Deployment of the Deere Production System in a Primary Manufacturing Environment

by

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Bachelor of Science in Civil Engineering, University of Notre Dame, 1997
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Submitted to the Sloan School of Management and the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degrees of

Master of Business Administration
and
Master of Science in Civil and Environmental Engineering

In Conjunction with the Leaders for Manufacturing Program at the Massachusetts Institute of Technology, June 2003

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ABSTRACT

Due to financial and performance pressures, Deere & Company created the Deere Production System (DPS) to, among other things, reduce assets and inventory in its manufacturing facilities. This thesis describes the DPS implementation within the Harvester Works facility, focusing mainly on the upstream batch-and-queue operations of its Sheet Metal Division (X-building).

The analysis starts by understanding the not-so-understood operations of the X-building, using an ABC analysis to categorize all parts produced within X-building into different inventory classifications. A simulation tool was then developed to determine the optimal relationships between these inventory classifications and their production frequencies, which were used to create optimal batch sizes.

The results of the analysis provide the foundation for the DPS implementation. By optimizing the current production, a potential for $350,000 reduction in inventory, 30,000 hours of eliminated setups, and a 7% improvement in delivery performance were identified. More importantly, the optimization reduces the turbulence of the X-building operations and provides much needed time and energy to focus on the DPS implementation. This thesis also links the importance of setup time reductions and other improvements to the final DPS state sought by Harvester Works.

Paralleling the operational analysis, this thesis presents an organizational analysis of Harvester Works and highlights the obstacles for change. Given the high number of stakeholders, the functional structure of Harvester Works, and an established culture, leadership’s understanding of the situation and commitment to the implementation are identified as critical success factors.

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ACKNOWLEDGMENTS

Clearly, this project could not have been completed without the help of many. I wish to acknowledge the Leaders for Manufacturing Program for its support of this project. The unique structure of the LFM internship certainly created a memorable learning experience. Also, I want to thank my thesis supervisors, Thomas Kochan and David Cochran, for their helpful perspective and encouragement.

Within Deere & Company, I want to start by thanking David Davis for his project leadership and mentorship, and everyone within the MPES group that made the LFM project possible. The X-building team of Ed Mickelsen, Larry Burkholder, and Gary Blunck was a pleasure to work with. The support, drive, and enthusiasm of the X-building BUL’s, Matt Street and Brian Howard, made the project a success. And, of course, I’ll never forget the personalities of the X-building that made each day exciting.

Finally and most importantly, I want to thank my wife, Terri, for her support and sacrifice over the past two years. She continues to be my motivation.
# TABLE OF CONTENTS

## Chapter 1. Introduction

1.1 Project Motivation .......................... 9
1.2 Company History ............................ 10
1.3 Project Setting and Goals .................. 11
1.4 Thesis Overview ............................ 12

## Chapter 2. Harvester Works’s Sheet Metal Operations

2.1 X-building Operations ..................... 13
2.2 Product Description ....................... 15
2.3 Part Demand ................................ 16
2.4 Current X-building Situation .............. 17
2.5 Project Direction ........................... 18

## Chapter 3. X-building Analysis

3.1 ABC Analysis .................................. 21
3.2 Current Production Analysis ............... 23
3.3 SLX Dynamic Simulation ................... 26
3.4 Fixed Order Procedure ..................... 30

## Chapter 4. Results

4.1 Inventory and Setup Savings ............... 35
4.2 Setup Reductions ............................ 39
4.3 Other Continuous Improvement Activities .. 41
4.4 Standardized Work .......................... 44
4.5 Avoiding JIT Disaster ....................... 46
4.6 Organizational Training ..................... 47
4.7 Future State .................................. 53
4.8 Implementation Plan ....................... 55
4.9 Foundations of X-building DPS Implementation .... 56

## Chapter 5. Organizational Analysis

5.1 Three-lenses Analysis ...................... 59
5.1.1 The Strategic Design Lens ............... 60
Chapter 1. Introduction

This thesis presents the work performed at Deere & Company as part of an internship project for the Leaders for Manufacturing Program at MIT. The project was sponsored by the corporate Manufacturing Planning and Engineering Services department, which is responsible for developing and supporting lean manufacturing implementation within Deere & Company. The project focused on the initial stages of a lean manufacturing effort within a vertically integrated Deere facility.

1.1 Project Motivation

“Although John Deere is a fabulous enterprise in so many ways, our results have lagged due to the fact that, as a company, we are asset-heavy and margin-lean. This means that we use too much inventory, receivables, and plant and equipment to serve our customers well and, further, that our cost structure is too high and needs improvement.” [1]

- Robert Lane, CEO

Given that John Deere has been the world’s premier producer of agricultural equipment since 1963 [2], much of the company’s focus has been customer and employee driven. [3] Only recently has there been a push by leadership to strengthen Deere’s financial position, and more specifically reach an ambitious goal of 20% operating return on operating assets (OROA) for Equipment Operations. Table 1.1 shows OROA over the last three years for these divisions. [4] One result of this push has been the development of the Deere Production System (DPS), which combines the best practices of all Deere facilities into a manufacturing strategy aimed to reduce assets and inventories while improving manufacturing cycle times and product quality.

Table 1.1. Deere’s Equipment Divisions OROA

<table>
<thead>
<tr>
<th>Year</th>
<th>OROA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>7.7%</td>
</tr>
<tr>
<td>2001</td>
<td>-0.5%</td>
</tr>
<tr>
<td>2002</td>
<td>5.6%</td>
</tr>
</tbody>
</table>
DPS is Deere’s application of the Toyota Production System, which was publicly described by Womack, Jones, and Ross in *The Machine That Changed The World* and is commonly referred to as lean manufacturing. [5] Lean manufacturing describes the philosophy used by Japanese manufactures to produce higher quality, in less time, at a lower cost, and has since been adapted by American manufacturers of every industry. When compared to batch-and-queue production systems, the benefits of lean manufacturing are well documented and include: [6]

- Double labor productivity
- 90% reduction in production throughput times
- 90% reduction in inventories
- 50% reduction in scrap
- 50% reduction in errors reaching customers

In addition to these production related improvements, the following general outcomes can be expected: [7]

- The voice of the customers becomes the primary driving force
- Relationships with suppliers have been revolutionized
- Responsiveness to changing market conditions is enhanced
- The organizational structure shifts from a vertical to a horizontal focus
- The workforce is empowered
- Improved operating margins and increased flexibility

1.2 Company History [8]

Deere & Company was founded in 1837 and has grown into one of oldest, largest, and most respect equipment manufactures in the world, doing business in more than 160 countries, employing approximately 40,000 people worldwide, and reaching nearly $14B in net sales and revenues in 2002. [4] Headquartered in Moline, IL, John Deere and its subsidiaries manufacture, distribute, and finance a full line of agricultural equipment; a broad range of construction and forestry equipment; and a variety of commercial and consumer equipment, with factories located in Argentina, Brazil, Canada, China, Finland, France, Germany, India, Mexico, New Zealand, The Netherlands, South Africa, Spain,
Sweden, and the United States. The company also provides credit and managed health-care plans for businesses and the general public. Despite its growth and success over the past 165 years, Deere & Company remains guided by the core values of its founder: quality, innovation, integrity, and commitment.

1.3 Project Setting and Goals

As Deere & Company begins to develop and deploy DPS throughout many of its factories, much of the early efforts naturally target assembly areas where the transition to single-piece flow and demand-based production is more easily accomplished. However, as requirements from these areas are “pushed” down through the vertically integrated facilities to internal suppliers, batch processes are eventually met, and these processes are not as readily adaptable to flow manufacturing techniques.

The site for this investigation was the John Deere Harvester Works in East Moline, IL. This plant manufactures combine harvesters and harvesting attachments, and represents one of Deere’s initial DPS implementation efforts, which started in early 2002. Within Harvester Works, this project focused on the Sheet Metal Division (X-building), which serves as an internal supplier to the rest of the weld and assembly operations.

This project has two main goals:

1) Deploy the Deere Production System at Harvester’s sheet metal operations while integrating the DPS requirements of the downstream customers to ensure timely delivery of parts in consistent quantities, containers, and locations. During this process, prepare the sheet metal operations for transition from MRP production to demand-based production.

2) Based on lessons learned during the DPS deployment, provide implementation recommendations for other primary manufactures within Deere. Primary manufacturing facilities are characterized as having batch-and-queue
processes, lengthy setups, and large capital equipment, typically serving as upstream suppliers to Deere assembly operations.

1.4 Thesis Overview

Chapter 2 provides more detailed information on the current situation within the sheet metal operations. This will set the stage for the analysis and discussion that follows.

Chapter 3 provides a description of the analysis used in this project to help optimize current production practices.

Chapter 4 describes the technical results of the project, based on the analysis described in Chapter 3. These include both tangible cost savings and intangible results that will support the X-building’s long-term DPS transition.

Chapter 5 presents an organizational analysis that parallels the technical analysis and discussion of Chapters 4 and 5. This chapter highlights the difficulties of lean manufacturing implementation.

Chapter 6 summarizes the conclusions of this thesis and presents the key lessons to Deere leadership.
Chapter 2. Harvester Works’s Sheet Metal Operations

This chapter provides background information on the X-building operations and its role within the Harvester Works facility. The information provided will serve as the foundation for the analysis and discussion presented in the rest of this thesis. In addition to specific tasks performed within the X-building, the current situation is also described.

2.1 X-building Operations

Harvester Works is one of Deere’s older facilities, opened in 1913, and remains fairly vertically integrated with sheet metal fabrication, welding, paint, and assembly as typical core competencies. Figure 2.1 presents X-building’s position within Harvester Works, namely supplying sheet metal parts to the various downstream sub-assemblies, either directly or through a storage space, and filling service part demand. The X-building supplies over 4,000 parts to more than 30 different sub-assemblies with Harvester Works, whose facilities account for nearly 3.3 million square feet under roof.

Within the X-building, Figure 2.2 presents the functional layout of the various operations. X-building receives raw steel in both coil and standard sheet form, and routes the parts

Figure 2.1. Harvester Works Operations

![Diagram of Harvester Works Operations]

Sheet Metal Division (X-building) → Storage → Sub-assemblies (Body, Grain Tank, Feederhouse, STS, Headers)
→ Service Demand → External Suppliers → Final Assembly
through cut-to-length, shear, punch press, bend-brake, press, laser, and weld operations before being shipped to the sub-assemblies. Generally, parts flow from left to right, but X-building parts are routed through anywhere from one to eight different operations, with the average part routed through three operations. Most workcenters can start with sheets of raw material, and parts can be shipped to the customer from essentially any operation. The result of these interdependent and complicated routings is the “spaghetti chart” shown in Figure 2.2.

In total, the X-building consist of approximately 80 workcenters embedded in the 10 operations presented in Figure 2.2. To add further complication to the part flow, most operations have multiple workcenters, and feed other operations with multiple workcenters. For example, three punch press workcenters receive parts from five different shears, and each punch press receives parts from each of the five shears. In addition, several X-building workcenters have multiple machines.
Depending on the part size, thickness of steel, depth of bend, and other factors, even engineer/operator relationship, each X-building part is assigned a routing when designed. These routings are usually fixed, but when considering the entire X-building, no independent paths or lines can be separated from the "spaghetti chart" of Figure 2.2

2.2 Product Description

The combine is Deere’s most complicated product made and arguably one of the most complex products produced outside the aerospace industry. A combine harvester with a header attachment is shown in Figure 2.3. Harvester Works produces seven different models, using three different harvesting technologies. To better serve customers, Deere offers a variety of options, making most of combines produced unique and many more being only two-of-a-kind. Within Harvester, each combine is composed of approximately 15,000 different parts, with a many more parts outsourced to external suppliers. The final weight of a combine reaches 22,000 lbs, with a price tag approaching

Figure 2.3. Combine Harvester with Header Attachment, Product of Harvester Works
$250,000 for the more sophisticated models. Despite all the product differentiation, John Deere combines are available in only one color – green.

2.3 Part Demand

A picture of the demand of X-building parts helps understand the complexity of the analysis presented in the following chapters. Given that combines are used only a few months a year, the seasonal demand of these products further complicates the situation. This seasonality, shown in Figure 2.4, applies equally to service and production demand. To offset the demand, Harvester Works relies on multiple build rates throughout the year, and factory shutdowns during the “slow” periods. Only 16% of X-building’s roughly 4,000 parts face production-only demand, which is more stable. Nearly 50% of X-building’s parts contain both production and service demand, and the remainders are service-only or inter-factory parts. Service parts are offered for Deere combines for at least 10 years following production, so the older models can represent extremely low service part demand. In addition to the seasonality, part demands amongst X-building parts vary drastically. Part volumes range from 800,000 to one, with the X-building producing approximately 10 million parts each year.

