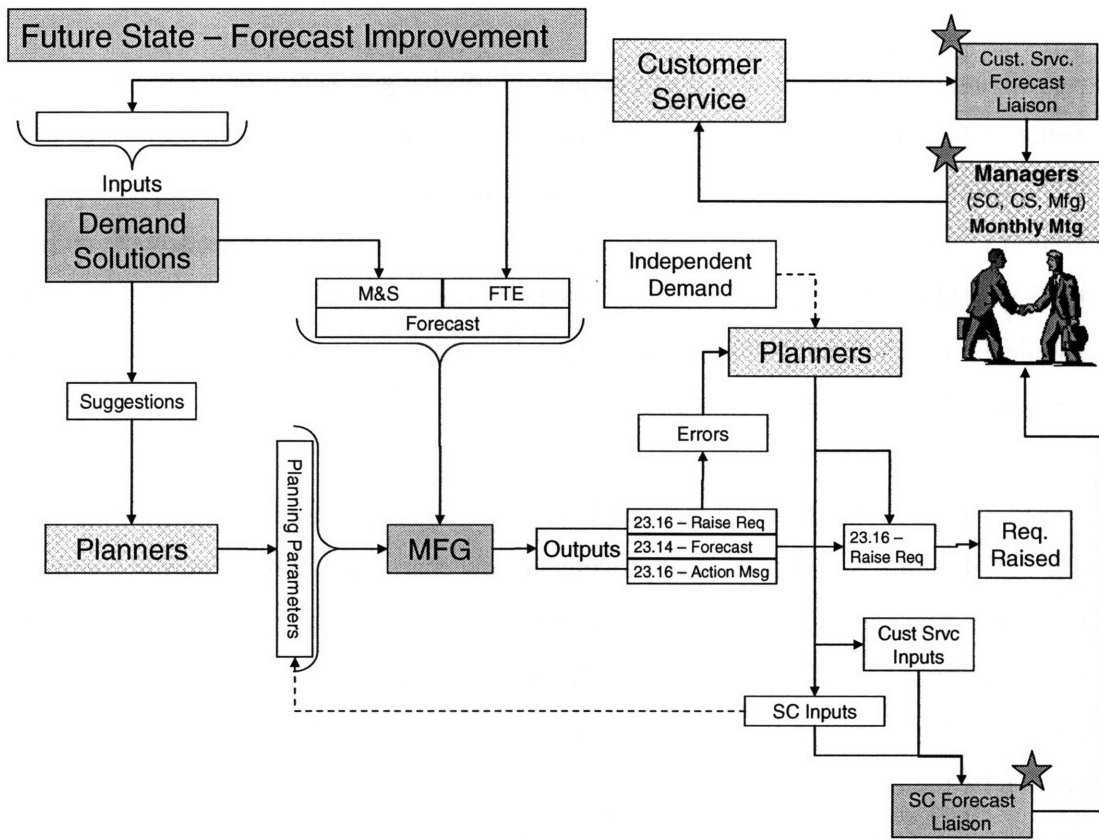


Figure 44: Future State with MRP Errors routinely communicated and corrected

Prior to the joint meeting, I spent some time with the Sales Manager individually, discussing the proposed details of this flow of responsibility and information. This preliminary meeting, with communication facilitated by the unambiguous diagrams, was indispensable to generating agreement with the Sales Manager. His initial response to the verbal proposal of the process was the same response he had always carried, reiterating why he needs control of the Forecast inputs. However, when he had time to see, in detail, how the proposed Future State operated, he became agreeable, and even supportive of the proposal. When the Forecast Liaison and Supply Chain Manager arrived to discuss the first round of proposed changes, both parties were on board with the defined new process.

Subsequent Forecast Liaison meetings have been successful. Lessons on follow-up are addressed in this respect in a later section, but the agreed communication channel under discussion here has remained successful.

It is significant to note that no process or responsibility changes were proposed for who controlled inputs into the different MRP systems. These responsibilities had been delegated, but the systematic flow could not be discussed objectively until there was an explicit illustration of these responsibilities. Both sides needed to “see” that their needs were addressed before they could discuss changes in an agreeable manner. Even if communication tools only communicate what is already defined, they can serve to effectively smooth inter-department tensions, and clarify perceived ambiguity.

It is worth noting, for the sake of a Process Engineer designing similar communication tools, that the initial Future State Forecast Improvement flow chart was modified during the meeting with the Sales Manager. The amendment was agreed to by the Supply Chain personnel when discussed during the first Forecast Liaison Meeting. While explicitly defined responsibilities are essential, the process design is based upon the needs of both parties. These needs must be understood by the Process Engineer, who can redesign the process accordingly as new needs are discovered. Explicit definition is necessary for preparation, but the process must be adaptable to improvement.

11.10.3. Batch Correction vs. Flow Correction

Getting this Forecast Liaison role and monthly meeting to become a regular process revealed the autocatalytic necessity of multiple efforts relevant to the overall system. The Forecast Liaison meetings were recommended over a month before the first one took place. The catalyst that finally got people on board for the first Forecast Liaison meeting was the Forecast Sharing. The first round of Forecast Sharing gave Planners a tool to immediately identify a multitude of errors, and document them for “batch” correction.

It helps to have an initial mass of change requests, to get people to initiate a process to close a loop for correcting systematic errors. The Planners frequently ran into errors on an individual basis, but always felt it was a small enough error that they would just adapt for it in that circumstance, and move on to their next task. They didn’t feel they were making an impact until they had a whole “batch” of errors to send for correction.

Even with Forecast Sharing revealing errors that the Planners wanted to fix, follow up was still required to initiate the first few monthly meetings. As identified in the follow up section, a new activity is first “new,” then a “repeat,” and then after the third time it begins to take on a sense of regular process. Even with aligning the desires and needs of operating personnel in crossing departments, the process engineer still needs to follow up to ensure the initiatives are carried out.

11.11. Standard Work Instructions – Iterative Design with Operating Personnel

11.11.1. Standardizing for Custom Needs

Right from the start of this Lean Transformation, it seemed that everyone in the Supply Chain, from the SC Manager through the Planners and Buyers, were supportive of generating Standard Work Instructions for each of the roles. At the same time, they were very resistant to the imposition of Standard Work instructions that didn't fit their custom tailored needs. Everyone agreed with the theoretical objective, but the path to reach that objective was much more complicated.

One of the first actions from the new SC Manager was to assign one of the Planners responsibility for drafting a set of Standard Work Instructions. Even though the task was assigned early on, and supported throughout, the work instructions were not drafted until the sixth month of the Lean Transformation. There are several factors leading to why these instructions were not drafted until several months into the transition. In addition, there are several factors that enabled them to be drafted after a few months. It is worth time to consider the progression of dynamics in the system by which the organization developed to the point that it was ready for Standard Work Instructions to be generated and implemented.

11.11.2. Developing and Implementing Work Instructions

Specific Work Instructions must be robust. Sometimes work instruction design is straight forward and simple, but more often than not, work instructions require intelligent engineering to ensure they meet the needs of all users, and achieve their intended purposes. This requires a detailed understanding of the needs of the users, the interactions within the system, and the concrete objectives of the specific work instructions under development.

When working with people to develop standard work instructions, it is important to approach the development diplomatically. Throughout this study, and from other relevant experience, it is shown that people are very reasonable in agreeing to change their methods, when they believe that the changes will be a benefit, or at least not make things worse.

Standard Work Instructions were initially developed for Work Order Release, Requisition Release, Forecast Sharing, and MRP Improvement. The development of instructions for Work Order Release is used in this study as an example of several applicable principles.

In order to develop Standard Work Instructions for Work Order Release, it is helpful to understand something of the unique nature of the four product lines. First, the Battery line involved large orders of standard materials, and could be adaptable to a number of methods. Of the other lines, one had many customizable features early in assembly, and another with customizable features late in assembly. The nature of these differences caused the numbering of sub assemblies in the MRP system to evolve in different ways, giving their WO Release methods different needs. Whatever standard instructions evolved, needed to account for these divergent needs.

11.11.3. Six Step Method

In developing the Work Order Release work instructions, I observed a pattern and method which worked effectively for developing standard work instructions with Planners, and generating “buy in” to adhere to the work instructions. This method is effectively illustrated in

the interactions with Planner 5. It will be illustrated in this context, but the method is applicable in all discussions of specific work instructions.

The method consists of:

- 1) Begin with a specific diagram of the Work Instructions, as well as a diagram of the overall system.
- 2) Discuss the intent of the proposed Work Instructions, including the relevance to the overall system.
- 3) Walk through the steps of the Work Instructions, addressing the details of what is done.
- 4) When conflicts are seen between the proposed Work Instructions, and the methods and needs of the Instruction User, set aside the proposed work instructions, and sketch a diagram of the User's current methods, and how they address their unique needs.
- 5) After understanding the current methods and needs of the User, discuss them in context of the overall system, and the purposes of developing standard work instructions.
- 6) Then return to the proposed work instructions, and discuss how the unique needs of this user can be served using these work instructions, or how the instructions need to be altered to serve their needs, as well as the systematic purpose.

In a nutshell, this method consists of alternating between consideration of the systematic big picture, and the detailed methods of addressing specific needs. All procedure users encountered in this study want to do a better job than they already are. They are cooperative and willing to amend their work methods when they believe the changes will be an improvement. The work of the Process Improvement Engineer comes in with developing procedures which really are an

improvement, and communicating with Users such that they discover the nature of the improvement in their own understanding.

11.11.4. Work Order Release Work Instructions

The procedure for raising WO's (Work Orders) essentially follows three steps: 1) Raise the WO, 2) Checking for part availability, and 3) Releasing the WO. These steps were common across the department, but each Planner had a different method for determining what WO's should be released, when, and checking on part availability.

An initial draft of Work Instructions was generated during the development of the VSM. The VSM included one of the approaches possible for WO's, but lacked sufficient detail to be Work Instructions. The level addressed in the VSM was intended for identifying where performance could be measured, and identifying where variability in work procedures was present.

