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An Unabridged Approach to Lean Implementation: Understanding the Impact Systemically and Supporting the Operational Changes

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ABSTRACT

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Lean Material Strategy (Lean) has become a governing principle for many companies. These strategies help managers identify waste within the process, and once visible, drive it from the system. One of the principle objectives of this approach is to achieve greater manufacturing efficiency. It is current practice, at a publically held automotive corporation (Company X), to employ Lean in new program launches for its manufacturing sites. While Lean served as the theoretical foundation for design of new assembly systems at Company X sites, insufficient consideration was given to developing an integrated “big picture” solution to the implementation of these new assembly systems within the broader manufacturing system (i.e. global supply chain, quality, etc.). Additionally, implementation of lean creates entirely new workflow procedures that demand a shift in organizational culture throughout the company. Without considering the integration of Lean and its attendant organizational culture change, a balanced system was unachievable at Company X – this thwarted realization of improved manufacturing efficiencies. To address these issues, the investigator developed a research protocol aimed at proposing the successful integration of Lean Assembly Systems into the entire manufacturing system. Using existing performance data at Company X, and a thorough understanding of Lean, the investigator was able to devise an integrated system capable of integrating manufacturing schedules, optimizing manpower, meeting efficiency targets, and ultimately driving waste back to the suppliers. As an active member of the Assemble Systems management team at Company X, the investigator has developed an implementation plan to adopt this more integrated approach immediately.

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December 10, 2012

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Department of Technology

An Unabridged Approach to Lean Implementation:
Understanding the Impact Systemically and Supporting the Operational Changes

A Thesis in
Industrial Technology

by

Joseph D. Wolkiewicz

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Chapter 1: Introduction

1.1 Background

Lean Material Strategies have become governing principles for many companies. These strategies help identify waste within the process, and once visible, drive it from the system. One of the primary outcomes of this approach is to achieve a more efficient manufacturing environment. Since efficiency is a component of value added work, the non-value added work is what becomes labeled as “waste”. There are seven forms of waste, these forms include: motion, over-production, correction, waiting, inventory, material movement, and processing.

The Company “X” team shares a passion for customers and a competitive spirit that drives us to excellence. Our culture -- one which represents diversity, inclusion, mutual respect, responsibility and understanding -- welcomes fresh perspectives and varied experiences. Our 202,000 employees work in 158 facilities touching six continents, they speak more than 50 languages and touch 23 time zones. From designing and engineering state-of-the-art plants and developing new vehicles and technologies to creating new marketing programs, our team members are valued for their unique contributions. Serving as the face of the new Company “X” in communities around the world, our 21,000 dealers are also important members of our team, and are integral to our success (confidential, 2012).

It is current practice, at Company “X”, to employ Lean Material Strategies in new program launches for manufacturing sites. Lean is the foundation for the design of these assembly systems and without consideration for the new techniques and how

they impact the entire system (i.e. global supply chain, quality, etc.), a balanced system cannot be achieved and; therefore, the desired outcome will not be realized. In turn, it should be noted, Lean Material Strategies may create entirely new processes, and these processes must be accepted and operationalized as they present a fundamental cultural change that must be adopted from the highest levels of management through the factory floor. Lean manufacturing is an attitude or philosophy, rather than a specific set of technologies (Songini, 2005).

Currently, an engine program launch is presenting just such a challenge. The capital costs of the assembly line have seen a reduction in cost. This can be largely attributed to a reduced operator footprint and the elimination of error-proofing controls. These features have reduced expenses, but have also created a challenge for the manufacturing and supply chain teams. To meet the Lean objectives, material must be presented to the operator in a manner that eliminates non-value added movement as well as operator decisions. This results in a requirement to sequence material to the assembly line. This has been a time proven system in vehicle assembly; however, this practice is new to powertrain divisions and goes completely unsupported by any Bill of Process or Bill of Equipment. This process is further complicated by the Information Technology group's failure to deliver an electronic solution that would provide global supply chain with a schedule for repacking material and a method to accomplish the sequencing of that material.

With a reduction in error proofing controls on the assembly line, that the integrity of the build would rest entirely within the supply chain department. With no method to achieve this, there is an impact to, not only, the responsiveness of the department to

deliver the part in time, but the quality of the engine through the supply chains ability to provide the correct part. Pure lean principles need to be looked at in tandem with industry-leading best practices in supply chain, such as intelligent inventory management, response management, and demand management, in order to create the ideal lean plant,” Viswanathan and Littlefield conclude. “Also, the approach of avoiding software is no longer realistic in today’s environment due to the simple fact that there are too many constraints, which cannot be handled manually with ad hoc tools (Katz, 2009).

An important tool in making waste visible is value stream mapping. In value stream mapping, a value stream map is created to capture the current state. This map should identify the current process, along with any delays associated with it. Also documented, is the material flow required to support the process. Once the current state has been modeled, an assessment is made on methods of reducing or eliminating waste. Upon completion, a future state model is created and work is conducted to achieve the desired state. This process can be applied theoretically and empirically.

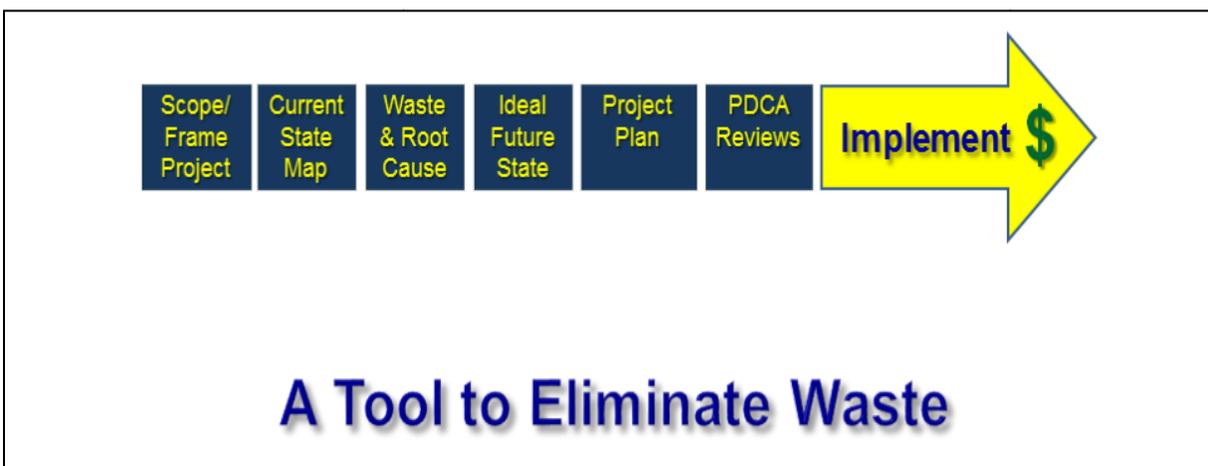


Figure 1: Lean Material Strategy (Wilson, J., & Killeen, W., 2011)

As the Lean Material Strategies team works to achieve the desired state, representative of gains in efficiency and reduction or elimination of waste, a determination on where to drive the waste must be made. It is clear that the waste should be moved to a functional group with an indirect relationship to manufacturing. The resultant move would preserve any gain in efficiency for manufacturing and protect against waste being driven into another department with a direct relationship – thus maintaining the desired effect. In most cases, it is logical for the material handling group to absorb this waste. Ideally, the material handling team would perform the same analysis to continually improve efficiency and push their waste further downstream. Shah and Ward (2003) found that the influence of lean practices contributes substantially to the operating performance of plants. However, the implementation requires customized solutions (Domingo, 2007).

It is clear that there are two components to successful achievement of Lean Material Strategies. The first is through an understanding of the concepts and applications of Lean; this is the technical side. The second component is the creation of an organizational culture that is supportive of the involvement of its employees in the continuous improvement process.

There are many different methods used to move toward lean manufacturing, and they can be implemented in whatever order is most convenient for a company as it examines the different steps of its process. As a continuous process, lean manufacturing is sometimes divided into three different stages. First, any wasted labor, space, supplies or time is removed to lessen production costs. Second, a policy of continuous improvement is implemented, where the company dedicates itself to finding

newer and better techniques to use in overall manufacturing. Third, the company investigates more specific techniques that apply directly to what sort of product it is manufacturing or what service it is providing and how innovations or new methods can be used to lower costs even more (Lacorna, 2012).

Value stream mapping is a comprehensive analytical tool that is frequently used by consultants and is also useful to lean disciples for identifying areas across the entire production process where lean improvements can be made. It is usual to include the suppliers and customers in the map, as well as communications methods. This allows for a holistic analysis of all the facts and all the opportunities for maximizing lean benefits. To demonstrate the changes and improvements intended, a before-and-after value stream map is drawn (Page, 2004).

In examining the culture at company "X", it is evident that the corporation is heading in the right direction. Past leadership practices were to manage through fear and intimidation, to dictate to the organization, to stifle creativity and discourage participation. The past few years have revealed a new company "X"; one where the leadership respects their employees, solicits their recommendations and concerns, provides empowerment and encourages the Lean principles that promote continuous improvement. Company "X" still has a long way to go to have entirely embraced the type of participatory organizational culture that fully promotes the Lean Material Strategies. There is a lot of work to be done to achieve the right culture, but it is fair to say that the transformation has begun.

1.2 Statement of the Problem

It is apparent that company “X” today places too much emphasis on the idea of Lean Material Strategies and not enough emphasis on the impact they have on the entire organization both technically and culturally. Becoming a Lean organization is not just based on the ability to prompt change, but also in the ability to instill the organizational culture to support it. Many companies fall short of this ideal in part due to the inability of leadership to create an environment conducive to change, empowerment, engagement and the like, which create and sustain a workforce that is willing and able to initiate continuous improvement.

1.3 Purpose of Study

This study will identify weaknesses in the selection, planning, execution and support of Lean Material Strategy initiatives on a technical and organizational level at company “X”. Once there is a deeper understanding of these weaknesses, improvements and corrective actions will be suggested. This study will recommend methods for addressing technical skills and knowledge creating a better understanding of the benefits and impacts of Lean. This will allow for the minimization of undesirable results down-stream from the initial improvement. There will also be a focus on the current culture at company “X”, and suggestions to stimulate a culture that promotes Lean.

The significance of this study is four-fold:

- First, there should be significant awareness as to the effect of any change to a subsystem, and its global effect to the entire system. This is intuitive,

presented best in comparison to Newton's Third Law, that for every action there is an equal and opposite reaction. Given a myopic focus on a single part of a system, with a functional team supporting these improvements in one area, it is almost inherent that the reaction to the change will be minimized at best, but more likely – ignored.

- Second, this study should demonstrate that there should be a cross-functional team implementing Lean techniques to protect the entire system and capture the impact downstream.
- Third, the result of this analysis should support the need for a shift in the organizational culture, one where creativity and involvement are encouraged.
- Finally this study aims to propose and implement a more integrated manufacturing system. The resources dedicated to the secondary and tertiary effects of these changes should have the same level of importance and focus in developing plans to identify the new waste in their subsystem and a method to manage, control, or eliminate it.