Figure 2.4. Annual Demand Curve for Combines

![Annual Demand Curve for Combines](image)
2.4 Current X-building Situation

“There has to be a better way to run a business.”

- 1st shift supervisor

From an X-building veteran, this phrase sums up the current situation within X-building. Essentially, each production day starts by the schedulers reviewing a multi-page list of “hot jobs” that are needed by the downstream customers. Schedulers then manipulate the MRP created orders to ensure that these parts become a priority. Throughout the days, phone calls are made and received, and the entire duty of many involves these expediting-type activities. The one overriding goal is to prevent the final assembly line from shutting down, and sometimes heroes are made from their late-night, miraculous efforts to do just this.

A notion exists in X-building that “we never catch up.” To keep up with the one-shift final assembly line, the X-building must work three shifts and often weekends. In addition, the final assembly line shuts down for several weeks at time due to demand characteristics, yet the X-building often continues to work. Most of the equipment in the X-building is old, and thus maintenance and downtime present issues and lead to some of the expediting problems. Lack of time off coupled with the pressure and chaos of “always being late” negatively affects the morale of the X-building.

Finally, well-defined processes do not seem to exist in the X-building operations, with manual manipulation playing a huge role in schedule and queue management. Clear answers are not available as to how, why, and when certain orders are produced, and most problems are solved in a reactive manner. Many of the X-building employees are quite experienced, having performed their roles for many years, potentially causing a sense of complacency. Until recently, X-building leadership consisted of managers brought up from within, thus trained in the current condition. Further organizational analysis and discussion is provided in Chapter 5.
2.5 Project Direction

Figure 2.5 presents a view of the past, present, and future state of Harvester Works with respect to its production philosophy. Before discussing, the appropriate definitions are provided to distinguish the pull and push scenarios: [9]

A *push* system schedules the release of work based on demand. The MRP used within Harvester Works, which releases orders into the system according to a schedule based on customer orders, is a push system.

A *pull* system authorizes the release of work based on system status. The Toyota-style kanban system, which releases work as a result of work completion in another part of the facility, has become synonymous pull production.

In the past, work within Harvester Works was scheduled using the MRP system. One consequence of this philosophy is that orders often arrive before or after needed by the downstream customer, resulting in either shortages or excess clutter. The MRP system is

---

**Figure 2.5. Harvester Works DPS Transition Plan**

**Past:**

- Raw → Push → Sheet Metal → Push → Sub-assemblies → Push → Final Assembly

**Present:**

- Raw → Push → Sheet Metal → Push → RIP → Pull → Sub-assemblies → Pull → Final Assembly

**Future:**

- Raw → Pull → Sheet Metal → Pull → Sub-assemblies → Pull → Final Assembly
based on forecasted customer demand, and the first rule of forecasting suggests that all forecasts are wrong. [9] As the orders are changed, the effects ripple down through the rest of the bill of material - the further away from the final assembly and longer the lead-time, the worse the impact. As a result, the X-building ends up producing many wrong parts at the wrong time.

One element of DPS is pull production or the notion of demand-based replenishment, and this is represented in Figure 2.5 under the present stage for assembly and sub-assembly operations. In this environment, orders are not produced until needed by the downstream customers, who send signals upstream at the appropriate time. However, the supplier must then be responsive enough to produce the order when the signal arrives, and deliver the order back to the customer in the desired timeframe.

The initial stages of the DPS implementation within Harvester Works focused on transitioning away from MRP scheduled work to demand-based production, and the transition started at the final assembly area and moved upstream. The new kanban system places new requirements on suppliers, and this is the exact problem facing the X-building - how to meet these new DPS customer requirements.

"Initially, the conversion to flow manufacturing will not eliminate the central storeroom. However, that is the ultimate objective." [10]  

- John Costanza

Eventually, Harvester Works expects to transition away from the MRP scheduling system for the entire factory, as seen in the future state of Figure 2.5. In the meantime, a RIP (an inventory management term meaning Raw-In-Process inventory [10]) or storage area acts as a buffer between the X-building and the DPS customers. Since the MRP schedule and X-building production capabilities will differ from the actual consumption rates of the customers, the storage area serves as the needed buffer until the X-building operations can be synched with the rest of the factory. How the X-building will improve the
“present” state and prepare for the “future” state will be discussed in the following chapters.

It is important to understand that lean production is not merely a set of practices found on the factory floor, but rather a fundamental change in how the people within an organization think and what they value, thus transforming how they behave. [7] Deere & Company recognizes this as well. However, as Harvester Works begins its DPS implementation, much of the focus is placed on transitioning toward pull production, for this is seen as a logical starting point by the DPS team.
Chapter 3. X-building Analysis

This chapter outlines the analysis performed during the X-building DPS project. As previously described, the goal is to develop a methodology to optimally meet the new, fixed order demands of the downstream customers while preparing the operation to transition to a demand-based production philosophy. The analysis starts with an understanding of the demand data and current production policies. After performing an ABC analysis to categorize parts into different inventory classifications, a simulation tool was created to help optimize the X-building operations. Finally, based on the simulation output, a link between inventory classification and production frequency was determined. The data presented in this chapter was collected at Harvester Works from July through September of 2002.

3.1 ABC Analysis

In most manufacturing systems, a small fraction of purchased parts represent a large fraction of the purchasing expenditures. To have maximum impact, therefore, management attention should be focused most closely on these parts. [9] This same notion was applied to all parts produced within the X-building. From process observation and discussions with X-building personnel, it became evident that a clear understanding of part data did not exist. To start the analysis, 52-week demand data was collected from the MRP system for all parts routed through an X-building operation, along with the cost to produce each part. Cost data included material costs, labor, and overhead. Together, the total annual cost for each part was calculated and plotted in descending order. The results are presented in Figure 3.1.

\[
\text{Total Annual Cost} = (\text{52-week demand}) \times (\text{total manufacturing cost per part})
\]
The results of this analysis show that the total annual cost of parts produced in the X-building range from $350,000 to essentially zero for many low-dollar, low-volume service parts. Parts were then assigned five different inventory classifications as shown in Figure 3.1: A, B, C, D, and E, with A assigned to the highest value parts. Table 3.2 shows the consistency with the 80-20 rule [9], where inventory classes A and B together account for approximately 75% of the cost while representing only 17% of the parts. In addition, 16 of the nearly 4000 parts account for 10% of the total annual cost of the X-building.

Table 3.1. Breakdown of X-building Parts

<table>
<thead>
<tr>
<th>Class</th>
<th>% of Part Numbers</th>
<th>% of Total Annual Cost</th>
<th>Max. Total Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3%</td>
<td>33%</td>
<td>$350,000</td>
</tr>
<tr>
<td>B</td>
<td>14%</td>
<td>42%</td>
<td>$63,500</td>
</tr>
<tr>
<td>C</td>
<td>20%</td>
<td>18%</td>
<td>$16,500</td>
</tr>
<tr>
<td>D</td>
<td>22%</td>
<td>6%</td>
<td>$5,000</td>
</tr>
<tr>
<td>E</td>
<td>40%</td>
<td>1%</td>
<td>$2,000</td>
</tr>
</tbody>
</table>
Five inventory classes were assigned, rather than the traditional three (A, B, and C), because these five inventory classifications currently existed in Harvester Works’s information systems, which were updated quarterly to account for demand changes. The main result of this analysis was awareness provided to X-building and Harvester management that huge cost discrepancies existed within X-building parts. Prior to this analysis, such insight was not considered in the decision making process.

3.2 Current Production Analysis

Amongst management and production control, a realization now exists that a link between inventory class and production philosophy is important to efficiently run the X-building operations. Without this alignment, unnecessary resources could be committed to small dollar parts or worse yet, high dollar parts could be ignored. At this point, the MRP system determined batch sizes for all the parts, but little visibly or knowledge of this process existed. Further analysis uncovered more insights into the current state of the operations.

Within Harvester’s MRP system, four production policies are used for the majority of X-building parts, and these policies are listed in Table 3.2. Three of these policies are time-based (A-5, A-10, and A-20), and the fourth is a fixed order defined specifically for each part number. Time-based order policies “lump” the demand within a certain time window into one order. In this particular case, 5, 10, and 20-day windows are used.

Table 3.2. Existing X-building Order Policies

<table>
<thead>
<tr>
<th>Inventory Class</th>
<th>A-5</th>
<th>A-10</th>
<th>A-20</th>
<th>Fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>65%</td>
<td>23%</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>B</td>
<td>42%</td>
<td>19%</td>
<td>23%</td>
<td>16%</td>
</tr>
<tr>
<td>C</td>
<td>45%</td>
<td>14%</td>
<td>24%</td>
<td>17%</td>
</tr>
<tr>
<td>D</td>
<td>58%</td>
<td>6%</td>
<td>17%</td>
<td>19%</td>
</tr>
<tr>
<td>E</td>
<td>73%</td>
<td>2%</td>
<td>13%</td>
<td>12%</td>
</tr>
</tbody>
</table>
Table 3.2 breaks down the order policies used for each inventory class, and three observations emerge. First, generally no significant difference exists between the different inventory classes. Second, the A-5 designation, meaning parts are produced in weekly buckets, is the dominant production policy assigned. And finally, very few parts are assigned fixed order policies. Therefore, the batch size for most for parts will vary, depending on a part’s particular demand profile. In addition, as this data was compiled, no one from X-building or Harvester Works seemed to know exactly how these order sizes were determined or assigned.

Varying production sizes creates two potential problems in addition to offering a non-standard work procedure: 1) machine operators have no way of knowing what the correct order size should be, especially those downstream of the initial operation, and 2) the customers will receive a varying number of parts per order. By assigning fixed order policies to all X-building parts, consistent quantities will be delivered to the customers (an X-building requirement as specific sizes and locations along customer assembly lines are assigned), and machine operators now can serve as a quality tool. If an order is something less than specific, upstream yield or quality problems can quickly be identified.

To better understand the magnitude in which production orders vary, all orders forecasted over a 52-week window were examined for each part within X-building, and the minimum, maximum and average order sizes were tabulated. A few examples are presented in Table 3.3. The analysis showed that the fluctuations are quite significant, and are independent of inventory class or demand. The minimum orders are especially frustrating for the machine operators, where machine setup times far exceed the actual run times for these orders. Also, the maximum order sizes can be so large that a batch must be interrupted (which leads to additional setups) as other parts need to be expedited through that particular workcenter. The inconsistency of the order sizes causes frustration and confusion for the machine operators.
Table 3.3. Examples of X-building Order Variation

<table>
<thead>
<tr>
<th>Part</th>
<th>Annual Demand</th>
<th>Inv. Class</th>
<th>Min MRP Order</th>
<th>Avg MRP Order</th>
<th>Max MRP Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>H172375</td>
<td>3,032</td>
<td>A</td>
<td>9</td>
<td>91</td>
<td>195</td>
</tr>
<tr>
<td>H174947</td>
<td>139,726</td>
<td>B</td>
<td>198</td>
<td>3211</td>
<td>12290</td>
</tr>
<tr>
<td>H133283</td>
<td>1,015</td>
<td>C</td>
<td>5</td>
<td>32</td>
<td>70</td>
</tr>
<tr>
<td>H87193</td>
<td>20,096</td>
<td>D</td>
<td>54</td>
<td>450</td>
<td>6472</td>
</tr>
</tbody>
</table>

In the previous section, the key learning was that a relationship between the inventory classification and the production policy is important for the X-building optimize their operations and efficiently meet their customers’ requirements. Up to this point, there appears to be little rhyme or reason as to how parts are produced, and certainly no correlation has been noticed between the inventory class and production philosophy.

To normalize and compare the order size and demand data for all the X-building parts, the production frequency for each part was plotted against the parts decreasing in total annual cost (the same x-axis that was used in the ABC analysis), and the results are shown in Figure 3.2. Production frequency is defined as the 52-week demand divided by the average order size over that 52-week period. Since the average order size is used, this

Figure 3.2. Existing X-building Production Frequencies
plot does not account for the order size variation for each part. From Figure 3.2, it becomes clear that no correlation between the inventory class and production frequency exists. Essentially, the low-cost parts are made with approximately the same frequency as the high-cost parts. In addition, within each inventory class, a large range of production frequencies exists. For example, the top 500 parts (accounting for almost 80% of X-building's total cost), can be produced at a frequency that ranges from 3 to 50 batches a year, which equates to producing cost equivalent parts anywhere from once every four months to once a week.