This initial draft of work instructions was reviewed and modified with each of five Planners on an individual basis, starting with one of the planners more interested in developing a standardized process applicable to all roles. Two of the planners were relatively new, so they took part in this process hoping to develop their work habits according to the process which would ultimately be defined. The process developed in multiple iterations, and was agreeable to these four Planners.

The last Planner returned from two weeks out of the office, and soon accepted an appointment to discuss the Work Instructions for applicability to her product line. Contrary to the method identified above, we immediately started discussing the detailed work instructions for Work Orders. Immediately, we discovered that her method for identifying which WO's she needs to raise was drastically different than the method used and agreed to by other Planners. We discussed this to understand her present method, and why the unique needs of her line required this method. At the same time, she was adamant about how her method was superior to the proposed method.

We stepped back from the proposed work instructions, and discussed the intent of standard work instructions across all product lines. We also revisited some recent analysis regarding the apparent erroneous output of the MRP software, and what steps must be taken to identify and correct a problem of that nature.

After discussing the big picture and systematic behavior, she looked again at the proposed work instructions, and said “I can use this method. It’ll take me an hour to adjust some settings in the system, and then I can use this.” She didn’t need to be “convinced” of the proposed system. She just needed time to consider the larger purpose, and then she found her own solution for adapting to the proposed work instructions.

It is significant to note that as a Process Engineer, lacking expertise in the software tools used by this Planner, I could never have developed the solution that she proposed during our discussion. However, I did understand the larger system and intent of the work instructions. When we discussed these things, the Planner likewise understood, and used her own expertise to develop a method for accomplishing the larger purposes. As a Process Engineer, I could not have invented a method that would have served her needs, as well as the system needs. By working with her to understand the system needs, she was able to invent and implement method that would improve the overall system.

The next variation in procedure progressed in a similar manner, identifying and understanding the reasons for the variation. With the understanding of the larger system and intent of standard procedures, she agreed to the proposed work instructions, even though it was a variation from her equally effective previous method.

In a third deviation in this procedure, the outcome resulted in amending the proposed work instructions. This instance addressed reviewing the shortage list before releasing a WO. The previous four Planners had agreed to a set of steps necessary to one product line, but indifferent to the other product lines. We now discovered that this set of instructions would be excessively tedious for the product line run by this last Planner. Having an understanding of why the proposed system was developed, and the alternatives foregone by other planners, the

work instructions were modified to a set of steps more convenient to the three main products lines, allowing for the needed deviation on the unique product line.

11.11.5. Process Engineer Role

As Process Improvement Engineers, we didn't approach the discussions as though the proposed work instructions were optimal, but discussed them as part of an ongoing investigation to improve the system. We didn't have to make a case for one system over another. We only had to discuss the larger system, and the better solution became apparent. When the Instruction Users understand the systematic reasons for the specific steps in procedure definition, they can effectively design and adhere to process changes. The role of the Process Engineer becomes one of system analysis, and change facilitation.

It is worth noting that had we attempted to implement the 2nd or 3rd iterations of the work instructions by managerial decree, the process would have received pointed resistance. Furthermore, if the process were followed, it would have significantly hindered the production of the fourth product line. Ultimately, the process implemented by managerial decree would have to be abandoned.

While methodically developing work instructions with the input of all the procedure Users is more difficult and takes more time, it is the only way to ensure the procedures developed are robust enough to serve the needs of the organization. Loosing patience with all the unique needs of people in different roles and resorting to managerial decree for implementation can be tempting, but may ultimately fail to create sustainable and comprehensive improvement. Just as all products engineered for specific purposes must be tested in the field, so must procedures be tested in the field where they will be used. These tests are carried out by the Process Improvement Engineer methodically evaluating the effectiveness of the procedure with each of the unique applications wherein it will be used.

11.12. Long Term Future State VSM

In this study, contrary to standard practice, I did not create a Long Term Future State VSM toward which we worked in increments. Instead, I made modifications for the Future State of specific process changes to be implemented right away. While developing a long term future state VSM may be beneficial in a later phase, at this time it was critical to quantify the performance of the existing system. I did not feel accurate judgments could yet be made about what worked, what didn't work, and how things could be improved. In essence, without quantified behavior, the Value Stream Map is only a Process Flow Map. Until the Current State is adequately identified, in both workflow and measured behavior, the Current State is incomplete. As noted before, attempting to create a Future State before the Current State is complete is only inviting resistance and risking detrimental process design changes.

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12. Analyze – Insight Enabled with Lean Tools

Measurement, Analysis, and Improvement will continually be cycling throughout a department operating with Lean principles. In this study, the reinforcing nature of Lean tools to this behavior is demonstrated by the deeper analysis enabled through the initial implementation of Lean tools. In this case, the development of Standard Work Instructions allowed localized tests to be run, which validated the surprising findings of numerical analysis on the behavior of the MRP system. Without implementing the initial Lean tools, Standard Work Instructions would never have been able to be developed. Then, as discussed in the following segment, the development of Standard Work Instructions enabled the next step of analysis.

12.1. Validate Software Behavior, Don't Just Believe It

12.1.1. MRP Changing Under Their Feet

As noted earlier, the judgment of the initial analysis was that the MRP System was the primary source of variability and error in the Supply Chain department. The first change recommended in this study, instigating a Forecast Liaison with monthly meetings, dealt with improving the MRP System accuracy. All the analysis measuring and quantifying the performance of the Supply Chain department reinforced that, while there is room for improvement in the department operations, the primary cause of variability in getting the right parts delivered on time is the MRP system. A few downstream initiatives were undertaken within the department, but the main focus of process improvement was toward improving the accuracy and usability of the MRP system. The final analysis culminating this study reinforced, more than any previous analysis, that the settings of the MRP System are the root cause of variability and error in getting the right parts delivered on time.

This final evaluation closed the loop on completing analysis of the sources of variability in the overall Supply Chain department.

From the perspective of creating “value,” and eliminating “muda,” effectively using the MRP system is by far the most important aspect for SHTC. As will be demonstrated in the following analysis, the MRP software is the largest source of firefighting. Planners and Buyers spend a large portion of their time and expertise smoothing out the variability emerging from use of the MRP System. This is not to say that *the MRP System* is inherently causing variability. It is saying that *the way the MRP system is used* is inherently causing variability.

12.1.2. Systematically Learning to Use the MRP System

It is beyond the scope of this thesis to discuss MRP characteristics and behavior. The intent of addressing this issue here is to show how the implementation of Lean Principles naturally identified this source of variation, and has created conditions wherein the organization can systematically learn to use the MRP System effectively.

12.1.3. Discovering the MRP Problem

The first step to solving a problem is identifying the problem. The analysis that unambiguously identified the MRP system as the source of system variability was first prompted as a direct result of quantifying department performance, and sharing information with Suppliers. In addition, the experiment which validated the suspected MRP System was enabled by the Standard Work Instructions under development.

After a couple rounds of Forecast Sharing with Performance Reports, one of SHTC’s top suppliers called, saying “70% of the orders you place are requested before the Lead Time!” The Buyer primarily interfacing with this supplier confirmed the probability of this condition. The SC Manager talked with the Supplier personally, and asked the Process Engineer to look into the data.

The problem discovered was that PO’s were placed with Suppliers, asking for delivery in time significantly shorter than the established Lead Time. For example, a part with an 8 week Lead Time would have a due date of 4 weeks. This is called a Rush PO. Frequently, the PO was asking for the part to be delivered immediately, totally ignoring any lead time. In addition, the

Supplier's performance was rated on these delivery dates, regardless of the established Lead Time.

12.1.4. Analyzing the MRP Problem

Three approaches were taken to understand the problem, including discussion with the Buyers, Planners and Mangers, historical analysis from the database, and a focused experiment in the daily processing of Requisitions. These conditions under inspection are called Rush PO's, and Rush Reqs.

12.1.5. 1) Discussions

Initial discussion with the Buyers confirmed that this condition wasn't unique to this single supplier. One of them exclaimed : "I spent all last Friday going through fifty PO's, and changing the delivery dates on every single line! Every Single Line! We don't have time to call for Confirmations when we're spending that much time changing delivery dates!" This pattern of adjusting delivery dates was identified when originally making the VSM. At that time, the magnitude suggested, on both volume and time, seemed too unreasonable to not be an exaggeration.

The Planners reaction to this problem was more casual, acknowledging "That sounds possible. It's always been doing that." They claimed the MRP software frequently introduced Reqs to be raised several weeks in the past, asking for delivery long before Lead Time. The Planners dealt with this by evaluating the nature of demand for the part, whether it was for forecasted demand or real demand, and passing on the rush status to the Buyers if it looked like we really needed the part in a rush. When the MRP software asks for a Req to be raised and delivered earlier than Lead Time allows, these are called Rush Reqs.

Both these behaviors, changing Delivery Dates for the Buyers and checking the nature of need for a part for the Planners, had been initially identified as muda in the Value Stream Map. These activities were purely resulting from upstream inaccuracy, with the Buyers and Planners running circles to respond to this inaccuracy.

12.1.6. 2) Historical Analysis

Historical analysis from the database took two steps, starting at the manifest problem of Rush PO's, and then moving one step back to Rush Reqs.

12.1.6.1. *Rush PO*

The initial historical analysis of Rush PO's was segmented by all PO Lines raised in a given manufacturing month. For each PO Line, the time between the Order Date and the Perform Date (termed: Allow Time) was compared to the Lead Time. A Rush PO was defined wherein the Allow Time was shorter than the Lead Time. A historical trend was charted for the entire Site (Figure 45). In addition, charts were created wherein a Supplier Code could be entered in a cell, and the history for that specific supplier would be displayed. Key examples are used herein to illustrate specific patterns observed.

Figure 45 shows the historical trend for all suppliers to SHTC. The occurrence of significant changes in the system operation are noted by the green arrows. In May, the Forecasting Software for M&S, the Clean Kit Policy as discussed in earlier sections, and the new Supply Chain Manager started. Then in August, the first Forecast Liaison meeting was held, initiating feedback from the Planners to Sales for improving the Forecast Software accuracy as discussed in the relevant section, and Forecast Sharing was implemented.

