A SOCIO-TECHNICAL STUDY OF LEAN MANUFACTURING DEPLOYMENT IN THE REMANUFACTURING CONTEXT

by

Robert J. Kucner

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Doctoral Committee:

Professor Jeffrey K. Liker, Co-Chair
Professor Lawrence M. Seiford, Co-Chair
Professor R. Van Harrison
Assistant Professor Young K. Ro, University of Michigan - Dearborn

DEDICATION

To Mom and Dad,

my most consistent friends and cheerleaders,

I could not have done this without your support.

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ABSTRACT

Remanufacturing, the process of restoring used material goods to like-new condition, has been lauded as “the next great opportunity for boosting U.S. productivity” and “the ultimate form of recycling” as it creates multiple iterations of the product lifecycle. Yet, remanufacturing has remained largely untouched by technology, productivity, and quality advances of the last thirty-years. Lean manufacturing, the principles, practices, and philosophies based on the real-life model of the Toyota Production System (TPS), has been benchmarked worldwide for the production efficiencies it creates through empowering workers to eliminate wasted time, material, and other resources. Yet, lean remanufacturing, the marriage of lifecycle efficiency and production process efficiency, has remained a largely untapped opportunity. This dissertation is a socio-technical study of lean manufacturing applications and deployment within the remanufacturing context.

First, the application of lean production tools and techniques are examined in four unique contexts of the remanufacturing industry. The organizational contingency design model of the product-process matrix is used to bridge the gap between manufacturing theory and remanufacturing application. In each case study, lean methods are applied with significant benefits to operations. It is recognized that lean methods must be adapted to fit the context in which they are applied. High-variability and low-variability applications of lean methods are identified for remanufacturing context.

Second, the methodology by which lean production is deployed within a single remanufacturing organization is examined. Two approaches are identified: (1) a mechanistic approach, prescribing widespread deployment, rigid organizational training, and infrastructure and (2) an organic approach, emphasizing focused deployment, organizational learning, and evolution of improvement initiatives. Ultimately, successful deployment must blend organic and mechanistic implementation.

Finally, the deployment of lean production throughout a large geographically diverse extended enterprise is considered. Theories of organizational life cycle growth and development are examined and integrated with theories of enabling and coercive deployment. The result is a greater understanding of mechanisms by which an organization can become subject to an internal deployment that is coercive, inhibiting true lean transformation, or one that is enabling, promoting true lean transformations.

This dissertation is useful to an organization implementing lean methods in any environment or context.

CHAPTER 1

A SOCIO-TECHNICAL STUDY OF LEAN MANUFACTURING DEPLOYMENT IN THE REMANUFACTURING CONTEXT

INTRODUCTION

The 20th century saw tremendous wealth created in the United States as American industry transformed vast raw materials into finished goods to be consumed domestically and shipped to lesser industrialized nations around the world. The dawn of the 21st century presents a very different global economic landscape as some of the world's most populous nations undergo rapid industrialization. Global competition to American manufacturing has arisen in nearly every industry. Raw materials goods, such as oil, iron, steel, copper, and plastics have seen a dramatic rise in both price and scarcity as they have experienced a significant spike in global demand. And the environment, particularly the emphasis on developing a sustainable environment, is at the forefront of social conscience in many advanced nations. This dramatic increase in scarcity of raw materials and increased emphasis on environmental responsibility places tremendous importance on the ways in which society reuses, recycles, and remanufactures material goods.

Remanufacturing, the process of restoring used material goods to like-new condition, has been lauded as "the next great opportunity for boosting U.S. productivity." (Giuntini and Gaudette, 2003) It re-introduces a product to the marketplace in "like new" condition at costs typically 40 to 65 percent less than original equipment manufacturing (OEM), and can retain up to 95% of both the material and geometric (shape) value of a used product. (EPA, 1997; Bras and McIntosh, 1999)

Remanufacturing has been termed "the ultimate form of recycling" for the way in which it prevents large industrial products and equipment from going to a landfill, and the way it requires only about 15 percent of the energy to produce a part as compared to an OEM process. (EPA, 1997) From a societal perspective, remanufacturing could represent an opportunity for significant job creation in the U.S. as it is a labor intensive industry with tremendous efficiencies in logistics to be gained through production occurring near markets of consumption. Germany is perhaps the world's most aggressive nation in promoting remanufacturing, as each year a certain percentage of automobiles sold must be remanufactured, and by 2015 only 5 percent of a used automobile may be discarded in landfills. (Giuntini and Gaudette, 2003) Yet, despite wide-ranging benefits and opportunities, remanufacturing has remained largely untouched by technology, productivity, and quality advancements of the last thirty-years. (Lund, 1996)

Lean Manufacturing, the production processes, tools, and techniques inspired by the real-life model of the Toyota Production System has been benchmarked worldwide for its ability to do "more with less" through efficient utilization of all resources in manufacturing (manpower, material, energy, machinery and equipment). (Womack, Jones, and Roos, 1990) Toyota's production system has proven to be a successful paradigm shift from traditional mass production in methods of production for mass markets. Lean production, with its primary focus on the elimination of eight production wastes (overproduction, overprocessing, waiting, excess transportation, excess motion, excess inventory, unnecessary movement, defects, and unused employee creativity) has been applied successfully in non-automotive industries such as job shop manufacturing, service organizations, supply chain management, home construction, and government agencies. (Liker, 2004; Womack and Jones, 1996; Ohno, 1978).

RESEARCH OBJECTIVES

Remanufacturing is benchmarked for its efficient creation of value in the product life cycle. Lean manufacturing is benchmarked for its efficient creation of value in OEM operations. The marriage of these techniques, lean remanufacturing, represents an opportunity to increase process efficiencies in the remanufacturing industry. An increase in internal efficiency would create broader opportunities for remanufacture, and result in a potentially far reaching economic, environmental, and societal impact. The primary objective of this research is to better understand the opportunities, challenges, and methodologies by which lean production tools and techniques can be successfully applied in the remanufacturing context.

In order to achieve this research objective, lean remanufacturing application is considered from both a social and technical perspective, as well as at three distinct levels of analysis within the organization, each representing a chapter of this dissertation: single process, single production facility, and extended enterprise. A summary of lean remanufacturing research sub-objectives, at each of the three levels of analysis are:

- Lean remanufacturing within a single process: In chapter two, the research sub-objective is to better understand the appropriate technical design of lean manufacturing tools and techniques in the remanufacturing context. This study seeks to de-mystify the question of if whether concepts of lean manufacturing apply in the remanufacturing context. Remanufacturing, lean manufacturing, and lean remanufacturing are all placed within a popular organizational design contingency model to bridge their contextual gap. Additionally, the application of computer integrated manufacturing (CIM) is compared and contrasted with lean methods in the remanufacturing context.
- Lean remanufacturing within a single facility/factory: In chapter three, the research sub-objective is to better understand the methodology by which lean remanufacturing is appropriately deployed within the remanufacturing context. This study builds upon the research of chapter two to answer the fundamental question of "where do I begin?" once the technical design of lean remanufacturing is understood. This study develops a roadmap for successful lean deployment within a single facility, giving appropriate emphasis to the social considerations of organizational change.
- Lean remanufacturing within an extended enterprise: In chapter four, the research sub-objective is to better understand the phenomenon by which a large and complex organization is transformed (or not) through deployment of

lean production. The life cycle of a normative lean transformation is examined, as well as the impact an enabling or coercive deployment of lean production can have on the success or failure of that transformation.

The linked results across the three levels of organizational analysis provide a comprehensive answer to the primary research question: what are the opportunities, challenges, and methodologies for applying lean production to the remanufacturing context?

RESEARCH METHODS

This dissertation is the compilation of six years embedded research within REMAN, a large multi-divisional U.S. organization that repairs naval ships and their associated components. The researcher was first introduced to remanufacturing in 2002 while working as a summer intern at a large REMAN naval ship remanufacturing depot. At that time, REMAN was in the initial stages of what became a very large and successful deployment of lean production throughout their extended enterprise. The particular remanufacturing depot hired the researcher to assist in the initial deployment of lean manufacturing tools and techniques. The context for applying lean manufacturing principles to remanufacturing was unlike anything the researcher had previously seen or experienced. A literature search found no previously significant application of lean manufacturing tools and techniques to the remanufacturing industry. At that time, this dissertation was conceived.

The three levels of analysis parallel the researcher's journey through lean remanufacturing. The first few years were spent on the production shop floor, learning the applications of lean methods in remanufacturing. This was a highly evolutionary period of discovery and learning within all areas of REMAN lean remanufacturing. The researcher led many shop-floor lean initiatives in a variety of remanufacturing contexts and was considered an internal expert within the organization on lean production and was able to advance personal and organizational understanding through participant observation. The lessons learned during this period form the theory and case studies presented in chapter two, "Lean Remanufacturing: Adapting Lean Tools and Techniques to the Remanufacturing Context."

As the maturation of lean grew within REMAN, the researcher became more engaged in managerial and strategic planning functions of the lean deployment. At this time, the researcher had the opportunity to gain intimate knowledge of lean remanufacturing efforts within six repair depots (totaling $5B annual business; products ranging from helicopters to transport jets, small turbines to naval ship hulls), as well as a cursory knowledge of ten additional public and private remanufacturing depots. A significant technical knowledge of lean remanufacturing had been garnered by the organization at this point, but significant questions arose as to the methodology for deploying such technical lessons. It was during this period of learning that the researcher was introduced to the two uniquely different methodologies of lean deployment that are highlighted by the case studies of "Big Ship" and "Little Ship." This period of learning represented a maturation of complexity for lean deployment within REMAN, the researcher, and this dissertation, all of which culminated in chapter three: “Comparative Cases of Lean Manufacturing Deployment: Organic versus Mechanistic Approaches.”

After success as an implementer of lean remanufacturing at the production level and strategic management at the facility level, the researcher was “promoted” to a desk job at REMAN divisional headquarters to act as a program manager for the lean remanufacturing efforts within a large division of the enterprise. Corporate program management of lean deployment was a tremendous challenge as lean production learned on the shop floor came in direct contact with bureaucratic corporate directives, policy deployment plans, point papers, and cost-reduction reports. Despite all the best intentions to create positive transformation, among senior managers lean was not well understood, and endorsement of lean transformation was seen as a method to gain favor politically as much as it was a paradigm of process improvement. The researcher spent two years observing lean production within REMAN from this corporate perspective, which significantly influenced chapter four: “Developing a Lean Bureaucracy: Enabling versus Coercive Transformation from an Organizational Life Cycle Perspective.”

INTRODUCTION TO REMANUFACTURING

This section introduces the remanufacturing market, the remanufacturing process, value in the product life cycle, and key differences between manufacturing and remanufacturing.

The remanufacturing market in the U.S. alone has been estimated to be $53 billion in annual sales, with direct employment of 480,000 personnel. The Department of Defense is the largest sector, spending $10 billion annually on remanufacturing; followed closely by transportation ($8 billion), automotive/light truck ($6 billion), and electric generation ($3 billion). (Giuntini and Gaudette, 2003) In recent years, remanufacturing has grown significantly in the United States, offering an alternative to landfill disposal of used products, bringing high-quality used products to market at cheaper costs with less energy, and lowering demand of increasingly rare raw materials such as precious metals.