Lean is, at the simplest level, identifying waste and, in this case, driving it away from manufacturing. Lean can be used across many industries; however, the focus of this writing is to discuss Lean Material Strategies in the automotive manufacturing environment. In a manufacturing setting, it is understood that identification of non-value added content should begin at the assembly line. Unfortunately, this is where many companies also end their analysis. This case study will take the reader through the

entire system; capturing what the company has done well from a Lean standpoint, and the pitfalls that require resolution for the system to realize a true gain from Lean implementation.

Lean isn't about a piece of the system, it is about the system as a whole. The waste needs to be made visible, and then it can then be grouped and eliminated. When a company identifies only one area for improvement, they are missing the benefit that Lean provides. By aggregating the efforts across multiple areas you can achieve throughput gains incrementally at an individual level and then maximize the gains collectively over the entire system with waste elimination. "If you truly focus on the 5S and the waste elimination and getting people at the shop floor level to understand what's waste and what isn't, they won't be worried about jobs. Instead, they will be worried about working efficiently because that is what most people want (Zubko, 2009).

It seems to have become commonplace for organizations to move the waste from one subsystem to another and consider their initiative complete. This is with great risk, as this method of operationalizing Lean can have undesired and negative effects. This study will identify several failure modes, which, if not identified and resolved will have a direct, damaging impact on the system as a whole. These impacts will include, but are not limited to: Quality, Responsiveness, and Cost.

In the past, companies could survive by focusing any lean efforts internally, creating more efficient cells and improving material flow. But now as lean principles are being applied to more transactional events such as controlling supply chains, reducing inventories and manufacturing to customer demand, being truly lean takes on a whole new level of complexity" (Ibid.).

When those kinds of transitions start happening, they become difficult to handle without some sort of IT involvement," explains Narayan Laksham, CEO of Ultriva Inc., a provider of lean manufacturing software. "IT can be used as a mechanism to systemize the lean discipline and help companies sustain it and scale it across the organization. However, software on its own is not going to solve anyone's problems (Zubko, 2009).

The company for which this analysis is based has taken a Lean approach to launching their new engine program. Lean was introduced at design, and was followed consistently throughout the engineering, sourcing and implementation of the manufacturing system. It is important to understand that these Lean Principles were the foundation for this launch. Many of the decisions that were made in the specification and procurement of the assembly line were directly related to Lean initiatives. The decision to reduce the operator footprint from 8'-0" to 6'-0", for example, resulted in a huge capital savings by reducing the cost of the assembly line itself. There were; however, several impacts to the supply chain department. The first was a requirement for the material delivery group to sequence material to avoid presentation of all versions of proliferated components to the operator. It also became necessary for the material group to repack components from the packaging that was shipped from the supplier to Minomi's that eliminated the need for an additional footprint line side for empty dunnage to be stacked. While the need for Minomi was initially driven from the need to minimize material's footprint line side, a secondary gain was with the elimination of non-value added work for the assembly line operator. Through the use of Minomi's came an improvement in value added elements in the operator's pillars due to the reduction in non-value added movement of packaging. Another key concept stemming from Lean

techniques was to reduce or eliminate operator choice on the assembly line. This also contributed to the widespread use of Minomi's, Kitting, and ultimately sequencing. By presenting the right part, in the right place, in the right orientation, at the right time, there was not only a reduction in value added content in assembly line pillars, but also a reduction in the burden to the operator – essentially, the stress that accompanies making a choice between which part to use.

With manufacturing well on the way to achieving a system design devoid of waste and burden, the equipment was purchased and subsequently installed, without much thought or consideration for how this waste and burden would be handled downstream. This oversight will be the focus of this thesis. The identification of potential failures introduced as subsequent effects in Lean System execution will be thoroughly reviewed. Research and analysis will be conducted to provide a conclusion that attempts to assist the reader in understanding the entire impact of lean on the whole system, not simply manufacturing, well as the organizational culture that will embrace these activities. Lean Material Strategies can be a very valuable tool in improving efficiency, creating value, driving down cost, and increasing responsiveness - thus streamlining a system; however, the net effect of its deployment must be analyzed and scrutinized iteratively, throughout the entire system. Every impact must have a plan or countermeasure, so that the very waste or burden that one is trying to drive from the system isn't magnified considerably in another area. It is important to understand that because the waste has been eliminated from manufacturing, it hasn't simply disappeared. The waste has moved, and to truly be Lean, that waste must be identified again, and again, until that waste is outside the organization. This thesis, will analyze

the waste driven into the internal supply chain system providing improvement initiatives and offer suggestions for creating a culture that embraces and encourages Lean techniques.

1.4 Significance of Study

The significance of this study can be viewed in several ways. The significance to the organization is captured in Company “X”’s ability to be competitive. With the application of Lean Material Strategies, Company “X” will realize an improvement in both cost (efficiency) and quality drivers, ultimately realizing an improvement in their performance and competitiveness. The significance to the workforce is best measured by an improvement in their satisfaction. Employees who are content in their jobs are efficient, effective, produce high quality work and are committed to the success of their company. They are also more loyal and less likely to leave the organization, resulting in an organization with less turn over. The significance to the customer is realized through higher quality and lower cost of ownership. The same initiatives that will make company “X” more competitive will also make company “X” more desirable to the customer.

1.5 Rationale and Scope of the Study

The scope of this study is limited to the automotive manufacturing industry, due to the structure of manufacturing and its inter-related support departments in conjunction with its unique processing requirements (i.e. ergonomics, safety, etc.). The scope within the manufacturing environment is at a macro level, including support departments such as its supply chain, quality, and facilities. The focus of this study,

however, will center on the role of the internal supply chain in Lean Material Strategies and the overall organizational culture at Company “X”.

1.6 Limitations

Literature research has been limited to Lean Material Strategies and the downstream effect to the supply chain. Any analysis in reference to the impact to Quality, Facilities, Human Resources, etc. is based on interviews with subject matter experts involved with this particular case study, as well as personal observation conducted by the author of record.

1.7 Overview of Paper

Chapter 1: In Chapter 1, the problem statement is introduced and the importance of research and study is provided. A brief background into history of the problem as well as tools used in the field to analyze manufacturing systems and identify waste.

Chapter 2: In this chapter, the necessary references have been provided to support the analysis and recommendations to effectively introduce Lean Material Strategies with a systemic approach. The research will provide greater detail into what Lean is, what its benefits are, and desired outcomes once steady state is achieved for the entire system.

- Chapter 3:** This chapter provides the framework for the analysis as well as defining the parameters of the research. This discussion will also include the methods and sources to collect supporting data.
- Chapter 4:** Chapter 4 focuses on the analysis and findings collected through data and observation of the current supply chain resources and systems. The analysis was conducted specific to the manufacturing site and its current operational plan.
- Chapter 5:** The final chapter offers conclusions and recommendations for improvement within the supply chain to reduce waste and improve efficiencies. The conclusions were based on the analysis and findings conducted in chapter 4.

1.8 Terms of Reference

- Pillar:** A tool used to visually display the utilization for a job. Within this display is the percentage of Value added work in conjunction with the non-value added work. This is used to help visualize opportunity within the job to create greater efficiency.
- Minomi:** In order to reduce the required space at the assembly stations and to reduce the materials handling, Toyota has introduced the concept of *minomi*, where parts are transported and displayed at the assembly

stations completely without packages. Instead, the parts are either resting on a component rack or hanging from hooks. In order to minimize handling, the transfer from materials supply unit (e.g. dolly) to component rack is often performed by letting the parts slide over by the force of gravity (Liker and Meier, 2006).

Dunnage: Packaging used to ship engine components from the supplier to the engine assembly plant. Dunnage is usually returnable in nature and comprised of a plastic “tote” with an engineered captive devices to protect and orient the part or a simple insert to separate a less sensitive part. In some cases, dunnage is expendable, and usually constructed of cardboard. In cardboard applications, parts may be placed inside of a bag to protect quality or provide rust prevention if parts if necessary.

Kitting: A concept that has helped in the elimination of line side floor space. Individual parts will be put together in a large tote, or “kit” and then sent to the assembly line to be used in assembling the engine. This is at an added cost as we gain floor space line side, we lose floor space somewhere else in the facility. There is also an additional cost of labor that now comes with putting these kits together and delivering them to the assembly line.

Chapter 2: Literature Review

2.1 Introduction

Considerable research supports the assertion that Lean Material Strategy efforts should be comprehensive in scope, and executed with considerable planning. It is highly recommended that organizations create cross-functional teams that evaluate and implement Lean techniques, not only in production, but in the supply chain as well. Unfortunately, it is common for these same organizations to take a micro approach to Lean Strategies, and focus on one area of improvement. Such an approach can have unintended consequences and may create additional waste or non-value-added work content. It is apparent that Company "X" today places too much emphasis on the idea of Lean Material Strategies and not enough emphasis on the impact they have on the entire organization. Through the application of scholarly research an attempt will be made to provide a systemic solution to their Lean initiatives that are inclusive of the effects to both, manufacturing and supply chain functions, as well as the culture that the company operates with.

2.2 Review of Related Literature

2.2.1 The Lean Material Culture

It is important to understand that Lean Material Strategies can only be successful and sustained in an environment that embraces the philosophies. A great deal of understanding and trust are paramount in an organization's ability to deploy these concepts.

Successfully implementing these concepts and principles requires the participation of all employees in a given firm. Everyone must work toward a common vision. We would state that deployment of these principles is “Top down,” while implementation is “Bottom up.” (Carreira 2006)

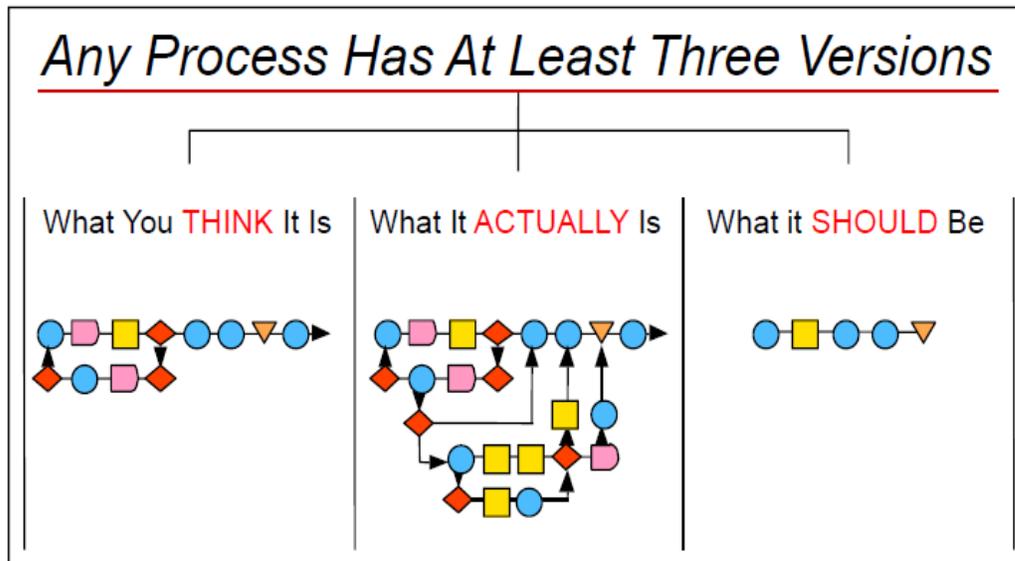


Figure 2: Way of Thinking (Phillips. J., 2011)

According to Basadur (2004), “In a future business the most effective leaders will help individuals... to coordinate and integrate their differing styles through a process of applied creativity that includes continuously discovering and defining new problems, solving these problems and implementing new solutions” (Jong and Hartog, 2007); (Dasgupta, 2009). Following Basadur’s line of thought, for the Lean initiatives to achieve success, there must be a shift in the existing culture of the organization. Traditionally, cultures were bureaucratic, authoritative, and un-engaging – the trend needs to move to a more organizational culture, which can be defined as the deeply seated (often subconscious) values and beliefs shared by personnel in an organization.

