Evaluating a Continuous Improvement Initiative using Stakeholder Value Mapping

by

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B.S. Chemical Engineering, University of Wisconsin-Madison (2000)

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Abstract

Lean implementations have had a mixed record of success in organizations. One possible explanation for this observation is that lean is built upon a value system that is not always shared by the organizations trying to implement the philosophy. For example, one element of lean is that employees at all levels of the organization are expected to share ideas for improving processes. This idea might seem foreign in companies where responsibility for process improvement comes only from management or specialized departments. Lean would not be expected to flourish in an environment where employee innovation and initiative is not valued. As this example demonstrates, lean loses its effectiveness when its values are incompatible with those prevailing in an organization.

Determining this compatibility has not been straightforward to date. Whereas lean literature is filled with methods and tools for discovering and removing waste, there is little guidance on how to determine if lean can be successfully applied to an organization's unique socio-technical system. Stakeholder Value Mapping (SVM), a technique adapted from the field of Enterprise Management, is presented to address this need. Whereas SVM has already been developed for use at the enterprise level, this thesis aims to extend the applicability of SVM to the micro level. A methodology for mapping stakeholder values around a specific lean project at Raytheon's Integrated Air Defense Center is developed. The project, a pull system for bolted cabinets, is described in detail in this thesis as a case study.

We find that SVM alone does not yield sufficient data to guide lean implementations. It is, however, an effective method for understanding the stakeholder interests that can serve as barriers to lean. Leaders trying to bring lean into their organizations will find SVM a promising tool for determining where to initially focus their attention. If lean and stakeholder values are aligned, the groundwork will be set for a traditional lean implementation that focuses on well-known tools for discovering and removing waste. On the other hand, if lean and stakeholder values differ significantly, consideration should first be given to aligning organizational interests with the lean strategy.

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1 Introduction

An underscoring theme of this thesis is that lean implementations can only be successful when an organization's prevailing values are consistent with the values underlying lean[1]. Determining compatibility between lean and organizations is not straightforward. Whereas lean literature is filled with methods and tools for discovering and removing waste[2], there is little guidance on how to determine if lean can be successfully applied to an organization's unique socio-technical system. Stakeholder Value Mapping (SVM), a technique adapted from the field of Enterprise Management[3], is presented to address this need. Whereas SVM has been used in recent years at the macro level to determine if enterprise stakeholders are aligned around common goals and values, this thesis aims to extend the applicability of SVM to the critically important micro level where lean often hits the greatest barriers to successful implementation[4].

1.1 Organization of the Thesis

The thesis consists of eight chapters as described below:

Chapter 2, Project Setting and Motivation, provides a brief overview of Raytheon Company and its organizational structure down to the group level in which the project took place. Raytheon Six Sigma and Continuous Improvement initiatives are also detailed because of their high relevance to the thesis topic. Chapter 2 ends with the motivating factors for conducting this work.

Chapter 3, Methods, discusses the formalized approaches used in this work. Value Stream Mapping is discussed because it triggered many of the continuous improvement projects being pursued by the Metal Fabrication group. Section 4.2 describes the novel application of Stakeholder Value Mapping developed during this work.

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[1] For an excellent description of lean principles, the author suggests The Hitchhiker's Guide to Lean: Lessons from the Road, co-authored by Jamie Flinchbaugh (LFM '98) and Andy Carlino.

[2] One well known work which influenced the author is Lean Thinking by James Womack and Daniel Jones.

[3] The author recommends Lean Enterprise Value by Murman,Allen, Bozdogan, Cutcher-Gershenfeld, McManus, Nightingale, Rebentisch, Shields, Stahl, Walton, Warmkessel, Weiss, Widnall.

[4] In related work, Shinkle, Gooding, and Smith discuss Lean Management Systems in their work Transforming Strategy into Success: How to Implement a Lean Management System. Whereas this book focuses primarily on management systems, many of the concepts are compatible with the focus of this thesis, namely lean implementations at the group level.

Chapter 4, Case Study, illustrates how a lean project was conducted at Raytheon's Integrated Air Defense Center. The details of a pull system design and implementation are first laid out. Factors that helped and hindered the success of the project are highlighted.

Chapter 5, Analysis of Stakeholder Data, discusses the results of the Stakeholder Value Mapping methodology described in Section 4.2. This chapter is divided into two sections. The first section covers the quantitative analysis of the stakeholder value data while the second section reviews the usefulness of this method as a management tool. Recommendations for improving the methodology are also provided.

Chapter 6, Organization and Change, covers how the Three Lenses framework was used to evaluate those parts of the Raytheon organization that most affected the implementation of the pull project.

Chapter 7, Conclusions, highlights the key points of the thesis.

2 Project Setting and Motivation

This thesis work was made possible through MIT's Leaders for Manufacturing (LFM) Program and took place from June to December, 2005, at Raytheon's Integrated Air Defense Center (IADC) in Andover, Massachusetts. This section will discuss the project setting, starting with a brief introduction of Raytheon Company and continuing stepwise down into smaller and smaller business segments of the organization. Next, a review of the Continuous Improvement and Raytheon Six Sigma initiatives is presented. These programs spawned the project that was studied during the six month research effort. The end of this chapter describes the motivation behind the project. The project itself is described in detail as a case study in Section 5.

2.1 Raytheon Company

Raytheon Company is an industry leader in providing integrated mission systems for defense and non-defense customers. Its seven Business Units provide a broad range of products and services in defense and government electronics, space, information technology, technical services, and business aviation and special mission aircraft. Headquartered in Waltham, Massachusetts, its CEO Bill Swanson leads 80,000 employees worldwide. 2004 revenues were $20.2 billion.[5]

2.2 Integrated Defense Systems

This thesis work was conducted within Integrated Defense Systems (IDS), one of Raytheon's seven Business Units. IDS is Raytheon's leader in mission systems integration and has a strong international and domestic customer base. It provides products and services for air and missile defense as well as naval and maritime war fighting solutions. Major customers include the U.S. Missile Defense Agency and the U.S. armed forces. In 2005, IDS generated approximately $3.5 billion in revenues and employed more than 12,700 people. Organizationally, the IDS business unit is further broken down into six Business Areas and two Collaborative Operations groups. Headquarters are in Tewksbury, Massachusetts.[6]

[5] Source: Raytheon website, http://www.raytheon.com/about/
[6] Source: Raytheon website, http://www.raytheon.com/businesses/rids/about/index.html

2.3 Integrated Air Defense Center

The Integrated Air Defense Center (IADC) is the name of the IDS Business Area located in Andover, Massachusetts. This site consists of manufacturing and support services that serve the Department of Defense (DoD) by providing total air and missile defense systems solutions and integration efforts. A number of key programs are served by the IADC, including the well known Patriot Air & Missile Defense System.[7]

Research was primarily conducted within two groups of the IADC: the Metal Fabrication group and the In-Service Radar (ISR) group. The Metal Fabrication group is an in-house provider of metal components for defense systems. Its capabilities include machining, milling, drilling, welding, assembly, painting and chromating. Approximately 180 highly skilled union employees are supported by about 50 support employees.

ISR is one of Metal Fabrication's clients and is physically located about one hundred feet away from the Metal Fabrication area. Importantly, however, the two groups are managed independently until their organizations are connected at the vice-president level, or two levels above the group level. Communication between the two groups is primarily directed through operations managers, project managers, and value stream managers.

While Metal Fabrication supplies dozens of parts to ISR, this research focuses only on the bolted cabinet product line for reasons explained in section 2.5. Bolted cabinets are a new method for housing electronics, cooling systems, and power supplies for defense systems. Until recently, all such enclosures were of welded construction. Starting in 2004, however, three types of cabinets have been transitioned to bolted construction for cost, quality, and aesthetic reasons. These are the Driver, 45 kV, and 17 kV cabinets which will be referenced throughout the thesis. Another bolted cabinet, the RFM, was introduced into production just after the conclusion of this research.

It is important to note that the bolted cabinet line is low volume, high complexity work. This is characteristic of the defense sector and different than many early applications of lean principles.

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[7] Source: Raytheon website, http://www.raytheon.com/businesses/rids/businesses/Integrated_Air_Defense/index.html

2.4 Raytheon Six Sigma and Continuous Improvement

In recent years, the US government has demanded defense contractors to adopt commercial practices to become more productive and accountable. As a result, the Raytheon Six Sigma (R6σ) program was established throughout Raytheon Company in 1998.[8] Really a hybrid of Six Sigma statistical tools and lean principles, this aggressive initiative strives to establish a company-wide culture of process improvement that will make the company more competitive. In the same vain, a Continuous Improvement initiative was recently started locally within the IADC. Synonymous with lean, Continuous Improvement has caught on quickly as each work group is rated annually on the progress they have made in lean metrics. The IADC in aggregate measures its success by how well it does in the Northeast Shingo Prize for Excellence in Manufacturing. In its inaugural year being evaluated by the Shingo Prize Board of Evaluators, the IADC won a silver medal.[9] It plans to build on this success and win a gold or platinum medal in 2006.

A Lean Office started up in the first half of 2005. With about a half dozen employees, the Lean Office is staffed primarily by lean experts. The philosophy is that lean improvements have to be driven by teams within the business units to be successful. As such, the Lean Office assists as knowledge experts and internal consultants on projects, but the day to day project leadership resides closer to the shop floor at the group level.

The Lean Office is responsible for stewarding progress in lean initiatives and assessing how each work cell is performing using the Manufacturing Excellence Model (MEM). MEM is essentially a list of lean capabilities in which each work group gets graded. Because employees and managers set annual goals to improve MEM scores in their divisions, a lot of effort is made to meet these goals. A second responsibility for the Lean Office is writing the application for the aforementioned Shingo Prize for Manufacturing Excellence. The application is itself a major undertaking which consumes the effort of the Lean Office for at least several weeks each year.

In addition to the Lean Office, Raytheon Integrated Defense Systems recently established a Lean Enterprise website. Here, all employees can easily access information about lean and related topics. For

[8] The author referred to Padmaja Vanka's thesis (LFM '04) to learn about the evolution of lean within Raytheon Company.
[9] Source: Raytheon website, http://www.raytheon.com/feature/shingo/

example, there are links to the Shingo Award and Manufacturing Excellence Model websites. Information about lean tools and completed improvement projects are also documented in this portal.

Additionally, the organization uses outside consultants to provide lean training to its employees. At the IADC, the Greater Boston Manufacturing Partnership (GBMP) works closely with the lean office to provide training on several subjects from general Continuous Improvement (an introductory course on lean concepts) to more directed offerings such as specific lean tools (e.g. classes on pull systems, jidoka, or 5s).

The rationale for using outsiders to provide lean training is twofold. First, Raytheon managers believe employees will take the training more seriously if provided by external consultants. Second, Raytheon wants to introduce new ideas into the plant from people who have outsider perspectives.

2.5 Project Motivation

The success of lean ideas in organizations has been mixed to date. Some organizations are able to adopt the lean management philosophy quickly and achieve immediate benefits. Others try but fail ever to see any benefit. The purpose of this thesis work was to develop a new methodology, Stakeholder Value Mapping, which could be used to determine to what degree the business environment supported lean. In the future, it is hoped that this methodology can be used a priori lean implementations. Company leaders would be able to better assess if lean makes sense in their environment before having to commit significant resources in an implementation phase.