Products that are remanufactured will typically share the characteristics of: (1) a non-consumable core, (2) slow product obsolescence, (3) a market for remanufactured products, and (4) an available supply of cores. (Lund, 1984) A component's "core" is typically the central piece of product geometry, the "guts" of a product. In many instances, a product's core is made of a solid long-lasting material and will not wear out as quickly as its sub-components, software, or other materials. An example of a product core would be the body of an electric motor or an airplane fuselage. Many remanufactured products are quite expensive, such as military assets or airplanes, resulting in a closed-loop market for product re-use through remanufacturing. For lesser priced goods, such as automotive part and printer cartridges, financial incentives are often given to the consumer for remanufacturing a product as opposed to disposal, enabling a profitable market for remanufactured products.

While many companies have established themselves as after-market suppliers of remanufactured goods; remanufacturing is quickly becoming an integral part of a lifecycle product ownership business strategy for many companies, as industrial giants such as General Electric and Boeing offer integrated manufacturing and life cycle maintenance packages to customers of their power turbines and aircraft, respectively. Lifecycle support becomes increasingly popular as OEM's are able to take advantage of concepts such as "Design for Life Cycle Maintenance" to both decrease life cycle costs to the final customer and for OEM's to recognize recurring profits from sales of large equipment through contractually planned and unplanned maintenance. (Amezquita, et al., 1995)

The Remanufacturing Process:

Remanufacturing will occur at one of two fundamental levels, those of <u>component remanufacturing</u> and <u>system remanufacturing</u>. A component remanufacturing process, the most fundamental level, is illustrated in Figure 1.1. A remanufacturing process can be initially triggered in one of two ways: the customer relinquishes possession of a specific product to the remanufacturing organization (closed-loop cycle, in which case they will wait to receive the same product in return), or the remanufacturing organization may take possession of a standard core asset for processing to an unknown customer (open-loop cycle). Both forms of customer-supplier relations are common and are typically dictated by norms of the industry.

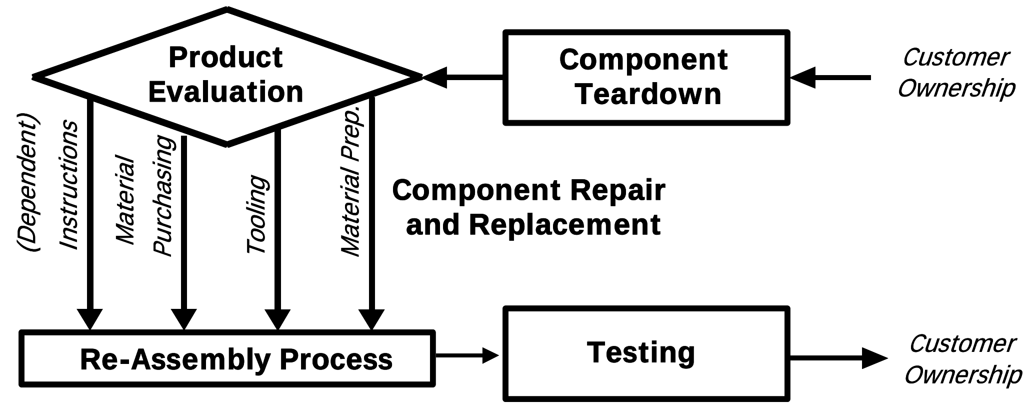


Figure 1.1 – Component Remanufacturing Process

Upon receipt of the core asset, the remanufacturing agent will disassemble the component (to the degree technically necessary) to determine the status of all critical surfaces and pieces. During component evaluation, the core is closely examined for deterioration or wear and all smaller pieces are evaluated for re-use. Often smaller, less expensive parts (nuts/bolts/o-rings), or parts with short obsolescence cycles (electronics) will be pre-determined for automatic replacement, regardless of condition. During the component evaluation process, it is determined what pieces must be replaced, repaired, or remanufactured. At this point the necessary material preparation and acquisition of materials, tools, and technical instructions will take place such that the core and required parts are prepared for re-assembly. Once all pieces resemble, in function if not form, those provided by an OEM, the assembly and test processes are completed.

A particular challenge in the remanufacturing process is that processing required to repair and replace parts may vary significantly, as a function of the components incoming condition. Incoming condition may be impacted by a variety of factors, including age, environment, usage, and regular maintenance. As a result, the component evaluation process brings inherent variability to the remanufacturing process. In the remanufacture of some products, this variability can be so significant it is not economically reasonable to remanufacture on a large scale, or in some cases a high-percentage of returnable cores are not eligible for remanufacture.

Remanufacture can also be completed at a second, more sophisticated level, that of systems remanufacturing. Systems remanufacturing differs from component remanufacturing only in that a system must be disassembled to its necessary components and sub-systems before material processing can occur, resulting in the potential for many components and sub-systems for remanufacture. Systems remanufacturing is illustrated in Figure 1.2, in which the system must be deconstructed and each component/sub-system evaluated individually. An example is the difference between the remanufacture of a single hydraulics pump (component manufacturing) and the remanufacture of a hydraulics system on a Boeing 737 (system of components). As would be expected, the complexity of a remanufacturing operation is greatly variable with respect to the number, size, and intricacy of subsystems and components that must be evaluated and repaired or replaced after evaluation.

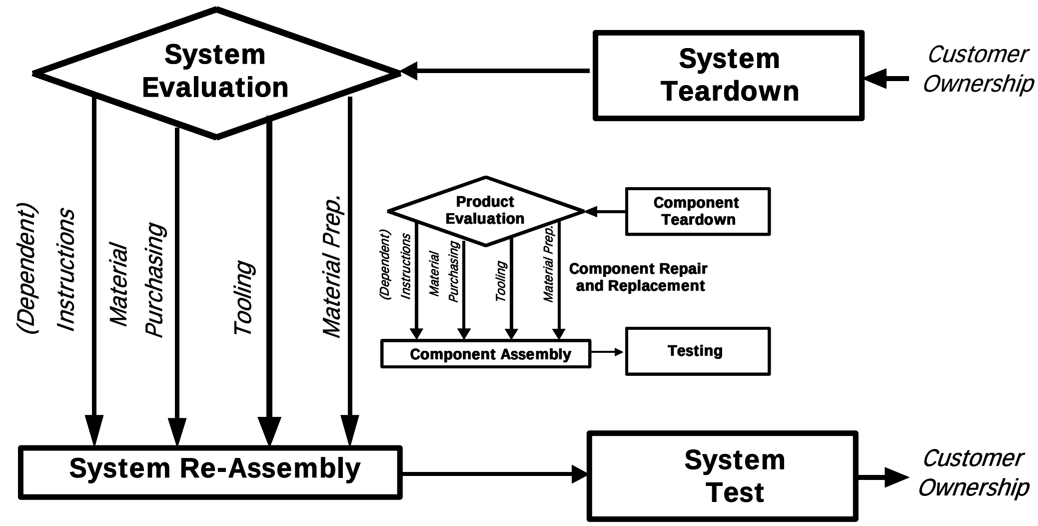


Figure 1.2 – Systems Remanufacturing Process

Creating Value in the Product Life Cycle through Remanufacturing:

As has been mentioned, remanufacturing is growing in popularity for a variety of economic (new products at a lower cost, sustained value of product, life cycle maintenance contracts), environmental (less waste in landfills), and societal (more jobs, less dependence on rare raw materials) reasons. (Giuntini and Gaudette, 2003) To illustrate the value created in the product life cycle through remanufacturing, Figure 1.3 identifies the relative "value" of a product at different stages of the product life cycle.

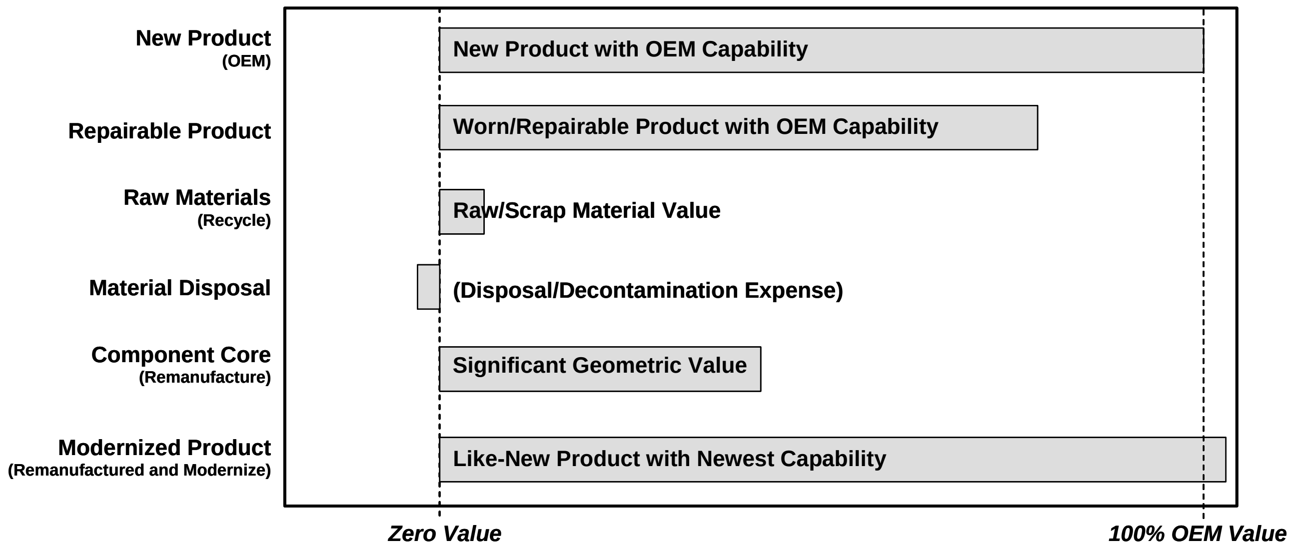


Figure 1.3 – Value in the Product Life Cycle

Utilizing a newly manufactured product as a baseline, this represents 100% of the OEM value. That same product, which is damaged yet repairable, would have a decreased relative value in that it could be repaired and put back into service at a relatively minimal cost. Recycling of scrap materials creates significantly less relative “value” to repair or remanufacture; recycling sacrifices all geometric value existing in a product, ultimately requiring a significant processing investment to retain a useable commodity. In many instances, material disposal, simply throwing a product away, has a negative value as costs are associated with disposal and decontamination of product. Remanufacturing offers a new set of options in the product lifecycle; a part which is damaged or worn beyond repair has less relative value than a repairable product, however, it represents far greater value than basic raw materials of recycling. In the event the component core is remanufactured, the resulting value is often higher than original manufacture, as the base component is typically restored to like new conditions, plus the latest materials, technologies, and advanced capabilities may also be integrated into the product.

A common example of these concepts in every day living would be in considering disposal of a plastic water bottle. In 2004, the United States consumed approximately 154 billion liters of bottled water, it is estimated that as much as 84-percent of these bottles become garbage or litter. (Arnold and Larsen, 2006) A plastic water bottle is a common consumer item which can be disposed of, recycled to raw materials, or reprocessed (remanufactured) for re-use. Recycling would suggest the water bottle is broken down into its fundamental materials and re-formed to make a new water bottle. Remanufacturing suggests the water bottle can be safely cleaned and sanitized for reuse. Disposal in a landfill takes up significant room, however, the bottle will likely biodegrade within hundreds of years. This is a simple example of bottled water, but the same example can be used for heavy machinery, military equipment, beer bottles, and many other products.

In many cases, such as with plastic water bottles, the U.S. consumer is not price sensitive to the point of desiring remanufactured goods, but it has been identified that almost 40-percent of “recycled” water bottles in the U.S. are shipped to China and other developing nations for both reuse and disposal. (Arnold and Larsen, 2006) These nations are also consuming large amounts of bottled water, by cleaning bottles (essentially remanufacturing them), these nations are able to create a cheaper, and ultimately more environmentally friendly water bottle, thus creating jobs for the local economy (processing bottles) and greater national wealth (less money spent on water bottles).