It is manifested in the typical characteristics of the organization. According to researchers like Hellreigal, Smith, and Cronje, “The components of routine behavior, norms, values, philosophy, rules of the game and feelings all form part of organizational culture” (Martins and Terblanche, 2003).

It is critical for senior leadership to support a Lean culture. In a Lean culture, employees are encouraged and empowered to take ownership of their roles. The workforce must have the ability to offer improvement initiatives and it must be demonstrated to them that their ideas are well received. In a timely manner, management needs to exhibit to their employees that these initiatives are reviewed, supported, and where applicable, executed. When feasible, the best approaches offer employees not only the ability to submit these ideas, but to be involved in the planning and implementation phases as well.

In practice, a creative and empowered organizational culture can have a substantial impact on the performance of the company. Several years ago when Steve Jobs was asked what the seed of the distinctive innovative ability at Apple was he replied, “Apple is a very disciplined company and we have great processes. But that’s not what it’s about. Processes make you more efficient. But innovation comes from people meeting up in the hallways or calling each other at 10:30 in the night with a new idea, or because they realized something that shoots holes in how we’ve been thinking about a problem. It’s ad hoc meetings of six people called by someone who thinks he has figured out the coolest new thing ever and who wants to know what other people think of his idea” (Fliaster and Spiess, 2007). Cross-functional communication and

cooperation is considered to be a vital element to respond to repeated changes in the environment (Calabrese, 1999); (Dasgupta, 2009).

A participatory type of culture that which is flat, has open communication channels, encourages participation and involvement in decision making, enhances sharing of information, is conducive to a good knowledge management practice, and promotes innovation (Rezgui, 2007);(Dasgupta, 2009). The value of an empowered environment cannot be emphasized enough. A workforce that participates in the improvement of an organization is ultimately guaranteeing its success. By engraining these concepts into the organizational culture, employees will feel engaged in the business.

To create a successful Lean environment, the organization must be flexible, agile, and possess the ability to adapt to change quickly. Adaptable organizations foresee problems and opportunities and devise timely solutions and new routines. Adaptability requires looking outside the organization for new technologies and ideas and bringing about a change in its internal routines (Dasgupta, 2009). Adaptability begets innovation, and innovation is a key to improved performance in the factory and in the market.

Empowering and challenging the workforce to seek out opportunities and applications for Lean initiatives will drive improvement. By providing this ownership, the employees responsible for activities related to the manufacturing and supply chain processes are best suited to evaluate waste and non-value added content in the work they do. They are best positioned to provide input into waste reduction, and with the ability to make the necessary changes can effectively realize substantial gains from

Lean applications. These employees are the subject matter experts in their respective roles in manufacturing or supply chain, and are best able to provide alternative solutions that reduce waste and improve value.

For one, lean production changes how people work but not always in the way we think. Most people – including so-called blue-collar workers – will find their jobs more challenging as lean production spreads. And they will certainly become more productive. At the same time, they may find their work more stressful, because a key objective of lean production is to push responsibility far down the organizational ladder. Responsibility means freedom to control one's work – a big plus – but it also raises anxiety about making costly mistakes (Taylor, 2001).

It is one thing to empower employees to act on Lean initiatives, but that doesn't guarantee that the workforce is engaged in the Lean activities. An employee can merely suggest an improvement, but without their involvement in the planning and execution of the solution – key ideas or concerns can be lost in translation. Active participation in the entire kaizen process by the very individuals who perform the work will ensure that all aspects of the enhancement to the process are captured and evaluated to maintain a net positive impact to the system.

We have found that simply applying tools such as value stream mapping, supermarkets, hirjunka, u-shaped cells, and pint kaizen workshops in isolation does not necessarily produce significant sustained changes in the flow. But organizations that allow people to be part of the kaizen culture – part of the design of the future state, part of the overall planning process – will certainly come closer to attaining world-class status than those that do not (Tapping, 2002).

Another important concept in the integration of Lean Material Strategies is collaboration. Without the proper representation of all effected disciplines, there is risk to the system – ultimately in the ability to adapt to the new process when enhancements are made. By involving a diverse group that captures the support functions as well as manufacturing, the team can work through downstream affects created by the improvements made to manufacturing. Specifically, the participation of the supply chain group in the development of lean initiatives will allow for, not only, the required reaction to the changes in manufacturing but presents the opportunity to employ real-time integration of Lean into supply chain’s new process as well. By enlisting the collaboration of team members representative of the entire system, silos will be eliminated. Departmental silos act independently, often ignorant of the problems that decisions in one department have upon another, or indeed the key customer service processes. The lean system is less introspective; less fixated with departmental thinking and is focused upon growth and harmony within and beyond the business (Rich, 2006).

Once an organization has made the commitment to utilize Lean Material Strategies, there must be an equal commitment to the planning stages of this process. Without proper analysis through techniques like value stream mapping, there is potential to adopt a solution that fails, drives additional cost, or negatively impacts quality. Wincel supports this in his writing, “What they don’t address is the pre-implementation events that need to occur in the supply chain to enable the lean efforts within the four walls. This is where the value of practical experience comes to play in how this question is answered. Linking supply chain efforts with lean efforts – really

making them one and the same – is the way in which both efforts are optimized. So while this book addresses the use of lean tools and the integration with lean implementation internally, it really creates a new definition and practice in lean “(Wincel, 2004).

In the identification of waste and non-value-added it must be recognized that a slight difference exists between the two. Waste is best described as something that is unnecessary to the manufacturing process, and for which the end customer is unwilling to accept an increase in cost. Non-value-added content is an activity or material that is not directly related to the product, but the customer recognizes as inherent in the manufacturing and distribution cycle and will assume the cost for in pricing. Confusion sometimes exists regarding the differences between non-value-adding activities and waste. Trent best illustrates this, “In fact, the two terms are often used interchangeably. One way to think about this is to realize that all wasteful activities are non-value adding. Waste creates only additional costs, therefore wasteful activities are immediate candidates for elimination. However, the reverse is not entirely true. Non-value-adding activities are not necessarily wasteful. In fact, customers are often willing to pay for these activities. Consider the movement of a product or material from one point to another. No change occurs to a product’s physical value when moving across a supply chain, yet transportation is required to move a product closer to the place where a customer wants that product” (Trent, 2008).

A final thought on the culture of the organization. It is universally recognized that the learning process in any organization results in the inherent logic of change. Change to cope with changes in the environment is always faced by resistance and hardened

mind-sets of the management. According to many researchers the answer to this problem lies in continuously leveraging and upgrading the knowledgebase within an organization. This is done by fostering a climate of learning in the organization (Smith, 1999); (Dasgupta, 2009). With an emphasis on education and knowledge, employees gain an understanding of the importance of change and continuous improvement as well as the confidence to foster and instigate this change.

2.2.2 Lean Techniques and the Business Cycle

Many organizations approach Lean with the expectation of reducing total manufacturing costs through improvements to manufacturing. The flaw in their planning exists in their failure to optimize the entire business process as opposed to just that of production. Not only is the organization short-changing themselves of potential gains that can be realized through improvements to the supply chain process, but they run the risk of negatively effecting the material flow by not being concerned or even aware of the downstream effects made by these changes in the manufacturing process.

This is one of our largest misunderstandings while studying lean manufacturing. Much more relevant is the constant joint analysis of the total value chain, and the rigorous effort to take waste out of the total system. These efforts are accomplished while sharing in the financial rewards made possible by the improvements in quality and profitability. Few have endeavored to put forward the value of utilizing the entire system approach complete with the tools of TPS and supply chain management in an understandable, applicable way (Wincel, 2004).

It cannot be emphasized enough that Lean Material Strategies must be developed through the work of a cross-functional team. With each member bringing their specific and unique knowledge base to the group, the team is ensured a more realistic outcome through their work. It is all too prevalent to see a department work through some of their constraints only to arrive at the fact that the downstream effect has created a less desirable condition than the original one. By providing for participation of all support functions a more efficient total system can be achieved. Taylor captures this best, "Although they wrote whole books describing specific techniques and a few high-level philosophic reflections as well (such as the memoirs of Taiichi Ohno), the thought process needed to tie all the methods together into a complete system was left largely implicit. As a result, we met isolated bits of a lean system without understanding the whole" (Taylor, 2001).

Most lean manufacturing initiatives focus on the primary elements of Manufacturing Flow, some on Process Control and areas of Logistics. Once in a while, there is the mention of Metrics and some discussion regarding Organization, usually training. This lack of attention to the whole is a shame, because it is the culture changes in Organization and the infrastructure improvements in Logistics that institutionalize the improvements and provide for sustained change within the organization (Feld, 2001).

Applying Lean principles to the supply chain can be a challenge to implement but will reap significant rewards. Lean materials, supply management, and supply-chain management are a constant challenge in most businesses. They are, by nature, among the most critical responsibilities in any manufacturing organization. Success is defined

by controlling all components of operations and the synchronization of the correct parts processed into salable units and delivered to the customer when the customer wants them (Sheldon, 2008).