PO Rush Orders

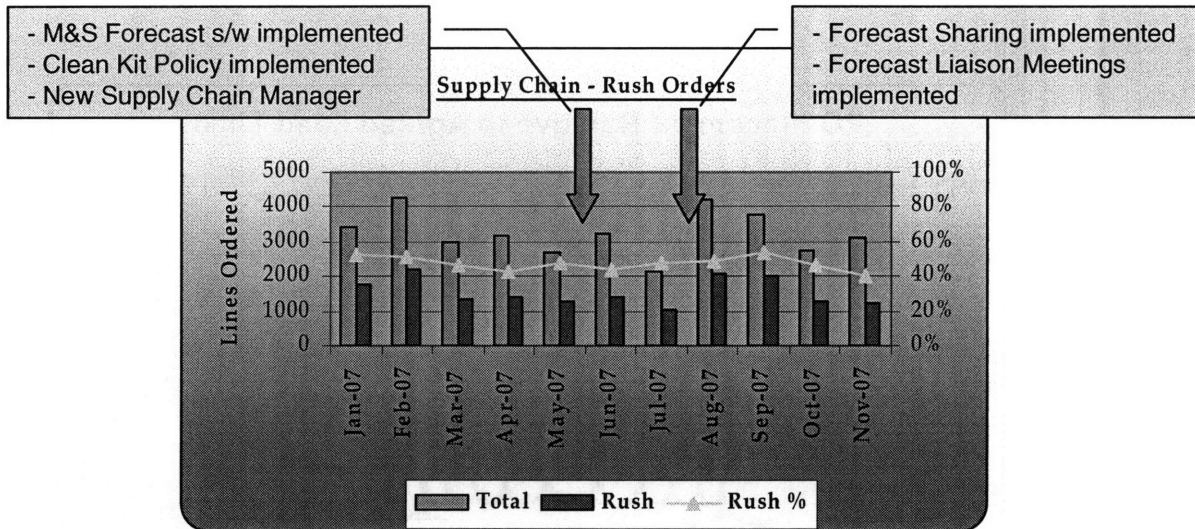


Figure 45: Rush PO Historical Trend for All Suppliers to SHTC

The first shocking insight from this is that consistently about half the PO's placed are in a Rush status. Furthermore, the pattern has been very consistent over the transition through new Forecasting Software, a New Supply Chain Manager, and even the implementation of feedback to improve the accuracy of the Forecasting Software. Even though improvements may have taken place within the Supply Chain, the suppliers are feeling none of the effect. To the Suppliers, no value has been created over the whole year.

Two other charts offer noteworthy insight into this behavior. Figure 46 is a histogram of all PO's placed for the November manufacturing month, distributed according to deviation from Lead Time. While Figure 45 shows orders in a binary state as Rush or Normal status, Figure 46 shows how much of Rush is called for, or how early an order is placed. This shows that most PO's are placed within a couple weeks of the ideal time, but a concerning amount are placed with extensive Rushes. The most logical conclusion for this is that the MRP system, or adherence to MRP, is a major cause. As the Rush Reqs are analyzed, more insight is gained on this issue. If the cause of Rush Orders were slow or erratic processing in the Supply Chain department, the majority of orders should show up with only one or two weeks rush. This is a

possibility given what the data shows, but again, the Rush Reqs offer more insight. In addition, the Req Release Experiments will show what is occurring on the most local level possible.

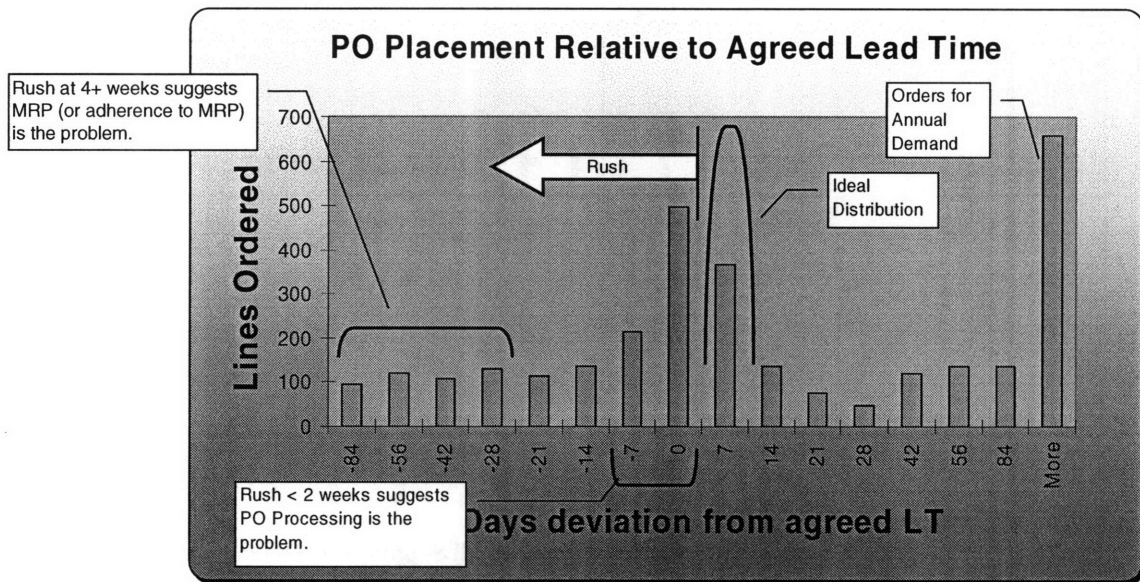


Figure 46: PO Allow Time Deviation from Lead Time

To show the general trend over time, Figure 47 charts the average Rush on an order, as well as the average time early. The average Rush shows up consistently around 40 days, with histograms and standard deviations for each month following roughly the same trend as Figure 46. This gives a fast, rough estimate of the extent of deviation.

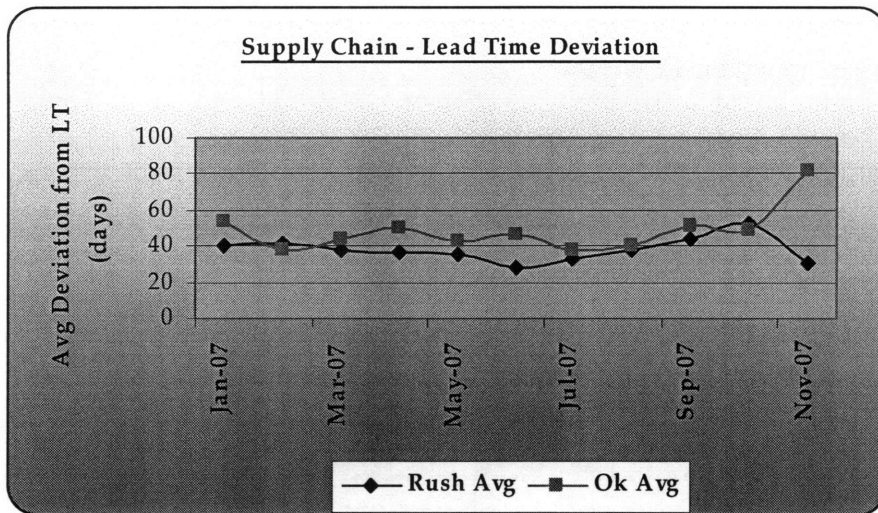


Figure 47: Average PO Rush or Early in Days

Analysis of Rush PO's is important to observe from the perspective of the Suppliers, but to improve the situation, it is necessary to understand the process by which Requisitions are raised, and the factors influencing the timeliness of this. After evaluating finding from the Rush Req analysis, we will return to the combination of both indicators, and their implications.

12.1.6.2. Rush Reqs

Because the MRP System is the head of the stream for workflow in the Supply Chain, followed by raising Reqs, analysis at the Req level was pursued in greater detail. First the aggregate was considered, then broken down by product lines and order nature, as well as by Supplier. The resolution gained by comparison of each one of these steps is insightful into, not only MRP and Supply Chain performance, but the effects of Engineering for New Product Development, Product Sustaining (new features and upgrades), rework, and field repairs. These different levels of resolution give insight into how the practices of all these groups impacts overall productivity, service levels, and stability.

Figure 48 shows the aggregate Rush Reqs raised by each manufacturing month. As with Rush PO's, the percentage has remained consistent throughout the year, with an increase in variability following June when the M&S Forecasting Software and other changes were

implemented. Included is a line showing Reqs raised with the parts immediately due within the week, totally discarding the Lead Time.

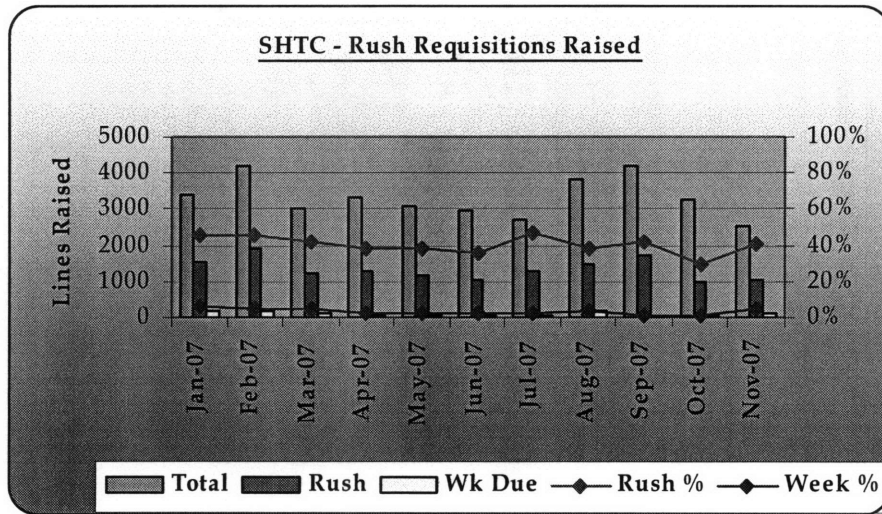


Figure 48: Rush Reqs Raised for SHTC by Manufacturing Month

It is important to note the dates used to calculate the condition of a Rush Req, and how they relate to the MRP system (see Figure 49). The MRP software has all kinds of dates for many purposes, and selecting appropriate dates is essential to drawing an accurate picture of actual conditions. The dates used herein are the actual date the Req was raised by the Planner, called the Req Raised Date, in combination with the date MRP says it needs the part, called the Need Date. Once the Req is raised, neither of these dates ever changes in the software. The Planners and Buyers set and change the Perform Date (delivery date the Supplier is rated on), and the Due Date (when the part is expected to arrive), but cannot change or modify the Req Raised Date or Need Date used to calculate a Rush Req. Therefore, Rush Reqs reflect what the MRP System is asking the Planners and Buyers to execute.