Understanding Key Differences between Remanufacturing and Manufacturing:

At a macro-level, the remanufacturing industry could best be termed as an industrial hybrid between original equipment manufacturing and a service organization. Figure 1.4 illustrates many of the similarities and differences remanufacturing shares with both manufacturing and service organizations.

Service Processes	Remanufacturing Processes	Manufacturing Processes
• Intangible output	• Tangible output	• Tangible output
• Quality is perceived and difficult to measure	• Quality is directly measured	• Quality is directly measured
• High customer interaction	• Moderate customer interaction	• Low customer interaction
• Labor and Knowledge Intensive	• Labor, knowledge, and capital Intensive	• Capital asset-intensive
• Production and consumption take place simultaneously	• Production and consumption take place nearly simultaneously	• Production can be inventoried for later consumption
• Site of facility is extremely important	• Site of facility is extremely important	• Site of facility is moderately important
• Rapid response time is usually necessary	• Rapid response time is usually necessary	• Longer response time is acceptable
• Human element is very important	• Human element is very important	• Human element may be less important

Source: Service, Reichheld and Sasser, 1990; Manufacturing, Bowen, Siehl, Schneider., 1989.

Figure 1.4 – Remanufacturing as a Product/Service Hybrid

Remanufacturing is similar to a manufacturing process in that it has tangible outputs, is capital asset-intensive (often requiring a large capital footprint), and quality of product can be directly measured. However, remanufacturing differs from classic manufacturing most significantly in the relationship between customer and supplier. In many instances, as observed earlier in Figures 1.1 and 1.2, the trigger for a remanufacturing process is for the customer to relinquish possession of the product to the remanufacturing organization.

With this relationship between customer and supplier, rapid response time is very important as production and consumption take place nearly simultaneously. Remanufacturing also tends to be very labor and knowledge intensive, while not as capital asset intensive as classic manufacturing. As observed in many instances, tradesmen in the remanufacturing industry have advanced from earlier jobs as tradesman in original manufacturing and possess a broader and higher skill set. In part due to the skilled workforce, also due to work content, the human element of production is very important in remanufacturing and less emphasis is typically placed on automation. Finally, due to the relationship between customer and supplier, a greater emphasis is placed on the geographic location of operation; it is more important that remanufacturing be located near customers for a rapid product turnaround.

In considering differences between remanufacturing and manufacturing at a more process-oriented level a key consideration is predictability of processing. A manufacturing process is relatively consistent and straightforward in that you acquire the necessary resources (manpower, raw materials, and equipment), technical instruction, and independently align them to customer demand. This may vary according to the complexity of the product or specificity of customer requirements, but manufacturing generally lends itself towards a highly-predictable repetitive process, as shown below in Figure 1.5.

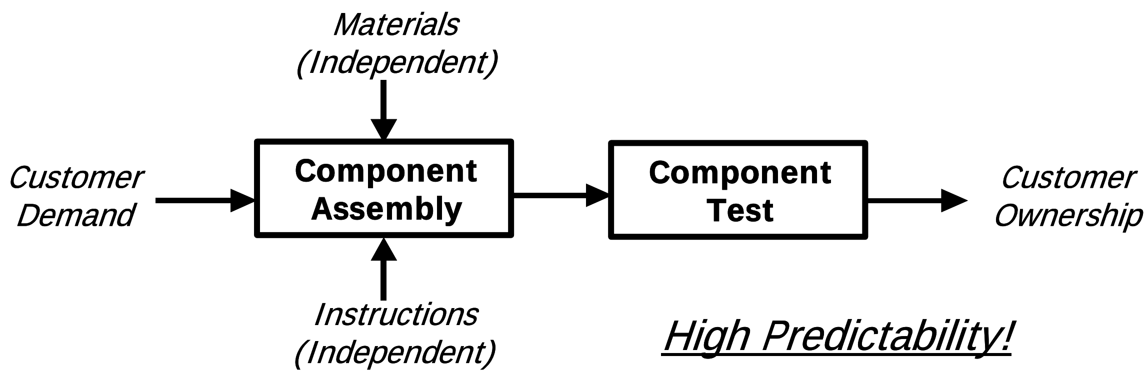


Figure 1.5 - Component Manufacturing Process

Over the course of decades, leading manufacturers like Toyota have been able to master manufacturing processes to the point of appearing as an "industrial symphony of moving parts and machinery" by continuously eliminating sources of variability in processing. However, as was discussed earlier, in the case of remanufacturing, product and process variability is naturally inherent as a function of the quality and condition of incoming parts. Whereas manufacturing can optimize productivity for a dependable set of operating conditions, remanufacturing organizations must be prepared to efficiently process the expected, while effectively processing the unexpected.

INTRODUCTION TO LEAN MANUFACTURING

The Toyota Production System is the real-life model from which all understanding of lean manufacturing originates. Lean will be introduced throughout this dissertation from a variety of perspectives and contexts. This introductory discussion is focused on the single most fundamental of being a lean producer; the ability to produce with minimal amounts of muda (Japanese word for waste.)

Toyota's Vision – The Fundamentals of Lean Manufacturing:

The Machine that Changed the World (Womack, Jones, and Roos, 1990), a summary of a worldwide benchmarking study of the automotive industry conducted at MIT's International Motor Vehicle Program (IMVP), introduced the concept of lean production as a new paradigm of manufacturing. This study identified the Toyota Motor company as a world-class manufacturer of automobiles for their product quality, production cycle time, annual inventory turns, employee turnover rates, and overall efficiency. An IMVP researcher termed the organization as being "lean", having the ability to do more with less.

The term lean has become a popular corporate buzzword, associated with lowest cost, highest quality, and shortest lead-time, all desirable outcomes for any organization. Yet the most fundamental definition of a lean production operation is: to create value to the customer with little or no waste existing in operations. (Womack and Jones, 1996) Waste is considered as the expenditure of any resource (time, money, material, manpower, opportunity) that does not add direct value which a customer is willing to pay for. Waste, also termed non-value-added activity, has been characterized by Toyota according to seven major types, with an eighth added later, they are:

- Overproduction; producing an item at an earlier time, or in greater quantity than a customer desires to consume.

- Waiting (time on hand); workers, materials, machines, or other resources sitting idle as another operation completes or as in waiting for material or information.
- Transportation; more than the minimum required movement of material goods during processing and delivery to the customer.
- Overprocessing or incorrect processing; producing a component which has more value added than the customer desires to consume (overprocessing), or does not meet customer defined requirements (incorrect processing).
- Excess inventory; possessing more than the minimum required quantity of parts or raw materials to meet customer desired consumption.
- Unnecessary movement; more than the minimum required human movement during processing and delivery to the consumer.
- Defects; production of parts which do not meet set specifications for quality and/or customer defined requirements, often resulting in corrective action.
- Unused employee creativity; lost ideas, skills, improvements, and learning opportunities by not engaging or listening to employees.

One model used to illustrate Toyota's methodology of waste elimination is that of the "Waste Reduction Model", developed by Liker and Meier (2006), show in Figure 1.6. This model illustrates the iterative process by which Toyota promotes waste reduction. Beginning with the fundamental philosophy of waste elimination will lead an organization to seek out continuous flow of value. Creating continuous flow of value will have the effect of reducing lead time, a significant value unto itself, but more importantly it will allow the producer to begin looking at their production system as a set of interdependent "connected processes." These would be the remaining process steps that can not be combined, condensed, or eliminated to produce continuous flow of value. These interdependent processes shall be connected by pull systems, so as to maintain minimal inventories and establish disciplined linkages between operations. Pull systems can be created using the lean tools of kanban (inventory card system), supermarkets, and first-in, first-out production lanes. As a result of disciplined adherence to pull system parameters, and an effort to continually reduce the size of the pull system so as to more closely approach a continuous flow system, problems (abnormalities) are clearly and quickly identified and dealt with to maintain production. As a result of rapid and disciplined problem solving, organizations are better able to both maintain production (band aid fix) and conduct root cause analysis and correction, all of which will lead to long-term waste reduction.

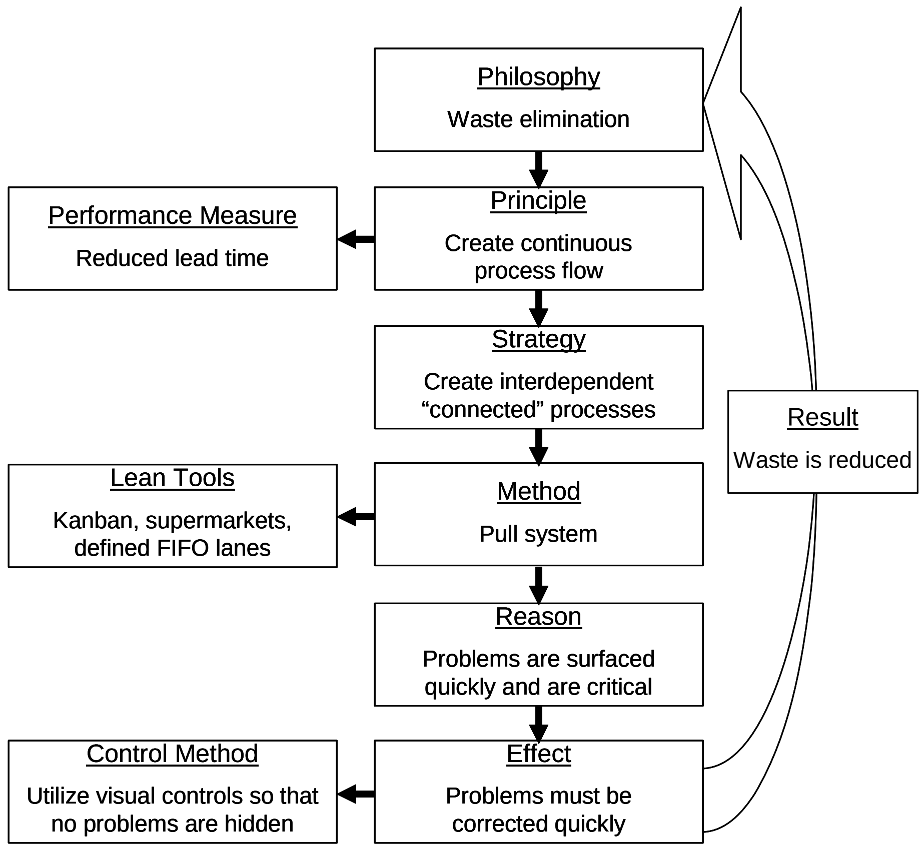


Figure 1.6 – Waste Reduction Model (Liker and Meier, 2006)

Moving forward with Research:

This chapter has introduced the research objective and research methods. It also provided a background concerning both remanufacturing and lean manufacturing. Chapter two examines the technical methods of lean production within the remanufacturing context.