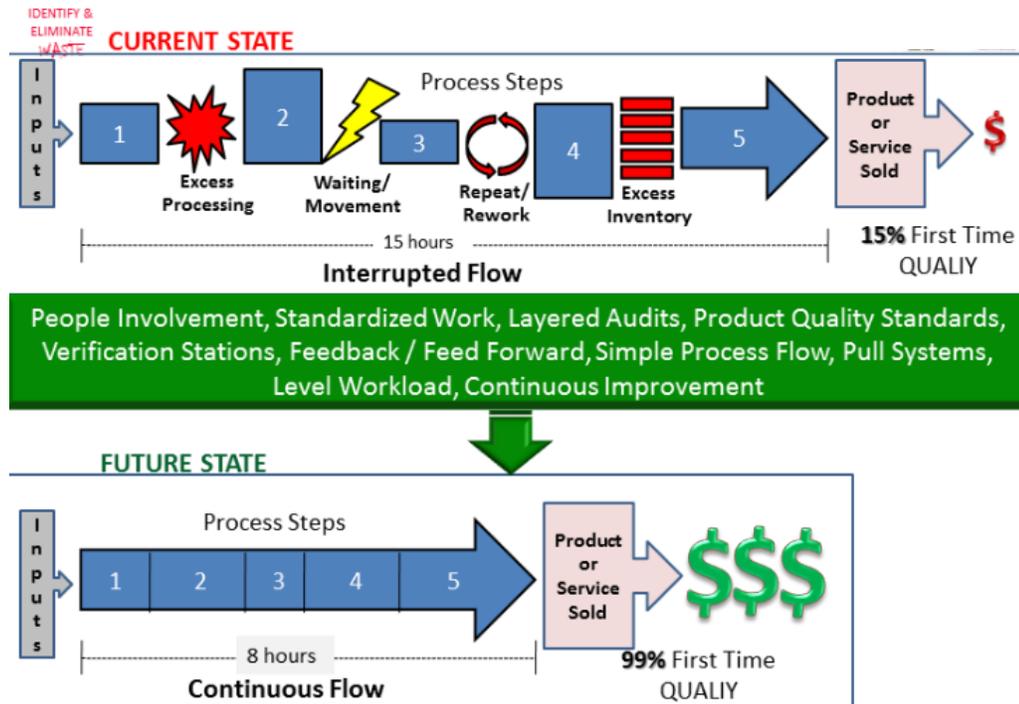


Figure 3: Value Stream Mapping (Hainsworth, S., 2011)

The idea of creating flow in Lean is to deliver products and services just in time (JIT), in the right amounts, and at the right quality levels at the right place. This necessitates that products and services be produced and delivered only when a pull is exerted by the customer through a signal in the form of a purchase. A well-designed Lean system allows for an immediate and effective response to fluctuating customer demands and requirements (Cudney, 2011).

As Lean techniques are implemented across a facility, it should be a priority to consider opportunities to improve the supply chain. With most focus centered on improvements to manufacturing, it should become a discipline to assess supply chain waste and non-value-added content to maintain a total Lean environment. This is best achieved using Value Stream Mapping Models. The models allow a team to assess a current system by identifying waste, producing a Current State model. The waste is then reduced through continuous improvement initiatives using Lean Techniques, and a Future State model is created. This provides potential monetary, safety, and quality gains. Lean books provide an excellent foundation for the transformation, but do not provide effective solutions to the transportation and customer demand variation that are such key factors in distribution. Taking Lean into a distribution environment requires a customer service-based approach that builds change around total cost minimization rather than the more traditional Lean approach: value stream mapping and using kaizen to improve each area of the process (Zylstra, 2006).

It is becoming accepted that variation in the production process is the cause of quality problems, but this concept has not moved into forecasting, planning, and scheduling (Ibid.). Although this is true, it can create a great deal of complexity in planning. With fluctuations in customer requirements, an organizations response can be limited based on manufacturing schedules, inventory on hand, and manpower allocations. The highly complex order processing systems within the assembler represent the biggest obstacle to improving system performance. The detailed mapping of these systems reveals that nothing less than a complete reconfiguration of the

ordering and production planning systems will be enough to move to a real customer order-driven system (Taylor, 2001).

2.2.3 Achieving Desired Results in Lean Implementation

To truly achieve the desired results of Lean Strategies, an organization must recognize and adapt to the downstream effects to any process improvement. Without stabilizing the entire business process, the improvements will be less than ideal. Being less than ideal refers to the fact that the logic starts to “thin,” meaning that in many cases the logic is focused on only one desired result, such as obtaining a certain inventory level. In many environments, inventory control takes second or third place to balancing demand and capacity or providing short lead time to customers (Kerber, 2011). Kerber exhibits that not only is it critical to understand potential disruptions in the supply chain created by Lean initiatives, but to evaluate potential for improvements within the supply chain that can be realized through Lean techniques.

It is also imperative to understand that Lean Techniques are iterative in nature. It is unrealistic to believe that all waste can be identified in one Lean exercise and that the downstream effects will be minimized or that the supply chain can adapt without the employment of continuous improvement. By design, the implementation of Lean techniques should be structured such that it is an ongoing process, with input from key stakeholders in both manufacturing and support groups. This will ensure that the system continues to reap the rewards of Lean initiatives, and balance is achieved throughout the system. The reality of lean is that while most managers likely have a basic understanding of the concept, few organizations have truly achieved lean, partly

because the pursuit of lean is a never-ending journey. Furthermore, lean adopters, as well as the research and writing that support the intellectual domain of lean, often focus narrowly on the internal operations of manufacturers (Trent, 2008).

A Lean environment is not achieved through pure maintenance of a system, but one in which you continually improve upon it. Lean Integration is not a one-time effort; you can't just flip a switch and proclaim to be done. It is a long-term strategy for how an organization approaches the challenges of process and data integration. Lean can and does deliver early benefits, but it doesn't end there. Lean principles such as waste elimination are never-ending activities that result in ongoing benefits. Furthermore, some Lean objectives such as becoming a team-based learning organization with a sustainable culture of continuous improvement may require years to change entrenched bad habits (Schmidt, 2010).

Without a comprehensive understanding of the inter-relationships between manufacturing and its associate support groups, it is difficult to understand fully what the best course of action is to achieve not just the desired result for manufacturing, but a favorable net result to the system. The most effective way to ensure that directionally the employed techniques create a "true" Lean Material environment is through pre-implementation investigation, research, and planning. To be 100% effective, even robust lean execution processes require good planning methodology as prerequisites although it is not often acknowledged in the lean "production" – centered books (as opposed to materials planning books.). Materials and supply-chain management adds a whole new element to the production execution equation for success (Sheldon, 2008).

2.3 Summary of Chapter 2

Substantial literature supports the concept of Total Lean Systems. Through both Lean Manufacturing and Lean Material Strategies organizations can see considerable improvements to their production and supply chain systems. The benefits to these processes reduce cost, improve quality, and allow for quicker response to customer demand. It is demonstrated that the process of creating a Lean environment requires discipline and patience. The planning stages are the most critical with participation of a cross-functional team being a key to success. The team should be empowered to pursue the initiatives that they feel offer the greatest impact to the system. They should also be engaged in the development and execution of any improvements. Through ownership, accountability, and collaboration successful outcomes are most commonly recognized.

It is clear, through the documented sources that a contributing factor to the role of the supply chain being minimized or altogether ignored is in the complexity of the system. Reaction to customer demand, fluctuations in schedules, availability of inventory and the like make the steady state of the supply chain hard to predict. It has been demonstrated that through value stream mapping, opportunity for improvement can still be identified, and in many case, the use of electronic systems and data integration – mathematical simulation can provide tremendous value.

With a focus for so many years on Lean Manufacturing, it is of no surprise that Lean Material Strategies lag in implementation. By utilizing available research and understanding the pockets of waste and non-value added work content within the supply chain system Lean techniques can be employed and result in improvements in

efficiency and quality. It's never too late for organizations to modify their current structures that support Lean to include subject matter experts within the supply chain. Integrating supply chain personnel into Lean planning will result in a more inclusive solution that drives out more waste, pushing back more non-value added content, and increasing efficiency and quality at an organizational level.

Chapter 3:

3.1 Introduction and Re-statement of the Problem

It is apparent that company “X” today places too much emphasis on the idea of Lean Material Strategies and not enough emphasis on the impact they have on the entire organization both technically and culturally. In an attempt to develop an entire Lean system, organizational and structural concepts will be evaluated and technical tools employed to assist in creating a total Lean environment. A Lean environment entails the application of Lean Material Principles but also the creation of an organizational culture that supports these methods. The first tool to accomplish this is a formal survey introduced to collect feedback from a cross-section of employees capturing their views of Lean and their perceived benefits to the organization. The second tool includes examples of Value Stream Mapping for both the manufacturing and supply chain processes. This exercise includes both current and future state value streams. The final tool, a database, was designed and created as an add-in tool to support the plant’s Access database. This application calculates manpower and inventory requirements as well as generating reports to support their analysis. Final recommendations are captured in Chapter 5, as to what initiatives will provide the most impact, suggestions for improving the organizational culture and guidelines for inventory levels as well as storage and manpower requirements to support the internal supply chain.

Many of the research tools used in this study can be applied for future continuous improvement initiatives. Value Stream Maps can provide insight to several potential

improvement ideas. The scope of this project did not evaluate all candidates for application of Lean Material Strategies. Company “X” can utilize the existing present state Value Stream Map to identify additional initiatives for improvement. During the execution of this research, training was provided to key supply chain employees in Value Stream Mapping so that this valuable form of analysis can be conducted in the future – this will allow the supply chain department to apply this tool on their other business processes. Also, the evaluation of the organizational culture at company “X” identified a need for training. This training, again, targeted a selection of key supply chain leaders and identified characteristics of a Lean organization culture and strategies to employ them. This training can be cascaded through the organization so that the effect has a greater reach.

3.2 Framework for Analysis

The overall approach used in this study was essentially the evaluation of the current condition, application of Lean tools to assess the current state and identify areas for improvement, a sampling of employees to document their perception of Lean, experience with it, and expectations of it, as well as the development and use of a data analysis tool to calculate manpower and inventory.