The Bolted Cabinet line within IADC's Metal Fabrication group seemed to provide an excellent environment for testing the new methodology. When this work started, a targeted transformation of the Bolted Cabinet value stream had just been initiated and more than twenty continuous improvement projects to improve the line were started. Setup reduction, standardized work, workplace organization (similar to 5S), and error proofing projects, among others, were all ramping up upon the author's arrival. Here was an environment where lean was being pursued at full speed. Stakeholder Value Mapping could be tested in parallel and the results compared to the actual implementation results observed during the internship.

The advantages of studying the bolted cabinet line over other potential areas were several. First, the bolted cabinet line had been performing far below expectations in terms of cost and delivery since its introduction less than a year before the author's arrival. The fact that the bolted cabinet line had existed for less than a year meant that traditional firefighting had already improved the manufacturing system to some semblance of stability, yet there were still large sources of waste for which lean was well suited to remedy. In lean literature, it is commonly stated that the benefit of lean is realized over a long time frame[10], yet expectations were high in the Metal Fabrication area that significant improvements would be realized within months due to the poor initial condition of the manufacturing system. If this turned out to be the case, the author would be present during his six month internship to observe some of the realized benefits.

Second, the bolted cabinet value stream cut across company and division boundaries, but the interactions were not so complex that it could not be studied within a six month period. This fact allowed the author to study the effects that various management philosophies have on each other. Could a lean implementation in an isolated part of a product's value stream generate benefits if the remainder of the value stream did not follow lean concepts? This seemed to be an important area for investigation.

And finally, one continuous improvement project, a pull system design and implementation for the bolted cabinet value stream, had been identified but not yet begun. This provided an opportunity for the author to lead a continuous improvement project firsthand and to learn what social and technical factors determine the success of change initiatives. This is the subject of section 5, a case study of the pull system project.

[10] Womack and Jones cite it takes five years to achieve the full benefits (page 98 in Lean Thinking)

3 Methods

This chapter compares two methods used during this thesis work. Value Stream Mapping, the topic of section 3.1, was used to map out the physical and information flows of the bolted cabinet manufacturing system. The bolted cabinet pull project was established as a direct result of the Value Stream Mapping activity. Section 3.2 focuses on Stakeholder Value Mapping and is a nice contrast to section 3.1. Whereas Value Stream Mapping is concerned with physical and information flows in a production system, Stakeholder Value Mapping is more concerned with determining the cultural, political, and organizational realities that are critical but often overlooked aspects of successful project implementation.[11] Since the tactical use of Stakeholder Value Mapping is a novel innovation developed during this internship, section 3.2 provides a detailed explanation of how it was used during this thesis work.

3.1 Value Stream Mapping

Value Stream Mapping is a tool used to understand the flow of material and information as a product or service makes its way through the value stream.[12] As used by Raytheon and many other organizations, the purpose of value stream mapping is to identify waste. Countermeasures or projects are then identified to eliminate the waste in the spirit of continuous improvement.

Exhibit 1 in the appendix shows the current state value stream map for the bolted cabinet line in April 2005. The top half of the map shows information flow throughout the value stream, including planning and ordering information flows. The bottom half of the map contains operating data for each of the processing steps leading from the suppliers to the customers. This portion of the map thus focuses on the material flow from raw material to finished product. Opportunities for improvement are shown throughout the map represented by starbursts. These starbursts are often used to generate improvement projects.

The next step in value stream mapping is generating a future state map and possibly a target state map. The future state map depicts the ideal material and information flows for a waste-less system. For

[11] In related work, see Ignaccio Grossi's thesis (SDM '02), "Stakeholder Analysis in the Context of the Lean Enterprise". As opposed to this work, Ignaccio describes stakeholder analysis at the enterprise level.
[12] Source: Wikipedia Dictionary. "Value Stream Mapping" dictionary entry.

example, a future state map might show how the manufacturing system would look if all the improvement projects spawned from the current state map were realized. The target state map, on the other hand, is a vision for the more foreseeable future. It is a map of how the system might look in a six month timeframe after the more immediate improvement projects are completed.

Most of the improvement projects that were initiated just prior to the author's arrival in Metal Fabrication resulted from the April, 2005 value stream mapping event. The author participated in another value stream mapping event for the In-Service Radar (ISR) group, Metal Fabrication's customer for the Bolted Cabinet line.

3.2 Stakeholder Value Mapping

Whereas Value Stream Mapping is useful in determining the technical and physical realities of manufacturing systems, Stakeholder Value Mapping as used in this thesis is used to determine the cultural and organizational realities that are critical but often overlooked aspects of successful project implementation. The nature of stakeholder interests is that there will be points in common and points in conflict. As such, by identifying and measuring key project stakeholder interests, one is able to reveal potential drivers and barriers for successful project implementation.

The author developed the following protocol for mapping stakeholder value around the Bolted Cabinet Pull Project. First, key stakeholder groups were identified. Metal Fabrication's managers clearly held a stake in the project because they committed the human and financial resources that made the project possible. Floor operators would also be impacted by the project because of changes in the manufacturing system. Similarly, the production control and operations groups would be affected because a pull project would change how they coordinate production and logistics. Because it was looking for early lean success stories in order to sell lean to other areas of IADC, the Lean Office also had a significant interest in the project. The last stakeholder group looked at was the internal customer, In-Service Radar (ISR). Changes in ISR's floorspace would be needed to implement the pull plan and additional cooperation would be needed to adhere to new demand-based run rules for obtaining bolted cabinets. Note that other stakeholder groups could have been included, such as Metal Fabrication's suppliers, but the stakeholder groups targeted were limited to the ones most instrumental to the project's success. This phase of the protocol, identifying key stakeholders, lasted approximately two months in total as the author familiarized

himself with the organization.[13] The author also spent this time in a floor leadership role ramping up the Bolted Cabinet Pull Project, which is discussed in detail in Chapter 4.

Once stakeholder groups were identified, an initial round of interviews was held to collect information about what mattered most to these groups. Exhibit 2 of the Appendix contains the interview protocol used during this step. The purpose of these interviews was to develop a large list of values for each group while at the same time trying to get a sense of which values were most important. This step could be described as having a brainstorming objective with the goal of articulating the many hidden motivations and priorities held by each stakeholder group. One setback occurred at this stage. It became apparent that the union labor force would not be allowed to participate in the interviews. Raytheon and the union were in the midst of contract negotiations and were sensitive to anything that might interfere with their successful completion.

All in all, nine stakeholders were interviewed in this initial round during a one week period and valuable insights were already gained. For example, various concerns along the lines of communication were identified. One stakeholder felt that there were a "yo-yo of priorities" coming from the Metal Fabrication group, suggesting either a lack of strategy anchoring the group's actions or a degree of ineffectiveness in communication the strategy. Another stakeholder felt that it was difficult to "see the whole picture" in the organization despite being in a leadership position. A lot of his understanding about the business occurred from "hearing through the grapevine", i.e. taking part in informal conversations with colleagues throughout the organization and then trying to make sense of the information. Two members of the In-Service Radar group made similar comments about determining who their appropriate points-of-contact were in the Metal Fabrication group. One senior member said that it took "tribal knowledge" to know who to contact for which problems. Another employee with less experience in the group said that he was "figuring it out along the way". Information gleamed from these interviews already hinted at some changes that could improve organizational effectiveness.

The next step in developing Stakeholder Value Maps was the gathering of quantitative data around two aspects of value: *importance* and *delivery*. Two approaches were taken at this point. The author first tried to inquire about importance and delivery for every single value identified during the first round of interviews. Since the list of values was two pages long (see Exhibit 3 in the Appendix), some stakeholders found it difficult to differentiate amongst the multitude of listed values. In other cases, the

[13] For someone already situated in an organization, identifying the key project stakeholder groups should be considerably easier and should take very little time to complete.

stakeholders were either discouraged by the number of responses required of them or were simply too busy to be bothered with what they deemed a tedious task of negligible personal benefit. A second approach was adapted to mitigate these concerns. Values were aggregated down to a much more manageable eleven categories of values (see Exhibit 4 in the Appendix). What was lost in data fidelity was gained in ease of use. Stakeholders were now universally willing to fill out the data collection form.

The result was a list of values that were rated on a scale of 1-7 ("not important/delivered at all" to "extremely important/delivered extremely well") for both Importance and Delivery. Importance is defined as how important the value is to the stakeholder filling out the form. Delivery is defined as how the stakeholder perceived the value was being delivered.

During a three week period near the end of the thesis work, fifteen stakeholders submitted data for the Stakeholder Value Maps. This data was next averaged for each stakeholder group and analyzed graphically by plotting each value by Delivery versus Importance, following the Stakeholder Value Mapping template developed by the Lean Aerospace Initiative.[14] This is illustrated in the idealized Stakeholder Value Map shown in Figure 1 on the next page. Ideally, all of the values would fall on the diagonal line signifying that values are being delivered in accordance with stakeholder expectations. Values 2, 3, 4, 5, and 7 demonstrate this desired behavior. Values located above the diagonal suggest that more effort is being exerted on delivering that value than requested by the stakeholder. This is represented by Value 1 in the example. Oppositely, values located below the diagonal indicate that not enough effort is being expended, demonstrated by Value 6 in Figure 1. Stakeholder value maps were made for each stakeholder group, and the actual data is presented in Section 5.1.

The graphical presentation of the data makes it simple to identify which values fall above or below each stakeholder's expectation *on average*, but it provides no insight about the variability of opinion within each stakeholder group. To determine how aligned each group is in its perception of value importance and delivery, the data was analyzed statistically. In addition to calculating the means for each value, standard deviations were determined. Heuristically, high standard deviations indicate a large difference of opinion and small standard deviations indicate alignment in opinion. This data is presented in Section 5.1 with a discussion of implications.

[14] Deborah J. Nightingale and Alexis Stanke, Enterprise Value Stream Mapping and Analysis, Version 1.0, August 2005

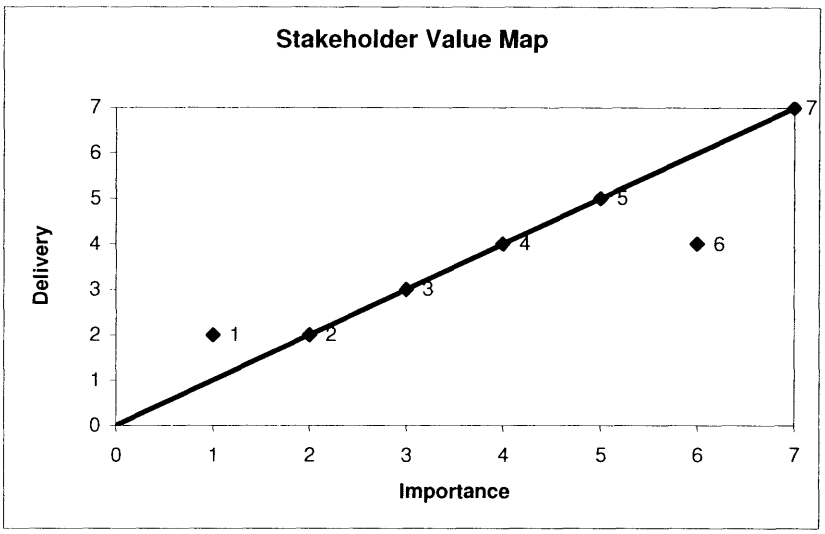


Figure 1. Idealized Stakeholder Value Map

4 Case Study

This chapter illustrates one example of a lean implementation project at Raytheon's Integrated Air Defense Center. The case describes the bolted cabinet pull system project from conception to implementation.