Before moving forward with the analysis and determining the optimal production frequency for each inventory classification, it is important to understand how the current situation came about. One hypothesis developed over the course of our analysis was that parts are initially given a time-based order policy when introduced into the system, but never maintained. Over the years, the model mix at Harvester Works changes, as will the inventory classification of the parts. However, because no link between the order policy and inventory class exists, the order policies remain at the original state. It is important to recognize that order policies assigned five years ago may no longer be appropriate today. Therefore, as X-building develops its new production philosophy, it is important to assign maintenance responsibilities to the process. Product demand and customer requirements will certainly change in the future, so it is critical that X-building's operations reflect these changes.

3.3 SLX Dynamic Simulation

As previously described, the X-building operations are extremely complex with nearly 4000 different parts routed through nearly 80 different workcenters. Due to the interdependencies of the routings and shared machine resources, the “spaghetti chart” of Figure 2.2 could not be broken down into simpler lines or paths. Given this complexity, analysis of the X-building operation in terms of throughput and machine utilization becomes extremely difficult.
To help with the analysis, a dynamic simulation model was developed that included all variables of the X-building operation. The model was not an optimization tool, but rather a re-creation of the flow of parts traveling through the X-building. Insights gained from the simulation analysis would help create effective production policies, and also identify the constraints of the X-building system. The simulation tool uses SLX program language and numerous Excel-based spreadsheets to input necessary information. Figure 3.3 shows three of these spreadsheets. Input data includes:

- workcenters
- available time per workcenter
- effective minutes per working shift
- part routings or sequence through workcenters
- total manufacturing costs per part
- setup times for each workcenter
- part number
- inventory class per part
- order policy for each part

Figure 3.3. SLX Dynamic Simulation Input Worksheets
From the MRP system, daily demand for each part was extracted, and this file drove the simulation. The model simulated production over two time intervals: 1) the summer peak production period, and 2) an entire 52-week production cycle. Through an iterative process, the order policies for each inventory class were changed, and the aggregate on-time delivery and inventory measures were monitored. Adjustments were made until the X-building management was satisfied with the outcome. In addition to the cumulative delivery and inventory metrics measured over the course of the entire simulation, output was also created on an individual part and workcenter basis. Table 3.4 presents a list of output metrics for each workcenter and each part number collected over the entire simulation run.

Table 3.4. Simulation Output Variables

<table>
<thead>
<tr>
<th>Workcenter</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td># of orders</td>
<td>total demand</td>
</tr>
<tr>
<td># of parts</td>
<td># of orders</td>
</tr>
<tr>
<td>hours available</td>
<td>fixed order size</td>
</tr>
<tr>
<td>setup hours</td>
<td>on-time delivery</td>
</tr>
<tr>
<td>run-time hours</td>
<td>inventory cost</td>
</tr>
<tr>
<td>utilization</td>
<td>order replenishment time</td>
</tr>
<tr>
<td>queue (min, avg, max)</td>
<td></td>
</tr>
</tbody>
</table>

For determining the optimal relationship between inventory class and production frequency, three main metrics were used: delayed orders, on-time delivery, and average inventory value. Table 3.5 presents the results of the simulation, showing the initial condition (based on existing average MRP orders) and the final solution. The number of delayed orders fell significantly causing on-time delivery to increase, while reducing the average inventory value. Table 3.6 presents the final solution in terms of inventory class. The optimal solution suggests that X-building produce class A parts 44 timers per year, or approximately once a week. Similarly, class B parts should be produced in two-week batches, class C parts in one-month batches, and class D and E parts in two-month batches. Through discussions with the quality coordinator, two-month batches were determined to be the maximum for any X-building part to prevent rusting and scrap.
Table 3.5. Simulation Results

<table>
<thead>
<tr>
<th>Run Description</th>
<th>Delayed Orders</th>
<th>On-time Delivery</th>
<th>Avg. Inventory Value ($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current State - Avg. MRP orders</td>
<td>10048</td>
<td>85%</td>
<td>3.43</td>
</tr>
<tr>
<td>Final Solution</td>
<td>4810</td>
<td>92%</td>
<td>2.85</td>
</tr>
</tbody>
</table>

Table 3.6. Optimal Relationship Between Inventory Class and Production Frequency

<table>
<thead>
<tr>
<th>Inventory Class</th>
<th>Production Frequency (batches / year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>44</td>
</tr>
<tr>
<td>B</td>
<td>22</td>
</tr>
<tr>
<td>C</td>
<td>11</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
</tr>
</tbody>
</table>

When this outcome is plotted in Figure 3.2, the production frequencies more closely resembles the ABC cost curve presented in Figure 3.1. Intuitively, making the lower-cost parts in larger batches makes sense, and based on Figure 3.2, this relationship did not previously exist.

As described in Chapter 2, many X-building parts contain both production and service demand, with the production portion being more stable and predictable. However, the service demand typically reaches the X-building in larger order “lumps” from either downstream customers or the service parts distribution center. The early functionality of the simulation tool is not equipped to handle the large service spikes, and thus the optimal solution reaches a 92% delivery. In actuality, the MRP system forecasts these spikes and would produce a number of fixed orders to handle the need, thus the delivery should exceed the 92% determined by the simulation. For the X-building analysis, the 92% delivery value is viewed as the optimal outcome under current conditions, and serves as the baseline for improvement activities.
In assisting in the X-building transition to DPS, the dynamic simulation model serves two purposes. In the short-term, the simulation allowed the X-building to determine the optimal relationship between the inventory class and production frequency. In addition, the simulation also provides insights into the X-building operations (namely identifying key bottlenecks), and allows users to try “what-if” scenarios to identify and justify critical continuous improvement efforts necessary for the longer-term DPS objectives. These latter insights will be discussed in Chapter 4.

3.4 Fixed Order Procedure

Again, the purpose of the analysis thus far is to determine the best way to meet the DPS requirements of the downstream customers, which includes establishing fixed order policies to ensure consistent quantity and container delivery. The production frequencies determined from the simulation serves as only one of the inputs used to determine these fixed orders.

While developing the dynamic simulation, discussions with shop floor workers, engineers, and customers revealed other considerations that need to be taken into account before fixing production order sizes. These include:

- **Manufacturing multiples.** This represents the maximum number of a particular part that can be nested on a single sheet of raw material. Therefore, to maximize material utilization, the new fixed order should be a multiple of this number.
- **Customer space requirements.** Prior to the Harvester Works DPS implementation, most parts were placed in large, metal containers, which were then transported by forklift. Because these containers consume a lot of space on the assembly line, for many parts, small hand-held totes will be used at the assembly area to reduce the assembly space required by the customer (X-building will then fill the large metal containers with smaller containers).
- **Parts per container.** In the past, even the largest orders would not fill the large metal containers used. However, with the transition to smaller containers, the number of parts that fit into a container will become important, considering both
nesting and weight requirements (maximum of 35 lbs for hand lifted container). In addition, by ensuring full containers, material-handling costs can be minimized.

- **Workcenter-specific requirements.** Discussions highlighted that a few workcenters and cells have unique requirements that did not subject their parts to our analysis. The overall X-building constraints did not govern their operations. In these situations, the workcenter operators were allowed to select a fixed order they felt appropriate.

- **Exceptions.** Many of the low-volume, service or special production parts did not have consistent enough demand patterns to warrant a fixed order policy. Through discussions, it was determined that no orders would be fixed to a quantity less than 10. These parts were then assigned an A-40 order policy, meaning that each production batch would contain the demand for the next 40 production days.

Taking these factors into account, a procedure was created to fix all appropriate X-building parts in two phases. The first phase optimized the X-building operations and was performed independent of the DPS requirements of the customers. These changes could be made quickly, considered only the production frequency determined by the simulation and the manufacturing multiple, and could be applied to all appropriate X-building parts without further input. The following equation was used to set these order policies, and Table 3.7 illustrates how the fixed order policies were determined.

$$\text{Fixed Order} = \text{Integer} \left( \frac{\text{Annual Demand}}{(\text{Manufacturing Multiple}) \times (\text{Production Frequency})} \right) \times (\text{Manufacturing Multiple})$$

### Table 3.7. Example Applying the Fixed Order Procedure

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Inventory Class</th>
<th>52-wk Demand</th>
<th>Production Frequency</th>
<th>Manufacturing Multiple</th>
<th>Fixed Order Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>H164151</td>
<td>B</td>
<td>6109</td>
<td>22</td>
<td>17</td>
<td>272</td>
</tr>
<tr>
<td>H176070</td>
<td>C</td>
<td>2402</td>
<td>11</td>
<td>72</td>
<td>216</td>
</tr>
</tbody>
</table>
Table 3.8. Incorporating Customer Input to Fixed Order Policies

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Customer Recommendation</th>
<th>X-building</th>
<th>Final Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Container</td>
<td>Parts Per</td>
<td>Container</td>
</tr>
<tr>
<td>H146446</td>
<td>RAK37</td>
<td>72</td>
<td>RAK37</td>
</tr>
<tr>
<td>H131706</td>
<td>RCB05</td>
<td>25</td>
<td>RCB05</td>
</tr>
</tbody>
</table>

The second phase of the fixed order processes incorporates input from the customer, namely container type and parts per container information. This information is then compared with the desired X-building order size, and the appropriate solution is generally reached through discussion that will optimize the entire process. Table 3.8 illustrates two examples of such negotiations. Generally, however, the fixed order size determined by the X-building was found to be sufficient by the customers. The implementation rate of the second phase depends on the DPS implementation of X-building's customers. Not until their processes are re-evaluated can the X-building incorporate their input.

Figure 3.4. X-building Production Frequencies with Revised Order Policies
Using the above procedure, the X-building order policies were fixed for all appropriate parts. The results are provided in Figure 3.4, which plots the new order policies as normalized production frequencies. From this plot, the new order policies more closely follow the ABC cost curve. The inventory and cost savings resulting from these changes are discussed in the next chapter.

The analysis described in this chapter provides the foundation for the X-building’s DPS implementation. With an understanding of the demand and operations, a link between the inventory classification and production frequency was established, and the X-building is now prepared to effectively meet the demands of its customers. Now, the X-building understands why it produces parts in the quantities it does, an understanding that did not exist prior to this investigation. Performing this analysis produced a number of benefits, which will be discussed in the next chapter.
Chapter 4. Results

This chapter discusses the results of the analysis presented in the previous chapter and key insights that will help the X-building more smoothly transition toward its final DPS state. The results can be classified into two categories: 1) immediate, tangible results directly obtained from the simulation optimization, which include inventory and cost savings, and 2) longer-term, intangible results that will prepare the X-building to proceed forward. The latter includes insights into the operations, recognition of the necessity of setup reductions, and workforce training.

4.1 Inventory and Setup Savings

One of the more immediate outcomes of the analysis was the optimal link that was established between production frequency and inventory classifications. As a result, all batches sizes of X-building parts were fixed such that their production frequencies were now aligned with the new philosophy.

Figure 4.1. Comparison Between New and Old X-building Order Policies
Figure 4.1 compares the old vs. new order policies (essentially combining Figures 3.2 and 3.4), with the x-axis being the X-building parts in decreasing total annual cost. Two areas are highlighted on the plot to represent the regions with the most significant impact on the X-building. In the upper right corner, the difference between the old order frequencies and new order frequencies are quite substantial for a significant number of parts. Referring to the ABC cost analysis in Figure 3.1, the parts in this portion of the plot are low-dollar parts and have little cost impact on the X-building operation. However, the old order frequencies suggest that these low cost parts were still produced with the same frequency as some of the more expensive parts.

Significant savings in total setup time for the X-building can be realized by producing the low-cost parts in larger batch sizes, thus requiring fewer setup times per year. For example, if a low-cost part with an annual demand of 3000 parts was originally produced at a frequency of 30 batches per year, the average batch would be 100 parts and 30 series of setups would be required each year for that part. However, if that same part were produced 10 times per year instead of 30, the average batch would be 300 parts and only 10 series of setups would be required. Assuming that each part travels through an average of three operations, and each operation requires a 30-minute setup, the total setup time savings for this particular part under the new batch size would be:

\[(30 - 10) \times 3 \times 0.5 \text{ hours} = 30 \text{ hours}\]

While the low-cost parts will generally experience annual setup savings under the revised order policies, the more expensive parts will not. In trying to optimize both on-time delivery and inventory costs, the batch sizes for many of the more expensive parts were actually reduced, increasing their production frequency. This, of course, would increase the amount of setup time required for those parts over the course of the year.