CHAPTER 2

LEAN REMANUFACTURING: ADAPTING LEAN TOOLS AND TECHNIQUES TO THE REMANUFACTURING CONTEXT

INTRODUCTION

Remanufacturing, the process of restoring used material goods to like-new condition, is a $53 Billion annual industry in the United States. Remanufacturing has been lauded as "the next great opportunity for boosting U.S. productivity" (Giuntini and Gaudette, 2003) and "the ultimate form of recycling" (EPA, 1997) as it creates multiple iterations of the product lifecycle. Yet, remanufacturing, an industrial product-service hybrid, has remained largely untouched by technology, productivity, and quality advances of the last thirty-years. In that time, computer integrated manufacturing (CIM), lean manufacturing, advanced mass production, and other techniques have significantly advanced original equipment manufacturing (OEM) strategies, structure, and technology. (Lund, 1996)

Lean manufacturing, the principles, practices, and philosophies based on the real-life model of the Toyota Production System (TPS), has been benchmarked worldwide for the production efficiencies it creates through empowering workers to eliminate wasted time, material, and other resources; all towards the goal of reducing lead time from customer order to product delivery. (Liker, 2004) The creators of the term “lean” estimate dramatic improvements of lean manufacturing over traditional mass production to roughly ½ the human effort in the factory, ½ the manufacturing space, ½ the tool investment, ½ the engineering hours, and ½ the time to develop new products as compared with non-lean competitors (Womack and Jones, 1990). The benefits of lean production have not been limited to the automotive industry. Lean has spurred improved efficiency and growth across many diverse industries; including job shop manufacturing, service organizations, supply chain management, home construction, and government agencies. (Liker, 2002, 2004, 2008; Womack and Jones, 1996).

Yet, lean remanufacturing, the marriage of lifecycle efficiency and production process efficiency, has remained a largely untapped opportunity. The remanufacturing process (which fundamentally consists of product teardown, product evaluation, component repair and replacement, assembly, and test) presents many unique processing challenges compared to an original equipment manufacturing process. (Lund, 1984) A traditional manufacturing process often is highly repetitive, allowing for a reduction in process variability through precise specification of standardized work, sequencing, process times, and work in process, all supporting a required takt (demand pace) time. In manufacturing, variability is most commonly a result of internal processing, while in remanufacturing variability is naturally inherent as a function of the incoming component condition such as age, environment, usage, and regular maintenance. In a sense, a remanufactured component is like an engineered-to-order product with different specifications and unique work content for each unit of production. The inherent differences of each unit complicate the application of lean manufacturing tools and techniques to remanufacturing.

This chapter examines the challenges, opportunities, and methods, for successful application of lean production tools and techniques within the remanufacturing context. This is done through a combination of adapting theories of technical system design and of real-world case studies in which lean methods were implemented in a remanufacturing context. Lean production is commonly recognized as being socio-technical in nature, in that successful deployment of tools and techniques must be both socially (cultural) and technically (process) oriented. Later chapters of this dissertation focus on the application of lean as a socio-technical system to remanufacturing. This chapter sets the stage by focusing primarily on the technical challenges of developing lean solutions in a remanufacturing context.

The introductory chapter of this dissertation discussed some of the fundamental differences between remanufacturing and manufacturing. This chapter builds upon this discussion to focus more closely on differences that may effect application of lean methods. This chapter goes further, utilizing the organizational design contingency theories, adapted from classic manufacturing, to describe (and ultimately prescribe) appropriate utilization of lean methods in a variety of remanufacturing contexts. The popular organizational design contingency model of the product-process matrix (PPM) (Hayes and Wheelwright, 1979a) is used to bridge the gap between the manufacturing theory and remanufacturing context.

Using this model, four unique contexts of remanufacturing are identified, a function of product variability (volume, standardization, dependability of condition), ranging from high to low. Case studies of lean remanufacturing application in each of these four contexts are examined to better understand the successful application of lean methods. The cases demonstrate ways lean methods must be tailored to each unique context. The result is an understanding of lean methods as applied across the spectrum of high-product variability to low-product variability remanufacturing. In the case of high-product variability remanufacturing, lean methods are applied to create greater efficiency and flexibility. In low-product variability remanufacturing, lean methods are applied to create greater efficiency and specialization. Ultimately, this paper increases knowledge and understanding of the successful application of lean methods to remanufacturing.

INTRODUCTION TO LEAN REMANUFACTURING

In 2002, the researcher for this paper arrived at a large naval ship remanufacturing facility to work as a lean manufacturing change agent. The researcher was equipped with lean manufacturing tools such as takt time calculations, strategies for implementing andon systems on an assembly line, methods for sizing kanban systems, and methods to reconfigure production lines to eliminate unnecessary travel and transportation. Yet, the observed processes did not match the context in which Toyota employed these tools. In fact, there were many within the remanufacturing facility who were convinced lean production did not apply in their industry, after all, they were not Toyota! It was quickly evident a tremendous gap existed between the application of lean tools and techniques to the manufacture of an automobile every 56-seconds and the 18-month remanufacture of a $2 billion naval vessel

Defining Waste in Remanufacturing:

The Toyota Production System has been benchmarked worldwide for its overall efficiency and continuous drive to produce "waste free." Toyota identified seven forms of waste (overproduction, waiting, unnecessary transport, overprocessing, excess inventory, unnecessary movement, defects) with an eighth added later (unused employee creativity), that are arguably present in any manufacturing process. (Liker, 2004) Yet, if being a "lean producer" fundamentally means to produce with little or no wasted time, material or other resources; do the same wastes exist in remanufacturing? In this discussion we question commonly held beliefs on "waste" in remanufacturing and highlight common examples of waste that must be considered.

Value, in contrast to waste, has been defined as "anything the customer is willing to pay for." A second common definition is "any process that transforms the form, fit, or function of a customer-desired product." Yet, in remanufacturing, much of the initial work (component and system disassembly) effectively decreases the value of the existing product. For example, a motor which can be "patched up" with little expenditure of resources has greater intrinsic value than that same motor which has been disassembled for remanufacture. How can a process be considered value-added if it reduces overall value of the existing product? Do processes of component teardown, component evaluation, and component test fit the definition of value add? Consider the component remanufacturing process illustrated in Figure 2.1. These processes require significant expenditure of resources for a remanufacturing agency, yet component teardown does effectively reduce the value inherent in a damaged/worn product. It is hard to argue these key processes add value to the end user. It seems repair of worn parts, acquisition of replacement parts, and component re-assembly are the only true value-added function performed in a remanufacturing process.

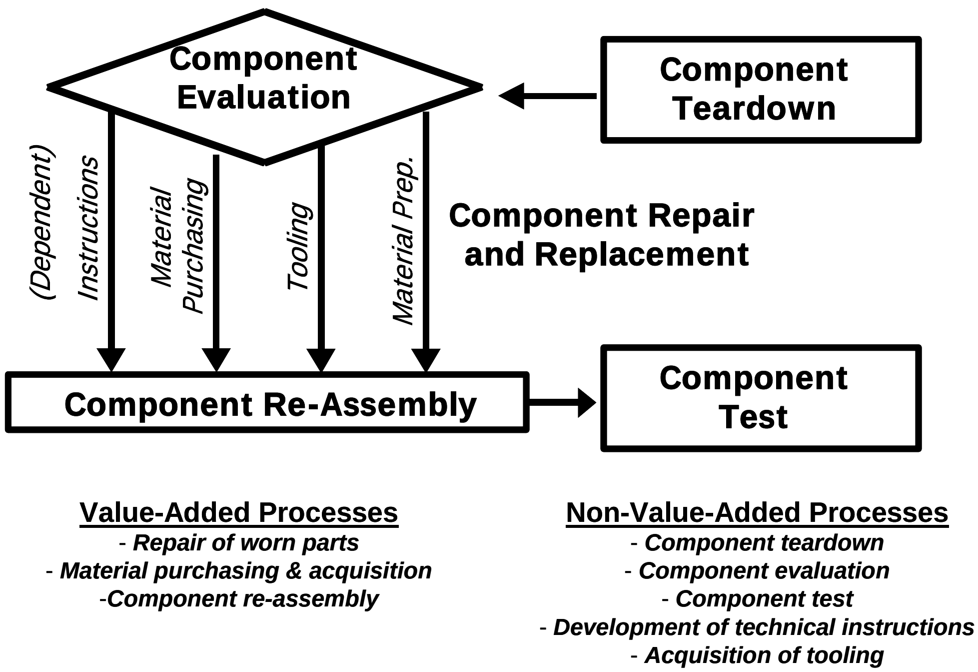


Figure 2.1 – Value and Non-Value in Component Remanufacturing

This is not to say component teardown, evaluation, and test can be eliminated as simply waste. Despite the fact they do change the "form, fit, or function" of the component these steps are clearly not value added, but are still required in remanufacturing. Toyota uses terminology of "non-value added work" for such items as logistics support and test;

processes which do not add value from the customer’s perspective, but are required to consistently deliver a quality product.

Some may debate value-add/non-value add while others may argue this discussion is simply semantics as the process is “required.” Yet, it is important when considering a lean producer would strive to eliminate non-value added activities altogether, while emphasizing the streamlining of value-added processes. Component evaluation or component test may be conducted with too much rigor for products that do not need to be evaluated or tested. Great care may be taken in disassembling components that will simply be discarded.

The remanufacturing context requires reconsideration of commonly held paradigms of value and non-value. Consistent with the definition of non-value added work, many resources are expended in remanufacturing (perhaps a higher percentage than in original equipment manufacturing) that transform the product, but do not ultimately add value to the final customer. While remanufacturing is appropriately lauded for its efficiency and effectiveness in creating lifecycle value, this inherent inefficiency (waste) in processing must be considered.

When waste is considered at a more tangible production-level of remanufacturing processes, the concept of waste is clearer. Figure 2.2 identifies common examples for each of the eight wastes as observed in remanufacturing processes.

	Common Examples of Waste in Remanufacturing
Overproduction	- Processing materials and components before the required time. - Processing components that ultimately can not be remanufactured. - Remanufactured components becoming obsolete.
Waiting	- Last-out first-in disassembly to re-assembly cycle leaves components idle. - Difficulty in aligning all resources (production, logistics, engineering, lifting & handling, other support) at the work site.
Unnecessary Transport	- Geometric complexities of disassembling large and complex systems with components being worked in smaller machine shop environments. - Large industrial footprint of most remanufacturing organizations
Overprocessing	- Tendency to error on the side of conservatism is hand-processed remanufactured materials and components. - Complex and interrelated customer/supplier relationships.
Excess Inventory	- A "bow wave" of materials and components is created as products are torn apart very quickly, only to be repaired and re-assembled more slowly. - Supply system must support a variety of condition/processing contingencies.
Unnecessary Movement	- Large industrial footprint of most remanufacturing organizations. - Difficulty in aligning all resources (production, logistics, engineering, lifting & handling, other support) at the work site.
Defects	- Overly-aggressive, overly-optimistic, or overly creative strategy for materials and components; resulting in: incorrect assessment of condition or incorrect processing of component.
Unused Employee Creativity	- Many remanufacturing tasks are non-repetitive and more difficult to incorporate employee ideas into future processing.

Figure 2.2 – Common Examples of Waste in Remanufacturing

In manufacturing, <u>overproduction</u> is considered the most significant form of waste because of the multiplying effect it has to create other wastes. (Monden, 1998) The remanufacturing context is no different. In remanufacturing, overproduction commonly occurs in the disassembly of components before the (internal) customer is ready to receive them. Component disassembly is a low-variability process with short cycle time (as compared to repair and re-assembly) that uncovers component condition (significant source of production variability). Many remanufacturing organizations will disassemble a product as quickly as possible to determine condition, creating a glut, or "bow wave" of components and materials for remanufacture; making it the most significant form of waste in remanufacturing. An additional form of overproduction can occur when a product is remanufactured for use at a later date. Often, an older component may be remanufactured, only to become obsolete while sitting on the shelf.