4.1 Conception of Bolted Cabinet Pull System

As described in Section 3.1, value stream mapping was used to identify opportunities for improving the bolted cabinet line. The team that analyzed the value stream noted several things:

- Metal Fabrication was not producing bolted cabinets within customer takt time, resulting in delivery delays.
- Bolted cabinets were being built in batch production, driving work-in-process (WIP) levels higher and increasing lead time and cycle time.
- Decisions about Metal Fabrication's production priorities were being driven by MRP-derived plans instead of actual customer needs, leading some products to be severely delinquent while others were produced ahead of schedule.
- Cycle times varied considerably due to quality issues and corresponding rework.
- Management oversight and engineering support costs were high due in part to the complexity and instability of the manufacturing process. The immaturity of the process also likely contributed to some of the early inefficiencies in the manufacturing system.

The factors listed above contributed to the bolted cabinet line running several million dollars over budget when the author joined the Metal Fabrication group. Of the several continuous improvement projects that were initiated to reduce process waste, this chapter focuses solely on the pull system project which the author helped lead.

The vision for the project was to control bolted cabinet production such that new cabinets would only be manufactured when customers consumed existing cabinets from finished goods inventory. Conceptually, the pull system would cascade upstream from the customer all the way back to the raw material supplier. As such, the project would cross two organizational boundaries, one internal boundary between the In-

Service Radar (ISR) group and the Metal Fabrication group and one external boundary between Metal Fabrication and its supplier of aluminum raw material.

Such a system would benefit the plant because the amount of work-in-process (WIP) and finished goods inventory would be reduced and controlled. In addition, production scheduling would be much easier using a pull system. With pull, responsibility for production scheduling is placed largely in the hands of operators using simple run rules. Experts with deep functional knowledge of MRP systems, while still important, would no longer need to focus so much of their time on day to day operations. Instead, they would be freed to devote more of their energy to intermediate and long term production activities, such as planning for new product introductions to the factory floor. Other benefits expected by the team were a reduction in manufacturing support costs and a step-change improvement in on-time deliveries.

4.2 Bolted Cabinet Pull System Project Team

Two individuals, the author and an operations manager, were given responsibility from the Metal Fabrication group manager to lead the pull system project. Besides the two project leaders, input on the pull system design came from several sources. The lean office shared their knowledge of best practices for pull systems and asked an outside consultant to review the design. Stakeholders from the In-Service Radar group and the aluminum supplier were involved in the parts of the design that affected them directly. Floor employees were asked to provide input and offer suggestions on how to improve the pull plan. In summary, the general approach in formulating and implementing the pull system was to bring in stakeholders and knowledge experts at different times during the process to influence the design.

After a month of primarily technical analysis, an initial design and implementation plan was completed for the bolted cabinet pull system. The design is represented schematically in Figure 2 on the next page. The drawing shows the material flow (from left to right) and the information flow (from right to left) for producing bolted cabinets under the new plan. A portion of the implementation plan is shown in Exhibit 5 of the Appendix for illustrative purposes. The plan was organized by grouping all of the specific activities required for each work cell. Team members were assigned to each task and agreed to a target completion date. For example, four tasks were required of the driver cell during a two month period.

4.3 Bolted Cabinet Pull System Design

The pull system is set in motion when the downstream customer, In-Service Radar, consumes bolted cabinets from kanban locations adjacent to its first operations (labeled "Driver Cell" and "Outfitting" in Figure 2). The empty kanban locations signal In-Service Radar's material handlers to replenish the cabinet from a finished cabinet supermarket located next to Metal Fabrication's front aisle (this is the inventory location marked "Front Aisle" in Figure 2). The choice of a highly visible location next to a heavily used corridor was deliberate. With this location, anyone in the plant could know if Metal Fabrication was keeping up with demand simply by walking by. There were two spaces for each type of cabinet in the finished cabinet supermarket. This created an inventory buffer designed to ensure that the customer would always have a cabinet available for replenishment. The visual power of this setup was significant. If both spaces were empty, one knew that the customer was at risk of starving their production line. In this situation, the Metal Fabrication operations team would receive additional resources to overcome any challenges that the production line was facing. The supermarket was also important in improving the relationship between Metal Fabrication and In-Service Radar. The loudest criticism placed on Metal Fabrication before the pull system was implemented was that they could not reliably state when cabinets would be delivered. The finished cabinet supermarket made cabinets available on demand.

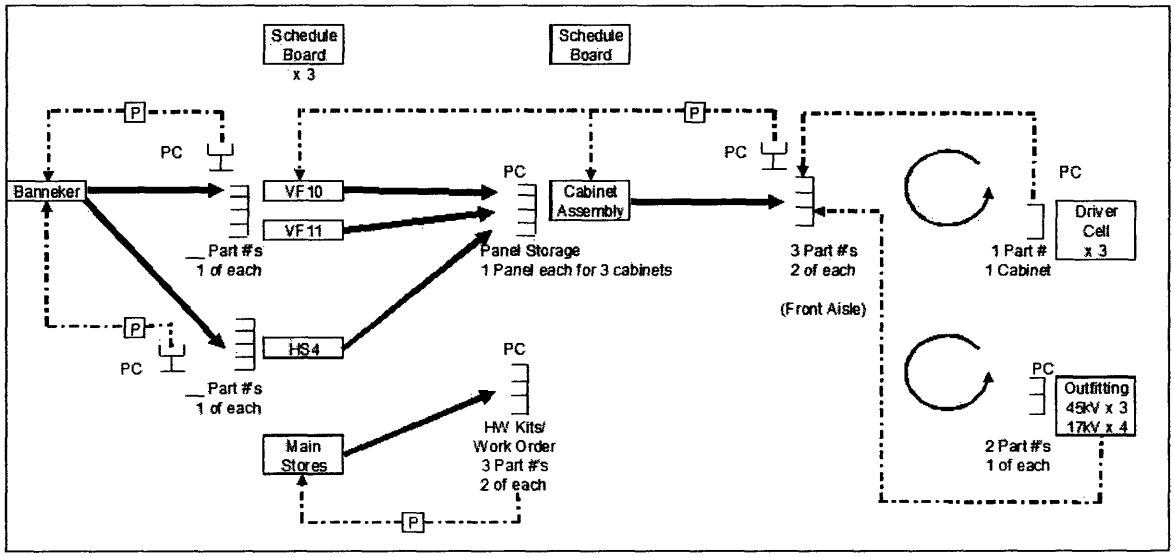


Figure 2. Bolted Cabinet Pull System Design

Continuing with the description of the pull system depicted in Figure 2, orders are sent to two upstream locations to start production on a new cabinet when In-Service Radar withdraws a cabinet from the finished cabinet supermarket. The first order is sent to Cabinet Assembly. This is where machined aluminum panels and hardware are bolted together to form finished cabinets. Finished machined panels are located adjacent to Cabinet Assembly for process control purposes. The inventory buffer is designed to allow Cabinet Assembly to produce a cabinet within takt time even if the next upstream process is experiencing process delays. The second location where an order is sent from the finished cabinet supermarket is Panel Fabrication (marked by machine names "VF10", "VF11", and "HS4" in Figure 2). At Panel Fabrication, raw aluminum slabs are machined, drilled, chromated, painted, and stenciled to produce the finished panels used in Cabinet Assembly. Since several panels are required to build one cabinet, the three machines are used in a way that minimizes setup times when switching between panels. The cycle time for making cabinet panels is also within takt time. The rationale for breaking cabinet production into two work sequences now becomes clear. Under the current manufacturing process, it would be impossible to build a finished cabinet from raw aluminum slabs within customer takt time. The process needed to be broken in half to ensure cabinets could be replenished by the time the customer needed it.

The last part of the pull design is the linkage between Metal Fabrication and the raw aluminum slab supplier. Aluminum slabs are stored in kanban locations in close proximity to Panel Fabrication. Working with the aluminum supplier (labeled "Banneker" in Figure 2), the slabs now arrive stacked on pallets in the precise order in which they are processed. Replenishment of this raw material is made using a pull system; an order is made for a pallet of aluminum slabs when the previous pallet is consumed.

4.4 Bolted Cabinet Pull System Implementation

As mentioned in Section 4.2, the pull system design took approximately one month to complete through the part-time effort of the author and the operations manager. If the project had been the full-time focus of the team, it is plausible that the design could have been completed in a week or less. This section describes the factors that impacted project implementations in the Metal Fabrication Group in general and then talks about the factors that were specific to the pull project.

To put everything in context, Metal Fabrication was a busy and in some ways unstable place in 2005. Section 2.5 discussed how the Bolted Cabinet value stream was going through a major transformation to

remove waste. More than twenty continuous improvement projects had been initiated to improve the line. It was not unusual for an individual to be on two to six project teams in addition to working their normal responsibilities. For this reason alone, progress on projects was in general slow. But there were several other reasons why progress on projects was measured during this period. Unexpected manufacturing problems would invariably arise and deservedly take the focus of employees until the problems were resolved. Also, management focus on the Bolted Cabinet improvement projects, at first quite strong, became weaker as the line improved and other parts of the plant experienced bigger problems. With less management push, many employees focused on their more immediate daily deliverables and responsibilities. Finally, coordinating twenty continuous improvement projects was difficult to achieve. Different teams working on projects targeting the same work cell would plan changes that were inconsistent with one another. For example, one team was assigned to reduce the amount of manufacturing floor space needed for the group. They planned to sell and move equipment to save floor space. Another team, working to improve product flow within the plant, was planning to move the same equipment to different locations. The result was frustration and additional planning for both parties. While the intentions were good, the logic for implementing the various improvement projects was poor. A strategy that sequenced the projects in time, one project building on another, would have been more appropriate. The benefits of such an approach would have been better employee focus and more efficiency as projects would not have to compete for scarce resources or have the potential to undercut one another.

Progress in implementing the pull system was slowed for many of the reasons described above, but there were additional reasons specific to the project. One, which is described in detail in the next section, was management discomfort with the plan once some of the project implications became clear. The other reason was that one of the key employees driving the project, the operations manager, was temporarily reassigned on a special project midway through project execution. For these reasons, the project was not fully implemented by the time the author finished his six and a half month internship. The two kanban systems linking In-Service Radar and the raw aluminum supplier with Metal Fabrication were fully functioning, but the pull infrastructure within Metal Fabrication was never put into action.

4.5 Drive for Improved Short-Term Financial Performance

As mentioned in the previous section, a manager overseeing Metal Fabrication became uncomfortable with the pull project once he understood one of its implications. Using the pull system, production of

finished cabinets would be regulated by the demand of the next downstream organization, namely In-Service Radar. This represented a direct conflict with the manager's plan to accelerate cabinet production ahead of schedule. By doing this, the manager aimed to improve Metal Fabrication's financial performance in two ways. First, producing more cabinets in a certain length of time reduces per-cabinet costs by spreading the fixed costs (mainly engineering support in this case) among more cabinets. Second, contractual terms allowed Metal Fabrication to get paid for cabinets as soon as they were completed. Since the Bolted Cabinet line was over budget by several million dollars, any initiative with the potential to close this gap significantly and quickly was very appealing to management. Whereas the pull system had the potential to improve performance in the *long term*, management incentives were primarily directed at *short-term* goals. A general description of one such incentive follows to demonstrate this point.