Rush Req Definition

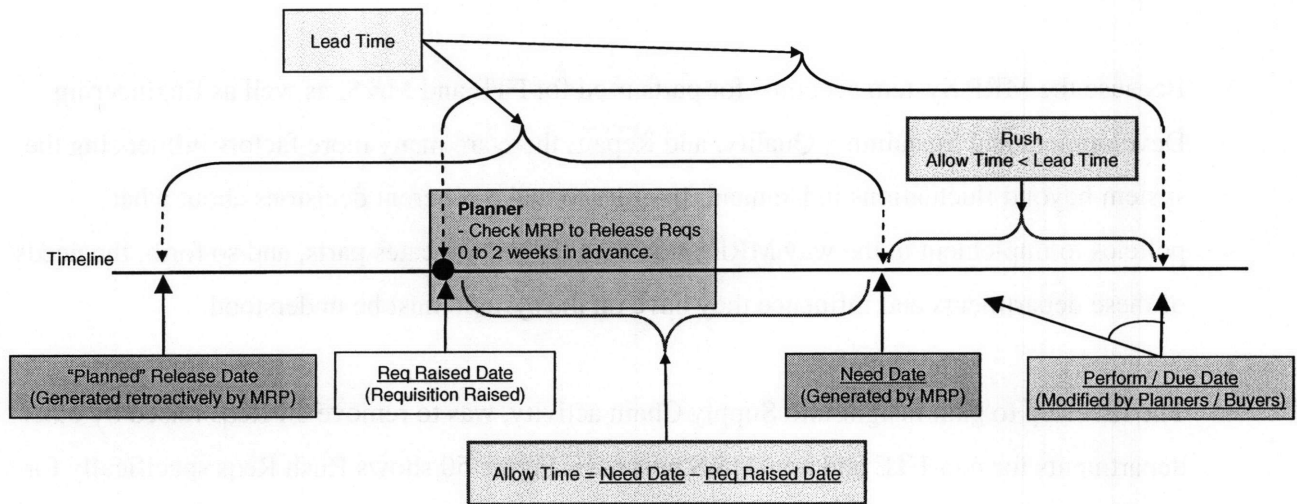


Figure 49: Req Rush Diagram

As will be shown with the Req Release Experiment in a later section, Planners regularly release all Reqs prompted by the MRP software between a week and two weeks in advance. However, each week the MRP system introduces new Reqs “planned” to be raised retroactively. Each of these constitutes a Rush Req. For example, on November 15th, a Planner will go through the process to release Reqs, and MRP will introduce a new Req never seen before with a Need Date of December 15th and a Lead Time of 60 days. The software also shows a Planned Release Date of October 16th, thirty days in the past. When the Planner raises this Req on November 15th, this results in a Rush Req of thirty days. The Planner may adjust the Perform Date and the Due Date to reflect the Lead Time, but the Need Date (used to calculate a Rush Req) remains unchanged. Therefore, a Rush Req can only occur from MRP instability, or from Planners not adhering to the promptings of the MRP system.

This seems fairly straight forward, but it has taken a barrage of data analysis, discussion, procedure mapping, implementing Standard Work Instructions, and running experiments to identify and validate this. Only after all of this were managers and personnel collectively able to believe this is the actual behavior of the system. What to do about this behavior is beyond

the scope of this thesis, but the dynamics illustrated in more detailed analysis offer more insight into the behavior of the overall interaction of the system.

Because the MRP System accounts for parts used for FTE and M&S, as well as Engineering Development and Sustaining, Quality, and Repair, there are many more factors influencing the system beyond fluctuations in Demand. In order to make coherent decisions about what policies to implement in the way MRP prioritizes orders, allocates parts, and so forth, the needs of these departments and influence they have on the system must be understood.

The first step to gain insight into Supply Chain activity, was to remove all Reqs raised by other departments for non-FTE and non-M&S purposes. Figure 50 shows Rush Reqs specifically for the four product lines. While volume decreases by roughly 15% to 25%, and %Rush Reqs slightly decreases, the variability in Rush Reqs increases, especially after June when M&S Forecast software and other changes were implemented.

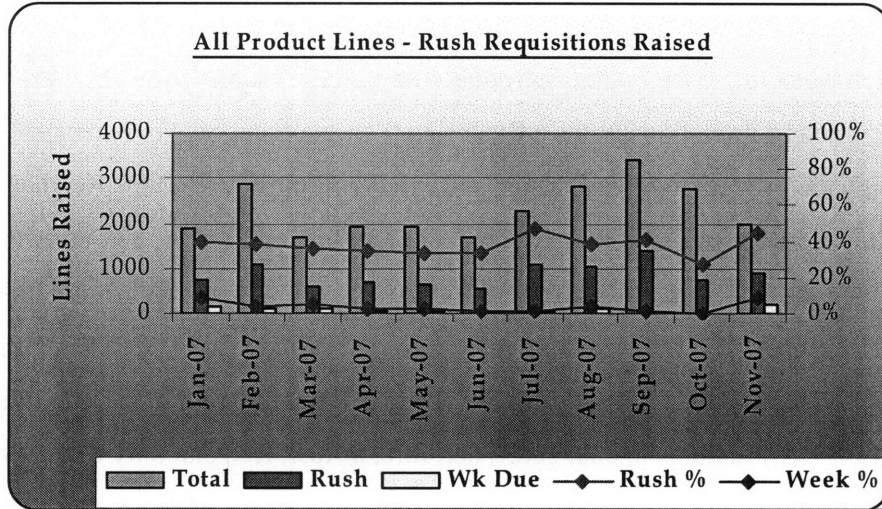


Figure 50: Rush Reqs Raised by Supply Chain for FTE and M&S

A Histogram of the data for the month of November illustrates a similar pattern to the Rush PO's. Many Reqs are lagging in the time they should be released, with a tail extending for increased Rush times (Figure 51).

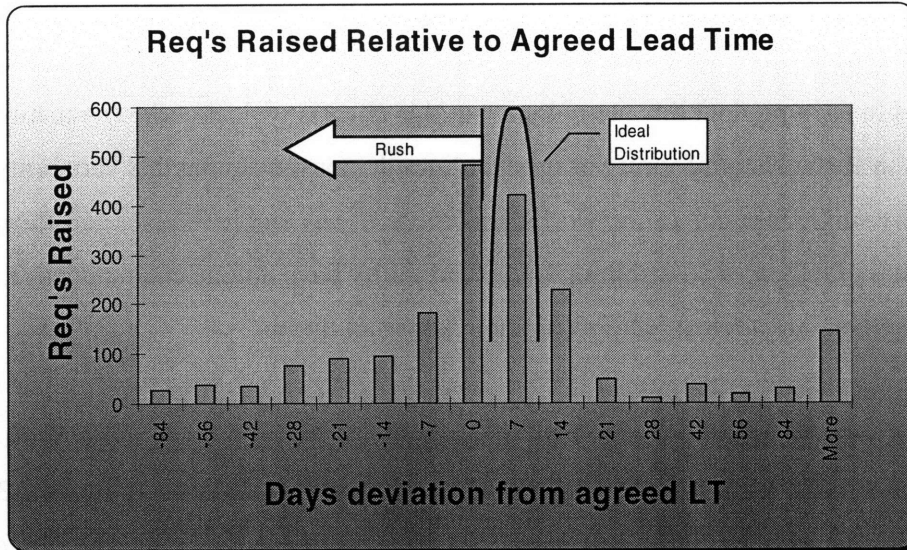


Figure 51: Rush Req Histogram for November

Next, this data was broken down by Product Line. Figure 52 shows the product Line with the highest spending and volume of Reqs raised. Displayed are the Total Req Lines raised, the number and percentage that were Rush Reqs, and the number and percentage of Rush Reqs due the same week. An additional metric included here is the Changed %, indicating how many Reqs had the Perform Date changed greater than a week from the MRP Need Date.

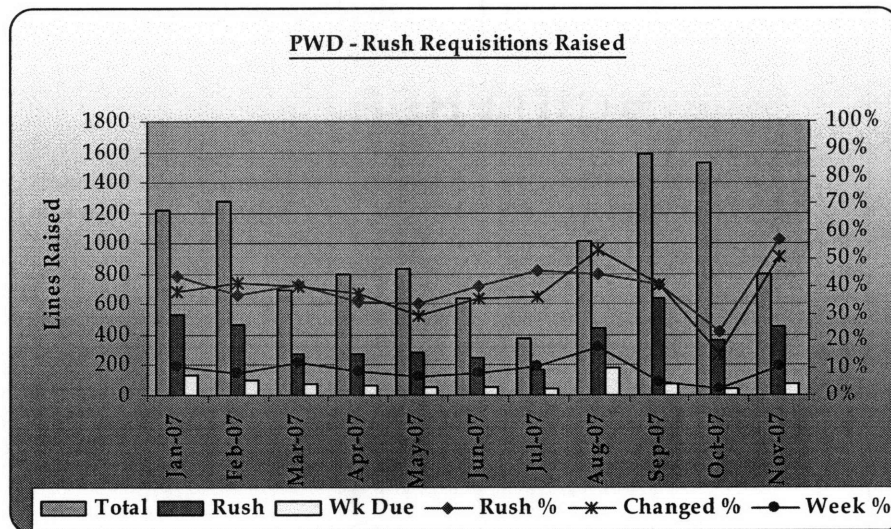


Figure 52: Rush Reqs Raised for Highest Volume Product Line

The patterns in each product line are unique, but this chart is typical of the fluctuation and proportions in each. The uniformity of product lines demonstrates that this variability is not unique to any single product, or the working methods of any single Planner and Buyer team. While the individual cases contributing to the variability have unique characteristics, it is apparent that there are several factors common across all lines.