Waiting frequently occurs as a result of production sequencing in remanufacturing. Similar to peeling back an onion, a large subsystem must be disassembled in layers, with the last component being removed often being the first component involved in re-assembly. This results in a last-out first-in sequencing results in waiting as significant material assets wait to be remanufactured. Waiting additionally occurs in remanufacturing due to the overall complexities in major system remanufacturing. Many components for remanufacture will cross multiple system and geographic zones of a major system at the same time. This results in significant complexities associated with all resources (production, logistics, engineering, lifting & handling, other support) required to complete a task.

For a major remanufacturing project, all components and materials will originate at a single location with disassembly of the product core. Then the components are likely to be taken to more controlled industrial locations for repair and processing. This will often result in unnecessary transport as components radiate out from the core and are then returned for re-assembly. Additionally, due to the major infrastructure requirements for large-scale remanufacturing, many remanufacturing facilities have a large geographic footprint, which exacerbates the transportation issue. Also, like many industrial organizations, many remanufacturing sites have evolved according to functional departments, creating physical and informational barriers to product-flow. In many observed remanufacturing processes such as paint, sandblast, engineering, and test are functionally located away from the flow of production.

Excess inventory is often the direct result of product and process variability, as well as the overproduction occurring in early disassembly. In most instances of remanufacturing, the condition of a product (and required repairs, materials, and components) is not known until the core is fully disassembled and assessed. In some instances, a long lead time may be associated with certain material items, if they can be purchased at all. As a strategic buffer against this product variability, many remanufacturing organizations will maintain significant levels of contingent repair material. In many instances this material will become obsolete or damaged over time and never used. This is not to suggest that all contingent repair material is excess inventory and should be disposed of, but that the remanufacturing agency must continually examine and refresh their inventory strategies.

Unnecessary movement, is rampant if one follows the mechanics around. They are the value-added workers in remanufacture. They spend a good deal of their time leaving the site of the actual value-added work to go and fetch things—tools, cleaning supplies, parts, and so on.

Defects can occur in remanufacturing as a result of incorrect condition assessment or improper processing. Much of the work done in remanufacturing is completed by hand, providing significant opportunity for variation that leads to defects. Whereas a component is particularly badly worn or damaged and a replacement does not exist, remanufacturing engineers may be overly aggressive in developing a repair or remediation strategy for a component that simply is beyond salvage through remanufacturing. This may be an extreme example, but has occurred many times for non-critical components.

Overprocessing, doing more work than is required, is also a significant form of waste in remanufacturing that is directly related to the waste of defects. Many large products for remanufacture, such as transportation equipment and military equipment, have extremely high-costs of failure while in use. As a result, many remanufacturing organizations tend towards extremely high degrees of technical oversight and low degrees of risk in processing of critical components, resulting in overly conservative product assessments and high processing requirements. Merely the prospect of process defects can ultimately create significant waste through redundancy of processes.

Finally, unused employee creativity exists in remanufacturing just as it does in any other industry. What is unique about remanufacturing is the infrequency of some operations. Repetitive processing provides more cycles for continuous improvement. If a process is only performed a few times a year, improvement initiatives may not be developed or the business case for their development may not exist. A bigger problem is that, like many other traditional organizations, the gap between top management and the worker is so large that worker ideas often simply get lost and never implemented.

The majority of these examples of waste are not remanufacturing specific. To a degree the objective of this discussion is recognizing the many parallels in manufacturing and remanufacturing processing. Yet, each explanation highlighted some unique aspects that are specific to the remanufacturing context.

A CONTINGENCY THEORY APPROACH TO UNDERSTANDING LEAN IN A REMANUFACTURING CONTEXT

"Lean production won't work in overhaul and repair, we don't build cars!"

This was a popular sentiment within the remanufacturing industry; many were convinced the Toyota Production System had no business in an overhaul and repair environment. Yet, to dig deeper into this question one must begin to understand the intersection of production theories relating lean manufacturing and remanufacturing. The discussion thus far has mostly emphasized differences to be considered when applying lean techniques to remanufacturing, yet, many remanufacturing processes are similar to original equipment manufacturing. To understand the similarities with manufacturing, it is necessary to first differentiate and define the unique contexts within remanufacturing.

Contingency theories of organizational design suggest an organization must first determine its core technical production processes and then relate this to the appropriate (contingent) organizational design. Contingency theory will be used to analyze the need for an appropriate "fit" between the process environment (e.g. remanufacturing) and the application of specific technical tools (e.g. lean production). This discussion uses the popular organizational design contingency model of the product-process matrix (Hayes and Wheelwright, 1979a) to provide a theoretical foundation for comparing traditional manufacturing methods, lean production, and the remanufacturing context.

Historical Perspective on Organizational Design Theory:

Many prescriptive models exist for design of organizations, organizational infrastructure, process layout, and technology selection in manufacturing operations. During the early-half of the twentieth century, many of these prescriptive models were built upon what was considered "universal principles of management." These theories promoted a one-best-way of organizational design based upon thinking of Adam Smith (division of labor), Frederick Taylor (scientific management), and Henry Ford (moving assembly line). By using these concepts, organizations were able to achieve never-before-seen levels of output and efficiency, which contributed significantly to rapid increase in the standard of living in industrialized nations. These theories are summarized best in the philosophy of scientific management; suggesting that individual jobs as well as the supporting management environment can be set up in "one best way" to maximize productivity. Over time it became clear these principles were ideal for a large organization operating within a very stable market, such as the automotive market and iron mining in the early 20th century (inspiration for philosophies of Henry Ford and Frederick Taylor, respectively), but may be mismatched in other industries. These universal management theories eventually gave way to contingency theories of organization.

Contingency theory suggests the ideal structure for an organization will vary according to the external environment of the firm and its technical core, and that an organizations structural design should "fit" with key operational and environmental parameters. Contingency theory had its origins with a 1950s study of British manufacturing firms by industrial sociologist Joan Woodward. At a time when one-best-way thinking was popular, Woodward (1965) identified a correlation between the "best" organizational design and the complexity of technology used in production within successful companies. This study identified three dominant organizational structures based on the utilized technology of unit production (small batches, customized products), mass production (standardized, large volume), and continuous process (continuous, automated) production. Each of these organizations was characterized by structural dimensions including: number of management levels, supervisor span of control, labor ratios, formalized procedures, centralization, and overall structure.

Woodward's (1965) contingency theory of organizational design was later enhanced by the work of Robert Hayes and Steven Wheelwright in the 1970s. Hayes and Wheelwright (1979b) recognized a relationship between the maturation of a product in the marketplace and the maturation of the process technology to be used in manufacture, effectively adding the product dimension to Woodward's theory. This model is known as the product-process matrix (PPM), a leading framework in contingency theory of organizational design. It will be the focus of discussion.

Economic/Efficiency Influence on Organizational Design Theory:

The theoretical foundation for the theories of Taylor and Ford, as well as Woodward, Hayes, and Wheelwright, is the economic theory known as <u>economies of scale</u>. This theory suggests the greatest level of cost efficiency exists with the largest level of output, where fixed costs of production are distributed over the largest number of production units. This paradigm suggests that to remain efficient a fundamental trade-off must exist between operational flexibility and efficiency. (Daft, 1978)

In a post-World War II Japanese economy, Toyota did not have the luxury of operating in the paradigm of economies of scale. As compared to their North American competitors, their markets were small and diverse. Toyota recognized that in order to survive they must offer quality cars at a competitive price to their larger overseas competitors, in relatively low-volume and high-variety production. (Ohno, 1978) Toyota was one of the first major manufacturers worldwide to achieve benefits from an economic model now termed <u>economies of scope</u>. This theory suggests that organizational efficiency can be gained through increasing the breadth of product options and capability, rather than size of markets and volume of production.

Toyota had developed a production methodology by which they were able to have both efficient production, and flexibility associated with small lot, customized products. Lean manufacturing was first introduced to a wide audience in <u>The Machine that Changed the World</u> (Womack and Jones, 1990). This study highlighted the efficiency and effectiveness of the Toyota Production System and presented a new paradigm of production, one in which both customization and efficiency could be achieved, without tradeoffs and without complex automation. As Toyota grew to the high-volume producer (they are today number-one in automotive sales), they never abandoned the original production philosophy that made them successful when operating in a low-volume environment. Toyota's efficiency, which is based in economies of scope, is not clearly understood through popular contingency theories, which are based in economies of scale.

CONTINGENCY ANALYSIS OF THE LEAN PARADIGM

Contingency theorists recognize that an organizational design must "fit" within its operating environment. Woodward (1965) further suggests an organization must first determine its core technical processes, then design the organization and social system to support the technical core. Organizational design contingency models are used to link production technique and the appropriate organizational application. Similarly, the contingency model of the product-process matrix will be used to link manufacturing and remanufacturing contexts for lean production.

Contingency Analysis: Product-Process Matrix:

The product-process matrix, first published in 1979, considered the appropriate fit of organizational design relative to the characteristics of maturity of product being produced, maturity of process used in production, maturity of the market, and maturity of core technologies used. The PPM, shown in Figure 2.3, specifically identified that new products to market are generally produced in low volume and should use technologies characteristic of a job shop environment; slightly more mature products suggest larger volume and should utilize technologies characteristic of an assembly line with connected line flow; and mature products will be produced as high-volume standardized products which should utilize technologies supporting continuous flow.

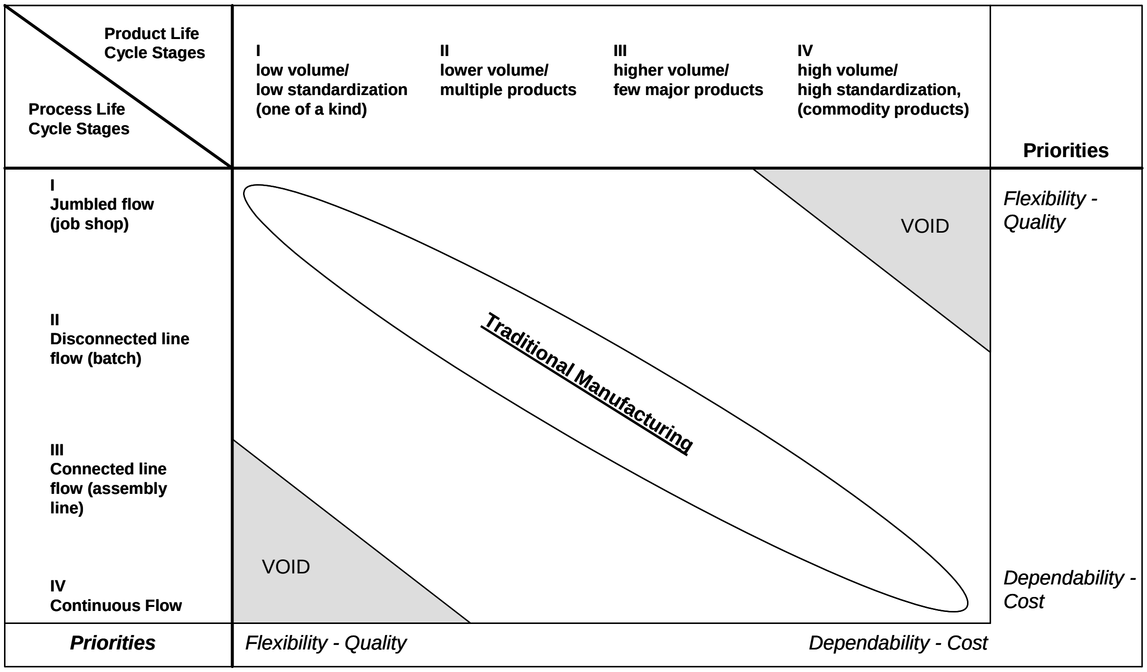


Figure 2.3 – Product-Process Matrix (Hayes & Wheelwright, 1979a)

The model proposed that trade-offs must occur between product and process characteristics. Efficient production could only occur within the diagonal axis of the PPM. Hayes and Wheelwright suggested organizations operating off the diagonal are less efficient, and would ultimately migrate to the diagonal in order to survive. As noted in the PPM model, processes can not exist in the corners of this matrix (continuous flow of customized parts or jumbled process flow of commodity goods) due to the misalignment of discrete and non-discrete manufacturing.