Estimate at Completion (EAC) is a term expressing how much money is expected to be spent at the completion of a contract. Recently, accurate EACs have become more important due to Sarbanes Oxley rules that emphasize proper disclosures and compliance procedures. At Raytheon, program managers are now evaluated on how well they meet or exceed program EACs. As reported by a senior manager, "Incentives are very strong for being under EAC – you never want to be over EAC!" Generally speaking, directors have performance goals to be below EAC by specific amounts. In this way, if a program exceeds EAC, significant pressure is placed on the organization to improve short-term financial performance even at the expense of long-term cost reduction initiatives. On the other hand, the organization is much more willing to invest in long-term improvement projects if a program is on track to meet its EAC goals. In this case, managers realize that they will need to improve current processes to meet future EAC goals.

Because of the Bolted Cabinet line's performance, the manager overseeing Metal Fabrication would not allow the pull project to proceed fully. Only the parts of the plan that did not impact production were implemented, namely the interfaces with In-Service Radar and the raw aluminum supplier. Instead, a new plan was introduced to produce six cabinets each month. Table 1 contrasts the accelerated schedule to the production expected for one year using the pull system. During this one year period, the accelerated plan would result in 19 additional cabinets being constructed.

Table 1. Expected Production using the Pull System versus Six-a-Month Policy

BOLTED CABINET REQUIREMENTS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Customer Requirements	3	5	5	5	5	6	4	7	3	4	3	3	53
New Production Plan	6	6	6	6	6	6	6	6	6	6	6	6	72

4.6 Violations of Lean Principles

This case study demonstrates a triple violation of lean principles. When lean is explained to Raytheon employees, they are told that lean will benefit them directly as well as the company. Work will become easier and less tedious as unnecessary movement and other waste is eliminated. Alternatively, job security will increase as Raytheon becomes more competitive in the marketplace and wins more contracts. Employees are also told that their ideas and suggestions will be appreciated and are indeed vital for continuous improvement. Above all, assurances are given that lean will not be used to eliminate jobs.[15]

The first violation from the case occurred when employees were told the pull system would not be fully implemented. A significant amount of input and suggestions had been gathered from employees in various positions within Metal Fabrication. There was a general sense of hope that the pull system would alleviate some of the larger problems employees were facing. Customer complaints and firefighting were expected to decrease while production priorities were expected to better reflect reality. By implementing a policy that went against employee input, an implicit message was sent that employee feedback was not very important. This message makes it extremely difficult or impossible to establish a flourishing lean culture. One of the basic tenets of lean is that improvement ideas need to come from all employees. It is not an initiative that can be driven top-down successfully over time.

The second violation occurred when the six cabinets per month policy was unveiled. According to lean literature, the worst form of waste is overproduction since it is a root cause of other kinds of waste[16]. By producing cabinets significantly ahead of schedule, workers were making cabinets that would not be needed for months. Not only does overproduction consume manufacturing resources that could be better used on more immediate orders, but the cabinets need to be moved in and out of storage, which itself is

[15] From the author's notes from a Continuous Improvement course given to Raytheon employees on June 29, 2005, taught by Dan Fleming of the Greater Boston Manufacturing Partnership (GBMP).
[16] Dennis, Pascal, Lean Production Simplified, New York: Productivity Press, 2002.

costly. Transportation and storage also increases the opportunities for damaging the product. Furthermore, it delays detection of defects that might only be found by the customer. The quicker defects are identified, the easier it is to determine the root cause of the problem and the fewer products with similar defects will have been built. On top of all this, employees were working costly overtime to build cabinets that would not be needed for months.

Whereas the second violation discusses potential types of physical waste generated by the six cabinets per month policy, the third violation concerns the human impact of the plan. By asking to build six cabinets a month, employees were being stretched to their limits. It was clearly unacceptable to build less than the six cabinet target, so employees would do everything in their means to complete cabinets by the end of the month. At the same time, Metal Fabrication had to satisfy other customer commitments. This became increasingly difficult as resources were diverted to the Bolted Cabinet line. The result was that employee stress and effort increased significantly. With a large scale lean initiative being undertaken at the same time, employees were observing that they were working harder (and not smarter) whereas they had been told that lean would make work easier (or more efficient).

Figure 3 is a causal loop diagram[17] illustrating the impact that the six cabinets per month policy had on the lean initiative. The two outer loops show how the lean initiative was intended to work. Continuous improvement projects would be initiated and completed leading to improved manufacturing performance. The increased performance reduces non-value added employee effort and/or increases customer orders since the process is more efficient and costs are reduced. In turn, employees feel less frustrated since they can complete their work with less effort and/or they sense better job security. Both of these factors contribute to growing acceptance of the lean initiative. As acceptance grows, more employees suggest ideas for new improvement projects and the cycle repeats and reinforces itself.

The inner loop, on the other hand, is introduced as a result of the six cabinets per month policy. The target of six cabinets a month is difficult to achieve and causes frustration among workers as stress and effort increases to achieve this goal. This frustration, along with reasons associated with the first two violations of lean principles, reduces employee acceptance of the lean initiative. As acceptance decreases, employees provide fewer suggestions for improvement projects and are less motivated to

[17] Causal loop diagrams come from the field of System Dynamics, a good source for which is Business Dynamics: Systems Thinking and Modeling for a Complex World (2000) by John Sterman. Causal loop diagrams are used to help understand how complex systems respond to stimuli. For example, in business, causal loop diagrams are often used to understand how complex organizations respond to management decisions. Complex systems are ones with multiple feedback effects, log time delays, and nonlinear responses.

participate in waste reducing activities. Improvements to the manufacturing system become few and far between. As employees see less impact from the lean initiative, they become even less willing to participate. Eventually, a status quo is reached with changes driven only occasionally from the top-down.

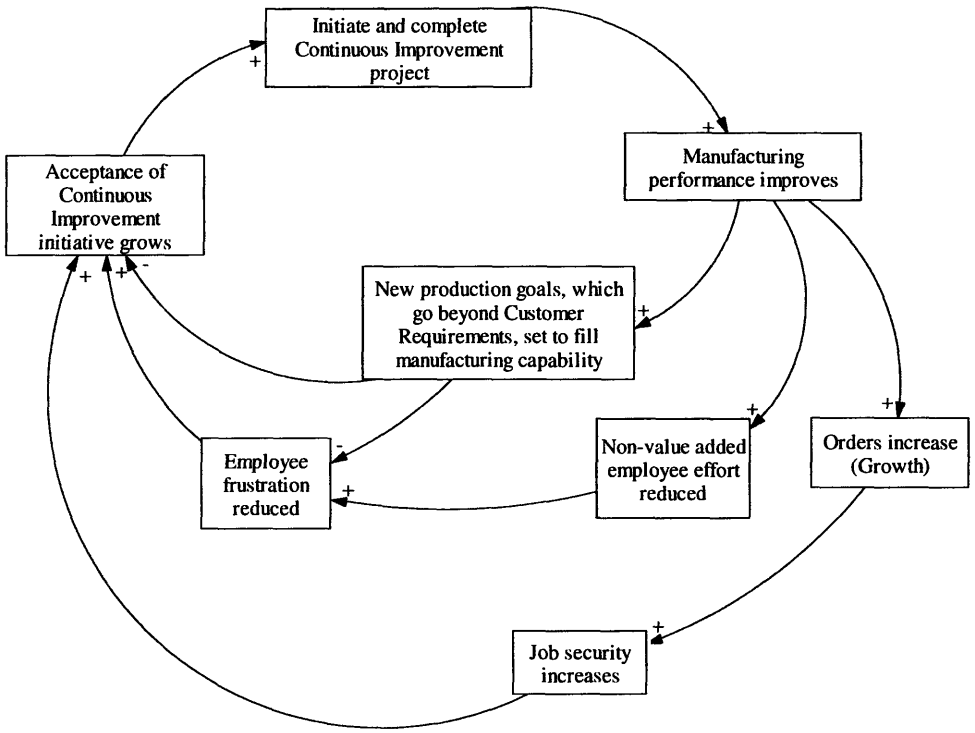


Figure 3. Causal Loop Diagram Illustrating the Violation of Lean Principles[18]

4.7 Bolted Cabinet Pull System Results

Despite not being fully implemented, work associated with the pull system did yield tangible results. The most significant benefits were associated with the linkages between Metal Fabrication and In-Service Radar and between Metal Fabrication and its raw material supplier. Fully functioning pull systems were established at both of these interfaces. On the raw material side, pallets were now received with

[18] To interpret the diagram, the arrows indicate causal linkages and the plus and minus signs indicate whether the linkage is positive or negative. For example, the box called "New production goals, which go beyond Customer Requirements, set to fill manufacturing capability" is linked negatively to "Employee frustration reduced". This indicates that if the new production goals are set, then employee frustration will *increase* (because of the negative linkage); alternatively, if the new production goals are eliminated, then employee frustration will *decrease*.

aluminum slabs stacked in the precise order in which they would be processed. Indeed, one piece flow was implemented as a direct result of the pull system. Before, pallets of aluminum would come stacked by SKU number and the same SKU would be processed in batches. Raw material and WIP inventories were therefore higher under the old manufacturing system. Also, machining problems tended to impact several pieces at a time under the old system because the problems would not be identified until after entire batches were processed. With one piece flow, problems would be identified much sooner and the consequences were smaller, typically being rework or scrapping of only one item. When asked how the raw material pull system was working, Ed Driscoll, Machine Shop Operations Leader, said, "It's fantastic! We're going to do the same thing in our other machining cell".[19]

At the interface between Metal Fabrication and In-Service Radar, the pull system helped to improve customer satisfaction in several ways. The finished goods inventory improved service levels dramatically. Before the inventory buffer was created, Metal Fabrication was constantly missing its commitments for cabinet deliveries. Even worse, trust between the two groups had largely evaporated because Metal Fabrication could not accurately forecast when cabinets would be delivered. Delivery dates would often be updated three to four times as previously predicted delivery dates passed. As one In-Service Radar manager explained before the pull system was implemented, "There is no confidence in metal fab [fabrication] that they can meet commitments." Improvements in the stability of the manufacturing process combined with the establishment of a finished goods inventory worked in tandem to achieve 100% on-time cabinet deliveries after the finished goods supermarket was established and stocked. A new program manager who worked in In-Service Radar in the past for many years was "absolutely dumbfounded to learn that the Fab [metal fabrication] area has cabinets standing tall waiting to be pulled by ISR. He lived for years always waiting for the cabinet to arrive."[20]

[19] Field notes from November 22, 2005.
[20] Excerpt from email message by Roger Hinman to Ben Lathrop on May 8, 2006.

5 Analysis of Stakeholder Value Data

Using the methodology discussed in Section 3.2, stakeholder value data was collected during a series of interviews which took place between August and December 2005. This chapter is divided into two sections. The first chapter covers the quantitative analysis of the stakeholder value data. The second section reviews the value of this method as a management tool. Recommendations on how to improve the methodology are also provided.