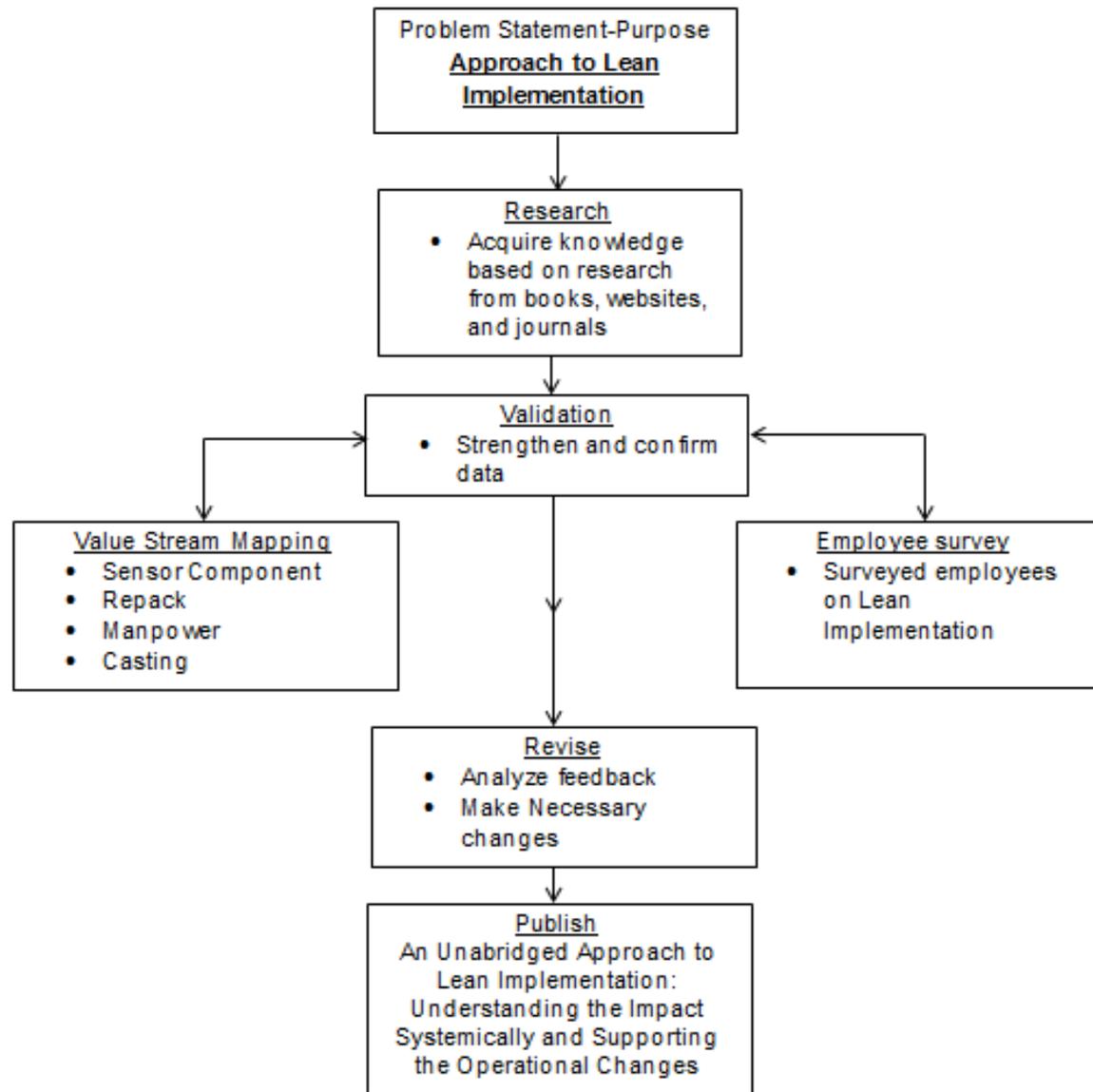


Figure 4: Framework for Analysis

3.3 Research Design

While concentrating their efforts on the concepts of Lean Material Strategies in manufacturing, almost ignoring the impact to the internal supply chain, company “X” has moved the inefficiencies, waste, and risk from manufacturing to supply chain without much consideration to the real impact to the total system. One of the contributing factors to this condition, where all energy is centered on manufacturing, is the organizational culture. To analyze the current state and provide solutions, the research emphasized the examination of empirical data and the application of organizational behavior concepts.

The data was collected using three methods:

- Employee “Lean Techniques” Survey
- Value Stream Mapping (Section 2.2.2 p. 25)
- MS Access Database: Manpower and Inventory Tool

These methods were utilized to present the greatest breadth to this narrowly focused study. The intent was to layer the research to create an analysis that spanned from theoretical to empirical. The survey was used to capture the perception of those who plan and deploy Lean Material Strategies and provided a feel for how well the organizational culture had been developed at company “X”. The Value Stream Mapping was used to identify actual data in reference to supply chain business processes and provided a tool for assessing the health of the system. The database gave instant feedback as to the impact of the proposed changes. This served as a sense check in reference to the direct savings or cost associated with any modifications to the system.

3.4 Database/Sample Selection/Identification of Study Participants

The employee “Lean Techniques” Survey was used to capture how employees “feel” about Lean Material Strategies. It provided an understanding as to what employees believe Lean is, how it works, what it will do, how it does it, and how it is supported. This survey was distributed to 100 employees at company “X” spanning the cross-section of the organization. The sampling was through a forced distribution based on percentage of on-role employees by department. This survey had questions that provided length of service and position to investigate any correlation between exposure to traditional culture and receptiveness to Lean strategies or if positionally in the organization there is a trend toward acceptance and rejection.

The Value Stream Mapping tool was used to highlight two internal supply chain business processes. The first process evaluated was the internal delivery of sequenced material. The exercise documented the current and future states for this circle of work, and identified several areas for improvement. Many of the areas fell outside of supply chains direct control, but could be easily managed differently to provide a more desired result. Some of the items that were highlighted for change required timelines for implementation and have not yet reached the future state. The second process evaluated illustrated the internal delivery process for non-sequenced material. The outcome of this activity provided some unexpected data. This was more of a traditional type of delivery system, one that supply chain had operationalized many years earlier – because of this, it had never been evaluated or reviewed for continuous improvement and, as a result, presented several opportunities to make the process better. Many of

the initiatives that are planned for implementation involve modifications to existing electronic systems, so these items will be on-going.

The manpower and inventory analysis tool was created to help assess what the manpower requirements really should be in the current state and what they will transition to in the future state. This tool proved valuable as, it aided the continuous improvement team in determining the impact of the change prior to implementation. The inventory analysis tool predicted the necessary material to have on hand to support the production volumes without excess carrying costs, but with the flexibility to respond to changes in customer demand and react to supplier issues.

3.5 Validity of Data

The validity of this data is based on survey participant's actual feelings and perceptions. Their responses are subject to some degree of error due to the nature of the collection of data and the honesty of their replies.

3.6 Originality of the Data

This investigation has been developed to provide a unique and original solution to the stated problem. It is not an application taken "off the shelf". The data collected for this study is specific to company "X" and its launch initiatives. The survey was created to parallel on-going and planned activities in support of the current launch.

3.7 Limitations of the Study

The limitations of this study are primarily based in the applications of the findings. Since this research was conducted to support company “X” it, for the most part, can only be applied to company “X”. It is anticipated that these recommendations are valid to be applied across several of the locations associated with company “X”. Limitations also exist in the in the depth of the study. This study was intended to provide the ability for the internal supply chain department to operate under the new operating conditions associated with the Lean Material Strategies employed by manufacturing. It should be noted that there are additional opportunities for improvement.

3.8 Summary of Chapter 3

The research conducted to support this study provided a deeper understanding of the people and processes at company “X”. This analysis allowed a structured, detailed approach to continuous improvement. Some of the findings were as anticipated, but some of the results of the Value Stream Mapping pointed at initiatives that were never considered problematic. After completing the three phases of research, it became quite clear that there is work to be done. The survey helped management assess training issues and cultural issues. The scholarly research in this study gave the leadership examples of the type of culture that best supports Lean Material Strategies. By categorizing the work that originated from the Value Stream Mapping exercise, company “X” was provided a pragmatic approach to improving their internal supply chain systems. The Future State Map illustrated to the department what work needed to be done, and in what order it would provide the greatest reward. Finally, the

database was able to demonstrate to the leadership team what manpower and inventory was and what it can be if the recommended changes are put in place.

Lean Material Strategies are great techniques to assist an organization in improving efficiency, reducing waste, and improving quality; however, the research in this study demonstrates the importance of the appropriate culture, driven by leadership. The survey used in this study clearly depicts a condition where the message from leadership is not making it to the plant floor. Fortunately, there are several things that management can do to improve the knowledge base of employees and move the culture to one that supports the goals of Lean Material Strategies.

Chapter 4: Presentation of Analysis and Findings

4.1 Introduction

It is apparent that Company “X” today places too much emphasis on the idea of Lean Material Strategies and not enough emphasis on the impact they have on the entire organization. In Chapter 4, the focus is on actual data and observations conducted and performed at Company “X”. The object of this analysis is to provide suggestions for improvement and draw an overall conclusion of the Lean systems in place at the company in Chapter 5. Several methods of collecting data were employed to provide a realistic portrayal of the company’s supply chain. To create an accurate model to provide for a valid study, three forms of data collection were utilized:

1. Employee Survey
2. Value Stream Mapping
3. Manpower & Inventory Analysis Tool

These methods were selected because of the depth the three tools used in conjunction would produce. The employee survey would communicate the culture that exists at Company X, and whether it is conducive or unfavorable to Lean initiatives. The Value Stream Mapping of select parts would illustrate the actual process as opposed to the perceived process. This, in turn, is used to construct a Lean process. Finally, the Manpower & Inventory Analysis Tool is applied to calculate an analytic model of the system requirements for inventory, floor space, and manpower. This analysis can be compared against actual values, and recommendations for improvement are made in Chapter 5.

4.2 Employee Survey

1. How long have you been with the company?
 - 0-1 Years
 - 2-5 Years
 - 6-10 Years
 - 11+ Years
 - No answer
2. Which best describes your level?
 - Union Employee
 - Group/Area Leader
 - Professional (engineer, accountant, etc)
 - Manager
 - Senior Leader
 - No answer
3. How do you think COMPANY "X" is performing relative to the competition?
 - Worse than
 - Equal to
 - Better than
 - The best
 - No answer
4. What do you anticipate the implementation of Lean will provide?
 - Lean will hurt COMPANY "X"
 - Lean will have no effect on COMPANY "X"
 - Lean will improve COMPANY "X"
 - Not sure
 - No answer
5. How much support is there of Lean Material Strategies by the leadership at COMPANY "X"?
 - Very supportive
 - Somewhat supportive
 - Neutral
 - Somewhat unsupportive
 - Very unsupportive
 - No answer
6. How much does your team support Lean Material Strategies?
 - Very supportive
 - Somewhat supportive
 - Neutral
 - Somewhat unsupportive
 - Very unsupportive
 - No answer
7. How much Lean Material knowledge do you possess?
 - None
 - Aware of concept
 - Some knowledge of concept
 - Very Knowledgeable
 - Very Knowledgeable and experienced in Lean Material Strategies
 - No answer
8. At what level has leadership trained you in Lean Material Strategies?
 - None
 - Awareness
 - Basic
 - Moderate
 - Extensive
 - No answer
9. Are there Lean Material Strategies applications at COMPANY "X"?
 - Not sure
 - None
 - Some applications
 - Same as other continuous improvement methods
 - A good amount of applications
 - Many applications
 - No answer

Figure 5: EMPLOYEE SURVEY (p.1)

10. What impact will Lean Material Strategies make to the complexity or difficulty of your job?
- Significantly less complex or difficult
 - Slightly less complex or difficult
 - The same
 - Slightly more complex or difficult
 - Significantly more complex or difficult
 - No answer
11. Will Lean Material Strategies affect manpower at COMPANY "X"?
- Significant reduction in required manpower
 - Slight reduction in required manpower
 - No impact
 - Slight increase in required manpower
 - Significant increase in required manpower
 - No answer
12. How well do you anticipate adapting to the Lean culture?
- I am enthusiastic about a Lean environment
 - I am receptive to a Lean environment
 - No thoughts
 - I am resistant to a Lean environment
 - I am opposed to a Lean environment
 - I am not sure
 - No answer
13. In your opinion will Lean deliver results?
- Absolutely
 - Yes, in most cases
 - Yes, in some cases
 - Not sure
 - I am skeptical
 - No
 - No answer
14. Have you read any books or articles on Lean Material Strategies?
- Yes
 - No
 - No answer
15. How committed do you think the leadership is to Lean Material Strategies?
- Very committed
 - Somewhat committed
 - Average
 - Slightly committed
 - Not committed
 - No answer
16. How prepared do you feel the leadership is to manage the transition to a Lean environment?
- Very prepared
 - Well prepared
 - Prepared
 - Slightly prepared
 - Not prepared
 - No answer
17. How well does the leadership understand what you do in your role?
- Very familiar
 - Familiar
 - Slightly Familiar
 - Not Familiar
 - No answer

Figure 6: EMPLOYEE SURVEY (p.2)

4.3 Value Stream Mapping

Value Stream Mapping is a valuable tool for analyzing a system to identify waste. Its value is present in the ability to compare what a system is believed to be and then compare that perceived system to what it actual is. Once the actual system is documented in the form of a Present State Value Stream Map, only then can the waste be identified to be driven from the system. After all of the plans to eliminate or move the waste have been established, a Future State Value Stream Map is created to capture potential gains and illustrate the desired system. Examples and discussion can be referred to from chapter 2 and 3.