The major contribution of the PPM was to suggest a second dimension, product-life cycle, to Woodward's contingency model of process technology. The PPM is grounded in economies of scale thinking, and highlights the perceived trade-off between flexibility and efficiency. This theory, along with Woodward's work, was significant at a time when organizations in nearly every industry were searching for mass markets and a mass production/assembly line approach to greater performance.

Remanufacturing and the Product-Process Matrix:

The remanufacturing industry can be placed within the product-process matrix; however, the industry as a whole is largely considered technically immature and would not exist on the diagonal of efficiency. Technical challenges associated with disassembling, analyzing, restoring, and re-assembling existing components have led to what is considered an over-reliance on hand tools, rudimentary diagnostic equipment, and generic machining capabilities within the remanufacturing industry. (Lund, 1996) Due in large part to these issues, the industry has been unable to fully capitalize on productivity improvements associated with advanced technology. Relative to the PPM, this would place remanufacturing generally above the diagonal of efficiency, as shown in Figure 2.4, suggesting immature selections of technology for the work conducted. This is consistent with observed remanufacturing organizations in which piece part production and a job-shop mentality are prevalent.

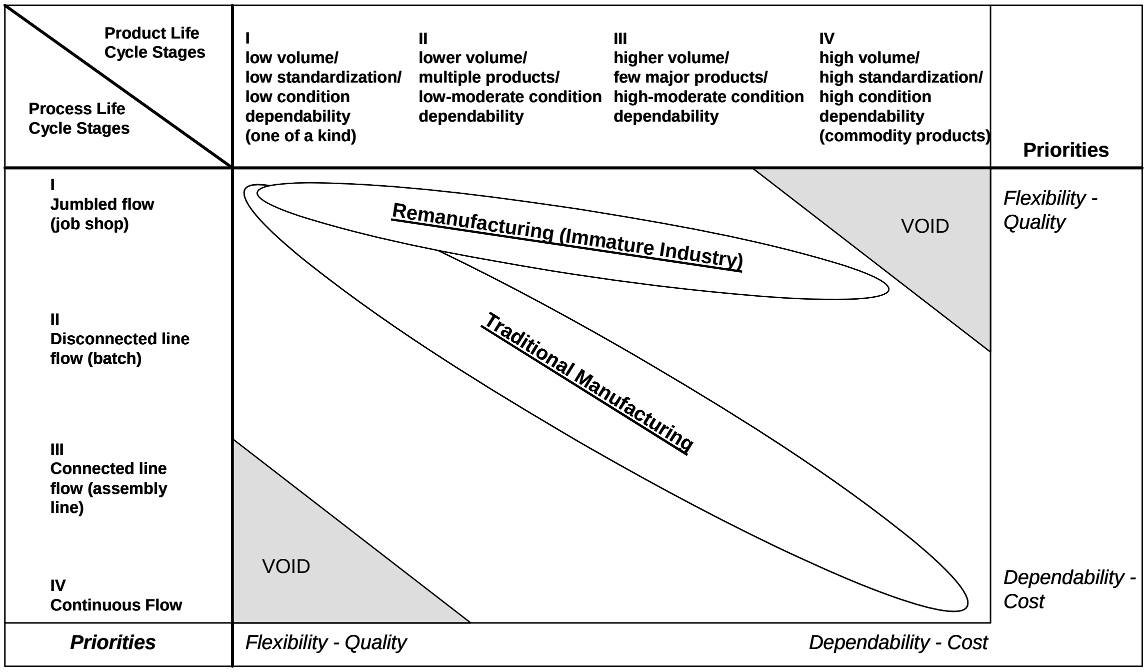


Figure 2.4 – Remanufacturing, an Immature Industry on the PPM

According to Hayes and Wheelwright, the placement of the remanufacturing industry above the diagonal would suggest an opportunity exists to improve remanufacturing through technology and production realignment. However, technical process challenges of the remanufacturing industry, as previously discussed, must first be overcome in order for this to be accomplished.

Lean Manufacturing and the Product-Process Matrix:

As previously mentioned, the PPM as prescribed by Hayes and Wheelwright, with a requirement operate on the diagonal for efficiency, and the assumed need for trade-offs between flexibility and efficiency does not align with the economies of scope efficiency paradigm of lean manufacturing. Furthermore, today’s environment of point-and-click design of laptops and customized clothing at low costs suggests other technologies such as computer integrated manufacturing and flexible manufacturing are similarly challenging these paradigms. In their 2004 updated commentary on the PPM, Hayes and Wheelwright acknowledged the model does not effectively resolve technical design considerations associated with lean production. As stated by the authors, "Many Japanese factories appeared to surpass their American counterparts on several competitive dimensions – lower cost, higher quality, greater flexibility, and faster production introductions – all at the same time!" (Hayes and Wheelwright, 2004) The resultant of lean manufacturing: with smaller batch production, emphasis on quick changeover, just-in-time production, and discipline to standardized work, is a production system which would serve to shift a production process along the dimension of process maturity, developing both flexibility and efficiency to create a new operations efficiency frontier, shown below in Figure 2.5.

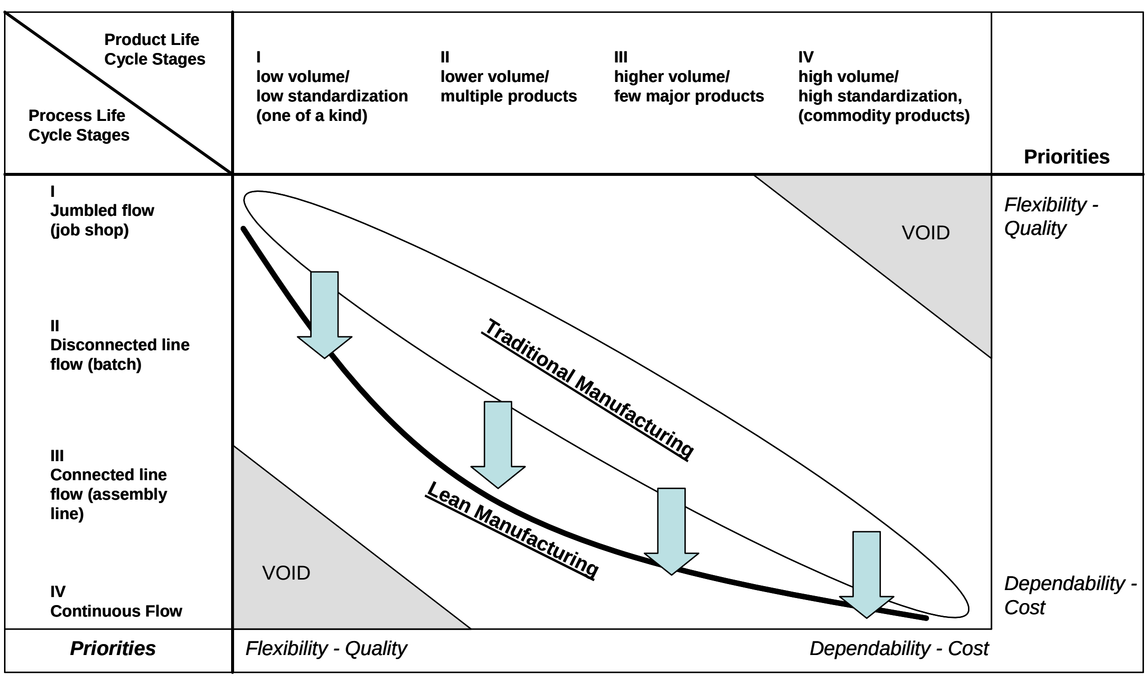


Figure 2.5 – New PPM Efficiency Frontier created by Lean

Lean Remanufacturing and the Product-Process Matrix:

In the manufacturing context, implementation of lean methods serves to move the process downwards in the PPM space. Yet, can the same impact be anticipated in the remanufacturing context? Is seems the answer should be yes. Remanufacturing is an industry that is managed according to a mass production paradigm and most often exists above the PPM diagonal due to relative process immaturity, as already discussed. Theoretically, the application of lean methods in remanufacturing would have a similar effect as in original manufacturing, that of moving the process downward in the PPM space. The result could easily be a new remanufacturing efficiency curve similar to the one originally proposed by Hayes and Wheelwright, shown in Figure 2.6. Advanced applications of lean remanufacturing could possibly exceed the diagonal of efficiency to establish a remanufacturing efficiency curve similar to the one described for lean manufacturing.

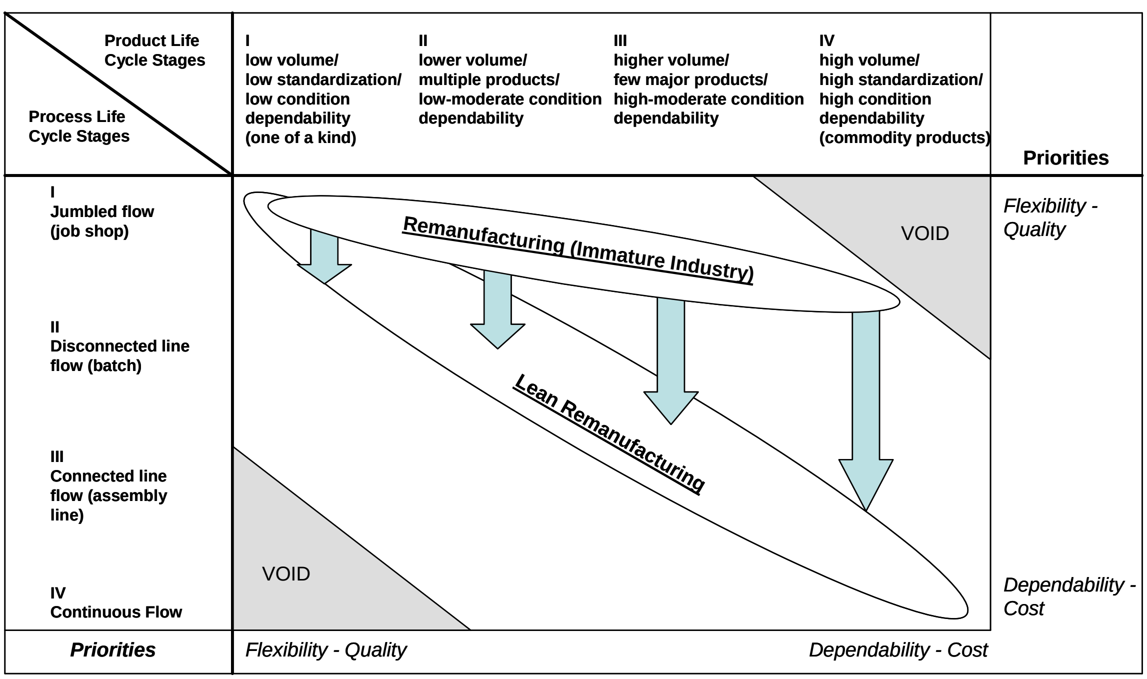


Figure 2.6 – Lean Remanufacturing and the PPM

However, lean production does not simply exist as a switch that can be turned on, a consulting firm which can be hired, or a piece of equipment that can be purchased. A snapshot of remanufacturing organizations today would see an immature industry predominately organized according to jumbled flow and a classic job shop mentality. As previously discussed, much of remanufacturing operates with an engineer-to-order mindset. This theoretical discussion suggests that remanufacturing should move downward in the PPM space so that one-of-a-kind parts are produced in an advanced job shop environment; low-volume, standard parts are produced with disconnected line flow; higher-volume non-standard parts are produced with connected line flow; and high-volume/high-standardization parts are produced with continuous flow. However, this theoretical discussion is irrelevant unless lean methods are effectively applied in the remanufacturing context.