5.1 Data Analysis

In this section, stakeholder data is analyzed to answer three underlying questions:

- Within stakeholder groups, is value delivery in line with value importance?
- Between stakeholder groups, is there consistency in the results or do value perceptions vary considerably?
- Within stakeholder groups, is there alignment amongst members around value importance and value delivery?

5.1.1 Alignment of Value Importance and Value Delivery within Stakeholder Groups

To answer the first question, data[21] for each stakeholder group is averaged and plotted graphically as described in Section 3.2, resulting in Stakeholder Value Maps. Figures 4, 5, and 6 are the Stakeholder Value Maps, respectively, for the Lean Office, Metal Fabrication, and In-Service Radar. As explained in Chapter 3, the data should ideally lie on the diagonal line such that values are equal in terms of "importance" and "delivery".

5.1.1.1 Alignment of Values in the Lean Office

Stakeholder data was collected from the two members of the Lean Office who were most heavily involved in the bolted cabinet pull project. The lack of sample data for this group makes statistical

[21] This data was obtained as described in Section 3.2. Fifteen stakeholders from three organizational groups within Raytheon provided all of the data analyzed in this chapter.

analysis almost meaningless; nevertheless general insights can be gained by inspecting Figure 4. Importantly, product cost is the least important attribute from the perspective of the lean office, most likely because these employees are largely immune from the affects of other divisions' cost overruns. Of the eleven values studied, product cost is the only one reported by the lean office where delivery exceeds importance. The other ten values are all below the diagonal line in Figure 4, indicating that performance in these areas needs to be improved. Communication, change management, product quality, organizational effectiveness, people, job satisfaction, and technical capability are furthest from the diagonal line. These are the areas that the Lean Office would emphasize for prioritization.

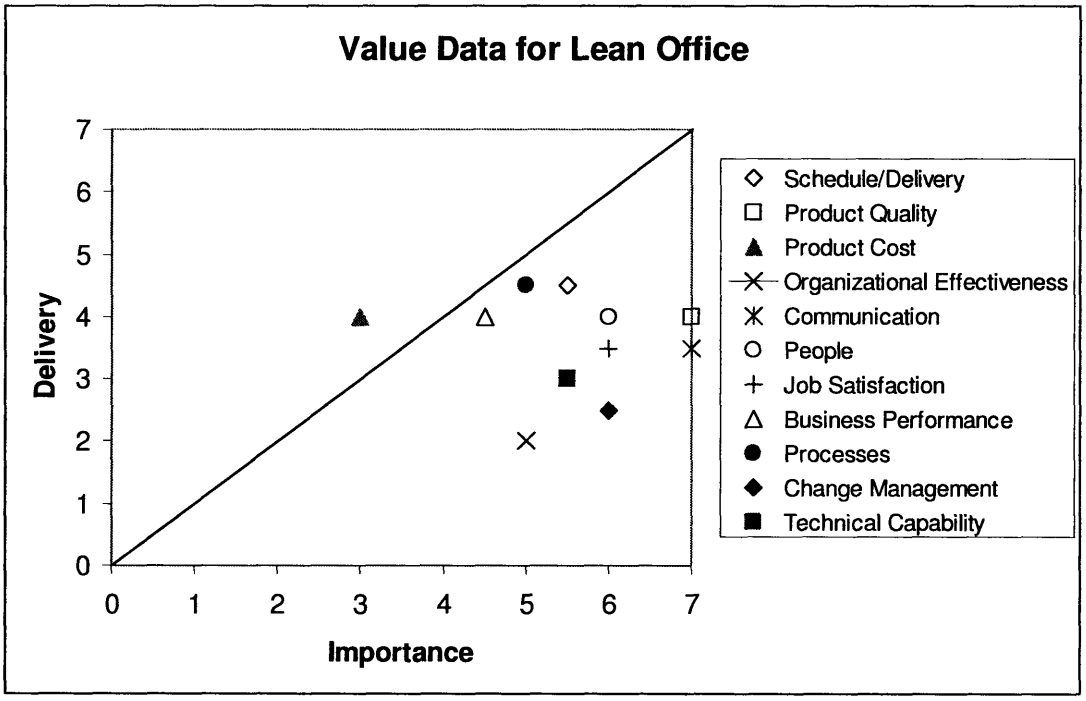


Figure 4. Stakeholder Value Map for Lean Office (n = 2)

5.1.1.2 Alignment of Values in the Metal Fabrication Group

Ten members of the Metal Fabrication group provided data for the Stakeholder Value Map shown in Figure 5. Compared to Figure 4, the Metal Fabrication map appears much cleaner because almost all of the values are tightly bunched near the top right of the graph. This indicates that, on an averaged basis, employees believe almost all of the values studied are highly important and are being delivered to a large extent. Product cost is the one value that lies somewhat outside the cloud; although an important value, employees of Metal Fabrication indicate that cost goals are not being delivered to the degree needed.

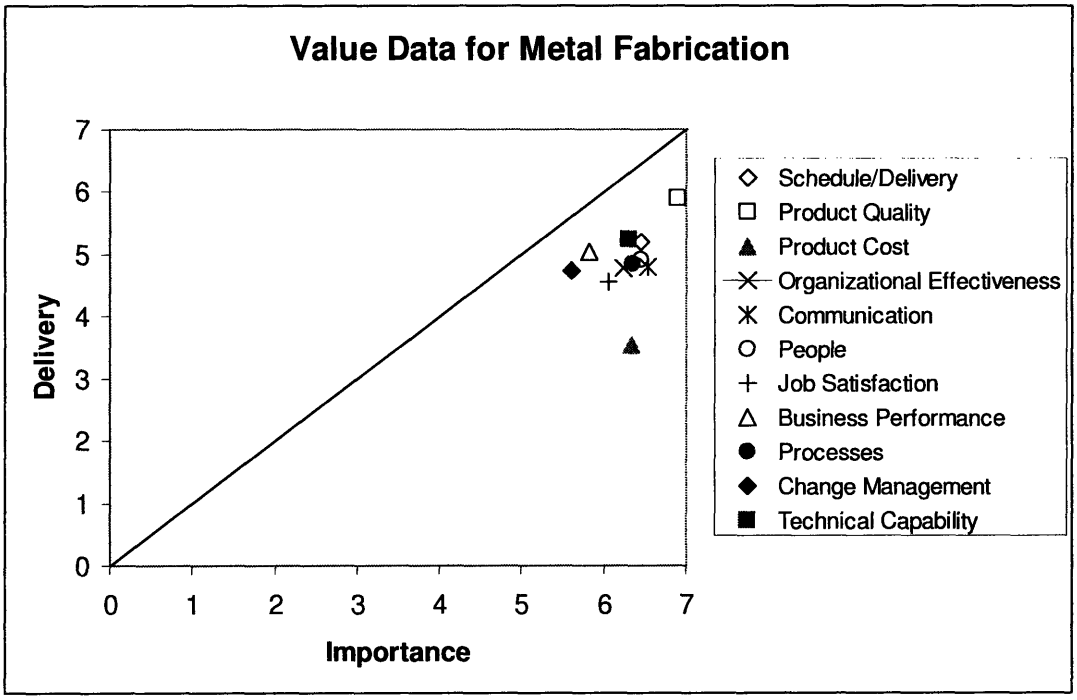


Figure 5. Stakeholder Value Map for Metal Fabrication (n =10)

5.1.1.3 Alignment of Values in the In-Service Radar Group

Three In-Service Radar employees provided the data that went into Figure 6. This Stakeholder Value Map is quite similar to the map for Metal Fabrication. Most values are located in the top right corner of the graph, again indicating that important values are being delivered to a large extent. There are two exceptions to this generalization, however. First, organizational effectiveness is deemed moderately important and is perceived to be moderately delivered. Since importance and delivery are more or less aligned, theory suggests that no additional organizational focus is needed to improve delivery of this value. Product cost, on the other hand, is reported to be an important value but it is not being delivered to expectations. Additional effort should be placed to control product costs.

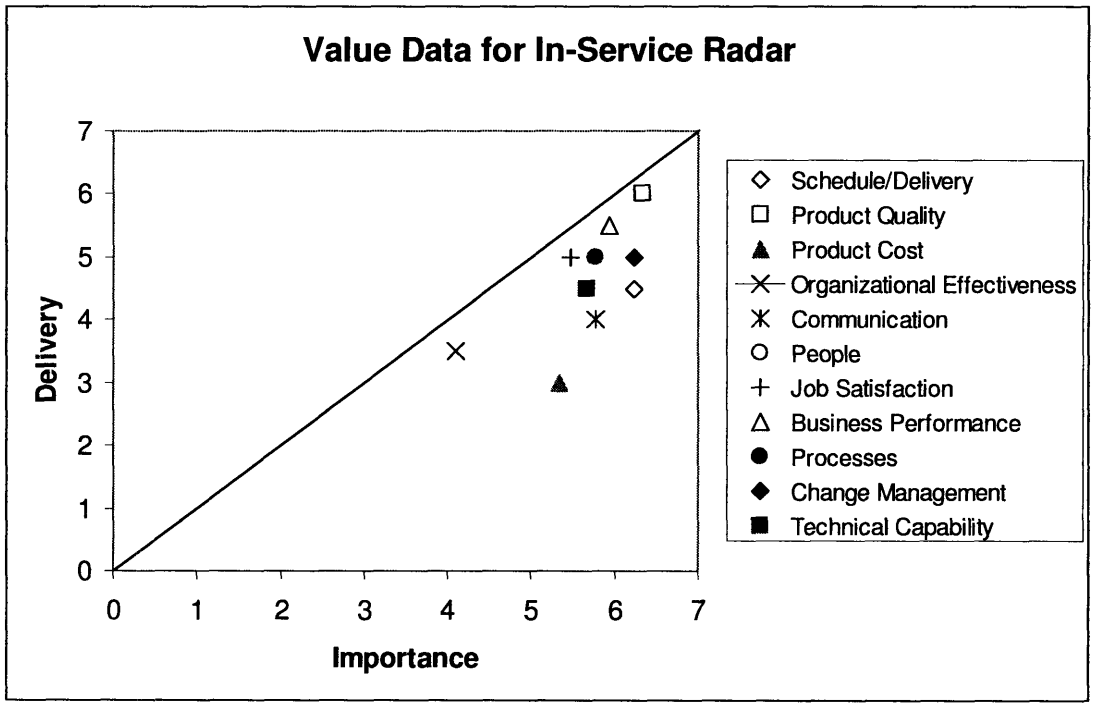


Figure 6. Stakeholder Value Map for In-Service Radar (n =3)

5.1.2 Consistency of Value Maps between Stakeholder Groups

To answer the second question, Figures 4, 5, and 6 above are compared with one another. It becomes immediately apparent that the Lean Office map is significantly different than those of Metal Fabrication and In-Service Radar. Metal Fabrication and In-Service Radar, on the other hand, have relatively similar value maps. Physical proximity could be a partial explanation to this finding. Metal Fabrication and In-Service Radar are located about 100 feet apart, whereas the Lean Office is much more distant. Physical proximity could facilitate informal communications between members of the two groups that could contribute to value alignment. Organizational proximity is another potential explanation for why Metal Fabrication and In-Service Radar share similar value perceptions while the Lean Office differs significantly. In-Service Radar is Metal Fabrication's direct customer, and both groups are evaluated primarily on operational metrics. Similar metrics imply similar goals and value prioritizations. Also, the client-customer relationship entails formal communications where goals and values are agreed to. The Lean Office, on the other hand, is not evaluated on traditional operational metrics. Lean Office personnel often have different incentives than the groups they advise. Closing the incentives gap may be the key to closing the gap in stakeholder values.