4.3.1 Purchased Component Analysis and Findings:

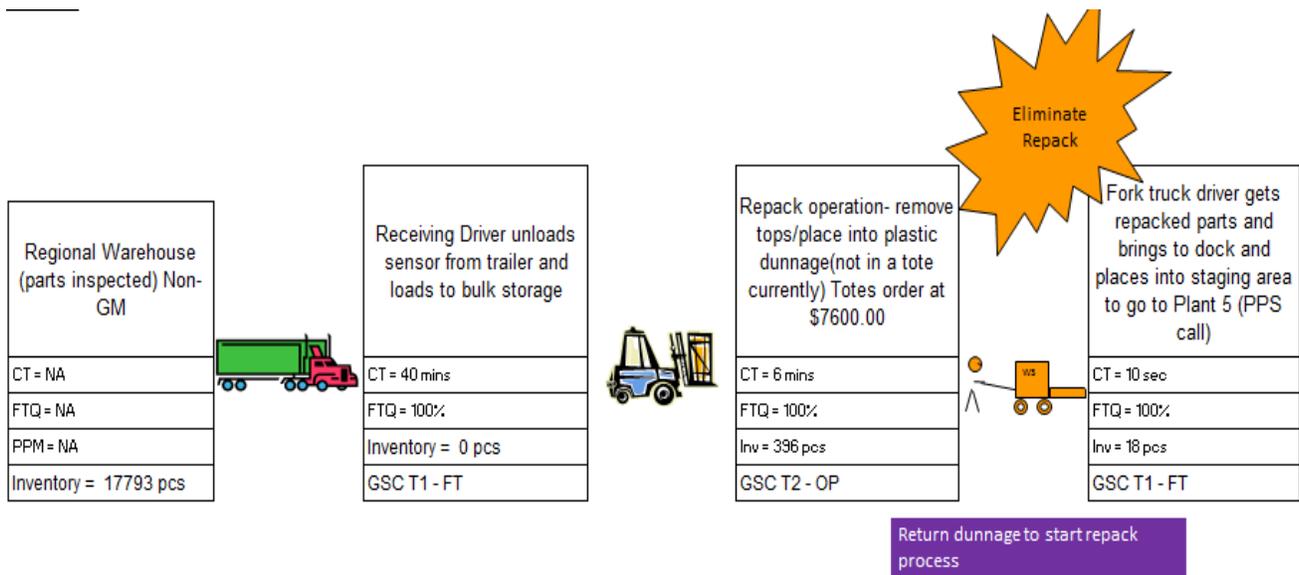


Figure 7: VSM COMPONENT CURRENT STATE

Inventory LOC: The inventory levels in the LOC for the sensor that was mapped are in excess by almost 15,000 pieces. This equates to an inventory dollar value that is inflated by \$357,433. Several contributing factors must be evaluated to determine the adjusted inventory level. The first consideration is non-conforming and teardown assemblies. These assemblies are included in the record balance for this component; however, the likelihood that these parts are actually salvageable due to the sensitive nature of this sensor is minimal.

The second explanation for a portion of the unnecessary inventory is attributed to the material procurement plan. The material order that is sent to the customer on a daily basis is actually higher than the scheduled production at the plant. In conjunction with the inflated schedule to the supplier is the back log of assemblies that production has failed to produce. The number of un-built assemblies approaches 3,000. Since production cannot, on most days, meet their daily schedule of 800, it would flow logically that the 3,000 assembly back log would not be produced in one day in addition to the daily schedule of 800. This environment of missed schedules and nonconforming assemblies creates a challenge for Company X to level their inventory; however, adjustments to the schedule and the bank are required to bring their inventory carrying cost to an acceptable level.

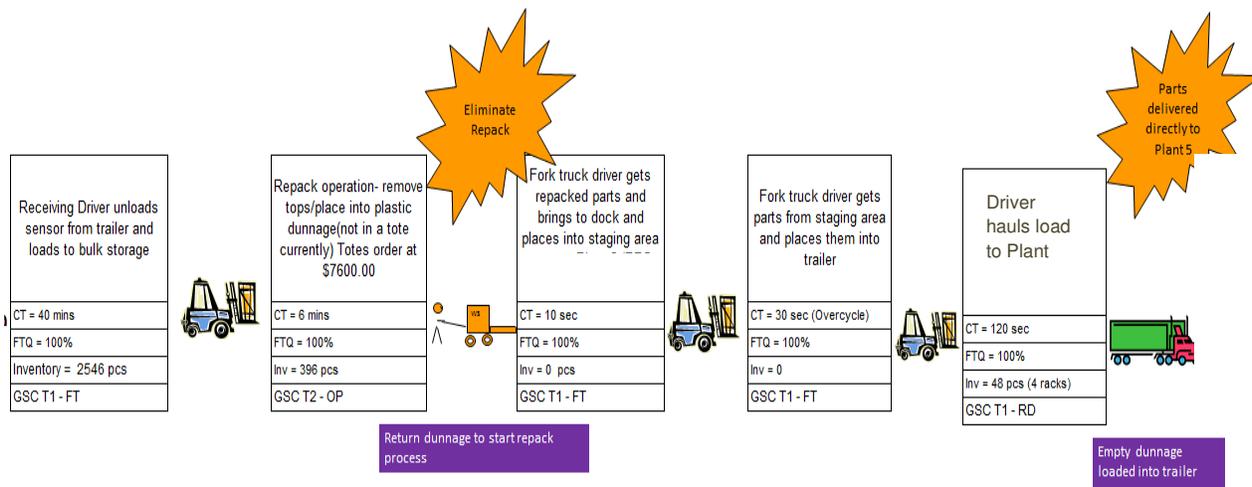


Figure 8: VSM MANPOWER CURRENT STATE

Manpower LOC: The manpower at the LOC was determined based on the assumption of receiving 1/5 of the weekly production volume of components daily, so essentially, the daily schedule. Unfortunately, due to the excessive inventory that is being carried by Company X, the Receiving Dock has been forced into an Overflow condition. The storage lanes required for the component were based on the calculation for storing bulk material [$\text{Max} = (\text{Schedule} / \text{Shift} \times \text{Shifts Worked}) + \text{Schedule} / \text{Shift}$]. Based on current schedule and operating plans, the number of components held in storage on the dock would be equal to 1,000 pieces. On the date of study, the actual number of components on the dock was 15,993. Since the storage lanes cannot support the excess volume of inventory, parts must be moved to a satellite “Overflow” area. This area is used for all components that are over their “Max” value, or, the maximum number of components (measured in totes or pallets) stored in a lane. The circle of work (COW) for a receiving driver (a driver who unloads a supplier trailer) consists of the following:

- Remove material from trailer
- Take material to assigned storage lane
- Assess inventory level for storage lane
- If Material is below Max level, store material in lane
- If material exceeds Max level, take material to Overflow area

If the material must be moved to the Overflow area, this activity is not measured in the manpower study. Because the movement of material to Overflow is out-of-process, the frequency and distance travelled cannot be anticipated. This makes it difficult for the dock personnel to manage the receiving of material, as well as effectively and efficiently store material to release outbound trailers. This, in turn, leads to congestion in the receiving area – not just for dock drivers, but tractor-trailer traffic in the yard. This inefficiency in manpower can only be absorbed such that the dock drivers pillars support it. Once the additional material movement exceeds available utilization, manpower must be added.

It was observed the day of the study that approximately 60%, or 97 parts, were in an overflow condition. The dock was congested with extra material being dumped from trailers in an attempt to release the outside drivers prior to their receiving window expiring so that the next trailer could be docked and chocked, and material unloaded. There was also increased driver congestion on the dock as manpower was brought in, in an attempt to keep the dock on schedule. A further constraint that dock personnel must deal with, is the potential to detain outside drivers, which results in a monetary penalty if the wait time is excessive. This type of detention is inevitable when the volume of parts in overflow is as excessive as in this case.

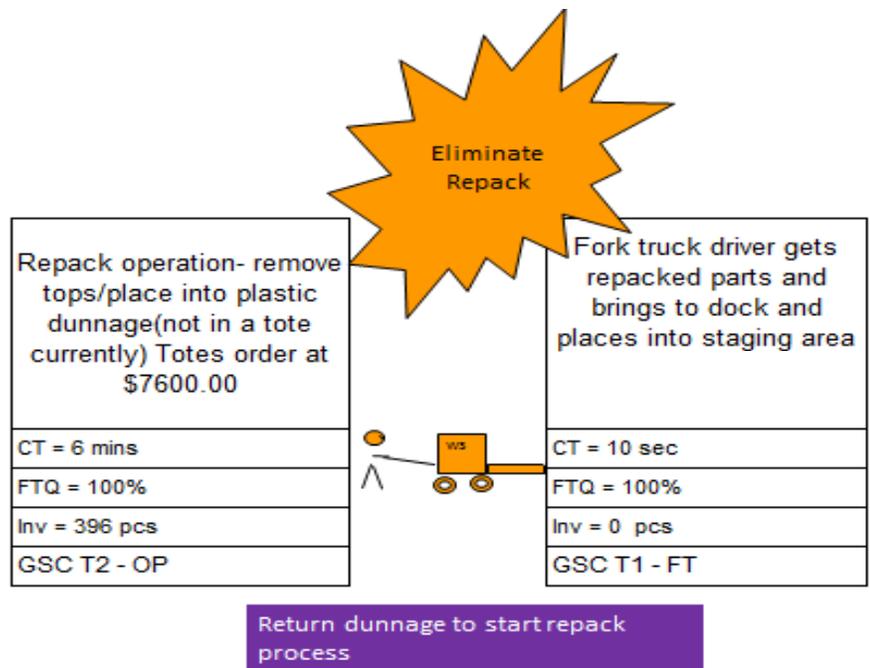


Figure 9: VSM REPACK CURRENT STATE

Repack LOC: A Headquarters initiative that was well received by manufacturing, and continues to be questioned by the supply chain group is the requirement for all material to be presented to manufacturing in returnable (non-cardboard) containers. With an overseas component, such as the component that was the focus of this VSM, it is not cost effective for the system fill to be established in returnable packaging. Not only would the system fill require a return segment of transportation, but the increased transit time associated with ocean going material would add approximately 12-16 weeks to the standard 15 day system fill of packaging. Because this is not feasible, the requirement is for this material to be repacked at the manufacturing facility by the supply chain group. There are costs associated with the one-time packaging procurement, as well as the on-going manpower requirements to

perform this activity. The argument remains that the cardboard will introduce sediment into the assembly environment. This can be countered with the ability of the packaging group to obtain “shoe” or “hat” box style packaging that does not requiring cutting cardboard to open the box. Manufacturing continues to refuse this style packaging and refutes the argument by supply chain that the parts travelled over the ocean in the cardboard, if the contamination is real, then the damage is done.