In addition to segregation by product line, the data is broken down by supplier. With some suppliers, Rush PO's seem to be the routine mode of operation as shown in Figure 53. At the same time, others (very few) display ordering patterns representative of a more stable system as shown in the last few months of Figure 54. Over this time period, some suppliers have seen improvement, others have become worse, while others have been unaffected.

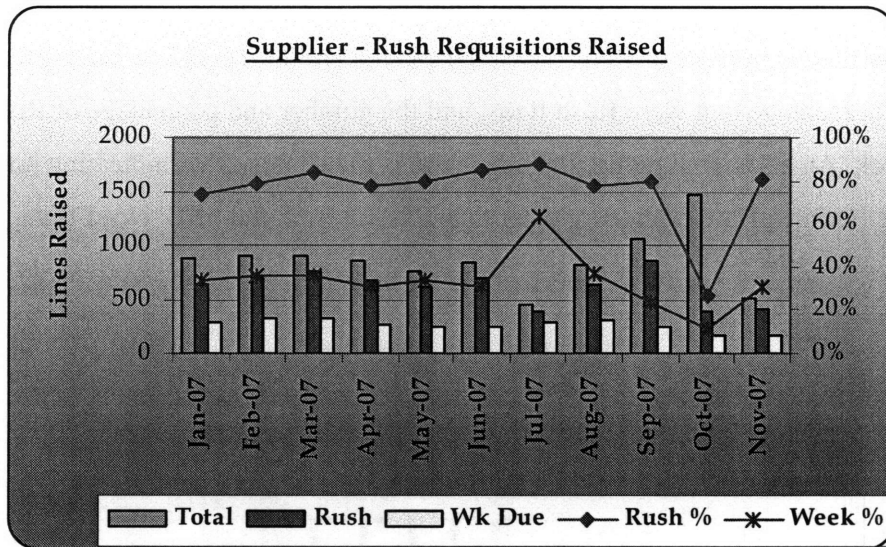


Figure 53: Rush Reqs as routine operation style for this supplier

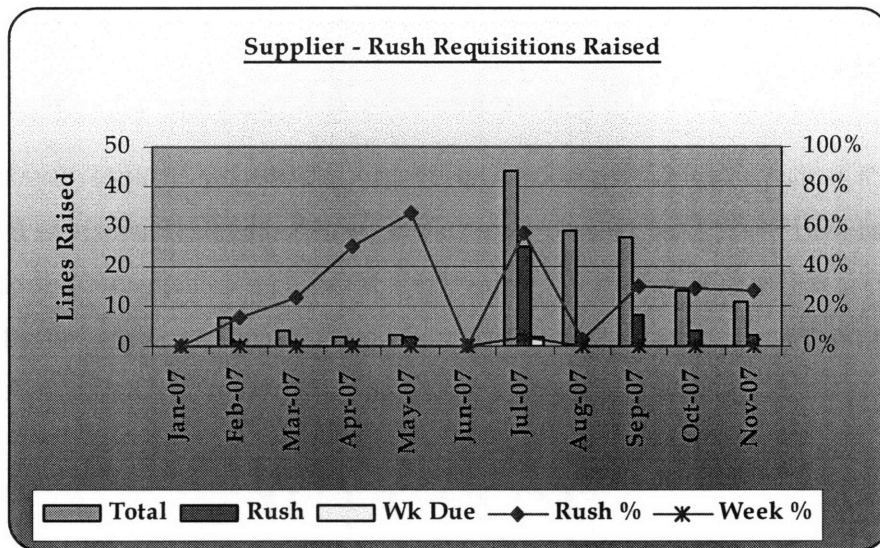


Figure 54: Relatively stable Rush Req demands

12.1.6.3. Non-MRP causes of Instability

Characterizing the unique causes for MRP instability in each product line is beyond the scope of this thesis. However, Looking in to individual Reqs, and the inventory changes surrounding the date the Req appeared in MRP, there are frequently occurrences where orders from another department (e.g. Engineering Sustaining), caused Supply Chain to raise a Rush Req in response.

It was significant to quantify the impact the non-production departments have on Rush Reqs and Rush PO's. This quantified impact has now given the Managers another path of insight into where and how they want to consider the implications of these departments's activities on production. A certain level of noise comes from Customer Demand, and managers now have quantified insight into the noise other departments contribute to Total Demand.

12.1.6.4. Rework from MRP – Change %

An additional metric included with Product Line Charts is the "Changed %." The Changed % metric roughly indicates the extent to which Planners and Buyers perform Rework on the Reqs, between pulling them from the MRP System, and sending the PO to the Supplier. All of this

rework is “muda.” Presently, it is Muda Type 1 which is necessary because of inaccuracies in the MRP System.

The Change % is the percent of Req Lines whose Perform Dates are changed more than a week away from the MRP Need Date. The Perform Date is modified by the Planners or Buyers before the PO is placed, after which it remains fixed. If this date is changed significantly, it indicates that the Planner evaluated the realistic need for FTE and M&S, and judged that the true need for delivery, or the true urgency of a rush, was different than what the MRP System calculated.

It is worth taking a moment to consider the implications these changes have regarding adherence to the MRP calculations. As with all dynamic feedback loops, if the feedback to the inputs are not consistently correlated with the outputs, then the system is unlikely to reach a stable condition. This holds for MRP algorithms just as it does for directional drilling navigation algorithms. At the same time, every feedback loop likewise requires filtering for noise and anomalies in the system, for it to reach stability.

The nature of changes made by Planners appear to consistently be intelligent decisions which prevent the system from making mistakes due to erroneous inputs, or external changes which cannot be compensated given the nature of the software. These include examples from obsolete parts scheduled for order, to momentary changes in demand which temporarily deviate from the programmed forecast. It can readily be shown that strict adherence to the MRP calculations (as they currently operate) would quickly increase inventory of unnecessary parts, and unnecessarily rush lower priority orders.

The Processes and Standard Work Instructions put in place during this study are all designed to feed back information into the MRP System such that its accuracy increases on a regular basis. While this stable state is anticipated through intelligently improving the way the MRP system is used, it is clear that the MRP System is not yet accurate enough to receive strict adherence.

Each time the Planners change a line, they are performing a role as a temporary buffer to the inaccuracy of the MRP calculations. Each time they feed back the corrections relevant to the system, they are closing the loop to improve the output of the MRP System. However, in addition to these local inputs regarding specific parts, it appears that some fundamental settings of the MRP System may need to be evaluated to reach the end objective. And of course, the ultimate objective is to get drilling equipment and services to the field when and where they need it. This may always require Planners to deviate from the MRP calculations, no matter how accurate they become. That is a strategic decision to make given all the long and short term considerations.

For the time being, with feedback mechanisms in place to continually improve the MRP system, measuring the Change % gives insight into the extent to which the Planner / Buyer team is deviating from the planned MRP schedule.

12.1.7. 3) Work Instruction Experiment

12.1.7.1. *Rush Req Experiment*

The third approach to understanding the issue of Rush PO's and Rush Req's was enabled through the implementation of Standard Work Instructions. This analysis of the Rush Orders and Reqs progressed concurrently with developing the Standard Work Instructions with the Planners. Both of these initiatives growing simultaneously enabled them to reinforce each other in furthering the intended objectives.

Analysis does no good if nobody believes it, and having variables controlled through Standard Work Instructions allows more people to believe quantified analysis. On the most basic level, Standard Work Instructions enables the Process Engineer to identify sources of variability, and begin quantifying possible causes. Maybe even more significant than the ability of the Process Engineer to eliminate possible causes, is the way Standard Work Instructions allow managers and key personnel to likewise *believe* which factors are influential and which are not. In this case, Standard Work Instructions for the Planners in releasing Reqs enabled a controlled experiment of MRP behavior at the daily execution level. This in turn enabled Managers and

Planners to believe that it really is MRP changing on a daily basis instead of the Planners simply being negligent.

12.1.7.2. MRP Req Rush Test

In order to study the part the Planners play in using the MRP system, it was necessary to run a systematic test of the behavior of MRP in light of Planner activities. The Standard Work Instructions provided an ideal system for designing and implementing a controlled experiment over two weeks. In turn, the need to perform the experiment, and the benefit its results would bring to the Planners, reinforced the value of immediately adopting the newly developed Standard Work Instructions.

The Planners had claimed they were executing MRP according to the way the software prompted them. However, the erratic availability of parts caused the Managers and Sales to question the validity of their claim. Combining the Forecast validation by Planners, the Forecast Liaison meetings, and the general perception even among the Planners that the MRP system was now largely working well, there was no explanation for why so many Reqs were being raised so late. The belief of Managers and Sales was “if the Planners will execute exactly to MRP’s requests, the system will stabilize over time.” The best place to start investigating was documenting exactly what was happening right at the interface between the Planners and the MRP software.

The experiment consisted of two simple steps inserted into the Planner Req Release Procedure. 1) Before releasing Reqs, the Planners would export the data from the Planned Req Screen, used to indicate all Reqs to be raised in the selected timeframe. 2) After releasing the appropriate Reqs, the Planners would again export data from the same screen for the same timeframe. If all Reqs had been raised, this second export would be empty. Often, a few Reqs remained because they were for obsolete parts, and the MRP system hadn’t been updated (these the type of errors would be communicated to the Forecast Liaison). These exported files were emailed to the Process Engineer.

The Process Engineer used these files to evaluate the unexpected changes arising in the MRP system. The Planners always used this Planned Req screen in intervals which overlapped each other. If the forecast had been correct, then no new demands would arise for the interval which had already been released. However, as MRP would change, it would plan Reqs to be released retroactively. These changes would show up between releases.

Comparing the exported Planned Req files one week apart, it was immediately apparent that a majority of the Reqs now planned for release were Rush Reqs, raised by the system with retroactive dates for “planned” Req Releases. Some of these Reqs were only on a few days rush, while others were rushing the full Lead Time. These Rush Reqs were distributed in similar proportion to the histogram shown in Figure 46.