The net setup time savings as a result of the changes in fixed order policies can be determined by comparing the old vs. new production frequencies, calculating the setup
time gain or loss for each part, and summing these values for all X-building parts. The following equation summarizes:

\[
\text{Setup time savings} = \sum_i (opf_i - npf_i) \times ops_{avg} \times setup_{avg} \approx 30,000 \text{ hours}
\]

where:

\[i = \text{parts from 1 to 4000}\]
\[opf = \text{original production frequency}\]
\[npf = \text{new production frequency}\]
\[ops_{avg} = \text{average number of operations per part}\]
\[setup_{avg} = \text{average setup time per operation}\]

The setup timesavings determined are quite significant, and the direct annual labor savings alone can easily exceed $1M. More importantly, eliminating 30,000 hours of setups provides relief and much needed time resources for other improvement activities.

In addition to the setup timesavings, a second area of improvement for the X-building comes in the form of inventory savings. From Figure 4.1, the bottom left corner is highlighted as a region that produces the most significant inventory savings. Assuming constant demand or consumption and a fixed order policy, the average inventory level is equal to one-half the batch size plus any safety stock. [9] Also assuming that the level of safety stock will not change, the change in average inventory level will simply be one-half the change in the batch size for each part. Multiplying by the part value gives an average inventory cost for each part. Therefore, as expensive parts are produced more frequently, inventory savings will be realized.

For example, consider an X-building part whose total annual volume is 30,000 and total manufacturing cost is $2 per part. If the production frequency of this part changes from 10 to 20, the inventory savings for the part would be:

\[
\text{Inventory savings} = \frac{1}{2} \times \left( \frac{30,000}{10} - \frac{30,000}{20} \right) \times \$2 = \$2,850
\]
As with the setup time calculations, the effect on inventory savings will differ along the x-axis of Figure 4.1. Given the increased batch sizes of the lower-dollar parts, the inventory value will actually increase in this region. Therefore, to determine the overall effect the new order policies have on inventory, the gains or losses of each part need to be calculated, then sum the values for all X-building parts. As with the setup time savings, the below equation provides the net inventory savings for X-building:

\[
\text{Inventory savings} = \sum_{i} \frac{1}{2} \times \left( \frac{\text{annual demand}_{i}}{\text{opf}_{i}} - \frac{\text{annual demand}_{i}}{\text{npf}_{i}} \right) \times \text{tmc}_{i} \approx \$350,000
\]

where:

\(i = \text{parts from 1 to 4000}\)

\(\text{opf} = \text{original production frequency}\)

\(\text{npf} = \text{new production frequency}\)

\(\text{tmc} = \text{total manufacturing cost}\)

The simultaneous inventory and setup improvements may seem counterintuitive at first, but the power of the 80-20 rule applies. For the most part, setup time savings are independent of part cost, therefore doubling the number of setups for the top 20% of parts, does not present a significant negative effect to the overall operation (assuming machine availability), while reducing the setups for 80% of the parts does provide a significant improvement. However, inventory savings are a function of cost, therefore doubling production frequency of 20% of the parts can cut 80% of the inventory costs in half.

As previously discussed in Section 3.3, the third measured improvement as a result of the new fixed order policies was a 7% increase in on-time delivery. Together, the most immediate expected results of the X-building analysis are presented in Table 4.1.
Table 4.1. Summary of Results from X-building Analysis

<table>
<thead>
<tr>
<th>Measure</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-time delivery</td>
<td>7%</td>
</tr>
<tr>
<td>Setup time reduction</td>
<td>30,000 hours</td>
</tr>
<tr>
<td>Direct labor costs</td>
<td>(8,000,000)</td>
</tr>
<tr>
<td>Inventory value</td>
<td>(40,000)</td>
</tr>
</tbody>
</table>

4.2 Setup Reductions

The improvements in inventory, on-time delivery, and setups listed above are recognized as the initial step of the DPS implementation project. The optimal fixed order sizes provide initial stabilization and improvement, but the long-term goal is to continue to reduce batch sizes and transition toward demand-based production. Thus, operational improvements need to be identified such that the production frequencies associated with the various inventory classes can be increased without affecting customer delivery.

Lean manufacturing depends on the precept that setup times can be reduced to almost zero. [7] Setups prevent the flow of parts through a factory and incorporate waste into the system. Although Deere management generally recognizes the importance of reduced setup times, resistance exists because a clear relationship between setup time reductions and the DPS implementation effort in X-building does not exist. It was unclear how setup reductions would help, and which workcenters should be targeted. In past years, expensive, factory-wide setup reduction efforts took place, and the results were not convincing. Rather, a more focused approach is needed, with emphasis on the constraints.
Using the simulation model, the analysis hoped to provide the necessary direction. From
the output, workcenters queues were measured over the course of the simulation trial, and
workcenters were sorted by maximum queue length. Figure 4.2 presents the results.
From this chart, it became clear as to which workcenters to address. Even without the
simulation data, supervisors and schedulers knew which machines had “held up” the
operation, and which machines had the largest queues. The simulation data confirmed.

To measure the impact of focused setup reduction effort, 11 of 80 workcenters were
targeted. The original setup data inputted into the simulation for these workcenters were
reduced by 60%, a somewhat conservative number based on the magnitude of
improvement noted in setup reduction literature. [11] With the new data, the simulation
provided the results presented in Table 4.2.

Table 4.2. Effects of Setup Reductions Based on Simulation Results

<table>
<thead>
<tr>
<th>Run Description</th>
<th>Delayed Orders</th>
<th>Total Setup Hours</th>
<th>On-time Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Solution</td>
<td>4810</td>
<td>11822</td>
<td>92.0%</td>
</tr>
<tr>
<td>Setups reduced 60% at 11 constraints</td>
<td>2279</td>
<td>10211</td>
<td>95.0%</td>
</tr>
</tbody>
</table>
The data can be interpreted in two ways. First, the setup reductions had a significant impact on the number of delayed orders, and thus on-time delivery increased. With 92% as the baseline, delivery was improved 3%. Or, the situation could be presented such that all parts flowing through these 11 workcenters could have their batch sizes reduced some percentage without affecting on-time delivery. Either way, the impact of reducing setups on a specific few machines was noted.

Another way to justify the expense of setup reductions would be to look at number of direct hours of labor saved by a 60% reduction in setup time. For the 90-day simulation during peak production, approximately 1600 hours were saved. Interpolating this over the course of an entire year, another $200,000 annual savings can be expected. This, of course, would exclude any new indirect labor to help with the new setup procedures, and the cost to perform the setup analysis and make the necessary changes.

4.3 Other Continuous Improvement Activities

The X-building analysis provided an opportunity for X-building management to better learn the operations, understand the data, and question some of the existing norms. In addition to machine setup reductions, other improvement activities were identified and will be studied by union continuous improvement groups. Two such projects are discussed in this section.

Looking at the demand data for the X-building and listening to shop floor complaints, a major source of concern were the extremely low-volume service parts that were produced. Approximately 500 service-only parts were produced in X-building with annual volumes of less than 100. These parts often resulted in small, sporadic production batches, causing more of a nuisance to schedulers, supervisors, material handlers, and machine operators than anything else. One recommended improvement activity is to examine the most effective way to produce these low-volume service parts without disrupting regular production.
Section 2.3 highlighted the three types of parts produced by X-building: production-only, production/service, and service only. Production-only parts generally have the highest volumes, with the least demand variation. To further optimize the X-building operations, the Product-Process Matrix presented in Figure 4.3 is helpful. [12] The authors of this matrix suggest that product and process characteristics should be aligned along the diagonal for optimal efficiency.

Figure 4.3. Product-Process Matrix

On the diagonal, production-only parts would fall on the lower right portion of stage II, while the low volume service parts would fall in the upper left portion of stage I. In dealing with service parts, the authors of the Process-Product Matrix offer the following advice: “To accommodate the specific requirements of spare parts production, a company might develop a separate facility for them or separate their production within the same
facility. Probably the least appropriate approach is to leave such production undifferentiated from the production of the basic product, since this would require the plan to span too broad a range of both product and process, making it less efficient and less effective for both categories of product.”[12] Along the same lines, the X-building operations, resembling an intertwined mess of routings as shown in Figure 2.2, could be disaggregated into smaller lines or cells to more efficiently handle the wide range volumes and total annual costs of the regular production parts.

Another common shop floor frustration was the lack of coordination of parts that shared dies. For example, several different parts could use the same die at the same workcenter, yet these parts seemed to arrive at the various workcenters following a Poisson distribution. After running a particular part, workcenter operators would switch dies, and find that a part using the same die to appear the next day. The frustration stemmed from seemingly performing a bunch of unnecessarily setups. A continuous improvement project could create a scheduling procedure to reduce this problem without negatively affecting inventory of delivery.

Unfortunately, the magnitude of the problem is unknown, for this type of same-die part information was not available. Sorting through the demand data, parts with identical demand and manufacturing multiples were assumed to be parent-child (or left-right) parts, which would share the same dies. (Through conversations with machine operators, these types of same-die parts were probably in the minority since a wide variety of parts (in terms of shape, size, and demand) can often share the same die.) Therefore, an extremely conservative estimate identifies approximately 150 parent-child parts, equating to a potential reduction of almost 1700 setups per year, or close to $50,000 in direct labor savings.

Jonathan Rheame studied a similar problem during his internship at Hamilton Sundstrand in which he developed a method to calculate optimal lot sizes for a family of parts that share setup costs. Rheame’s premise is that the classic EOQ formula assumes each part had an independent setup, but if some setups are common, the optimal batch
size, and thus inventory, will be significantly smaller. [13] One example presented in his thesis suggests a 25% reduction in lot size and inventory when same-die parts are scheduled appropriately. While this example highlights the impact of same-setup considerations, the challenge for X-building is not determining the optimal batch size, but rather determining an effective procedure such that same-die parts arrive at the appropriate workcenter at the appropriate time.

4.4 Standardized Work

"Standardization is the foundation of continuous improvement; create high agreement and no ambiguity. Every improvement, every problem solved and every process changed must be standardized. If it isn’t standardized, then you don’t have high agreement on how things work." [14] Within the X-building, the fixed order policies are the start of standardized work, which are based on agreement between customers, schedulers, supervisors, and shop floor workers. Prior to the project, most order policies were time-based and subject to manual manipulation by schedulers and shop floor workers. By fixing the order policies, benefits are realized by both X-building and the customers.

Fixed orders are necessary from the customer perspective. As new assembly layouts are constructed, a specific location and space are assigned for each part. Therefore, the part must be delivered from the X-building consistently in the appropriate container and quantity. No room exists for excess parts, as they would end up cluttering the isle of work area. Too few parts will require additional material handling and production by the X-building and customer.

Within the X-building, standard or fixed orders provide the workcenter operators and schedulers a tool for improvement. In the past, orders were generated from some “black box” and since the orders varied, no one knew what the correct order should be. Now, the machine operators and schedulers are informed of the fixed order, and any discrepancies from this number can be brought to the supervisors’ attention. For example, if the third operation for a part expects an order of 100, but receives only 80,
this is an indication that something happened upstream, possibly a quality problem at one of the workcenters, or shortage of raw material. Regardless the cause, the problem can now be brought to surface, and given the structure of the union contract. Coincidently, it is in the machine operators’ best interest to produce as close to the fixed order as possible (producing batches of 80 vs. 100 will negatively affect pay.) Problems should then surface naturally.

A final side effect of standardized orders is a reduction in MRP volatility. The reinforcing loop shown in Figure 4.4 describes this effect. Fixed orders equate to more consistent delivery to the customers, which improves inventory accuracy. Inventory adjustments serve as a main source of variability within Harvester Works, and reducing these adjustments will improve MRP accuracy. With more accurate MRP schedulers, delivery to customers will be improved. While studying several scheduling and production alternatives at Hamilton Sundstrand, David Greenwood concluded that one of the easiest and quickest solutions to reduce MRP schedule variability is to switch to a fixed lot size policy. [15]

Figure 4.4. Reinforcing Loop for Improved MRP Performance
4.5 Avoiding JIT Disaster

As mentioned in Chapter 1, a main goal of this project analysis was to determine the best way to satisfy the new DPS requirements of the X-building customers. Prior to this investigation, customers designed their assembly areas and operations around using the general kanban formula: [10]

\[ K = D \times Q \times R \]

The desired order size by the customer, \( K \), is a function of the replenishment time, \( R \). However, it was uncertain exactly how long it took parts from the X-building to be produced and delivered to the customer. Therefore, a somewhat arbitrary 5-day rule was used, which assumed one day per operation plus one day to schedule and another to order. Intuitively, this made sense and would “force” X-building to produce only what was needed. Only one customer used this philosophy before the link between inventory class and production frequency was established.

Using the simulation tool described in Section 3.3, a hypothetical scenario was analyzed in which all X-building parts were produced with a replenishment time of five days, or every part was produced every week. The results are listed in Table 4.3. Inventory values were much lower, as desired, but on-time delivery suffered dramatically. Given the current operations, X-building could not have met these requirements. Fortunately, a disaster was avoided.