5.1.3 Alignment of Value Importance and Value Delivery amongst Stakeholder Members

The stakeholder value maps above make it simple to identify which values fall above or below each stakeholder's expectations *on average*, but it provides no insight about the variability of opinion within each stakeholder group. To determine how aligned each group is in its perception of value importance and delivery, the data was analyzed by calculating standard deviations for each stakeholder group. Heuristically, high standard deviations indicate a large difference of opinion, and small standard deviations indicate alignment in opinion. Using this approach, we are able to answer the third question posed at the beginning of this section.

Table 2 is a summary of standard deviations for each stakeholder group. Using an arbitrary cutoff point, standard deviations above 1.5 are highlighted to make it easier to detect trends. In general, one sees that there is more uncertainty in "Delivery" than "Importance". If this is indeed the case, it suggests that priorities are communicated adequately to the group but feedback on performance is lacking. For areas that have a high standard deviation in "Importance", a possible explanation is that the importance of that

area has not been adequately communicated to the group. Thus, for example, leaders in the In-Service Radar group may want to reiterate to their group how they see the importance of meeting product costs and being organizationally effective. Similarly, they should consider providing more feedback about how they view the progress of their change management processes. Similar types of conclusions can be made for the Lean Office and Metal Fabrication.

Table 2. Summary of Standard Deviations for Each Stakeholder Group

	Lean Office		Metal Fabrication		In-Service Radar	
	Importance	Delivery	Importance	Delivery	Importance	Delivery
Schedule/Delivery	2.1	0.7	0.5	1.0	1.3	0.7
Product Quality	0.0	0.0	0.3	0.6	1.2	0.0
Product Cost	1.4	N/A	0.8	1.4	2.1	0.0
Organizational Effectiveness	1.4	1.4	1.1	1.1	1.7	0.7
Communication	0.0	0.7	0.6	0.9	1.1	0.0
People	1.4	0.0	0.7	1.0	0.4	0.0
Job Satisfaction	0.0	0.7	1.3	1.6	1.4	1.4
Business Performance	0.7	N/A	1.6	0.9	1.1	0.7
Processes	1.4	2.1	0.8	1.6	1.1	1.4
Change Management	1.4	2.1	1.2	1.8	0.7	2.8
Technical Capability	0.7	2.8	0.5	1.4	1.2	0.7

5.2 Thoughts on Stakeholder Value Mapping Tool

The discussion above provides an idea of the type of information one hopes to obtain from Stakeholder Value Mapping. As such, the methodology is indeed tactical in nature. It can best be used as a diagnostic tool to gauge the effectiveness of existing project implementations. Because of the direct communication with key project stakeholders, Stakeholder Value Mapping is an excellent method for gaining real understanding of stakeholder motivations. The data analysis performed in the previous section clearly indicates areas that need improvement. This makes the method valuable as a prioritization tool and should therefore make it attractive to practitioners of Continuous Improvement. The last strength of the methodology is that it is easy to implement. The final version of the tool that had a short list of eleven values to be rated (see Exhibit 4 in the Appendix) eliminated most of the inhibitions that stakeholders initially felt when confronted with a list of values two pages long (see Exhibit 3). Mapping only the key values was fundamental in making the tool easy to use and the results easy to analyze.

There are also several weaknesses with the tool as used in this work, mostly dealing with potential data biases. For example, union represented employees were not allowed to be interviewed. Would the results

have changed if this key stakeholder group had been included? Another indication that data bias may have existed is that most of the values were deemed highly important by the Metal Fabrication and In-Service Radar groups. Is this a true reflection of these stakeholders' value perceptions, or were these groups somehow biased toward indicating that all values were important? Another bias problem has to do with sample size. Only two and three individuals were interviewed from the Lean Office and In-Service Radar group, respectively. Any sort of meaningful statistical analysis is impossible with such a small sample size. Also, stakeholders used different rating techniques when filling out the survey. Some people used significant digits to refine their ratings whereas others used either whole number or half number increments. In addition, the timing of the interviews varied during a three week period, possibly impacting the results. Last, the list of values may have been incomplete. There could very well have been other important dimensions not captured in the list of values examined.

Other issues exist dealing with the practical implementation aspects of the methodology. It has already been stated that stakeholders resisted being interviewed when they were asked to rate very specific values. There is a problem, though, when stakeholders are asked to rate a short list of general values (e.g. organizational effectiveness). The difficulty arises because different stakeholders understand the values differently. A shorter list enables the methodology to be implemented because surveys take less time and stakeholder participation increases, but the results become more obscure.

A second practical issue is: Who is the ideal person to use the tool? As an outsider working inside the organization, the author was able to survey stakeholders without them bearing much risk. The situation could be much different if a company insider used the tool. Imagine, for example, if the manager overseeing Metal Fabrication interviewed his direct reports to collect data for the tool. Respondents would likely be more cautious in responding to any question that the manager might interpret as personal criticism. Other candidates for using the tool are members of the front-line workforce. One immediate benefit would be front-line workers' more active engagement in Continuous Improvement than has happened in the past, a necessary element for lean to succeed. Front-line workers would also be quite familiar with many of the key stakeholders, although they might not have the same system-wide view as someone in a management role. Perhaps the most effective arrangement would be a manager and a front-line employee in each area working together to collect the stakeholder data.

6 Organization and Change

This section evaluates the organization using the Three Lenses framework.[22] The emphasis of this section is on evaluating those parts of the organization that most affected the implementation of the pull project. By complementing the analysis using the Three Lenses framework with the results of Stakeholder Value Mapping (VSM), one is able to achieve greater insight into the organization as it currently stands and how it might be.

6.1 Strategic Perspective

As a company, Raytheon states its strategy with the following four points[23]:

- Grow our position in core defense markets through a focus on key strategic pursuits, Mission Support, technology and Mission Assurance.
- Use the Strategic Business Areas to leverage domain knowledge of core defense markets across the company to achieve growth and to expand our Mission Systems Integration opportunities.
- Establish the Beechcraft® and Hawker® brands as the industry standard for quality, service and support.
- Be a Customer Focused company based on:
  - **Performance** – Promises made, promises kept.
  - **Relationships** – Listen, anticipate, respond and follow through with our customers, partners and each other.
  - **Solutions** – Develop and provide superior customer solutions.

At the work cell level, company strategy did not seem to guide employee actions. Some IADC employees would likely be unaware that Beechcraft® and Hawker® are Raytheon brands and would be hard pressed to explain how they could contribute to making them the industry standard. Of the four points composing company strategy, the two elements that were most frequently communicated at the IADC were Mission Assurance and being a Customer Focused company. Mission Assurance essentially means making sure that Raytheon products work as designed every time they are used. The phrase "No Doubt" is almost always used in conjunction with Mission Assurance, implying that the "war-fighter"

[22] Carroll, John S. "Introduction to Organization Analysis: the Three Lenses"
[23] The four bullet points are taken directly from Raytheon's website: http://www.raytheon.com/about/vsgv/

(i.e. customer) has total confidence that the Raytheon systems they use will work each and every time they are needed. Being a Customer Focused company was interpreted by many IADC employees as providing three things: on-time delivery, low cost products, and perfect quality. All three of these goals seemed to have equal weight with employees, although some would argue that quality was most important, followed by both cost and service.

Strategic initiatives targeting lower levels of the organization existed as well, although the lower one went organizationally, the more tacit the strategy would be. At the IADC, the main strategies were a reiteration of Mission Assurance and the implementation of a lean initiative where the goal was to reduce waste and otherwise make processes more efficient. Stakeholder Value Mapping (SVM) showed that group level strategies were not always communicated effectively (see Section 5.1.3), supporting the idea that strategies somehow became more blurred the lower one went into the organization.

The bolted cabinet pull project was well aligned with both corporate level and IADC goals. The project aimed to improve on-time delivery of cabinets and lower their costs. In addition, communication with key stakeholders throughout the project to get buy-in instead of "pushing" the project was an intentional project strategy; this was in line with strategies around Relationships and lean.

Organizationally, Raytheon is first broken down into Business Units and then Business Areas (or "Mission Centers"), which tend to be the names of specific plants. For example, the Andover plant is the Integrated Air Defense Center (IADC). It was harder to understand the exact structure of the organization at the lower levels. Since no up-to-date organization charts existed for the IADC during the internship[24], the following understanding of the organizational structure was constructed through employee interviews. Within each Mission Center are Directorates, or collections of work groups that are run by Directors. Directors may oversee work groups that are closely related to each other, but this is not always the case. The main purpose of Directorates seems to be to divide Mission Centers into more manageable groupings. Below Directorates are Centers of Excellence (COE) and Programs. Metal Fabrication, for example, is a COE that specializes in metal processes. Similarly, AEGIS is the Program that uses bolted cabinets; the program is essentially designed to manage and fulfill obligations associated with a particular contract. COEs and Programs are composed of work cells, teams, and individual contributors. Besides the building blocks described above, there are support functions such as manufacturing engineering, integrated supply

[24] Up-to-date organization charts existed for the corporate and divisional leadership teams but did not extend down to the group level. Frequent organizational changes and leadership moves made it difficult to maintain updated charts.

chain, and finance. Raytheon organizes its employees through a matrix structure so that employees report both to a functional leader and to a business leader. For example, John Doe might report both to Metal Fabrication (the business) and to process design (the function).

In the context of VSM, the matrix design and organizational structure at the lower levels of the company made it difficult to determine all of the stakeholders for the pull project. The confusion extended to employees as well. Some employees interviewed during the project found it difficult to explain their responsibilities and loyalties when conflicts arose between their functional and business organizations. The vertical organizational tiers presented additional difficulties in implementing the project. The pull system had vast support at the Metal Fabrication and In-Service Radar group level, but managers overseeing these areas resisted the plan for political reasons described in the next section. The point here is that the strategic design of the organization, due to its matrix structure and vertical hierarchy, creates a situation where many powerful stakeholders can influence the success of a project. What this means in practice is that projects need to be championed from a powerful individual high up in the company to have a high probability of success. Projects championed at the work group level simply do not have the clout to overcome resistance from more senior managers, and most lower-level employees lack the organizational visibility to successfully manage the political currents that run through the company.

6.2 Political Perspective

The political lens focuses on understanding the different interests and goals that guide individuals, groups, and departments both within and outside of the organization that have a stake in the project. The main stakeholders for the pull project were union employees in Metal Fabrication and In-Service Radar, middle managers in charge of these groups, the two co-leaders of the project, the lean office, the outside supplier of aluminum raw material, and the director with responsibility over Metal Fabrication. Figure 1 is a map of these stakeholders showing both their connection to the project and whether or not they were for or against it (plusses = for, minuses = against). Arrows indicate when the author's impression of stakeholder interests changed over time. For example, the director overseeing Metal Fabrication initially seemed to be in support since he signed a Performance Management Goal Agreement outlining the project. As it turned out, the director halted project implementation halfway through the internship for reasons explained in Chapter 4.