This experiment conclusively showed that the source of this Rush volatility was not due to the actions of the Planners, but the behavior of the MRP System. Analysis of the data, and experimental sessions with creating different forms of orders in the MRP system, revealed how the principles upon which the MRP system calculates reacts to the aligned priorities set in the system, and within the organization.

In the end, this analysis exonerated the Planners from suspicion of negligence in MRP adherence, and identified the policy decisions with the MRP software as the source causing this behavior. The natural progression of these findings was to study the policies that SHTC wants to implement with the MRP software, while currently having more accurate insight into the systematic behavior it causes. This is discussed further in the section on recommended future work.

12.1.8. Sharing the Analysis

Sharing this analysis while it was ongoing proved to be a benefit to both the analysis, and to the managers and operating personnel involved. As will be discussed in greater detail in the next section, involving the Planners was essential recruiting the expertise necessary to perform a truly relevant analysis. On the part of the managers, staying informed of the analysis as it

progressed enabled them to consider the nature and reality of the problem, as well as broader implications of actions that need to be taken.

One of the most telling reactions to this analysis came from the Sales Manager: “Is the forecasting software working right?” To emphasize the significance of this observation, pretend this text takes a momentary pause for dramatic effect. Up until this point, the Sales Manager had entertained the possibility that the forecasting software may be mildly inaccurate, but was adamant that it was working properly, and the only presence of significant error was in the Planners adherence to the software.

Relevant to the current activities of the Planners, after understanding this behavior of MRP, the managers saw clearly why the Planners perform all the routine evaluation they do. It became obvious why a Planner cannot blindly follow the MRP system, hoping that a perfect world results. The Planners really do have to double check everything the MRP system prompts them to do, continually revising and prioritizing the requests from the software.

As it turns out, the MRP system sends requests in such a manner that it cannot stabilize over time, and will continually be in a state of “nervous” response to deviations from forecast, asking for unreasonable response to deviations, each day those deviations occur. Involving relevant parties throughout this analysis enabled this reality to be discovered, quantified, and finally, believed.

In summary, this study shows that historical analysis enabled through a quantified VSM, and procedure based experiment enabled through Standard Work Instructions, are necessary reinforcing principles to identifying the sources of variability in a system.

12.1.9. Involving Stakeholders – both Opponents and Neutral Parties

It is worth illustrating some of the personnel dynamics and diplomatic tactics involved with the development of this analysis. Process Change requires the support of the people involved, but so does Analysis. A Process Engineer will often be dependent upon the expertise of others to generate accurate analysis. Furthermore, beyond being accurate, the analysis must be effective

in persuading personnel and managers to take action, and be informative enough to guide toward what action must be taken. This situation provides an example of the benefit of having opponents involved in an analysis, as well as neutral parties. As a Process Engineer, for any initiative or analysis, it can be useful to follow the old adage to “hold your enemies as close as your friends.”

One of the Planners in particular is an ardent believer in the effectiveness of MRP (if used correctly). He is very adept at navigating throughout the MRP software, and digging into the details of what is occurring on an individual basis. When the Req Rush analysis was first presented to him in the aggregate form (Figure 50), he laughed at it, and immediately began citing a litany of possible flaws in the analysis, insisting that reality couldn't be as bad as shown.

This response was unexpected because this Planner had been very helpful and objective in many other discussions. The difference between this and other discussions was, instead of offering a procedural approach to improving the MRP System, it offered a concrete illustration of a miserably performing MRP System. It was as though he took this criticism of MRP as personal criticism of himself and his performance. Of course, he believes he was always being objective about the issue, but this response was drastically different from every other objective response.

Such a personal association with a software system can initially be surprising from an external viewpoint. However, evaluated from the perspective of somebody who has spent years developing a genuine expertise in using the software, and defending an ardent belief in its effectiveness, it is not surprising to see somebody reflexively take such a position. It is part of human nature. In fact, during my first conversation with this Planner when I started five months earlier, I gave my impression from classroom training that “a lot of companies sink a lot of resources into MRP systems, and it never quite works as they'd like.” His immediate response was adamant enough that it stuck in my memory. “MRP works, and it works Very Well! People just need to learn how to use it.”

An effective change agent must be aware of personal connections, and be aware of how they can turn to their benefit, as well as to their detriment. The connection could be with any tool, software, process, etc. People develop attachments to things in their lives, and we can't always predict where they will occur.

In this case, this Planner had the expertise that he could spend all day nit-picking the analysis I had produced. On the other hand, he had the expertise (and personal interest) that he could guide me to develop a comprehensively legitimate analysis. The latter approach can be more difficult to navigate, but ultimately it is the best way to get things done.

Immediately after the meeting, I invited this Planner to join me at my computer with the raw data, and identify, one by one, the inconsistencies present in the analysis, and how I could remove them. I started with the most obvious factor, and he returned to his regular duties while I revised the data. When each step was complete, I would consult with him on the new results, continuing a few iterations in this manner.

It was apparent that his expectation (and desire) was each of these clarifications in the analysis would bring the results down to single digit Rush Req %'s. He believed, and wanted to show, that MRP was working just as well as he believed it did. Working with someone with a preset conclusion can be difficult. It's like every step in the analysis is a negotiation. As he would make suggestions in ways to split and reorganize the data, it would be easy to reduce the analysis to irrelevance.

12.1.9.1. *Identify the Objective to be Measured*

As the Process Engineer in such discussions, it becomes important to have a clearly identified objective of what you are trying to measure. In this case, it was MRP instability. Sorting data is easy, but sorting data specifically relevant to an objective takes more thought. When working with someone who is reflexively working to prove a foregone conclusion, it is frequently necessary to consider their suggestions for sorting data in terms of the end objective. Most people are objective when making individual decisions about analytical relevance, even if they are reflexive in the conclusion they want to see. In this situation, frequently returning to the

objective by asking “will that help us more accurately see the instability present in MRP?” helped to bring us both to objective discussion about the relevance of different data. Every time we evaluated suggestions from that perspective, this Planner was very objective in his answers and explanations. He acknowledged when certain steps would reduce relevance, and we’d move on to other considerations to increase relevance. This process took place over two working days.

An equally important component to this process was my discussions with a Planner who was reflexively neutral on the outcome of the analysis. Between discussions with the pro-MRP Planner, I would walk down the hall and discuss the rationale of certain criteria with the neutral-MRP Planner. Even with my conscious efforts to be objective, discussing analysis criteria with a reflexively biased Planner caused my mind to reflexively oppose his efforts to parse data into irrelevance. Later, when I would discuss things with the neutral Planner, it really made a difference in the clarity with which I made certain decisions. After the discussion in a neutral environment, I could proceed knowing that I wasn’t being swayed by one agenda or another, but being objective consideration. In addition, the neutral Planner introduced more factors into consideration, or put them in different perspectives, which was valuable to the analysis.

This process of iterating between Planners to develop the analysis was important in the way it developed analysis of a quality that otherwise would not have been achieved. First, were it not for the personal stake the pro-MRP Planner felt in the analysis, the analysis would not have proceeded as quickly, nor with as much understanding associated with the development. At the same time, without the neutral Planner and Process Engineer involvement, the data (if followed through), would have been less relevant from over-exclusion.

Second, by the time the analysis was complete, the Pro-MRP Planner had been sufficiently involved that he no longer felt threatened or criticized by the result. Even though the detailed results were dismally similar to the aggregate results, he now had a deep understanding of the data; where it came from, and what it meant. He shared expertise in this analysis of his special field of expertise. Far from being an opponent of the analysis, it was now one more tool which

he felt confident working with to discuss decisions with managers. Furthermore, the pro-MRP Planner now has another tool which he can use to analyze and understand the behavior of the system on a more accurate basis.

It is worth taking a moment to recognizing the alternative scenario; that of abandoning the analysis because someone was “difficult to work with.” Had the analysis been abandoned because of the initial litany of faults cited, neither the Managers nor the Planners would have any more insight in how to solve the problem. The Rush Req problem would be another vague unknown phenomena believed by some, and not believed by others. Nobody in the organization would know the real magnitude of the variability, and they would have even less insight into the forces causing it.

As a Process Engineer, it is important to remember that you are dealing with humans, and that you yourself are human. It is beneficial to learn to leverage the natural biases people carry to increase the relevance and accuracy of analysis. At the same time, it is important to provide an environment wherein you can remove yourself from the bias that interacting with others can induce on your own decisions.

Investigating a complex business system, such as the Supply Chain department, requires the expertise of many people. Changing a complex business system requires the support and good will of all personnel involved. Building a sound scientific case for causes and effects of problems is essential to earning the support necessary to get a critical mass of people moving in the right direction. If the system isn't controlled enough for managers and personnel to believe the analysis, then any proposed changes will have little or no effect.

13. Control

13.1. Institutionalizing Process Improvement – Sustain the Acceleration

Institutionalizing continuous Process Improvement must take place on several levels, including practices of the process engineer, management practices, and performance measurement. The aspects considered herein are essential to sustaining the process improvement role, the momentum of initiatives, and the ultimate cultural transformation within the organization. We begin by evaluating critical considerations for the process engineer, process improvement generally, several management considerations, and then touch on performance measurement.

13.2. How to Sabotage Lean

In every engineered system, it is important to understand how the system works. Equally important, but often overlooked, is understanding how the system breaks. Much of the preceding material in this study has dealt with how things work. Here we will take a moment to observe two instances of how the Lean Transformation can be broken. One was on the level of personal interaction, and the other was on the systematic level of managing priorities in change initiatives.

13.2.1. Inspiring Personal Resistance

A catastrophic pitfall to be avoided is the misstep of inspiring resistance amongst the operating personnel. If the good will of the operating personnel with whom you are working is lost, much of the autocatalytic behavior of Lean tools will be lost. The greatest source of ideas, the operating personnel, will be lost. The best source of expertise for analyzing and understanding the system will be averse to working for you. The best source of expertise for developing improved processes may be averse to the changes. Ultimately, willing implementation and feedback throughout the process will be lost, greatly crippling the localized tuning necessary for every initiative.