Table 4.3. Simulation Results with Five-Day Replenishment for All X-building Parts

<table>
<thead>
<tr>
<th>Run Description</th>
<th>Delayed Orders</th>
<th>On-time Delivery</th>
<th>Inventory Value ($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Solution</td>
<td>4810</td>
<td>92%</td>
<td>2.85</td>
</tr>
<tr>
<td>( R = 5 ) days for all parts</td>
<td>35493</td>
<td>45%</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Two key lessons for Deere management came from this exercise. First, there is more to just-in-time delivery than just slashing batch sizes. Operational improvements need to take place in order for reduced batch sizes not to affect delivery. In this case, setup times reductions at the bottlenecks need to be performed before batch sizes can be reduced. Second, the replenishment time used in the customer kanban formula needs to take into account supplier capabilities. For this to happen, open communication and operational visibility need to exist.

4.6 Organizational Training

By far, the most important element in any organizational transformation initiative is that of education and training. These are especially critical in transitioning an organization from a mass-production paradigm to a lean production paradigm. [7] One advantage of this project is that it provided the X-building with a full-time resource dedicated to the DPS project. Given the hectic schedules of most X-building personnel, the addition was needed to collect and analyze date, coordinate DPS activities, and visit customers. Another indirect benefit was the education of X-building employees along the way. This was accomplished with informal and causal conversations to actual training sessions and games.

Beer Game

“I just don’t understand how one week can be so different than the next. Final assembly makes the same number of combines each day. It makes my job difficult, and it’s pretty damn frustrating.”

– X-building 2nd Shift Supervisor

During a meeting with an X-building supervisor, the above frustration emerged. Knowing his description fit the classic bullwhip effect; a session was arranged in which this phenomenon was explained, how it can be dampened, and how the DPS project will improve the situation. The Beer Game, a role-playing simulation designed by MIT to
teach principles of management science [16], was used as the main instruction tool to demonstrate these effects. Supervisors and schedulers from X-building were the main audience for the exercise.

The four stations used in the Beer Game were related to the situation at Harvester Works, as shown in Figure 4.4. The final assembly line represents the Retailer, which sees constant demand, while the X-building presents the factory, three steps removed from the final assembly. As the game was played, the regular, expected emotions surfaced. Frustrations, confusion, and anger were a few. During the game, one retailer shouted, “How come I keep receiving so much? Something must be wrong. I can’t take any more beer.” Comments like this one were recorded and discussed at the conclusion of the game. Figure 4.5 shows one team playing the Beer Game.

Figure 4.4. Four Stages of Harvester Works’ Supply Chain

![Supply Chain Diagram](image)

Following the game, the participants playing the factory and distribution roles were asked to graph their expectations of customer demand at the retail end of the supply chain. Most concluded that some type of oscillation must have caused their problems, and all were surprised to learn that the demand was constant. Then when asked whether miscommunication or self-optimization existed between departments at Harvester Works, laughter erupted. Of course it did. Finally, the effects of these problems were related to the oscillation of demand that so frequently frustrates the X-building.

This exercise resulted in an understanding of how DPS will improve the X-building situation. First, open communication and a production system that optimizes the entire chain rather than each individual department will reduce the amplification. Second,
synchronized production between the final assemblies and the sub-assemblies prevent some of the problems as well. And finally, the importance of reduced lead times within X-building. Having smaller batches and faster response times will also improve the situation.

In addition to highlighting DPS lessons useful to improve X-building performance, the Beer Game provided an opportunity to have fun and increase enthusiasm and excitement for the DPS implementation project, and again communicate the long-term vision of DPS. Being able to recognize that the long-term benefits are superior to the current situation will create more patience for the short-term pains of the implementation process.
"What’s a kanban again? I took the 4-day DPS training class a while ago, but I don’t remember."

X-building 1st shift scheduler

Two concerns surface from the statement above. First, a scheduler, who plays a critical role in the X-building operations, lacks understanding of one of the main principles of the DPS implementation, replacing MRP scheduling with demand-based signals or kanbans. Since this portion of the implementation is a ways away for the X-building, this concern was less important than the second: after spending four days in training, a main DPS principles was not retained. The lack of retention of the kanban concept, and the repeated questions brought about the development of a simulation exercise that hoped to reinforce some of the key principles. Like the Beer Game, one objective of this tool was to make it fun and create excitement around DPS.

The game simulated the consumption and replenishment of products, and the products of choice were Kit Kat candy bars. The simulation started out by placing two kanban squares on the desk of each of the three X-building schedulers. When the “products” were consumed, inventory was replenished from central location in X-building, and responsibility was assigned for that process. The central store in the X-building was stocked once a week by purchasing three bags of Kit Kats from the local grocery store. Based on consumption forecasts, three bags were thought to be sufficient for the week.

Figure 4.6. Supply Chain for Kit Kat Simulation
This was all the information provided as the exercise began, and it was up to the schedulers to suggest improvements. Figure 4.6 shows the flow of material, and Figure 4.7 shows the Kit Kat location on a scheduler’s desk.

Figure 4.7. Kit Kat Kanban Squares

At the start, a lot of excitement surrounded the game, and consumption was rapid. The material handler used visual management (an empty kanban square) to restock inventory, and all was well. A time came when the material handler was tied up in his office and was unable to rely solely on the visual management techniques, and as a consequence, the “production line” ran out of product. To remedy this situation, the schedulers developed an electronic signal (email) to the material handler when replenishment was needed – lesson #1: communication is critical. As the game went on, the material handler was often tied up for extended periods of time away from X-building, and again, the production line ran out of product. Instinctively, the schedulers added additional kanban squares (see Figure 4.7) to prevent this from happening again was found to be tied up in meetings or away from X-building – lesson #2: the amount of inventory is a function of replenishment time. A third lesson that evolved from the game was the negative impact of shrinkage. As expected, passerbies snatched many of the Kit Kats.

Via the Kit Kat Kanban exercise, the schedulers became familiar with the concepts and started using terminology in their every day language. Lasting almost four weeks, the
game provided continuing reinforcing of these principles. Union leadership on the Harvester Works DPS team caught word of the exercise and applauded the activity as a fun, innovative, and effective teaching method. The most remarkable outcome was that the schedulers arrived at the two lessons above on their own in response to delivery problems. The email below was sent to the material handler after one stock-out, and represents his improved understanding of the entire supply chain.

"Due to the inability of our supplier to produce and furnish us with needed raw material, we have shut down the line. We have remedied this by substituting green peppers in place of Kit Kats, but customers don't seem to be as happy with the substituted material. This will only be a temporary fix as the temperatures are expected to drop below freezing which will put an end to the growing season at Charlie's House of peppers and adversely affect the supply of peppers. During this critical time we must act fast and find a more permanent supply of the original material or a more viable substitute."

Informal Conversations

In addition to the more formal training exercises, a full-time DPS resource committed to X-building provides many opportunities for informal conversations about operational improvements from a broader perspective. These continual discussions were the most valuable for both the employees to learn more about the DPS vision, but also the DPS team to learn more about the subtleties of the X-building operations. As an example, a scheduler was once asked how the expediting process worked, and what were the criteria for interrupting jobs at certain workcenters. With no formal procedure in place, the situation was viewed from a larger perspective.

Figure 4.8 shows the reinforcing loop that evolved from the conversation. Essentially, hot jobs lead to more expediting, which leads to more partial batches. Partial batches lead to more setups at a workcenter (rather than one setup for the whole batch, a setup is required for the initial portion, and again to finish the order once the expedited order
passed. Given a fixed capacity within the X-building, more setup time reduces the amount of time available to produce parts, which in turn creates more hot jobs. As a result of this discussion, the scheduler realized that there are consequences for his actions, and the consequences are not always obvious. His response, “I never looked at it like that before.”

Figure 4.8. Effects of Expediting

4.7 Future State

Only understood processes can be improved. [17] Thus far, much of the discussion focuses the understanding and stabilization of the X-building processes. Knowing that the final state of the DPS implementation would replace MRP production scheduling with a demand-based production philosophy, another result of the analysis was the formulation of this vision, and link it with the continuous improvement activities that have been described. It is important for X-building and Harvester to understand how all the activities within X-building strive for the same goal.

The feederhouse (Dept. 965) sub-assembly was X-building’s customer that was furthest along with their DPS implementation efforts. Batch sizes had been fixed for parts routed to this particular sub-assembly, and delivery had become somewhat consistent in terms of container and quantity. The next step was to work with this customer to identify the
necessary steps for the transition, and understand mechanics of the current processes before proceeding.

Figure 4.9 presents the current and future state of product flow between X-building and Dept. 965. Currently, based on MRP forecasts, X-building produces the desired fixed quantity and delivers to a storage unit in the desired container. Within the assembly area, two kanban squares house two containers of these parts. When the first container is consumed, a signal is sent for material handlers to move the second container to the assembly area. Once the second container is moved, an electronic signal is sent from the Dept. 965 area to the storage area for another container of parts. The storage area acts as a buffer between the actual demand of the downstream departments and the MRP production of the X-building, and thus results in an extra layer of inventory. The future state hoped to eliminate this storage area, but only when MRP production to each customer was consistent.

Figure 4.9. Current and Future State Material Flow Between X-building and Dept. 965

Current State - 965 Replenishment

Future State - 965 Replenishment
Although the future state has yet to be implemented, a series of discussions took place and a number of questions surfaced about the mechanics of the new system. A few questions include:

- How will information sent from the Dept. 965 area to the X-building, and communicated within the X-building?
- Who will receive the information, what will he/she do with it?
- How will the X-building machine operators be affected?
- How will the transition process take place? Customer-by-customer, part-by-part, etc?
- What information systems improvements need to be made once the processes is scaled up to include all X-building parts?
- Should all X-building parts be included?
- How will the X-building steel suppliers be affected?
- What will be the new responsibilities of the X-building schedulers?
- Who will be responsible for delivery of parts from X-building to Dept. 965?
- How can the flow of these “triggered” parts be monitored

In addition, the discussions opened communication channels and brought together key stakeholders, such as systems engineering, customers, production control, and X-building supervisors and management to better understand the benefits of the system, and understand the new roles and responsibilities if such a system were to be implemented. The discussions also revealed that such a transition is not merely an X-building-specific project, but requires the commitment and resources of the entire factory in order to be successful.

4.8 Implementation Plan

The final tangible result of the X-building analysis was a summary of the steps of implementation such that the overall picture can be communicated within Harvester Works and the lessons learned could be transferred to other primary manufacturing facilities within Deere. Essentially, the initial successes and projected next steps were
categorized into four main steps, as presented in Figure 4.10. This implementation plan was developed with and supported by Deere’s corporate engineering department responsible for DPS development.

The first step involves understanding the internal operations, using simulation models to gain insights, identifying an optimal production strategy, and making quick operational improvements to provide stability. Once the primary manufacturing facility has its operations in control, it can communicate with its customers to meet their DPS needs in a way that is optimal for both parties. After satisfying customer needs, the manufacturing operation can then identify a number of improvement activities that will help reduce batch sizes and drive toward one-piece flow. Finally, the fourth step of the transition would be to “unplug” the MRP system, and build to demand.

Figure 4.10. DPS Implementation Plan for Primary Manufacturing

<table>
<thead>
<tr>
<th>Fix Order Policies</th>
<th>Work with Customers</th>
<th>Continuous Improvement</th>
<th>Pull Production</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Provide DPS, Demand Flow, and ALiSS training</em></td>
<td><em>Gather customer requirements</em></td>
<td><em>Continually review batch sizes based on worker and customer feedback</em></td>
<td><em>Map future state of order triggering process</em></td>
</tr>
<tr>
<td><em>Map current processes</em></td>
<td><em>Negotiate batch solution</em></td>
<td><em>Train in 5-S, setup reduction, and CI</em></td>
<td><em>Determine system and organizational requirements</em></td>
</tr>
<tr>
<td><em>Understand and categorize demand</em></td>
<td><em>Adjust to full container</em></td>
<td><em>Focus improvement efforts at constraints</em></td>
<td><em>Address service spikes with non-replenishable kanbans</em></td>
</tr>
<tr>
<td><em>Create ALiSS/SIX simulation model</em></td>
<td><em>Input necessary changes into system</em></td>
<td><em>Annually review demand and sizing criteria</em></td>
<td><em>Create kanban monitoring system</em></td>
</tr>
<tr>
<td><em>Identify batch size restrictions</em></td>
<td><em>Create procedure to digest feedback</em></td>
<td><em>Drive toward ever shrinking batch sizes</em></td>
<td><em>Pilot projects to gain additional insights and prove impact</em></td>
</tr>
<tr>
<td><em>Determine appropriate sizing criteria for each inventory class</em></td>
<td><em>Continue to drive with MRP</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.9 Foundations of X-building DPS Implementation

To summarize the results presented in the chapter, Figure 4.11, shows a common framework to represent the Toyota Production System, which includes its three highest level goals: highest quality, lowest cost, and shortest lead time. [18] To better understand the framework, the following definitions are provided: [6]
**Just-In-Time** – a system for producing and delivering the right items at the right time in the right amounts.