The enterprise cost to the system includes the procurement of totes to repack parts into, totaling \$7,600. There is also additional inventory required to support this repack. Material must be made available in advance so that repack activities can commence transparent to production. This introduces an additional 352 pieces to the system, at a minimum. The other cost associated with this repack is the manpower required for the actual repacking activity. This repack takes place, on average, one time per shift and requires approximately 15 minutes to complete each instance. The incremental effect is 30 minutes per day and is aggregated with all other required repacking activity with the net result of two jobs per shift.

Staging Plant X: The staging required for buffering material before the assembly line is currently set at three hours total inventory. The result is the carrying of two pallets of material (704 components) in a staging lane, combined with 1 pallet (352 components) staged on a dolly, ready for delivery to the assembly line. The three hour staging requirement adds additional inventory to the system without providing any real value or protection, as semi's move between the LOC and Plant X every half hour. The math provides that the staged pallet holds enough to cover a maximum of four hours of assembly builds. This is sufficient to cover the pull from the LOC without requiring

additional staged material in a lane. Through this staging activity in a lane, there is extra manpower and movement that is not conducive to a lean system and drives extra manpower and inventory cost, especially when applied throughout the entire system.

Quality Considerations – Overall: The quality considerations involved in a system that does not exhibit Lean characteristics can harbor many behaviors and conditions that adversely affect quality. Overflow is three-fold in its risks to quality. The first factor is in the excess inventory itself. With excess inventory the impact of a quality issue is magnified by the volume of material present at the plant. More inventory means more non-conforming parts when a quality issue is detected. In a Lean system, with minimal inventory carried at the plant, the fewer non-conforming parts in the pipe-line, and the quicker the turn-around to conforming inventory. The second factor is embedded in the FIFO (First In First Out) process. Additional inventory, being stored in satellite areas makes the movement of inventory following a FIFO process very difficult. When inventory is moved and used outside of FIFO process, quality defect detection is compromised, as the containment of suspect material is made more difficult when product is not stored in the order it was manufactured, and subsequently, received. The third factor is duplicate handling. As with all freight, the more it is handled, the increased likelihood that it will be damaged. Handling such as dropped, speared, and crushed pallets are not uncommon in handling, and the more movement that is required, the more opportunity for the quality to be compromised.

4.3.2 Machined Component Analysis and Findings:

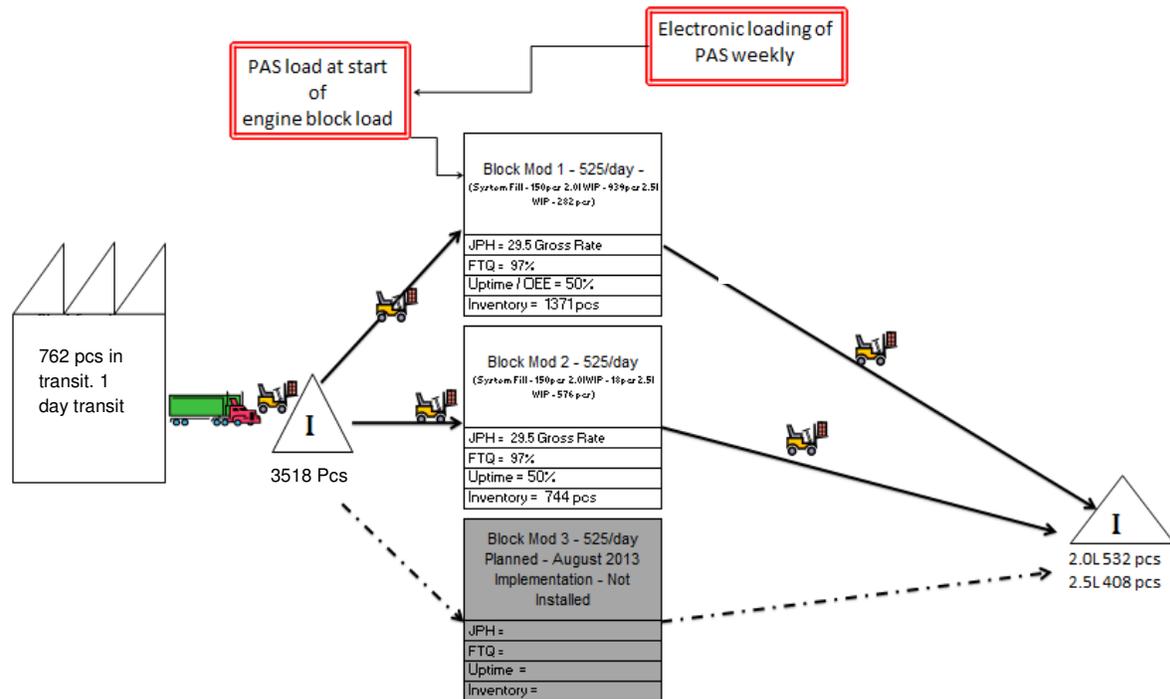


Figure 10: VSM CASTING CURRENT STATE

Casting/Forging Inventory: The inventory currently held for raw materials ahead of the machining operations is inflated by almost 700%. This is gross negligence by the procurement team. This additional material adds approximately \$2M in plant inventory. Not only is this a waste in inventory carrying cost, but it creates additional problems as well. This inventory is not routed through the LOC. This is because the machine floors run decoupled from the assembly line. It would create vast inefficiencies in manpower to operationalize the LOC when the assembly line is not running, therefore; transportation is direct.

All Floor Operations considerations are based on the maximum inventory level set at 1,000/day. This would include:

- Floor Space
- Window Times
- Manpower

With the inflated inventory calculating, on average for the three machined components, at 550%, the necessary floor space is unavailable. This results in unsafe storage practices, multiple storage areas, and reduced storage for other components. The excess inventory also creates congestion on the receiving dock, as trucks require additional time to unload due to increased inbound freight. This puts the dock in jeopardy of not being able to unload trailers in their allotted time, and creates late windows for waiting drivers. The plant is, again, at risk for being charged detention fees, and when trailers are unloaded late, there is an opportunity to affect the assembly line with material unavailability – even though the material is on the property. Manpower is negatively impacted with large volume of casting and forging inventory. The movement of material in and out of overflow is not captured in any manpower requirements and the additional lifts from receiving further burden the receiving dock team, it was observed, to the point where an increase in manpower may be warranted.

Finished Float Inventory: Typically, the plant likes to buffer the finished machine floor components before the assembly line at a two day level, which would translate to 1,600 pieces. Looking at the inventory counts on the date of study, it is clear that all machine floors fall below this level. Since there has been no negative

impact to the assembly line, even though the machine floors are below their targets, it flows logically that these levels are inflated. The numbers appear to fall more in line with the inventory levels that are help for supplier components.

Quality Considerations: The current operating plan has manufacturing machining in very large batches. This can contribute to higher fallout when quality defects are identified. If quality checks are missed in a higher volume run, there are more non-conforming components produced. Also, the handling of inventory over the maximum level creates difficulties in maintaining FIFO. When FIFO is violated, quality issues are harder to contain, because material is not in the order it was received, and subsequently produced.

4.4 Manpower & Inventory Analysis Tool

The Manpower & Inventory Analysis Tool was developed to simulate, on a high level, the required manpower and floor space associated with a project. This tool was validated as accurate when compared with other, more time-consuming, methods used to calculate the same information. The M&I Tool takes into account inputs that include: part number, quantity per pallet, size of pallet, pieces per assembly, distance traveled, delivery method, and handling times. This data was entered into an MS Access database, and queries were created to calculate key attributes for manpower assessment and material storage layouts.

4.4.1 Manpower Analysis

The Manpower Analysis portion of the database uses the data specified in section 4.5 and based on user variables (delivery type, travel distance, etc.), provides

an approximation of the necessary manpower to support a range of parts or activities. The range associated with this study is limited to “Bulk” parts, where bulk parts are defined as parts that are stored by the pallet. These parts are not broken down further from shipment, and are stored in the original packaging from the supplier.

Analyzing the Manpower extrapolated from the database tool, it is interesting to see the correlation between on-roll manpower and that which was calculated. These numbers are within 8% of each other. The method currently utilized to determine manpower requirements consists of a spreadsheet that lists all parts associated with the assemblies, and the corresponding data – similar to what is used in the MS Access tool. The spreadsheet is conceptually very similar to the database tool; however, there are many advantages to using MS Access.

It was observed that using an Excel spreadsheet, updates to data require separate manual entries on several tabs, with the resultant impact displayed on a summary tab. Error is inherent in this type of system. Updates in the MS Access database are captured through data entry into one form. This form feeds queries and reports so that the user can have the impact of updates and changes immediately, and displayed in any number of formats that can be developed for the analysis that is being conducted. Upon inspection, it was noted that several errors existed in the Excel spreadsheet, and it appeared to be related to the multiple redundant entry updates required in that process.

4.4.2 Inventory Analysis

The Inventory Analysis portion of the database uses the same data as for manpower, combined with some storing and stacking guideline calculations that allow the user to determine the storage requirements for a range of parts. As with the Manpower Analysis, the parts associated with the Inventory Analysis study are also “bulk” parts.

The Inventory that was calculated using traditional methods, correlated within 5% of the Inventory Analysis tool. The plant layout corresponds to the traditional planning method, and has demonstrated that it can accommodate the material storage required for manufacturing today. The difference between the tool and the traditional calculations is the time required to collect data input, calculate storage requirements, and analyze data output. With the tool, there is only a requirement to analyze the data output. The significant savings is measured in not just time, but accuracy. Every replication of redundant data lends itself to error, corruption, and obsolescence.

4.5 Summary of Chapter 4

The analysis of the data collected clearly presents several opportunities for improvement. Examination of the employee survey has yielded responses that do not reflect the desired state of the workforce. The Current State Value Stream maps illustrate a system that is not representative of the perceived system – and when contrasted with the desired state, or Future State Value Stream maps, demonstrates a considerable amount of waste reduction potential through Lean initiatives. Finally, the Manpower and Inventory Analysis Tool has been successfully validated for accuracy.

Chapter 5: Conclusions and Recommendations

5.1 Introduction

In this chapter, recommendations and conclusions are provided based on the analysis and observations conducted in Chapter 4. There is considerable opportunity to improve the efficiency of manufacturing operations at Company X.