To transition the discussion from theory to application a better understanding of diversity within remanufacturing context is necessary. In the same way it is inappropriate to compare the manufacture of widgets to that of a large complex system, it is similarly inappropriate to compare the remanufacture of such components. It would also seem inappropriate to assume lean methods are not impacted by the specific component remanufacture to which they are applied, whether a widget or large complex system. The PPM is used once again to characterize the remanufacturing environment.

The product life cycle dimension (product variability) is the dominant dimension that is used to characterize the remanufacturing industry. Product variability is a function of product volume (demand), standardization (variety of demand), and in the remanufacturing context, dependability of incoming condition (product remanufacture scope of work). Utilizing the PPM, this would prescribe four groupings of remanufacturing processes; those of high-product variability (Type I), high-moderate product variability (Type II), low-moderate product variability (Type III), and low-product variability (Type IV), as shown in Figure 2.7.

Product Life Cycle Stages (independent variable) **Process Life Cycle Stages (dependent variable)**	**I** **low volume/ low standardization/ low condition dependability (one of a kind)**	**II** **lower volume/ multiple products/ low-moderate condition dependability**	**III** **higher volume/ few major products/ high-moderate condition dependability**	**IV** **high volume/ high standardization/ high condition dependability (commodity products)**
I **Jumbled flow (job shop)** **II** **Disconnected line flow (batch)** **III** **Connected line flow (assembly line)** **IV** **Continuous Flow**	<u>TYPE I</u> <u>REMANUFACTURING</u> <u>high</u> product variability remanufacturing context	<u>TYPE II</u> <u>REMANUFACTURING</u> <u>high-moderate</u> product variability remanufacturing context	<u>TYPE III</u> <u>REMANUFACTURING</u> <u>low-moderate</u> product variability remanufacturing context	<u>TYPE IV</u> <u>REMANUFACTURING</u> <u>low</u> product variability remanufacturing context

Figure 2.7 – Characterization of the Remanufacturing Context

To prescribe the appropriate application of lean methods in remanufacturing, the four remanufacturing contexts of Type I to Type IV will be considered. This is the methodology by which lean remanufacturing of widgets (Type IV remanufacturing) is differentiated from lean remanufacturing of large complex system (Type I remanufacturing). A parallel structure of four unique methodologies of lean remanufacturing are defined; those of high-product variability lean remanufacturing (Type I), high-moderate product variability lean remanufacturing (Type II), low-moderate product variability lean remanufacturing (Type III), and low-product variability lean remanufacturing (Type IV), as shown in Figure 2.8. In each instance the process dimension is dependent upon the application of lean tools and techniques. The appropriate application of lean tools and techniques in the four remanufacturing contexts is developed in a contingency discussion of Type I to Type IV lean methods in remanufacturing.

Product Life Cycle Stages (independent variable) / **Process Life Cycle Stages (dependent variable)**	**I** **low volume/** **low standardization/** **low condition dependability** **(one of a kind)**	**II** **lower volume/** **multiple products/** **low-moderate condition dependability**	**III** **higher volume/** **few major products/** **high-moderate condition dependability**	**IV** **high volume/** **high standardization/** **high condition dependability** **(commodity products)**
Appropriate application of Lean Methods **(yet to be determined)**	TYPE I LEAN REMANUFACTURING METHODS lean production in a high product variability remanufacturing context	TYPE II LEAN REMANUFACTURING METHODS lean production in a high-moderate product variability remanufacturing context	TYPE III LEAN REMANUFACTURING METHODS lean production in a moderate-low product variability remanufacturing context	TYPE IV LEAN REMANUFACTURING METHODS lean production in a low product variability remanufacturing context

Figure 2.8 – Lean Methods in the Remanufacturing Context

"Toyota House" as Framework for Lean Remanufacturing:

The Toyota Production System is built upon the fundamental principles of developing internal process stability (standard work instructions, work cells, visual management, developing process capability), just-in-time production (process and information flow, pull systems, production leveling, set-up reduction, work-in-process controls), and built-in-quality (error-proofing process and paperwork, andon systems, and teamwork), with a lifeblood of empowered employees conducting kaizen (continuous improvement); all intent upon achieving the shortest lead time from customer order to product delivery. (Monden, 1998) These concepts are illustrated in the "Toyota House", shown below as Figure 2.9.

To describe the technical application of lean methods in remanufacturing, particular emphasis will be placed on the three key structural elements of TPS: building internal process stability (foundation), just-in-time production (pillar), and built-in-quality (pillar).

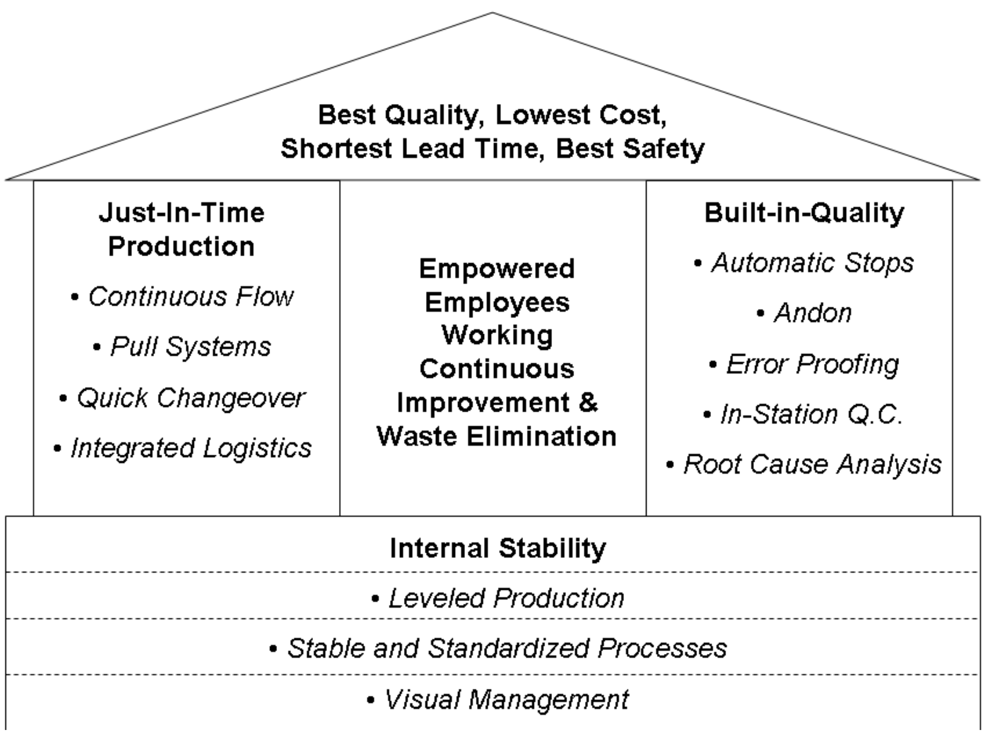


Figure 2.9 – The Toyota Production System "House" (Monden, 1998)

Contextual Challenges: High and Low Product Variability Remanufacturing:

The fundamental challenge of producing in a high-product variability remanufacturing process is that every component may be unique; with unique technical and resource (material, tooling, and manpower) requirements. The greater the product variability in remanufacturing, the greater the system requirements for flexibility in responding to production needs. However, the challenge in applying lean methods in this context is to increase processing flexibility (traditionally by increasing production buffers) while maintaining efficient use of resources. In this context a high-variability model of lean methods must be applied.

In a low-product variability remanufacturing process the fundamental challenge is nearly reversed, as production processes are highly stable (similar to original equipment manufacturing), yet must be designed (buffered) to process the occasional instability. As observed in many remanufacturing examples, a low-product variability process can ultimately migrate to the point it is designed to handle the exception in production, rather than the norm, and therefore every component is considered uniquely and efficiencies of standardization are lost. In this context a low-variability model of lean methods must be applied.

Internal Process Stability in High and Low Product Variability Remanufacturing:

For the foundation of the Toyota House to build internal process stability a high-variability lean design must create flexibility of resources and control variation where possible, in order to bring stability to a highly variable process. The application of work cells and standard work in this environment would help place boundaries upon sources of high variability. Standard work instructions would not be overly detailed, but would provide process flexibility so that a highly trained, non-specialized workforce could use a high-degree of expertise to complete complex repairs. To sustain throughput at a high level of process variability, strategically placed resource buffers (tooling, material, manpower) must be used to maintain stability in processing. Visual management would be used to indicate irregularities in processing, but also as a key communication device with external support groups.

In a low-product variability remanufacturing context, lean methods would be utilized to increase overall standardization and efficiency of production processes. In this context a low-variability lean design would utilize highly-specific standard work instructions and tightly coupled work cells with minimal resource buffers. Workplace layout, tool and material presentation would all be highly standard through utilization of point-of-use applications, kitting, and pull systems; with contingencies developed for the occasional process irregularity. In this context, visual management would be utilized in a highly mature way to not only identify irregularities, but to assist in preventing them.

Just-In-Time Production in High and Low Product Variability Remanufacturing:

In a high-product variability remanufacturing context, just-in-time production is required to support the high degree of flexibility required in resource management and allocation. The concepts of pull systems and control of work-in-process would be applied to every type of resource, so as to better manage breadth (create flexibility) while maintaining minimum required levels (create efficiency). Production leveling would be used to better control peaks and valleys in resource and process utilization, while set-up reduction is used to reduce overall resource requirements.

In a low-product variability remanufacturing context, just-in-time production is created to support the near continuous flow of components. Lean methods are applied to create a high degree of efficiency and specialization through co-location of equipment, continuous production flow, as well as machining fixtures and material handling systems to reduce machine set-ups and set-up times. Work-in-process is tightly controlled in this context, coupled with first-in first-out flow, as it can be used as a mechanism to pressurize the production system and drive towards a higher degree of continuous process production.

Built-In-Quality in High and Low Product Variability Remanufacturing:

In a high-product variability remanufacturing context, built-in-quality is used to reduce process variation, and in particular, reduce variation in the support-process response to process variability. A tightly coupled technical support team and rapid response andon are keys to achieving high-output and containing variability in this context. Simplified production processes and instructions, along with error-proofing devices are used to reduce variability in this context.

In a low-product variability remanufacturing context, the tools of built-in-quality are used with a great deal of specificity and specialization to simplify and error-proof production processes. An andon system is important in this context to respond when irregularities occur, and andon calls will be used as indicators of problems to support continuous improvement. (Toyota uses andon in a low variability environment and finds it critical)

Lean methods applied in a high-product variability context increase process flexibility and efficiency, grounded in the economies of scope paradigm. On the other hand, in the low-product variability context, lean methods increase process flow and efficiency through an emphasis on standardization, grounded in the economies of scale paradigm.