**Jikoka** – transferring human intelligence to automated machinery so machines are able to detect the production of a single defective part and immediately stop themselves while asking for help.

**Heijunka** – the creation of a level schedule by sequencing orders in a repetitive pattern and smoothing the day-to-day variations in total orders to correspond to longer-term demand.

**Kaizen** – the continuous incremental improvement of an activity to create more value and less waste.

Figure 4.11. Toyota Production System Framework

This framework emphasizes the importance of a stable manufacturing base before proceeding through the implementation process, and then identifies the two pillar to reach the highest level goals: perfect quality and perfect delivery (in terms of time, quality, and mix). [18] Due to the demand characteristics of Deere’s products, philosophies such as Heijunka are not followed by Deere, but generally the X-building’s DPS project parallels
this framework. The fixed order optimization resulted in significant inventory, setup, and delivery savings, stabilizing the manufacturing environment and reducing the turbulence surrounding the current operations. This is the current state of the DPS project. Moving forward, the X-building will direct the training and employee involvement generated during this project toward the continuous improvement activities described in this chapter. Again, the goal is to synch the X-building operations with the rest of the factory, and transition toward a pull production philosophy, resulting in improved cost, quality, and delivery.
Chapter 5. Organizational Analysis

“The hard stuff is easy. The soft stuff is hard. And the soft stuff is more important than the hard stuff.” [19]

- Steven Wheelwright

Up to this point, this thesis has focused mainly on the technical analysis involved in Deere’s DPS transition. The premise that a process must be understood before it can be improved was presented in the previous section, and this also applies to the organizational issues of the DPS implementation. This chapter presents an organizational analysis that parallels the technical analysis presented in the previous chapters. After performing a three-lenses analysis, this chapter applies the MIT Leadership Model to the X-building DPS implementation.

5.1 Three-lenses Analysis

Each of us has schemas that affect what we pay attention to and what we ignore. [20] Because personal biases, beliefs, and positions affect our interpretation of a situation, it is important to use a framework in an organizational analysis to ensure that all relevant data are captured, and the situation is fully understood. The three-lenses analysis provides this framework by focusing on the following three classic perspectives: [20]

- The Strategic Design Lens
- The Political Lens
- The Cultural Lens

This section applies each of these three perspectives to the DPS implementation within X-building, and considers the larger DPS initiative which continues today, and which encompasses much more than the analytical analysis presented in Chapters 3 and 4.
5.1.1 The Strategic Design Lens

People who take this perspective look at how the flow of task and information is designed, how people are sorted into roles, how these roles are related, and how the organization can be rationally optimized to achieve its goals. [39] Through discussions with Harvester veterans, many have considered the X-building the “neglected child” of Harvester Works, yet sheet metal manufacturing has been identified as one of Harvester Work’s core competencies. It is difficult to identify a strategy for the X-building. As outlined in Section 2.4, the current strategy of the X-building was essentially expediting in order to keep the final assembly line from shutting down. On a short-term basis, inventory and delivery goals are the main focus of X-building management, and somewhat arbitrary 20% improvements were sought each year. The amount of overtime used by X-building is extreme when compared with the final assembly line schedule. Three shifts and entire shut down periods were needed to support the single-shift assembly line. Reducing this is also a priority.

The strategy of Harvester Works is to continually reduce assets and strive for the 20% OROA, so these expectations are also handed down to the X-building. In addition to the DPS project, other initiatives include removing the Cut-to-Length machines (old machines used to cut sheets of steel from coils, which would require suppliers to cut sheets rather than X-building) and in-sourcing material and machinery currently used in other parts of the factory. Yet despite the number of improvement activities, the long-term strategy for the X-building was unclear, for lack of investment in people, time, and equipment was evident. One result is that machine downtime plagues X-building operations.
Figure 5.1 presents the organizational structure within Harvester Works with respect to the X-building project. The X-building Business Unit Leader (BUL) is responsible for the operations of the X-building, and his only reports are five first and second shift supervisors. The BUL from each department reports to one of two manufacturing managers. The Harvester DPS team also reports to this position. The X-building project presented in this thesis worked jointly with the DPS Team, the X-building BUL, and the corporate engineers from Deere & Company.

The DPS project fits well with the strategy of both Harvester Works and the X-building. First, lean manufacturing is a proven philosophy that produces significant improvements in inventory, cost, and quality. In addition, Deere’s version, DPS, is recognized and
supported as the tool or methodology to reach the 20% OROA target. An improvement effort of this magnitude finally provides much needed time and resources to improve X-building operations.

However, despite the fit, many structural challenges within the organization potentially make the transition difficult and may hinder its success. First, X-building is currently very functionally divided, with only the shift supervisors under the direction of the X-building BUL. Schedulers, engineers, and maintenance are critical to X-building operations; yet they report vertically through many layers to other organizations. Getting cross-functional collaboration in this type of functional environment is difficult.

Another concern is the traditional roles of X-building supervisors, schedulers, and engineers, who involve reactive problem solving to issues that arise. Rarely during the X-building project was there mention of any type of proactive improvement effort to relieve some of the pressure and frustration, and the reasoning for this state may be: 1) This is how each role has always been performed, and that is how training was given. As described by one scheduler, “I’ve been doing this for 20 years, and this is how we’ve always done it.” Or 2) Peak production season hits during the summer and early fall, so naturally things are worse. Time just does not exist for any preventive or corrective actions.

A third major concern is the structure of the union contract for the shop floor workers. The basic points of the contract define a worker’s specific role and the pay associated with these tasks. Pay for each worker is based on an output over input ratio, which provides incentives to produce in larger batches with fewer changeovers. With the final vision being a state of one-piece flow, this contract structure presents potential problems. In addition, to pay, job assignment and responsibilities are defined in the contract and thus the flexibility required by a lean manufacturing implementation is less. Also, the union workforce is divided into several departmental teams, and each team is awarded for superior performance. While this promotes teamwork within each department, it does not promote teamwork across the various departments within X-building.
Experience has shown that lean manufacturing conversion does not typically require extensive capital investments, however, the primary investment required is the time of the entire management team and workforce. [7] The current work roles (expediting and fire fighting) of the X-building supervisors, schedulers, and engineers provide little of this necessary time, which could potentially hinder the success of the DPS implementation. Similarly, the Harvester DPS team consisted essentially of only two full-time personnel; while others were suppose to be committed part time. During busy times, these commitments often fell to the bottom of the priority list. This structure could also limit the success or pace of the DPS implementation.

Another organizational issue that may hinder the success of the implementation project is the transient nature of the X-building BUL position. One X-building supervisor put it best when he said, “I’ve had five different bosses in the last four years. How am I supposed to keep anything straight?” It has also been suggested that senior Harvester management perceives the X-building as a “training ground” for future leaders of the company, and therefore a long-term stay is not expected. Each BUL has a different managerial style, method, and expectations, and this lack of consistency is difficult for the direct reports. Fortunately, the BUL currently in place appears to offer at least a 2-year commitment to the department, which will help with the project.

And finally, at times, the metrics for X-building performance were misaligned with the DPS strategy of Harvester Works. Figure 2.5 shows the transition plan, which includes a RIP area to store inventory until the MRP system is “disconnected.” This RIP area will benefit the entire factory, yet is considered X-building inventory. Therefore, increasing the usage of the RIP areas contradicts the 20% inventory reduction target assigned to the X-building.
5.1.2 The Political Lens

People who take this perspective look at how power and influence are distributed and wielded, how multiple stakeholders express their different preferences and get involved (or excluded from) decisions, and how conflicts can be resolved. [20] The first step in a political analysis is to understand all the stakeholders involved in the project, and their respective interests and stance on the project. Figure 5.2 presents a map of the key stakeholders. Stakeholders are individuals and groups who contribute important resources to an organization and depend on its success but who also have different interests and goals and bring different amounts and sources of power to bear in organizational interactions. [20] This map indicates whether each party is for or against the project when it started in June of 2002. Being for, “+”, the project or against, “-“, takes into account each stakeholder’s role in the project and potential impact on the project. For example, a critical department being uninterested in the department (and not necessarily against the project) still leads to a negative political effect.

Figure 5.2. Stakeholder Map for X-building DPS Project
Table 5.1. Stakeholder Interests

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Interests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deere &amp; Company</td>
<td>Support and develop DPS</td>
</tr>
<tr>
<td>Factory Management</td>
<td>Reach 20% ROA</td>
</tr>
<tr>
<td>Harvester DPS Team</td>
<td>Implement DPS</td>
</tr>
<tr>
<td>X-building BUL</td>
<td>Meet customer demand and improve operations</td>
</tr>
<tr>
<td>Systems Engineering</td>
<td>Provide technical support to DPS</td>
</tr>
<tr>
<td>Production Control</td>
<td>Schedule</td>
</tr>
<tr>
<td>X-building Supervisors</td>
<td>&quot;Make it through the day&quot;</td>
</tr>
<tr>
<td>Shop Floor Workers</td>
<td>$$$$</td>
</tr>
<tr>
<td>X-building Customer</td>
<td>Consistent delivery in small batches</td>
</tr>
<tr>
<td>X-building Engineers</td>
<td>&quot;Business as usual&quot;</td>
</tr>
</tbody>
</table>

To accompany the stakeholder map, Table 5.1 lists each stakeholder and its respective interests. This will help identify the motives and perspective of each stakeholder, and will bring to light the reasons for their stance for or against the project.

From Figure 5.2 and Table 5.1, a couple of issues emerge – many stakeholders exist for this project, and each stakeholder represents different interests. This highlights the importance of a cross-functional team approach to such problems, which provides an opportunity to communicate and incorporate the various interests of the organization. By taking these considerations into account early, potential devastating conflicts can be avoided. In addition, as the stakeholder analysis is performed, it is important to understand the sources of power each party offers, which can be used when goals or interests conflict.

For the most part, all parties external to the X-building understand DPS and recognize its importance to the Harvester Works strategy. The corporate engineers from Deere & Company developed the DPS manufacturing philosophy by studying the best practices of the various facilities and compiling the results into a universal plan. They now are interested in implementing the entire DPS plan within Harvester, and offer their support in the processes. This stakeholder definitely supports the project, and the power this party brings to the project is their expertise. When conflicts between parties emerge, the corporate manufacturing engineers can objectively provide their recommendation, based
on experience in other factories. Yet, they provide no authority to implement the recommendation.

When describing the implementation process, *Lean Transformation* states that, “Strong, committed leadership will be absolutely essential.” [21] Clearly, leadership offers the most influence and power of any stakeholder during a change initiative, and the DPS effort is no different. However, from the perspective of X-building, the leadership commitment was not always present. Rarely did senior leadership of Harvester Works visit the X-building and promote the DPS effort, and rarely did leadership sit in on the weekly Harvester DPS meetings to show interest or offer encouragement. Some argued that the Harvester leadership team was not as sold on lean manufacturing as they should have been, and that may have showed. This may have happened for three reasons: 1) DPS was new to the organization, and the full benefits and implementation approach were not fully understood by anyone, 2) the hierarchical structure hindered communication from penetrating all levels of the factory, or 3) X-building is just too early in the implementation processes, and other departments further downstream may have attracted leadership’s attention. Regardless the reason, during such difficult long-term transitions, visible leadership commitment is critical.

Within the X-building, however, the leadership commitment was evident. Continually, sessions were held with CI Grow teams, supervisors, and engineers to collect feedback, discuss the process and status, answer questions, and rally change. As noted earlier, the X-building position had become a training ground for future leaders of the company, so ambitious, educated MBAs brought fresh perspective and life to the department. In addition, the BUL showed effective leadership skills and was well respected by all levels of the organization. This certainly supports and helps the DPS implementation process.

Regressing in power, the next major stakeholders were the shop floor workers. X-building’s Quality Coordinator and respected union employee assured the project team that, “Those guys (the union) can either make a bad plan work, or a good plan fail. They will determine the success of the project.” So, clearly this stakeholder had power, but
their interests were primarily tied to pay. With the initiation of DPS, the notion quickly spread that DPS meant smaller batch sizes and smaller containers, which would equate to less pay under the current contract. This concern obviously led to negative feelings toward the project, and answers to the questions were not initially available. But this negative stance did not necessarily oppose DPS, it opposed the pay reductions the workers expected to result from DPS. As a result of this tension, two insights surfaced:

1) Communication and involvement are important. Explain exactly what DPS would do, and what it would not do. Initially (as shown in the analysis in Chapters 3 and 4), huge cost and timesavings existed for both Deere and the union workers, but this was in the short term. And 2) As DPS became more fully implemented, batch sizes would only get smaller, and this did conflict with the current pay structure. With the current contract up for review in Fall 2003, these DPS issues need to be incorporated such that incentives of all parties are aligned.