Figure 7 shows an interesting picture because all of the key stakeholders except the director seemed to support the pull project. The reasons for stakeholder support differed, however, as summarized in Table 3. Since the pull project was not fully implemented due to the director's guidance, the data reinforces the point made in the Strategic Lens section above. The organizational structure at the IADC creates an environment where projects need to be championed by powerful (i.e. high level) individuals in the company to have a high probability of success. In this case, the overwhelming support of the project at the working group level and even in the higher ranks of the lean office were not enough to get the project fully implemented.

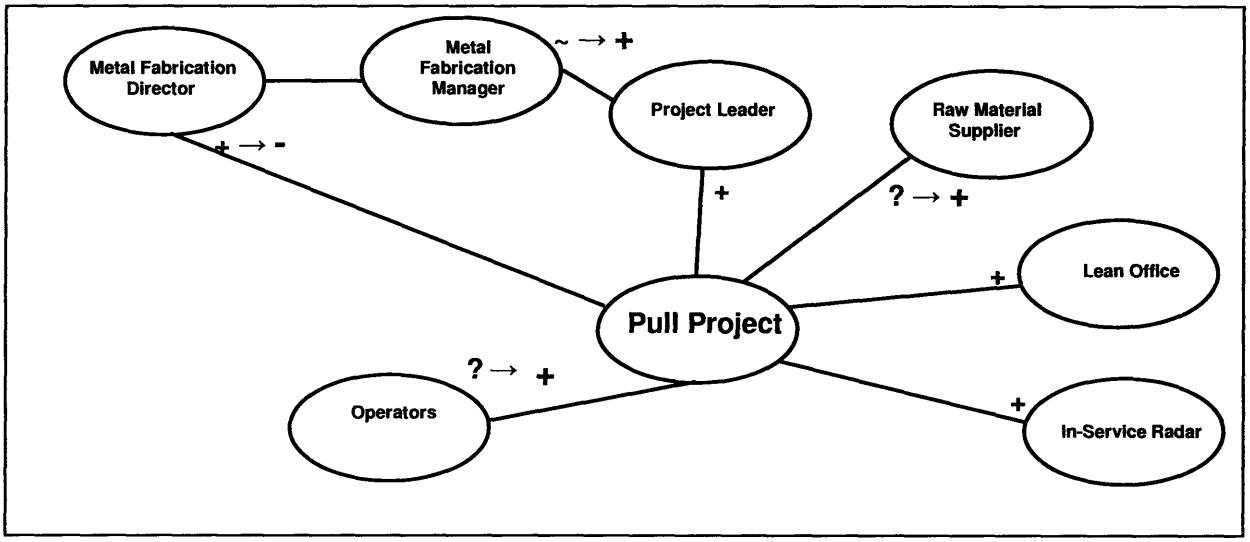


Figure 7. Stakeholder Map for Bolted Cabinet Pull Project

Table 3. Summary of Stakeholder Interests in the Bolted Cabinet Pull Project

Stakeholder	Stands to Gain or Lose
Metal Fabrication Director	Loses ability to produce cabinets faster than cabinet demand. The director preferred to implement a plan that would reduce per-cabinet costs by accelerating the production schedule. Fixed costs would be spread among more units, thereby lowering per-cabinet costs using standard accounting procedures.
Metal Fabrication Manager	Gains ability to meet new lean metrics that each work group is committed to achieve. In addition, by leveling production of bolted cabinets, Metal Fabrication will be better able to satisfy delivery commitments to customers other than In-Service Radar. Several long-term benefits are also likely.
Project Leader	Gains credibility as an effective leader and also fulfills a personal desire to introduce world class manufacturing techniques to Metal Fabrication.
Raw Material Supplier	Gains perception of being a collaborative business partner.
Lean Office	Gains a highly visible example of lean principles in action that can be showcased to other departments.
In-Service Radar	Gains better service levels for cabinet deliveries, which in turn makes it easier for ISR to satisfy end-customer commitments.
Operators	Gains benefits from project side effects such as level scheduling and visual management that make work more enjoyable and predictable.

6.3 Cultural Perspective

The culture at the Integrated Air Defense Center is in the midst of change. Traditionally, many employees expected to be told exactly what to do by their superiors; this is especially true for the union workforce. Now, with lean being championed throughout the company, behaviors are gradually changing. Employees are being told that they should take the initiative and speak up when they see something being done wrong or if they have ideas on how to improve processes. With the Raytheon Six Sigma initiative now in its seventh year, the importance of data in decision-making has also become more important.

Because of the changing cultural climate, some employees were more receptive to the pull project than others. Upper management and new employees seemed especially open to the lean initiative. Middle managers and employees with long tenures at the company tended to be less warm to the change. There were of course many exceptions to these broad generalizations.

Middle management's deep-seated norms of top-down leadership were often apparent despite the fact that they committed themselves to the lean initiative. Some of my peers called this a "whips and chains" management style. To illustrate, several middle managers said on different occasions: "I don't care what it takes, just get it done". The manner in which this was said made it clear that no excuses would be accepted if the task was not completed. This behavior was counterproductive in creating an environment of openness and personal initiative that other parts of the organization were trying to foster.

In the context of the pull project, the culture of strict adherence to management instructions was evident. For example, after parts of the pull project were terminated in favor of a plan to accelerate cabinet production, shop floor employees asked their managers where the cabinets should be stored since the customer would not need them right away. Instead of an answer, the employees were told "not to worry about it". The employees did not question the matter further and proceeded to accelerate production with no plan for storage. In the transition between traditional and lean management cultures, the traditional culture is currently dominant.

7 Conclusions

This thesis explores the idea that lean implementations can only be successful when an organization's prevailing values are consistent with the values of lean itself. Straightforward methods for determining compatibility between lean and organizations are hard to come by, although Stakeholder Value Mapping (SVM) is a technique from the field of Enterprise Management that comes close. This thesis demonstrated the use of SVM at the micro level. Stakeholder values were mapped around a specific lean project at Raytheon's Integrated Air Defense Center. The project, a pull system for a line of sophisticated bolted cabinets, was described in detail as a case study. Insights from the pull project, the results of SVM, and the use of the Three Lenses framework all provide support for the idea that organizational values need to be compatible with the values underpinning lean.

The implications for Raytheon's lean initiative are not immediately dour even though signs of value misalignment are evident. Activities already in progress need to stay on track, such as the work coming out of the Lean Office which is helping to transform the culture at the shop floor level. New initiatives can also be started to align stakeholder incentives across the organization. Stakeholder value mapping uncovered a difference in value perceptions between the Lean Office and the Metal Fabrication and In-Service Radar groups. Common incentives should be considered for all three groups to gain better value alignment. When stakeholder incentives are aligned in accordance with lean thinking throughout the value stream, a lean transformation is more likely to succeed.

In a more general sense, this thesis argues that it is not appropriate to begin lean initiatives without first considering the organizational, political, and cultural implications. Instead of kicking off with a mapping of material and information flows (i.e. Value Stream Mapping), companies should first understand whether organizational values are aligned with those of lean through Stakeholder Value Mapping (SVM). While SVM alone does not yield sufficient data to guide an implementation, it is an effective method for understanding the stakeholder interests that can serve as barriers to lean. Leaders trying to bring lean into their organizations will find SVM a promising tool for determining where to initially focus their attention. If lean and stakeholder values are aligned, the groundwork will be set for a traditional lean implementation that focuses on well-known tools for discovering and removing waste. On the other hand, if lean and stakeholder values differ significantly, consideration should first be given to aligning organizational interests with the lean strategy.

8 Bibliography

Carroll, John S. "Introduction to Organizational Analysis: The Three Lenses." MIT Sloan School of Management Working Paper, 1-13. MIT Document Service, Revised July 2002

Flinchbaugh, Jamie and Andy Carlino, The Hitchhiker's Guide to Lean: Lessons from the Road, USA, Society of Manufacturing Engineers, 2006

Grossi, Ignaccio, "Stakeholder Analysis in the Context of the Lean Enterprise," Masters Thesis, MIT Systems Design and Management Program, March 2003.

Murman, Earll, Thomas Allen, Kirkor Bozdogan, Joel Cutcher-Gershenfeld, Hugh McManus, Deborah Nightingale, Eric Rebentisch, Tom Shields, Fred Stahl, Myles Walton, Joyce Warmkessel, Stanley Weiss, and Sheila Widnall, Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative, New York: Palgrave/Macmillan, 2002.

Nightingale, Deborah J. and Alexis Stanke, "Enterprise Value Stream Mapping and Analysis", Version 1.0, August 2005

Pascal, Dennis, Lean Production Simplified, New York: Productivity Press, 2002.

Raytheon Company Website. 2006. < http://www.raytheon.com/about/>.

Raytheon Company Website. 2006. <http://www.raytheon.com/about/vsgv/>

Raytheon Company Website. 2006. < http://www.raytheon.com/businesses/rids/about/index.html>.

Raytheon Company Website. 2006. <http://www.raytheon.com/businesses/rids/businesses/Integrated_Air_Defense/index.html>

Raytheon Company Website. 2006. < http://www.raytheon.com/feature/shingo/>.

Rother, Mike and John Shook, Learning to See, Brookline: The Lean Enterprise Institute, 2003.

Shinkle, George, Reb Gooding, and Mike Smith, Transforming Strategy into Success: How to Implement a Lean Management System, New York, Productivity Press, 2004.

Sterman, John, Business Dynamics: Systems Thinking and Modeling for a Complex World, Irwin/McGraw Hill, 2000.

Vanka, Padmaja, "Line Coordination in a Rapid Change, High Volume Environment," Masters Thesis, MIT Leaders for Manufacturing Program, June 2004.

Wikimedia Foundation. "Value Stream Mapping." Wikipedia Dictionary. January 2006. <http://en.wikipedia.org/wiki/Value_Stream_Mapping>.

Womack, James P. and Daniel T. Jones, Lean Thinking, New York: Free Press, 2003.