The instance derailing Lean on the personal interaction level was observed early on while initially developing the Value Stream Map. This instance was quite possibly the most destructive thing to Process Improvement I've ever observed. This particular case is so important because it is liable to happen at the very beginning, and throughout every Lean Transformation.

At the beginning of this project, the Site Lean Six Sigma Champion appropriately joined us for the initial Value Stream Mapping meetings, and played a shared role in facilitating the diagrams. She had a strong focus on concrete activities, which helped while drafting the steps in the workflow. At one point though, she must have forgotten that we were intent on mapping the Current State, and became focused on a point where Engineering was circumventing the Planners to order parts. This activity put a kink in the workflow we were mapping with the Planners. Instead of inquiring why Engineering was circumventing the Planners, and what alternatives may exist, she became very forceful and exclaimed "Then we'll tell them they have to start doing it this way! We won't let them get around you anymore!"

Such a forceful attitude is guaranteed to inspire resentment from anybody. Even the Planners, whom this directive would be serving, were hesitant about that idea. Up to this point, and throughout the project, I hadn't experienced any resistance to proposed initiatives when they had been discussed and understood. In my first meeting with this Site Lean Six Sigma Champion, she rolled her eyes several times commenting about the resistance she received from everyone in the company. The stark contrast between her experience working at this facility, and my experience working here, seems to be most closely tied to this Enforcement Attitude.

This pitfall in this particular instance could be avoided in focusing on mapping the Current State, as opposed to the Future State. More generally, as a Process Engineer coming from outside the group and having less expertise, it is important to avoid making preliminary judgments about the way things "should" be done. Understanding first, then sharing and communicating the understanding, followed by developing improvements with the operating personnel directly involved, is the pattern that must be followed. As soon as the operating

personnel, the experts, are removed from the process, it will be exponentially more difficult to design a solution they will accept.

This tendency must simultaneously be approached with consideration of the end purpose of bringing value to the customer. When the focus on bringing value to the customer is lost, and emphasis is placed on Lean Tools for the sake of using the Lean Tools, it is natural that decisions will be made which harm the overall system. To initiate and sustain change in an organization, it may require a persistent and tenacious personality to break people out of their comfort zone. These traits may be good, but the end objective of bringing value to the customer must always be kept in mind, and each step of measurement and analysis must be taken objectively and considerately. Trying to move too quickly, or push too hard, or work toward non-value-added objectives, will only inspire resistance to current change initiatives, and future change initiatives. The result of this behavior, far from reinforcing a sustained Lean Transformation, will sabotage current and future efforts in the Transformation.

13.2.2. Overcoming Missteps

It would be easy to observe forceful behavior as was demonstrated by this Site Lean Six Sigma Champion, and write it off as a character flaw. The reality is that many things can lead to this behavior, from an innocent loss of focus on the end objective, to pressure from managers to push initiatives through, or any combination of conditions. The reality is that at one point or another, any Process Engineer is susceptible to slip up at one point or another. After working to prevent the slips, the next focus is on recovering from actions that inspire resistance.

It is beyond the scope of this study to analyze detailed tactics for overcoming missteps, but a good place to start is acknowledging the error, and offering appropriate apology. As a Process Engineer leading a continuous Lean Transformation, it is absolutely essential to earn and maintain the good will of the operating personnel with whom you are working. Without their participation and efforts in analyzing and understanding processes, any change initiatives may ultimately end in failure.

13.2.3. Systematically Losing Focus

The second instance evaluated in this study is not as catastrophic as the first instance inspiring personal resistance, but it does impact the autocatalytic nature of Lean tools by affecting the response from personnel. People respond most strongly to personal interactions, and next to systematic interactions. If the priorities of a Lean Transformation are systematically misaligned, or perceived as systematically misaligned, it will negatively impact the support of the operating personnel. These systematic issues can be addressed by management, both locally and generally.

In The Goal, Goldratt emphasizes a relentless pursuit of improving the bottleneck in the system, arguing that no improvements will make as significant a difference as improving the bottleneck. While this is familiar to anyone who has studied Lean principles, it is intuitively obvious to operating personnel steeped in mass production mentality. When Lean initiatives are undertaken in areas which don't influence the overall productivity of a system, the operating personnel notice, and become disinclined to apply their minds to support the initiative.

While expanding the Value Stream Map to include departments outside of Supply Chain, I visited the assembly line personnel to understand their operations and needs. After going through their full roles and responsibilities, we visited a whiteboard in use by the Process Engineer working with this particular assembly line. The workflow diagrams and performance measurements were familiar, and it looked like she was on a good track with her efforts. The attitude from the assembly personnel was something different; not resistance, but certainly not enthusiasm.

The greatest holdup on the assembly line was having the parts they needed. They could easily handle more volume with their given production methods, but they spent a lot of time waiting around for parts to arrive. They were on good terms with the Process Engineer working with their group, but questioned the value of the time spent on the improvements. One worker expressed "What's the worth of saving two minutes here, or thirty seconds there, when I turn around and wait two hours for the next job to arrive?"

Solving this issue reaches into the management structure surrounding process engineers, and an enterprise wide Lean Architecture. This is beyond the scope of this study, but it is worth noting the behavior of the assembly personnel in light of these conditions.

This assembly team had a process engineer who was working with them well, and making progress. At the same time, they knew that the work she was doing wasn't helping them. When they learned that I was working with Supply Chain to help get their parts in on time, it improved their judgment of Lean and the decisions management were making about process improvement. They would have been supportive of their process engineer being temporarily reassigned to the warehouse (where there were not process engineers), or another department where it could help them with the real bottleneck in the system.

Overall, operating personnel are supportive of decisions that are made which improve the overall productivity of a system, and their ability to deliver value to the customer. It is also helpful to allow them to see the efforts that are being made. When they see that Lean is being applied to the most important problems, it reinforces their support of the overall concept of continuous process improvement. Conversely, when they don't see the most important problems receiving attention, they grow disenchanted with Lean and continuous improvement, and their support wanes.

13.3. Managing a Process Engineering Team

In a Lean Transformation, it is often likely that even the manager will be new to Lean principles, as was the situation in this study. It is important that the manager learns and adapts with the Lean Transformation, along with the operating personnel.

While an extensive treatment of managing a Process Engineering Team is beyond the scope of this text, observations are included from the first six months of this Lean Transformation. This is treated herein because a significant component of the changes to take place amongst the personnel naturally resides in the way a manager manages the Process Engineers. All members in a Learning Organization participate in the learning, including managers.

13.3.1. Manage a Process Engineer just like any other Engineer

A Process Improvement team will be most effective if managed similar to any other engineering team. While the manager of an engineering team needs to understand the concepts and challenges approached by an engineering team, the manager doesn't need to dictate and approve every detail of the implemented design. At the same time, the manager must ensure that the engineers have intelligently approached all their design decisions, preventing faults from slipping into the design. Ultimately, the manager must sufficiently understand the design to coordinate the various engineering disciplines in producing a successful product.

Managing a process improvement team is similar to managing an engineering team. A manager needs to understand the analysis and process design decisions, and how it will influence the flow of work. At the same time, the manager needs to find the threshold at which they can trust the judgment and methods of the Process Engineer. While the manager coordinates the activity of all the roles in the department, the role of process improvement should receive similar treatment.

One impediment experienced early on was the tendency of the manager to micro-manage the process improvement. Instead of supporting the Process Engineer to create the Value Stream Map and other fundamental tools necessary for understanding the system, he directed the Process Engineer to simply collect data already available on high level performance metrics. This only included metrics reflecting the results of the system (e.g. On Time Delivery, Spending, Volume, etc) since few measurements of causes were available (such as MRP Accuracy, Wait Times, etc).

As the VSM began to take form (largely through persistence from the Process Engineer), requests were frequently made for identifying Non-Value Activity, in the form of unnecessary steps, which could be eliminated. While eliminating unnecessary steps is important, it is only a single component of eliminating Non-Value Activity, and only a small portion of the benefits to be gained from the Value Stream Map.

In the eyes of a manager newly introduced to Lean, it may not be intuitively apparent that Wait Time and Rework are the largest sources of Non-Value Activity. However, to the Process Engineer who has focused on learning Lean principles, such dynamics have been observed and understood. If the manager micro-manages the Process Engineer to implement the managers own idea of Lean, the expertise of the PI Engineer is lost. Instead, the manager will gain the greatest benefit by seeking recommendations from the Process Engineer, understanding the recommendations, and managing accordingly.

13.4. A Learning Organization Including Learning Managers

An essential component to a Learning Organization is to be composed of Learning People, including managers. The Supply Chain Manager in this study initially micro-managed process improvement, but incrementally learned how to more effectively manage a Process Improvement team.

A few months into the Lean Transition, the Process Engineer developed a standard form for the Planners to use for communicating MRP Change Requests, and discussed it with the Planners to integrate feedback. The Planners all liked the final template and process, and believed it would help them in their roles.

While discussing the template with the Supply Chain Manager, he spent an appropriate amount of time questioning to understand the form, and its importance in the system. He didn't seem to fully understand how it was necessary, but he was satisfied it wouldn't impede the Planners in their job. The SC Manager concluded that topic saying: "I want to be a facilitator, and not a blocker. If you have talked with the guys and they like it, then let's go ahead."

The MRP Change Request Template went into use. Over time, the intended effects of implementing the standard template came through, enabling more routine MRP Improvement communication. In this case, the manager intelligently evaluated the recommendations of the Process Engineer, and appropriately trusted in the judgment of the expert positioned to design the process in the department.

13.4.1. Managing for Schedules and Deadlines

As with everything, a Process Engineer commonly faces more projects than time allows. The most important thing is to prioritize the projects. This includes allowing priority for evaluating priorities, making progress on analysis, developing communication and implementation tools, following up on projects, and other such activities necessary to a sustainable Lean transformation. A manager must effectively use schedules and deadlines to drive strong progress, without short circuiting efforts.

One of the most important components of process improvement is having time to think about how the system is behaving. Process Engineers need time to analyze the system and share insights. It can be easy for less important tasks to crowd out the time she needs to analyze the behavior of the Supply Chain system. An effective manager will allow a Process Engineer time for such analysis.