For the most part, the remaining stakeholders, the engineers, schedulers, supervisors, and systems engineers were in favor of the DPS transition to the X-building but may potentially hinder the transition for two reasons: 1) personnel in these disciplines have generally held the same position for a number of years and have become content with “business as usual.” Therefore, enthusiasm and involvement were at times less than desired. And 2) many times, these disciplines are resource constrained and lack the time to commit to the change. Yet, they all recognize the current frustrations of their jobs, and the opportunity for improvement, so continued education and time for such activities could switch their stance on the DPS project.

Relationships between stakeholders within X-building were “pleasantly” traditional. The schedulers insisted that the engineers were lazy. Generally, the union workers thought the schedulers and engineers were morons. And according to most, the supervisors never did anything right. Despite many such jokes that floated around the area, all departments had pretty good relationships, and could usually work together when needed. But two exceptions existed, 1) the union pay issue was a more serious concern and involved higher-level management. These were really the only conflicts that surfaced thus far in
the process. And 2) the departments really only worked together when they needed to, and never proactively. One of the schedulers said it best when he described his relationship with the shop workers, and why help was not offered:

"They are like stray cats. Once you feed them, they will always come back for more."

Relationships external to X-building were even better, largely due to the reputation and abilities of the BUL, who served as the main boundary manager for the X-building DPS project. Customers, systems, the Harvester DPS team, and corporate engineers were always willing help and cooperate. A main reason for these “let’s work together” relationships was due to Deere’s culture, which will be discussed in the next section.

5.1.3 The Cultural Lens

People who take this perspective look at how history has shaped the assumptions and meanings of different people, how certain practices take on special meaningfulness and even become rituals, and how stories and other artifacts shape the feel of an organization.

[20] Deere has a long history of quality and integrity, and thus these are two of the most important characteristics of the Deere culture. Recognized as one of the oldest industrial companies in the US that produces the premier products in its market, this commitment to quality originated with the founder when he stated, “I will never put my name on a plow that does not have in it the best that is in me.” [22] Founded in 1837, Deere & Company was run by family until 1978, a stretch of 141 years. [23] The family run business instilled a great sense of tradition, pride, and employee loyalty, and coupled with its Midwest location, a friendly atmosphere. Deere’s commitment to integrity continues today as it is continually recognized as one of the most admired companies in America. [24]

The long, continued success of Deere led to a culture that can assist in the X-building DPS project. As noted earlier, the relationships between all stakeholders are genuinely good, as a result of the “sense of family” and friendly work environment at Deere. Also,
Deere has provided good jobs and security for generations of workers, thus employees demonstrate a great sense of loyalty and commitment to the company and its products. Figure 5.5 shows the Quality Coordinator’s loyalty to the company, as he painted his golf cart John Deere green. These characteristics are definitely beneficial in the transformation process, and will help in resolving conflicts and problems.

While the culture remains strong, the Harvester Works DPS project signals a transition for Deere. No longer can the company compete solely on hard work and quality. Cost, speed to market, and efficiency are becoming increasingly important, especially given that the US agricultural market is not growing, and international operations have begun to pressure US facilities. Bob Lane’s, the current CEO, message and goal was clear, “Build a business as good as our product.” [1] And as a result, Deere had to challenge and change its current operations, which have been grounded on over 160 years of success and stability. Employees also recognized the situation. Reflecting on the past when the factory was humming at an employee and production rate over three-times its current level, the notion that “Deere just isn’t what it used to be” often emerged.

Figure 5.5. Symbol of One Employee’s Loyalty to Deere
The strong culture at Deere also provides some interesting challenges for the DPS project. The old, industrial company presents a very hierarchical structure, which contradicts the flatter, more flexible organizational structures of world-class lean manufacturers. During the change process, leadership commitment must be visible to all employees, not just the respective direct reports. Decisions will start being made at point of the problem, rather than communicated upward.

Another cultural challenge involves dealing with the lifetime of success and stability felt by many employees. The main issue is the notion that success can breed complacency, and this was noted in the stakeholder analysis as a possible project hindrance for the engineering, scheduling, and supervisory functions. The same personnel have played out these roles for many years, so changing habits and responsibilities will be difficult. To make matters worse, the old Harvester Works workforce is entering the disengagement stage of their careers [25], in which they are nearing retirement and potentially becoming less involved. During a DPS meeting, this tone was expressed when one participant suggested the project “wait another year and a half” to implement a significant production change, since he would no longer be around at that time. Bringing in new, MBA perspective to the X-building BUL position helps offset some of this inertia. And finally, another side effect of an old workforce is that past improvement activities are remembered. Communication and leadership commitment are necessary to ensure the workforce that the DPS transition is a permanent, long-term change, and not another flavor-of-the-month type activity.

Deere’s commitment to employees provides potential conflict with the DPS effort and efficiency improvement. The sense of security established over the years promotes a sense of complacency, and X-building has identified several workers that provide questionable contribution. Harvester’s philosophy reassigns or essentially accepts these low performers as a result of its sense of family or employee commitment. Deere has to juggle its reputation as being a good employer with its desire to become an efficient operation. Removals may be necessary.
The X-building cultural response to the DPS initiative was unclear, which is consistent with its “business as usual” attitude. The message was communicated to the X-building workforce that leadership is committed to this project, and things will change. As the X-building BUL explained, “We can either become part of the transition and influence the decision, or be directed what to do later in the processes. Either way, DPS will happen.” Despite this message, little reaction existed. Many inquired and asked questions about the project, but not much more than that existed. A reason for this may be that the optimization presented in the previous chapters provides minimal change to the current X-building operations. However, the next steps of the DPS implementation will, and the reaction by the different stakeholders should be more dramatic.

5.1.4 Organizational Conclusions

Despite the many aspects of the Harvester Works organization that encourage change, the three-lenses framework highlights some difficult organizational challenges faced by the long-term X-building DPS project. First, it should be recognized that the current culture is embedded in many generations of Deere success, so change will neither be easy or quick. Much inertia for the status quo exists. Couple this with a perceived lack of Harvester Works leadership commitment (no sense of urgency, no visibility, little investment, under-staffed DPS team, etc.) and the functional structure of the organization, and cross-functional collaboration, a necessary process to include all stakeholder interests, will be slow. And finally, the union workforce is committed to Deere and the quality of their work, but their current contract will only breed hostility. Flexibility with regard to this issue will be necessary. These conclusions point out that the organizational issues are equally, if not more, challenging than the analytical aspects of a lean implementation.

5.2 MIT Leadership Model for Catalyzing Action and Change

To continue the organizational analysis, the MIT Leadership Model for Catalyzing Action and Change is applied to the X-building DPS project. [26] The model consists of
six steps for creating change within an organization: 1) discovering the organization, 2) developing relationships, 3) building momentum, 4) creating a vision, 5) innovation and change, and 6) refining and learning. The context for this analysis is the longer-term X-building DPS project, of which the analysis presented in the previous chapters is only the start.

5.2.1 Discovering the organization

Understanding the organization and situation serves as the foundation for the entire change process. Identifying goals, expectations, processes, motives, sources of power, structure, and culture for all stakeholders are necessary for change agents to construct a viable change management plan. Success depends on one’s ability to understand and adapt to the situation. In discussing leadership that gets results, Daniel Goleman suggests that “leaders with the best results do not rely on only one leadership style; they use most of them in a given week – seamlessly and in different measure – depending on the business situation.” [27]

Being an outsider new to an organization, as was the case for this project, this step is especially important. Referring back to the premise that organizations and processes must be understood before they can be improved, “discovering the organization” was a main focus during the first two months of the X-building project. Through conversations and observations with the stakeholders, the following information was obtained:

- A three-lenses analysis of the organization
- Process maps of X-building operations
- Goals and expectations from Deere and Company, the project sponsor
- Systems architecture and how information was collected and communicated
- Current challenges and frustrations facing the X-building
- Status of the Harvester-wide DPS project and X-building’s role in that
- The language and acronyms unique to Deere
In addition, insights from those external to the stakeholder map were useful, including classmates, MIT faculty, and other Deere employees. Two of the more important lessons that emerged from this stage of the leadership process were: 1) with all the complexity and different interest, the realization that this project definitely needs to be solved by a cross-functional team, and a self-selected team was assembled to do just that, and 2) this process allowed the organization and X-building to become aware of the DPS project, brought much needed attention to the X-building, and introduced a single-source X-building contact for future questions or concerns.

5.2.2 Developing Relationships

While “understanding the organization” provides the ice-breaker, this stage of the leadership change process allows change agents to further explore and understand issues that surfaced during the previous stage, and to build necessary coalitions (politically, culturally, and structurally) for successful implementation. Developing relationships allows for better listening and more open communication, encourages expression of diverse viewpoints, and advocates own point of view to others. [26] In addition, good relationships provide visibility to and support from many areas of an organization.

Referring to the stakeholder map in Figure 5.2, relationships were critical for a wide variety of departments and functions, and the structure of the project allowed for this. As mentioned earlier, the BUL of the X-building was well respected by all levels of the organization, from shop floor to plant management and corporate staff. Therefore, relationships for this project were partly developed by association with the BUL.

Another structural issues was that despite the project being sponsored and supervised through Deere & Company, full-time “positioning” at the factory was essentially granted. This allowed for the day-to-day informal interactions that are important in relationship building.

Developing relationships with the shop floor workers was critical for this project due to the fact that the current union contract required their support and cooperation in the
change effort. If not, contractual grievances could and would be filed. In addition, they knew the X-building operations better than anyone, and given the relative inexperience of the DPS team, their insight was critical. Approaching a similar situation during his internship at H.C. Starck, Matt “Coach” Capeci offered the following advice, “Don’t talk about work for the first week.” [28] This held true within the X-building, where Euchre and golf were the main levers for relationship building. Getting directly involved with these activities provided social interaction, identified common interests, and developed personal relationships. Coincidently, social interactions and informal conversations also developed stronger relationships with the engineers at Deere & Company, more so than formal meetings and presentations.

Reflecting on this process while at Deere, two key characteristics appeared to correlate to successful relationships: humility and sincerity. Within X-building, a sense of humility suggested that feedback and input from everyone was valuable, which contradicted the authoritarian and hierarchical structure that traditionally existed. In addition, the X-building employees were quite observant and quick to spread rumors regarding reasons for various actions, so sincerity was critical. Knowing that the best interest of Deere and the X-building were in mind, rather than a personal political move, helped develop communication and relationships.

Thus far, the discussion of relationship building appears to solely be based on strategic or tactical intent, but this is not necessarily the case. Within X-building, many of the relationships were sincerely developed and would have transpired regardless of the project focus. These types of relationships were generally stronger and more sustainable, and could be leveraged throughout the change processes.

5.2.3 Building Momentum

With a firm understanding of the situation and the support of various stakeholders, the next step in the change processes is to build credibility and momentum for the project. With regard to the long-term DPS implementation strategy, the X-building was fortunate
to have considerable low-hanging fruit to offer initial victories for both Deere and the union workers. Namely, the batch size optimization discussed in Chapter 3 provided early momentum for the DPS project, offering significant improvements to both Deere and the shop floor workforce. But, the overall effects of these batch size improvements will not be fully realized until the end of a full production season, which will come in Fall 2003. If these improvements match the results predicted by the model, significant cost and timesavings will be realized, and this will free up resources and energy for further DPS activities.

Even though the batch size optimization provides momentum for the long-term DPS strategy, all parts numbers were not changed at once. Within this optimization effort, small experiments were undertaken to gain support for two issues: 1) whether or not the batch size changes would result in any negative side-effects, and 2) sincerity with regard to considering and incorporating shop floor feedback. The first test occurred with Butch, a press operator from first shift and vocal leader of a department within X-building. After presenting the optimization strategy to the shop floor, Butch supplied a list of parts that had been causing him problems. These batch sizes were immediately changed using the production philosophy presented in Chapter 3, and Butch commented to one of the schedulers:

"I've been telling you the same thing for 15 years, and you don't do anything about it. This guy here makes it happen in two minutes."