Conclusions from this study provide that the overall culture does not support Lean Material Strategies in its current state. There is a need to shift the thinking at Company "X" to create an environment that is conducive to continuous improvement. Also identified is a weakness in discipline with supply chain procurement activities, that if corrected, can yield significant improvements to inventory and manpower.

Recommendations to accomplish this include, but are not limited to, employee training, eliminating extra fork truck travel, providing electronic systems, and reducing inventory. The analysis that was conducted generated considerable ideas for eliminating waste in several forms. Although any activity associated with supply chain is considered non value added, it is important to identify those activities that are pure waste. Highlighted in the following text are recommendations that vary in ease of implementation, but will all create a significant positive impact on the business.

5.2 Conclusions

5.2.1 Employee Survey

The conclusion can be drawn from the employee survey that there are gaps in Lean Material Strategy understanding and perceived managerial commitment. Most responses echo the same concerns: training, support, and having the ability to make desired changes that improve the business. Of the 58 respondents, only 6% felt that they were equipped with the necessary knowledge base to interpret the waste in the system, to put in place a plan for improvement, and finally, execute that plan. It should be noted that there is a strong correlation between Lean knowledge and whether the employee was involved with a launch role. It is evident that the only training available to employees at Company X at this time is conducted through launch activities. This training was loosely structured and not as comprehensive as is required to shift an entire organizational culture.

5.2.2 Value Stream Mapping

Through the analysis of both value stream mappings conducted, it is clear that there are too many castings, forgings, and sensors in inventory. The dollar value of inventory is in excess of \$2M. Although this translates to carrying costs instead of a true dollar value, the constraint on Company X's cash flow position is significant. This is money that Company X could invest somewhere else. Since Company X is a publically traded corporation, the direction should be to create stockholder equity, not tie up cash in unnecessary inventory. The time that the inventory requires to be converted into finished goods, less the actual required inventory to buffer the assembly process, is the

waste in the system. This waste in inventory carrying cost translates to a true dollar value that Company X could be using to create stockholder equity in growth type investments versus tying cash up in an inventory asset that will not create additional equity.

The additional inventory also creates additional manpower and storage requirements that are not value added. By carrying excess inventory, parts are double and triple handled. This work does not come free and with this handling comes storage requirements outside the steady state plan. This manpower and storage will also create variation in the process that will contribute to quality issues and the strained ability to contain product should a quality defect be detected. It is also difficult to standardize out of norm processes, so there is an increased likelihood that material will be lost or damaged when inventory hits overflow levels. Also, it should be noted that the storage that is required to manage overflow is valuable real estate in a plant manufacturing environment that should be utilized for value added activities like machining or assembly instead of warehousing, which does not have the value associated with it that the cost of manufacturing floor space has. Essentially, the cost of taking warehousing activities off site compared to that of production carries a much smaller price tag.

5.2.3 Manpower & Inventory Analysis Tool

The Manpower and Inventory Analysis Tool proved that the manpower and storage requirements that represent the baseline for manufacturing activity and an 800/day schedule are in line with what has been routed and laid out, respectively. Unfortunately, the amount of noise created in the system has generated additional

manpower and storage requirements in both the LOC and the plant. Although necessary storage is less in the plant than it is in the LOC, the requirement to create non-value added work and storage should be addressed.

It also should be noted that the Manpower and Inventory Analysis Tool provides a realistic and accurate picture of what the established methods for calculated the same requirements would provide. The use of a database versus an excel spreadsheet can reduce salaried manpower and allow for real-time data analysis of changes in volume, packaging, manufacturing process, and delivery methods. It is also a valuable tool for establishing “what-if” effects to manpower and storage requirements, which is valuable as Company X pursues continuous improvement initiatives.

5.3 Recommendations

5.3.1 The Workforce: The 3 E's - Educate, Engage, Empower

As the survey has indicated, there is a considerable lack of understanding in Lean Material Strategies and their subsequent initiatives. There is no solid understanding at Company X of how Lean works and what it will actual do for the Company, it's processes, and ultimately, it's employees. Therefore; it is impossible to have the workforce engaged in improving the business and empowered to drive those changes. It is recommended that Company X establish a formal training program that provides a background in Lean Material Strategies and then follow with examples of Lean improvements conducted at the plant – highlighting the gains and improvements associated with these initiatives. It would be beneficial for the employees to participate

in a Lean Material Strategy exercise where they are empowered to select an area where they feel improvements can be made using Lean techniques and then employees are supported as they execute these changes using what they have learned. This type of structure would provide an environment where education, engagement and empowerment are the foundation to the Lean culture at Company X.

Through education, employees will be better equipped to identify areas of improvement. Through the selection of improvements that they feel will benefit them and the Company, engagement will follow. Once Company X has secured their employees engagement in the Lean Material Strategy process, through the continued support and financial backing of their suggestions for improvement, employees will feel empowered to continue to drive these changes. It is important for management to allow their employees the freedom to select the initiatives that they can demonstrate will make a positive impact of the business. Once this commitment is made to the employees, support for these improvements must remain constant, and it is key that management continue to encourage and support without interference. Management must accept their role as advisors to Lean initiatives, and allow the employees the ability to initiate and drive the improvement.

5.3.2 Elimination of Waste: The 3 M's – Manpower, Material, and Movement

The elimination of waste is the foundation of continuous improvement. Waste comes in many forms, but as identified in Company X's supply chain, it has manifested in waste in manpower, material and movement.

The current manpower carried to support supply chain activities has been validated through analysis and observation as very efficient. The manpower pillars are loaded and translate to high worker utilization. Most jobs studied approach 90% +, with only one job falling below 85%. It is recommended that the staging job be further studied to evaluate opportunity to reduce routed jobs to one or add content to the job with the potential to collapse another pillar or reduce routed jobs in another area. One opportunity would be for the staging drivers to deliver machined components, reducing deliveries for the dolly delivery team – enabling the reduction of manpower to four routed jobs.

The waste associated with carrying the excess inventory is considerable. As identified in the previous chapter, in raw machine floor components alone, the dollar value associated with this inventory approaches \$2M. When all supplier components are considered, it is not improbable, that inventory dollar value is inflated by \$5M. There are several contributing factors to the additional inventory: nonconforming product, supply base constraints, throughput issues, and overbuild protections. The lowest risk area to begin the inventory reduction would be in nonconforming product. This would protect for the assembly lines ability to produce product, without putting any strain on the inbound supply chain.

Through the analysis of excess inventory, the waste associated with the extra material was quantified. After considering the handling and distance traveled, it has been calculated that a fork truck lift costs the corporation \$2.10 based on his daily wage. On the day that the study was conducted, there were 352 pallets of material in the overflow area in the warehouse alone. This material, if the assumption is made that

it will only be moved one extra time – which is not always the case, will drive an additional \$740 in associated manpower cost.

Since one of the initiatives is to reduce inventory, that should translate to a reduction in movement as well. However, it may be beneficial to incorporate some of the excess inventory into the actual material storage lanes. Production is still in ramping to volume, so there is opportunity to treat overflow in this manner. The only caution would be, that since the overflow is “hidden” in storage lanes, it is important to continue to identify and reduce the excess material, to subsequently reduce movement, and then manpower.

5.3.3 Reducing Error and Providing Real-Time Feedback on Updates and Changes

The Manpower and Inventory Analysis tool demonstrates not only its accuracy, but the timeliness of its data. By incorporating this tool into the existing material flow plan database, engineers and analysts could produce concise and detailed reports that provide an instantaneous account of manpower, inventory and floor space requirements.

The use of this tool would reduce cost and time to implementation. Cost impacts are realized through a reduction in engineer and analyst staffing as well as a quicker response in time to implementation. By reducing the time required to execute changes to manpower or material flow, the sooner the cost savings in seen in operations. It has been a long standing struggle for engineers and analysts to identify forms of waste, create a plan to move or reduce it, study the impact of the change, and then execute that change. The required documented studies, especially when there is a reduction in

manpower, create a significant increase in the continuous improvement timeline. The Manpower and Inventory Analysis tool streamlines this activity, not only through its ability to simulate the effect of any change in manpower, inventory, or storage, but document it through its reporting functionality.

5.4 Areas for Further Research

The recommendations provided in this literature will provide a solid foundation in Lean Material Strategies; however, other opportunities for research exist to expand on this topic. It would be beneficial for Company "X" to initiate a study into the integration of electronic systems to assist with the management and subsequent elimination of waste as it is pushed into the supply chain. As the system evolves, and waste is moved from manufacturing to the supply chain, the work performed is not always traditional in terms of supply chain activity, and may be difficult to manage. Through a strong manual process, operator training, and electronic systems, supply chain will be better equipped to process the new content, identify the waste in it, and ultimately reduce or eliminate it. A second area for further research would be in the area of Lean Manufacturing Strategies. Although the topics are similar and many times overlap, a more extensive understanding of creating a total Lean system and the tools to attain it in a manufacturing environment will serve to supplement the Lean effort at Company "X".

5.5 Summary and Final Conclusions

The recommendations associated with the employee survey present an opportunity for management at Company "X" to show their support of, not only, Lean

Material Strategies, but the workforce that will be trained to employ them. Management can demonstrate that there is a willingness to invest in their employees who will, in return, exhibit a commitment to Company “X” and its success. From this commitment, the recommendations discussed in reference to the Value Stream Mapping will provide a valuable exercise in the execution of Lean Material Strategies. More importantly, the Value Stream Maps will serve as a catalyst for the understanding of these principles, the confidence in implementation, and the resolve to continue to identify waste.

With the integration of the Manpower and Inventory Analysis tool into the current part planning database there can be a significant savings in both cost and time. This will be accomplished through the streamlined maintenance of data and the ability to create real-time and on-demand analysis of calculated manpower and inventory levels. This has the ability to eliminate a large portion of salaried work content associated with manpower and storage planning while improving the timeliness of analysis.

The application of Lean Material Strategies to the current operating systems at Company “X” presents tremendous opportunity. Through the implementation of the aforementioned recommendations, Company “X” can realize a substantial reduction in manpower, inventory carrying cost, and a decrease in reaction time associated with time-to-implement. However, the most notable gain that Company “X” can recognize would be a shift in the climate and culture that embrace Lean Material Strategies, engaging and empowering the workforce to seek opportunities and drive positive change, which will ultimately create a workforce that in a constant state of waste elimination and continuous improvement.

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APPENDIX

Manpower Report



Manpower - Bulk.pdf

Storage Report – 3 Hours Staged



Staged Material
Storage 3 hr.pdf

Storage Report – 2 Hours Staged



Staged Material
Storage 2hr.pdf

Value Stream Map – Current State Purchased Component



Currentstatecompon
entVSM.pdf

Value Stream Map – Future State Purchased Component



FutureComponentVS
M.pdf

Value Stream Map – Current State Purchased



Machinedcomponent
VSM.pdf

Plant Layout – 3 Hrs



Pl Layout 3 Hrsl.pdf

Plant Layout – 2 Hrs



Pl Layout 2 hrsl.pdf