Some people are naturally inclined to take time for such analysis, while others are naturally more inclined to be task handlers, completing assigned tasks before taking time for brainstorming and subjective evaluation. Each Process Engineer needs to personally learn their own tendencies, and how to manage their own time and priorities, but the manager can play an influential role in making such balancing more or less difficult. If a manager consistently dictates deadlines and schedules for tasks and analysis, it is easy for a process engineer to become occupied with those tasks (e.g. data reports, updating progress tools, etc.), foregoing follow up and the easily overlooked value in developing effective communication tools.

In this study, the tendency to micro-manage activities almost prevented the development and implementation of Forecast Sharing, an initiative that proved to be one of the most immediately valuable changes. The idea for Forecast Sharing was developed early on, and a pilot macro could be easily developed with a few hours.

At this time, the manager was pressing for a rapid schedule to develop a comprehensive set of Key Performance Indicators. The manager didn't understand that these measurements didn't exist, so he was very focused on the format that this single page summary would take. During

his regular meetings with the process engineer, the dialog was focused on the format of this KPI summary page, and which general indicators should be included. Every meeting ended with a date for one step or another to be completed. Meetings were very drawn out with discussions over minute details, with a very rushed pace, and no opportunity given to discuss other ideas or initiatives.

Throughout these weeks, the Value Stream Map was in the early stages of development, and was treated as an elementary academic exercise of little consequence. The VSM was given a cursory inquiry in each meeting, with the directive to quickly find non-value activity that could be eliminated.

The net effect of this was unnecessary pressure on the process engineer to deliver very ineffective collections of non-existent data without discussion of how the system was performing. The intentions of the manager were good, in that he wanted to understand the behavior of the Supply Chain to improve it, but it was approached from a very authoritarian, mass-production mentality.

Eventually the manager was out of the office for a few days in a row, so the process engineer took a morning to develop a pilot macro to demonstrate feasibility for Forecast sharing. The macro worked as intended, and the Planner with whom Forecast Sharing discussion had originated loved the macro.

Notwithstanding this successful demonstration, the next few meetings with the Supply Chain manager were so narrowly pointed that no room was allowed to introduce this improvement initiative. Finally, over two weeks after the macro had been developed, the process engineer imposed on the manager's schedule to show him a report generated using the macro. Without even asking how the report was developed, or why it was developed, the manager asked for a similar report "for each of the top suppliers, completed by next Friday. This is top priority."

Long story short, the manager was so task oriented that he inadvertently crowded out the development of valuable and effective tools. Beginning with this experience, and through a

series of discussions and other initiatives, the Supply Chain manager eventually learned how to effectively leverage the creativity and insight of the Process Engineering Team. To the extent a manager can learn to use the expertise of a Process Engineer to understand the system, beyond handling analysis tasks, the Lean Transformation can begin to take hold.

13.4.2. Prioritizing Tasks

To be most effective, a Process Improvement Engineer must be free to pursue the highest impact projects. With that, it must be understood that the projects can quickly change in priority, and that follow-through often takes more time than expected. A Process Improvement Engineer needs time and freedom to follow-through, as well as explore for higher impact projects.

Initiatives already underway will require a lot of time for follow through. This time requirement isn't readily apparent, since it is difficult to gauge how much attention an initiative will need until the need arises. As demonstrated with the development of the Forecast Sharing Process, the needs of personnel were far higher than expected. Giving such priority to timely follow up may seem like fire fighting, but thinking about it quickly makes it apparent that support early on will save time in the future process refinement, ease the implementation, gather ideas for next initiatives, and address unforeseen dynamics that may change the priority of other initiatives.

Because process improvement dynamically addresses dynamic business systems, the process engineer will be most effective if they actively scan and read the behavior of the system, continually focusing on the highest priority made apparent by the system itself. Instead of managing to rigid schedules and deadlines, a manager may be most effective by managing to a hierarchy of priorities, as opposed to a sequence of dates and deadlines.

13.5. Measuring the Performance of a Process Engineer

Measuring the performance of a Process Engineer can be tricky. Due to the differing nature of business departments and changing dynamics within each department, a common set of

quantitative metrics seems to be an misguided approach. Measuring the number of initiatives undertaken, or “on time performance” with initiatives will only induce the Process Engineer to segment their initiatives in such a way as to game the system. As discussed in the section 9.6.6on Behavior Metrics vs. Performance Metrics, measurements should be geared to assist the Process Engineer in performing their role more effectively.

It is beyond the scope of this study to propose such metrics, or a method for developing such metrics. Such a measurement system may merit further study.

13.6. Mass Production Mentality vs. Lean Production Thinking

When controlling the Process Improvements implemented, it is important to keep in mind that you are sustaining a Lean Production system, as opposed to a Mass Production system. The emphasis in a Lean organization is continually learning, continually improving. This is contrasting to the “Faster, faster, faster. More, more, more.” mentality of a Mass Production organization. The elements that merit focus are the indicators of learning and improving, as opposed to perpetually increasing speed and volume on the same steps. Focus should be applied to continually developing and improving tools which help operating personnel to perform their roles more effectively.

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14. Future Work

14.1. Overview of Recommended Future Work

This section entails recommendations flowing from timely and local level, moving to broader application across SHTC generally. The first recommendation is to evaluate the settings of the MRP software in light of the temporary and strategic objectives of SHTC's intent for customer service. Next is to develop a systematic approach to working with Suppliers to evaluate and update the Lead Times used in the MRP System. Reaching to SHTC as a larger organization, it is recommended to undertake an enterprise wide Value Stream Mapping initiative, leading to an SHTC Behavior Measurement System giving quantified insight into key aspects of the entire production and engineering efforts.

14.2. Evaluate MRP Settings in light of strategic and temporary objectives

The current behavior of the MRP system is the greatest detriment to predictable stable flow of material to Assembly. This behavior is not due to MRP malfunction, but due to the settings selected in the algorithms according to management's stated priorities. For example, parts required in the field for repairs are given priority over parts needed for Assembly, and the MRP algorithms execute on this prioritization. Other settings are chosen to serve the expressed priorities, and these settings have created the highly unpredictable plague of Rush Reqs, and Planner rework as a result.

The settings selected in the MRP system should be evaluated in light of the strategic and temporary objectives of SHTC. This is the most immediate and pressing recommendation following this study. While the present MRP settings reflect the intentions of management, it may be that the emergent behavior from these settings inadvertently reduces their ultimate production capacity, in addition to sending inventory soaring, with obsolete parts, and the other problems identified. If the system is managed under more controllable conditions, reducing total variability, SHTC may be able to serve their customers better at lower cost, achieving their expressed priorities.

The detailed analysis for these settings is beyond the scope of this study. It would require a detailed study with simulations to understand the short and long term systematic effects of different combinations of settings. Because the behavior of the organizational operations will be highly influential in the behavior of the MRP system, this analysis of MRP settings should be closely integrated with further process improvement.

It goes without saying that one set of MRP settings and policies will not be appropriate for all of SLB production centers. The varying nature of different production centers, with different customers and suppliers, and different levels of internal operational control, all introduce enough variables that the emergent behavior in every system will be different for a different set of policies. While the Lean Transformation initiated in SHTC Supply Chain should be extended to other production centers, they should each be given localized implementation strategies and evolutionary paths.

14.3. Implement a systematic approach to work with Suppliers to Evaluate and Update Lead Times

This study has shown that unpredictable parts delivery is primarily due to the erratic ordering patterns induced by the MRP system, and that the Suppliers have been consistently delivering parts faster than the scheduled Lead Time.

As SHTC develops more control and predictability with the MRP system and their internal operations, they will be able to order from their suppliers with greater confidence in the real needed Lead Time. With greater reliability in the orders, SHTC can begin working with suppliers on a systematic basis to generate more accurate lead times for parts. Consequently, suppliers will be able to promise Lead Times more representative of their actual capacity to produce parts. This in turn leads to lower inventory holding costs, lower overproduction, shorter overall lead times, and greater production control and efficiency for both SHTC and Suppliers. This must be a systematic relationship, as opposed to a one-time update of lead times. The intent is to generate predictable coordination between SHTC and their suppliers.

Implementing this relationship with suppliers is easier said than done, and it will take time and have its own set of complications, but the resultant benefits to arise will impact SHTC's existing production, and pay off on future products as well.

14.4. SHTC Value Stream Mapping

The foundational tool used to initiate and sustain this Lean Transformation in Supply Chain has been the Value Stream Map. This could likewise be a tool applied for spreading Lean principles through other departments, and the whole SHTC site. Ultimately, Value Stream Maps ought to be created spanning the full workflow of the products and services delivered by Schlumberger, all the way back through Suppliers. If done correctly, this endeavor will spark the initiation of a Lean Transformation in each of the departments wherein it is implemented.

Such an effort will require commitment by upper management, and support with attention and resources through all levels. Management should avoid VSM'ing a department until resources are made available to dedicate a Process Engineer to carrying out the Lean Transformation. If the natural momentum in Process Improvement cannot be sustained, it may only disrupt the department as it presently operates. Furthermore, the process improvement ideas that naturally occur while building the VSM will be lost if not immediately implemented, as will the enthusiasm for the change, which is a necessary component.

14.5. SHTC Enterprise Behavior Measurement System

As an enterprise wide VSM is created for SHTC, this will naturally include quantifying performance at the relevant steps in the organization. A major component of the Lean Transformation in this study involves the behavior measurements applied to the Supply Chain. Consideration was given to the substance of the metrics, as well as the intuitive meaning in the display of the metrics. Similar considerations should be given to an Enterprise Behavior Measurement System. As noted before, for the purpose of enterprise wide process improvement, emphasis should be placed on "behavior" measurements, as opposed to "performance" measurements.

While the VSM is the foundational tool for initiating a Lean Transformation, behavior metrics relevant to Lean Principles can and ought to be implemented immediately for the departments undergoing Lean Transformations. Relevant metrics on the enterprise level are essential to sustaining and encouraging improved performance in single departments. As insight is gained into the whole organization, management will be able to more effectively allocate resources for improvement, and know how to adapt their organization to changing market conditions.

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