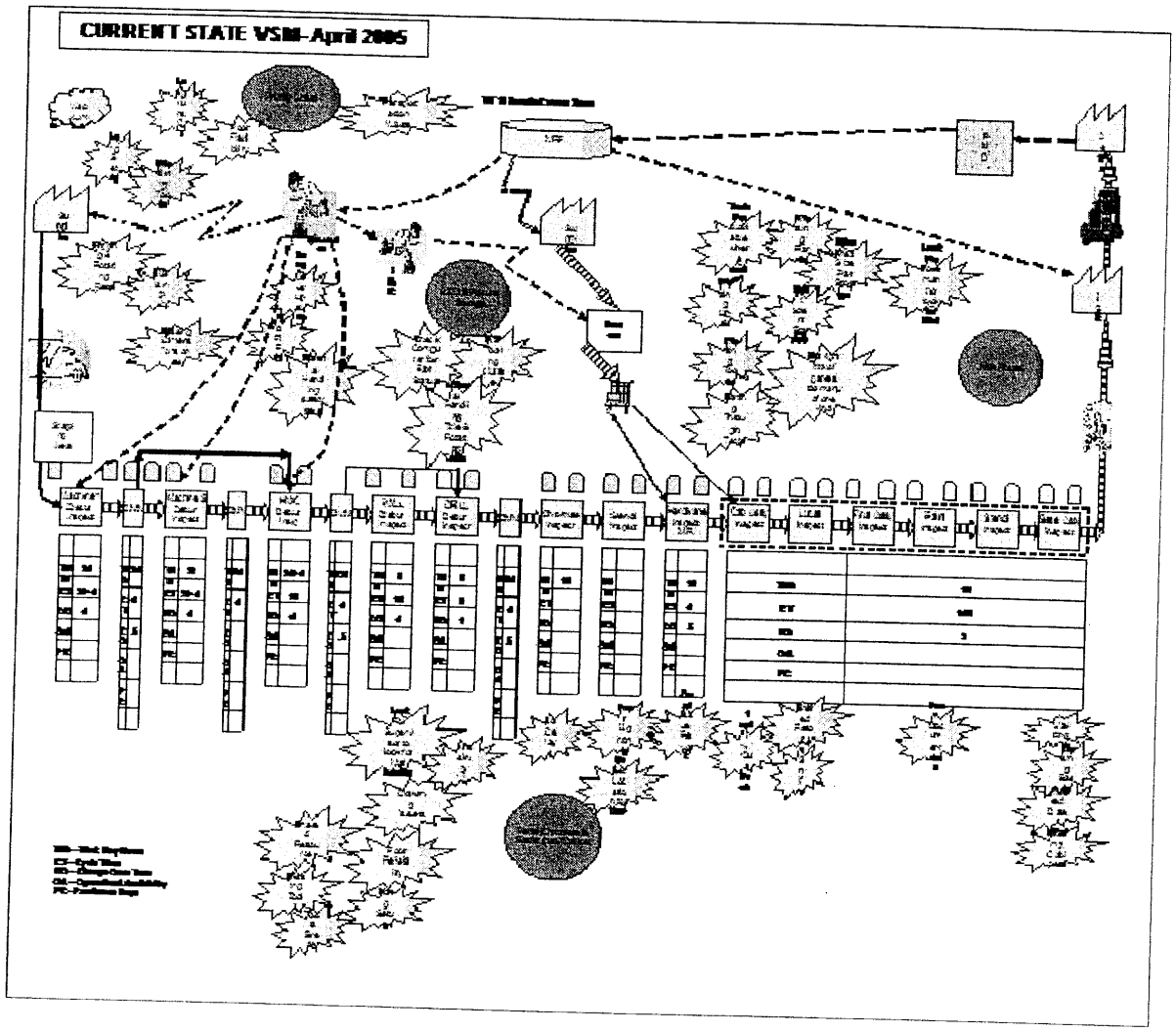
9 Author's Biography

Born in Chicago, Illinois, the author shortly thereafter moved with his family to Cincinnati, Ohio where he spent most of his childhood years. His family moved again in 1990, this time overseas to a small municipality located north of the Arctic Circle called Tromsdalen, Norway. His knowledge of Scandinavian culture and history proved useful for one of his two undergraduate degrees received from the University of Wisconsin-Madison. In 2000, the author graduated with a BS Chemical Engineering degree and an additional major in Scandinavian Studies. From 1998 to 1999, he worked at Dow Chemical in the co-op engineering program, completing three assignments in technical service and development, operations, and R&D roles. From 2000 to 2004, he worked at ExxonMobil Research and Engineering Company as a process engineer first in the Catalytic Cracking Section and then in the Lubricant and Specialties Section. His main responsibilities included troubleshooting catalytic cracking and lube hydroprocessing units, optimizing process conditions, and developing technical proposals in support of ExxonMobil licensing efforts.

In 2004, he joined the Leaders for Manufacturing (LFM) program at MIT for his MBA and MS Chemical Engineering degrees, where this thesis was completed in 2006. Upon graduation from MIT in June 2006, the author will be joining Honeywell as a Project Manager for the Aerospace business in Phoenix, Arizona. The author can be reached at his permanent email address – blathrop@sloan.mit.edu.

10 Appendix

10.1 Exhibit 1 – Current State Value Stream Map for Bolted Cabinet Line[25]



[25] Exhibit 1 is intentionally blurry. It is meant as a general illustration of what a value stream map looks like and not as a specific example to be studied in detail. A good source on Value Stream Mapping is Learning to See by Mike Rother and John Shook.

10.2 Exhibit 2 – Stakeholder Value Mapping Interview Protocol

Interview Protocol: Stakeholder value for AEGIS Bolted Cabinets (ABC)

Questions are listed in Bold
Key points of information needed are listed as sub items

Introduction:

Thank you for participating in the interview. It is part of a research project which is being conducted by a graduate student from the Massachusetts Institute of Technology in partnership with Raytheon Company. Your participation in this interview is voluntary – if you are uncomfortable with any questions, you don't have to answer them. The main focus of this interview is on issues of value and enterprise communication associated with the Aegis Bolted Cabinet Line. Shall we begin?

1. **Please describe your relationship in the Aegis Bolted Cabinet enterprise.**
   Organization
   Stakeholder relationship
   Percent of time engaged in the Aegis Bolted Cabinet enterprise

2. **What do you value/what would you like to value as a stakeholder in the bolted cabinet business?**
   Use stakeholder value sheet to capture values. Some examples might be: Quality, dependability, lead time, risks, pride, influence, communication, lead time, on-time delivery, budget, affordable, product meets requirements, teaming, responsiveness?

3. **How would you rank the values you mentioned in order of importance?**

4. **How well does the enterprise perform in delivering value?**
   Numerical grades between 1 and 7 preferable (1 = low, 7 = high).
   Would you be interested in continuously "grading" the enterprise on a bi-weekly basis?

5. **How do you feel about communications throughout the bolted cabinet enterprise? What opportunities are there for you to provide input or feedback?**
   Extent of communication – who do you talk to?
   Opportunities to provide feedback?

6. **Is there anything else that we should be aware of regarding issues of communication and value?**

Thank you for participating in this project.

10.3 Exhibit 3 – Stakeholder Value Data Collection Form (ver. 1)

Stakeholder Group:		
Stakeholder Name:		
Date:		
Ask the stakeholder what they value. What do they expect to get from their involvement with your project? What are the things that would make your project highly thought of by them?	On a scale of 1 to 7 how important is this value to the stakeholder?	N/A
Deliverying cabinets when needed/when promised/when planned		
Being able to meet customer takt time		
Having consistent demand from customer		
No quality issues when cabinets reach customer		
First-time quality (No MRBs, no non-conformances)		
Meeting or beating budget		
Keeping product costs low		
Clear organizational structure and understanding of responsibilities		
Knowledge of contacts throughout the enterprise		
Well functioning systems that require little to no intervention		
Effective meetings with identified actions, owners, and expected completion dates		
Coordination between organizations		
Receiving adequate resources to affect change		
Consistent organizational message		
Ability to reallocate resources quickly		
Clear work priorities/clear expectations		
On-going communication to prevent firefighting		
Open, honest communication		
Two-way communication with management		
Clear communication of business performance		
Open access to information		
Communicating potential problems before they blow up		
Delivering on commitments		
Delivering on expectations		
Effective teamwork		
Competence		
Reliability		
Trust		
Ethical behavior		
Integrity		
Responsiveness		
Accountability		
Pride in work		
Job Security		
Positive feedback and recognition		
Customer satisfaction		
Learning		
Little to no firefighting		
Work/life balance		

Ex. 3 Cont'd.: – Stakeholder Value Data Collection Form (ver. 1)

Ask the stakeholder what they value. What do they expect to get from their involvement with your project? What are the things that would make your project highly thought of by them?	On a scale of 1 to 7 how important is this value to the stakeholder?	N/A
Manageable workload		
Work satisfaction		
Career growth		
Relationship building		
Salary		
Bonus		
Challenging work		
Stability		
Achievement awards		
Enjoyable work environment		
Performance feedback		
Working in a strategic growth business		
Being in a world-class organization		
Raytheon's success		
IDS' success		
Revenue growth		
Profit growth		
Accelerating product delivery		
Mission Assurance		
Repeat business		
Bringing in new business		
Maintaining meaningful work for employees		
Ability to execute		
Predictable processes		
Flexible manufacturing capability		
Realistic budget planning		
Willingness to change		
Removing waste from work processes		
Continuous Improvement/Sustained Improvement		
Meeting MEM score goals		
Simplified processes		
Reducing need for management decision/ More responsibility at the operator level		
Smooth transition from welded to machined parts		
Maximizing value of the individual		
Accurate technical drawings (prints) that contain all the information required to do a job		

10.4 Exhibit 4 – Stakeholder Value Data Collection Form (ver. 2)

Stakeholder Group:			
Stakeholder Name:			
Date:			
Ask the stakeholder what they value. What do they expect to get from their involvement with your project? What are the things that would make your project highly thought of by them?	On a scale of 1 (not important) to 7 (very important), how do you value the following themes?	On a scale of 1 (poor) to 7 (extremely well), how is the enterprise delivering this value?	N/A
Schedule/Delivery			
Product Quality			
Product Cost			
Organizational Effectiveness			
Communication			
People			
Job Satisfaction			
Business Performance			
Processes			
Change Management			
Technical			

10.5 Exhibit 5 – Excerpt of the Pull System Implementation Plan

Area	Activity	Lead	Team Members	Planned Compl. Date	Actual Compl. Date
Driver Cell	Confirm buy-in from Ralph Grande to implement pull between metal fab cabinet kanban store and driver cell.	Ben Lathrop	Dereck Ouellet, Grant Leung, Matt Mercer	1-Sep	30-Aug
	Verify kanban location is set up in the driver cell area.	Dereck Ouellet	Ben Lathrop	1-Sep	30-Aug
	Train driver cell production control people on how the pull system will work.	Dereck Ouellet	Ben Lathrop, Grant Leung, Matt Mercer	8-Sep	8-Sep
	Confirm the kanban is working effectively	Derek Ouellet	Grant Leung, Matt Mercer	20-Oct	
Outfitting of 45 kV and 17 kV Cabinets	Get buy-in from Mike Dente to implement pull between metal fab cabinet kanban store and high volt outfitting cell.	Ben Lathrop	Grant Leung, Matt Mercer	1-Sep	31-Aug
	Set up two kanban locations at the outfitting cell -- one kanban for the 45 kV and one for the 17 kV	Bruce White	Ben Lathrop, Matt Mercer	6-Sep	12-Sep
	Train outfitting cell production control people on how the pull system will work.	Bruce White	Ben Lathrop, Grant Leung, Matt Mercer	13-Sep	14-Sep
	Confirm the kanban is working effectively	Bruce White	Ben Lathrop, Grant Leung, Matt Mercer	20-Oct	
Cabinet Kanban Store	Get buy-in from Curt Goldsberry to set up metal fab cabinet kanban store ~~in the display area~~ near the front aisle.	Ben Lathrop	Grant Leung, Matt Mercer	1-Sep	31-Aug
	Set up one temporary kanban location for each type of cabinet (17 kV, 45 kV, driver) ~~at the current display area~~ near the front aisle.	Ben Lathrop	Grant Leung, Matt Mercer, Charlie Maclean	6-Sep	1-Sep
	Develop and build production kanban card holder and kanban cards (cards for assembly and fabrication at VF10, VF11, and HS4)	Ben Lathrop	Grant Leung, Matt Mercer, Sarah Dechiaro	8-Sep	16-Sep
	Train metal fab production control people on how the pull system will work.	Grant Leung	Ben Lathrop, Matt Mercer	8-Sep	
	Confirm the kanban is working effectively	Ben Lathrop	Grant Leung, Matt Mercer	20-Oct	