Coincidently, Butch’s machine was one of the most severe bottlenecks in the plant, so monitoring these adjusted batch sizes provided confidence for the remainder of the X-building parts. The second part of these early tests was to prove that shop floor response was actually considered, unlike in years past. In addition to Butch’s comment above providing evidence of success, information was also sought proactively from the shop floor. For example, when determining a batch size for a customer, the final weld operator was asked how many parts would fit in a full container, and if a full container seemed to be an appropriate number of parts to produce at one time. He enthusiastically responded:
“Thanks for stopping by. No one has ever asked for my input before. Let me know if you need anything else.”

Unfortunately, these small experiments and communications cannot reach everyone, and some pitfalls did occur along the way. One production cell in particular was somewhat autonomous from the rest of the X-building, and their processes did not align with the overall production strategy. The three workers responsible for the cell took a lot of pride in their delivery performance, essentially never making the delinquency list. When mass fixed order change took place, this particular cell was negatively affected, and became fairly upset as a result. Their message was simple; “Why didn’t you come talk to us first? We would have told you this would be a problem for us.” This is exactly what the project team intended on doing for the X-building at large, but a small critical few were missed. The batch sizes were quickly corrected, and this cell would be consulted directly during future DPS changes.

A final momentum builder during the initial DPS efforts was testimonials from the first subassembly requesting new delivery requirements. After a transition period, the products were being delivered consistently in quantity and container, and as a result their own DPS implementation was successful in drastically improving performance. However, as noted earlier, incentive structures need to be reviewed to insure that the all stakeholders reap the reward of improved performance, not just the local winners.

Small experiments were for the most part successful in demonstrating success and establishing project credibility. These experiments were also useful to the project team to uncover unforeseen challenges and issues before the mass implementation effort began. During the later stages of the implementation, it is recommended that small victories be established for these two reasons. Michael Hammer in *The Reengineering Revolution* agrees, stating that:
"Before implementing a process in the real world, create a laboratory version in order to test whether your idea works. You will inevitably discover shortcomings and mistakes in your design, which you can then repair. Proceeding directly from idea to real-world implementation is a recipe for disaster." [29]

5.2.4 Creating a Vision

Creating a vision centered mainly on modifying the DPS principles to the X-building operations. In general, the lean manufacturing philosophy is powerful and well understood by Deere leadership, yet uncertainty surrounded the implementation of these principles within the primary manufacturing environment. While leadership understood the DPS vision, many at the shop floor or X-building level did not, so communication again became critical.

During the first portion of the implementation, the primary tools used to create the vision were the simulation model, the accompanying analysis, and discussions with various stakeholders and Deere & Company manufacturing engineers. The expected improvements became quantifiable, and an inventory reduction of $350,000 and removal of 30,000 setup hours can be quite energizing to anyone. These intuitively simple savings were communicated to schedulers, supervisors, factory management, and shop floor, and tied to some of the problems extracted during the discover process. In addition to the formal presentation of the problem, day-to-day interactions provided an alternative means to communicate the vision. Having multiple stakeholders involved with the project provided multiple avenues of communication.

The next steps of the implementation will be more difficult, for the process changes will be less intuitive. The transition from the MRP system to demand-based production will result in loss of visibility, increased fragility, and removal of feel-good time and inventory, and the resulting benefits may not be as easily understood. To help create and communicate this vision, Deere organized company-wide leadership tours of various facilities to showcase best practices and provide the sense of vision. At the factory level,
4-day and 1-day training sessions were provided to all employees to understand the benefits of DPS. And finally, within X-building the tailored training programs described in Section 4.6 were used to further drive home the concepts.

5.2.5 Innovation and Change

With respect to the long-term DPS project, this is the current X-building position. A solid understanding of the operations and various stakeholder interests exist. Communication channels and relationships were created with various parties, and small victories helped position the X-building for a successful transition out of MRP. But the current plan states that this phase of the project to continue during the Fall 2003. Due to the seasonal nature of product demand at Harvester, the spring and summer months are busy with higher production levels. Therefore, many of the improvement activities will pause until the upcoming production peak has passed, when more time and energy is available. In addition, one full production cycle will provide insights into current changes before moving forward with the implementation. In the meantime, the X-building supervisor now leading the DPS project will continue to work with customers and shop floor workers to improve delivery under the MRP system.

The changes made thus far have essentially left the current processes and modes of work unchanged. However, in visioning the final state, a number of hurdles were identified (Section 4.7) and will need the attention of the DPS team and stakeholders. This is where the inventing and monitoring of the DPS team, and flexibility of shop floor roles will become important.

5.2.6 Refining and Learning

The first goal of this DPS project was start the DPS implementation process within the X-building. The second was to create an implementation plan for other primary manufacturers across Deere to follow. With this in mind, the refining and learning aspects of this project were important. This process involved several activities from
reflective sessions with the DPS team to documenting and internalizing the procedures used. Frequent discussions were held with the project sponsor to review progress, look for areas of improvement, and identify areas ready for adoption. Throughout the project, input from all stakeholders was continually sought for these reviews.

Although successful by most accounts, the process followed was not without its flaws. The setbacks were noted, discussed, and incorporated into a revised implementation strategy to avoid reoccurring themes in future implementation efforts. The final result of this phase of the leadership process was the implementation plan presented in Figure 4.10, and internalized by the corporate engineering office. To be used by other manufacturing facilities within Deere. In addition, the corporate engineering group was able to gain additional insights throughout the project that will help them assist other plants.

5.3 Organizational and Change Management Conclusions

From the organizational and leading change analysis presented in this chapter, several conclusions are drawn.

1) The Sloan Leadership Model describes the first stages of the change process as “sensemaking” and “relating.” [26] In established cultures, outside perspective may be necessary to accurately assess a project and organization. While tangible results are not likely to emerge from these stages, understanding the situation and developing relationships are the necessary foundations for change, yet these steps can take time, especially for outsiders new to an organization. Without losing a sense of importance or urgency, it is important for company leadership to understand and support these stages. Pressure for immediate results may hinder the sensemaking and relating, which could lead to less than optimal long-term results. The staff from Deere & Company supervising and sponsoring this project offered the right mix of patience, support, and drive.
2) A common theme presented throughout this is the need for communication, and it is essential in every step of the change process from sensemaking to refining and learning. However, effective communication is difficult, and despite the project team’s intentions, many X-building employees were left uninformed. From this project, it was learned that a mix of formal and informal communication techniques more effectively spreads vision and enthusiasm throughout an organization, from meetings and presentations to casual lunch and social conversation. But even more was needed. There never will be too much communication.

3) In this analysis, the MIT model for change is applied to a context in which the project situation already existed. Before this, and before the first stage of the leadership process even begins, the success of the project may already be determined. This is due to higher-level leadership commitment. As noted during the three-lenses analysis, concern existed for just this reason. Harvester Works noted the importance of DPS and the X-building operations yet remains hesitant to devote resources and visibility to support the improvement. Much of the equipment is old and unreliable, and the supervisors are stressed with time. The words and actions of leadership need to be consistent. In addition, given the “business as usual” culture noted within Deere, a jolt of energy by high-level leadership into the organization may be necessary to ensure DPS success.

4) A final observation from the change process analysis is that a lot of attention is focused on an effective approach for entering an organization and leading a change initiative. However, equal consideration should be given to exiting a change initiative to ensure project momentum is sustained. Within the X-building, the two most familiar with the project ended up leaving within two months of each other. This made the transition difficult and potentially threatened the success of the project. A more effective plan would have included identifying the longer-term project leadership, and involving them earlier in the process.
Chapter 6. Conclusions

This chapter reviews the major topics discussed in this thesis and highlights the results. Both the analytical and organizational issues are included, and this chapter concludes by summarizing for Deere leadership the main lessons extracted from this project.

6.1 Technical Analysis

When Michael Hammer talks about process reengineering, he states that: “Only processes can be reengineered. Before you can reengineer your processes, you must identify them.” [29] The same notion applies to the X-building’s DPS effort. Entering the project, one of the main goals was to effectively meet customer demand, but the X-building operations were not well understood. Performing an ABC analysis provided insight into the demand characteristics and identified the small percentage of parts that account for the majority of X-building’s costs. While creating a dynamic simulation tool, insights surfaced during the input collection process and the output analysis. Specifically, the results of the simulation and analysis were production frequencies dependent on inventory class, which theoretically would drastically improve X-building performance.

The analysis identified an opportunity for nearly $350,000 in inventory savings, elimination of 30,000 setups, and a 7% increase in delivery performance. More importantly, the analysis provided X-building management an optimal production methodology, which replaced the existing ad-hoc, manual-manipulated procedures. Yet, this is only the start of the DPS implementation process.

The most significant contribution of the analytical portion of this project was setting the stage for further DPS implementation activities. First, the optimization attempts to reduce the consuming expediting processes and free up much needed time for improvement activities. In addition, the simulation highlighted the importance and necessity of setup reduction initiatives. Toyota’s slogan is “small lot sizes and quick setups.” However, in order to produce small lot sizes, quick setups are required, and the
simulation demonstrated the potentially disastrous results if batch sizes are slashed without improving setup times. And the final advantage of the X-building analysis is that it provided much needed attention to the X-building, opened channels with customers, and communicated DPS information and vision to the X-building employees. All of this positions X-building well for future DPS activities.

6.2 Organizational Change Analysis

Companies that have enjoyed the greatest success in transitioning to lean manufacturing are those that take a holistic approach and view the transformation as a fundamental restructuring of the Enterprise, including its organizational structures, business and information systems, workforce policies, incentive systems, and relationships with customers and suppliers. [7] Deere recognizes that the analytical and factory-floor aspects of DPS are only a start, but to sustain early DPS momentum, the organizational issues need to be included. When studying the relationship between the technical and social systems of an implementation project, Sean Hilbert describes the situation as follows: “The challenge is to somehow balance, coordinate, and leverage the social and technical aspects of lean manufacturing throughout the design and launch process. This is especially important when attempting to transform a traditional mass production brownfield site.” [19]

From the organizational analysis, a number of insights arise. First, the significant number of stakeholders and their array of interests suggest the need for a cross-functional mindset during lean implementations. Another insight is that the organizational structure must be aligned with the DPS objectives. The X-building’s currently does not, with only one key stakeholder reporting to X-building management. Functional departments impede effective communication, coordination, responsiveness, and overall system optimization. [7] A second area of misalignment may be the current union pay structure, which provides incentives for large batches and mass production, a conflict with the future DPS state.
The organizational analysis also highlights the complexity of a lean manufacturing transformation, and due to the need of cultural adjustments, the need for committed leadership. Again, Michael Hammer preaches this same notion as he describes process reengineering: “If you proceed to reengineer without proper leadership, you are making a fatal mistake. If your leadership is nominal rather than serious, and isn’t prepared to make the required commitment, your efforts are doomed to failure.” [29] *The Machine That Changed The World* describes situations to promote lean diffusion, two that are applicable to Deere’s existing culture. [5] First, by seeing local competition successfully deploy the lean philosophy, management and workers can start eliminating excuses as to why the philosophy cannot work at home. Second, a crisis is often needed for an organization to become serious about lean implementation. Deere has enjoyed generations of success and remains the dominant agricultural equipment producer today. This success leads to complacency and outside perspective or crisis could help remove X-building and Harvester Works from its current rut.

6.3 Concluding Remarks

Lean transitions are extremely difficult, and since they rely heavily on cultural changes, lean transitions take time. Even Toyota struggled for nearly 30 years to perfect their lean production system, but the documented results are astonishing. As Deere moves forward with its DPS development and implementation, a few lessons emerged from this project, and the lessons are mainly targeted to leadership:

1. Understand and align the operations. Nowhere will lean manufacturing literature suggest increasing batch sizes to improve performance, yet this is what was done to stabilize the X-building operations, because this best optimized the operational hand dealt. To strive for the final DPS state of “small lot sizes and quick changeovers”, significant setup time reductions and other improvements are necessary to align the X-building operations with that philosophy.
2. Leverage the Deere culture. Commitments to teamwork and quality are fundamental characteristics of the DPS and have long been associated with Deere employees.

3. Seek out success stories. There is no need to entirely reinvent the wheel with DPS. Visit successful facilities external to Deere, and talk to external experts. These insights and perspectives can be extremely useful and inspirational.

4. Understand the necessary commitment. Lean implementations are difficult, and a lack of communication, time, resources, or expertise may hinder the success.

5. Consider the scope of the problem. DPS is more than factory-floor mechanics. If the entire organization and all supporting processes are not included, the results may be nominal.

In 2001, Bob Lane, CEO, described Deere as “asset-heavy and margin-lean.” One year later, Lane stated that: “Much more needs to be done, but we’re off to a great start.” [4]
This same view is shared within Harvester Works and X-building, where changes are taking form and operational improvements are being noticed, while recognizing that this is only the beginning of a difficult journey.
Bibliography


85