RESEARCH METHODS

The objective of this study is to better understand the appropriate technical design and application of lean manufacturing tools and techniques in the remanufacturing context, an industry with promising environmental and economic growth opportunities. This paper is the culmination of six years of in-depth field research within the naval ship repair industry. During this time, the large shipyard organization advanced a widespread initiative to deploy techniques of lean production across a broad base of remanufacturing depots. The researcher was hired as an employee and had the opportunity to gain intimate knowledge of lean remanufacturing efforts within six repair depots (totaling $5B annual business; products ranging from helicopters to transport jets, small turbines to large tanker ships), as well as a cursory knowledge of ten additional public and private remanufacturing depots. The researcher was considered an internal expert with the organization on lean production designs within the remanufacturing context, and was able to advance personal and organizational understanding through participant observation.

This paper utilizes the organizational design contingency model of the product-process matrix to develop a theoretical linkage between manufacturing process design theory and remanufacturing application. Utilizing this theory, four unique contexts of remanufacturing are identified and models for application of lean methods in the extreme cases of high and low product variability remanufacturing are developed. Four illustrative case studies of lean remanufacturing are examined in detail, one for each identified context of remanufacturing. In each case study, the Toyota Production System foundational elements of developing internal process stability, just-in-time production, and built-in-quality are examined through a detailed look at the application of 13 key lean production tools and techniques. Research methods are summarized below in Figure 2.10.

	Research Methodology
Study Objectives:	*To better understand the appropriate technical design and application of lean manufacturing tools and techniques in the remanufacturing context.*
Unit of Analysis:	*Industrial processing of individual products for remanufacture, ranging from single components to integrated systems.*
Study Design:	*Comparative case study of lean remanufacturing in four unique contexts of remanufacturing. A theoretical model of lean methods in extreme remanufacturing cases is developed and assessed.*
Cases to be Studied:	*A wide selection (applications, successes, methodologies) of lean remanufacturing case studies were examined; four illustrative cases were are highlighted for discussion.*
Data Sources:	*Technical Assessment, Direct Observation, Interviews with Key Personnel, Review of Documentation and Reporting, Participant Observation*

Figure 2.10 – Research Methodology

The unit of analysis for each of the four case studies is the industrial processing of an individual product for remanufacture, ranging from single components to integrated systems. The cases varied in applications, successes, and methodologies, but each of the numerous cases would fit appropriately into the theoretical design framework of Type I (high-product variability) to Type IV (low-product variability) remanufacturing. The four illustrative case studies highlighted in this paper were selected because each fit within a unique context of remanufacturing and was a strong illustrative model for the appropriate lean methods (Type I lean remanufacturing methods to Type IV lean remanufacturing methods).

Data sources for each case included technical assessments, direct observation by the researcher, internal reports on lean production, participant observation, and interviews with key deployment personnel. Interviews were conducted to gain understanding of the technical nuances of lean deployment in each of the selected cases; interview subjects included shipyard site management, production management, production workers, production analysts, and the site lean production deployment team.

LEAN REMANUFACTURING CASE STUDIES

The Product-Process Matrix was introduced to illustrate the diversity of the remanufacturing processes, and four distinctive types of remanufacturing were identified, ranging from high product variability (low volume, low standardization, low condition dependability) to low product variability (high volume, high standardization, high condition dependability). In this section, case studies of lean remanufacturing applications from the naval ship repair context are analyzed that illustrative each of the types of remanufacturing. The cases to be examined ranged from the highest to lowest variability as follows: shipboard component remanufacturing (Type I), propulsion shaft remanufacturing (Type II), large valve remanufacturing (Type III), and transponder remanufacturing (Type IV).

For each case the preexisting condition (before lean) is first described, followed by a general overview of the lean methods applied and their results, and then a detailed account of how the lean tools were used in this specific context. Particular emphasis in analysis is placed on application of the three major aspects of the Toyota Production System; developing internal process stability (foundation), developing just-in-time production (pillar), and developing built-in-quality (pillar).

Case Study Example: Shipboard Component Remanufacturing

Case Study Context: Type I Lean Remanufacturing (High Product Variability):

<u>Remanufacturing Context:</u> Shipboard component remanufacturing is the overhaul and repair of a set of components or a major physical subsystem that can not be removed from the ship. This remanufacturing onboard a ship is an example of a Type I remanufacturing process, which is performed in low volumes (a handful of similar components processed in a year) with low standardization (each component can be different and the failure modes can be unique). This work is done aboard the ship when it is located in dry dock. All manpower, tooling, materials, and other equipment must converge on the specific component to be worked on. The ship has a largely integrated

product architecture that creates additional challenges for work done in this environment. Many components cross both physical and system boundaries (e.g., hydraulics, electrical, etc.), yet must be repaired independently.

Work is conducted by skilled trades such as electricians, pipe fitters, welders, and mechanics. A single component would typically be worked on by several workers at a time. They have traditionally worked in teams according to their trade specialization. Each specific component would be broken down into a set of tasks to be completed by each of the various work teams. A "lead trade" would be identified per component. The "lead trade" would conduct their work and hand the technical instruction package off to a "support trade," who would similarly complete their work before handing off to another trade group. The primary responsibility of supervisors is to optimize utilization of personnel, while a secondary responsibility is to resolve production problems when they are identified.

<u>Pre-existing conditions:</u> Shipboard component remanufacturing had tremendous variability in all aspects of processing, resulting in a large degree of "fire fighting" every single day. The primary emphasis was always on the macro-level ship remanufacturing schedule and resources were regularly pulled from jobs in progress to support tasks that were on the daily "critical path" towards achieving the macro-level schedule. Workers gathered at a wide variety of locations in the morning according to trade. Supervisors were often at these diverse locations with no co-location of a core leadership team. Tooling was acquired from a variety of tool cribs around the facility, and material was

specifically ordered and delivered to an employee's supervisor. Technical instructions consisted of short (vague) descriptions of the task to be accomplished and blue-prints of the components to be worked on.

Significant inefficiencies existed in production coordination between trades, as work was functionally organized according to area of technical competence. Shipboard component remanufacturing commonly delayed the schedule for overhaul and repair of an entire ship, and/or the work package was de-scoped (some items that were thought to be important for future reliability were skipped) due to inability to deliver hull remanufacturing on schedule and cost.

<u>Post-lean remanufacturing conditions:</u> The first two ship overhauls conducted after lean methods had been applied to shipboard component remanufacturing were two of the best in overall performance up to that time in achieving cost and schedule targets. Through empowered cross-functional teams with close engineering support, the production workers had a greater capability to quickly and appropriately resolve production logistics and technical issues as they arose. The flow of production that was created and the focus on virtual "work cells" lead by cross-functional teams were transformational. The greatest benefits, by far, were job site communication and coordination. Work is being continued to apply these concepts to the entire work package completed aboard ship in dry dock. A summary of lean methods as applied to hull component remanufacturing is shown in Figure 2.11, discussed in detail in the next section.

Observed Lean Methods to Develop:	*Context:* *Type I Lean Remanufacturing (High-Product Variability)* *Case:* *Shipboard Component Remanufacturing*
Internal Process Stability	- **Virtual work cells created.** - **Cross-functional production teams were created.** - **Standard work developed for each work cell, highly general in nature.** - **Consumables trailer established near dry dock for materials.** - **Tool kits created for trade and specific job tooling.** - **Visual metrics board established to track productivity to schedule.**
Just-In-Time Production	- **Work-in-process controls established for each supervisor and skilled trade.** - **Pull system developed between work teams to manage WIP.** - **Visual control board established to manage flow of production personnel.** - **Production leveling through utilization of critical chain scheduling and WIP controls.**
Built-In-Quality	- **Implemented job rotation and cross-functional training.** - **Phones strategically placed in production zones with direct line to engineering.** - **Daily stand-up meeting of production team to discuss process abnormalities.** - **Engineer assigned full-time to the production zones.** - **Engineers carry pagers at all times for immediate contact.** -

Figure 2.11 – Lean Methods Applied to Shipboard Component Remanufacturing

Lean methods to develop internal process stability

- *Virtual work cells were created:* This is not a work cell in the usual sense of a flow line in which materials move one piece at a time from station to station. We call this a virtual work cell because it was a physical segment of the ship to which teams of workers flowed to complete a defined set of work tasks. Significant discussion was held as to whether work cells should be created according to physical boundaries or functional system boundaries. The team realized that a system cut across large portions of the ship and interacted with other systems so it would not be a defined piece of work. Thus, it was important for work cells to each encompass a single work area; similar to a room in a house.

- *Cross-functional work teams were created:* Cross functional work teams were created of employees from multiple trades to work together within a single work cell. These cross-functional work teams encompassed workers from each of the major trades; with a team lead from the lead trade group for that specific work cell. The creation of these work teams lead to tremendous gains in terms of teamwork, training, and communication between trade groups. Technical engineers were not assigned specifically to work teams, but would rotate amongst a small number of teams.
- *Standard work developed for each work cell:* This was not at the level of detail one would see in a Toyota assembly plant in which tasks are shown in sequence with times per task to the second. Initially, this work encompassed simply generic operator instruction sheets and a checklist of steps to complete, supported by a technical drawing for specific questions. Over time as the process matured there were opportunities for further detail in the definition of tasks and a preferred sequence.
- *Consumables trailer established for materials:* A portable trailer was established alongside the dry dock, which housed a wide variety of low-cost consumable tools and materials that were regularly needed to complete common tasks. The readily available tools and materials allowed the work teams to stay closer to the work site, greatly reducing motion waste.
- *Tool kits created for trade and specific job:* In the preexisting condition each worker had their own personalized set of tools in a very large, space-consuming tool kit. These individualized tool kits were expensive to purchase and to

maintain and there were too many to locate them close to the point of use. Each trade group identified a core set of tools that they were required to carry at all times. These tools were acquired by the shipyard and distributed to all appropriate personnel. Additionally, job-specific tool kits were created to augment the trade-specific tool kits for key jobs (long-duration or repetitive).

- *Visual metrics board:* A visual metrics board was established in the main production offices. The primary production metric on these boards was the percentage of overall work complete and the number of specific jobs that had been completed. This board also was used for visual management to track the schedule versus actual times for key activities of the work cells on a daily basis.

Lean methods to develop just-in-time production

- *Work-in-process controls established:* Work in process controls were established for each supervisor. This prevented single supervisor from becoming overloaded with open work items and forced them to complete tasks before moving on to new work.
- *Pull system developed between work teams:* Pull systems were created by which each supervisor would place all open jobs on a visual control board. This board indicated current priorities (highest priority at top of board) and number of open jobs per supervisor. The board also identified when the supervisor closed a particular job so that another could be opened.
- *Visual control board for flow:* A visual management board was created that highlighted the active work cells on the boat and the number of workers in each

area. This allowed for improved communication and coordination of work in very tight work areas.

- *Production leveling*: Major initiatives were taken to level production within the ships hull remanufacturing. A macro-level schedule was established and critical chain project management software was used to develop the top priority tasks for both lead and support trades. Later, the ability to create a critical chain, resource constrained schedule was added to the software capabilities, this was an IT solution that helped level production. However, it had the effect of redefining top work priorities on a regular basis, frequently pulling workers from open jobs to shift priorities to a new task.

Lean methods to develop built-in-quality

- *Implemented job rotation and cross-functional training:* Cross-functional work teams dedicated to specific geographic zones of the boat were created. These teams had a tremendous benefit for cross training of employees and effective job rotation. Cross-functional training significantly improved the effectiveness of each work team as expertise grew within several key skilled trades.
- *Daily discussion of abnormalities:* During morning job briefings each supervisor held a meeting with employees to discuss abnormalities from the previous day's work. Issues for immediate resolution were addressed. Also, feedback was provided to technical engineers, improving their technical instructions for the next time that specific task was completed.

- *Engineer in the production work area:* Engineers were assigned to specific work cells to support production from a technical perspective. Engineers had a pager on them at all times so they could be reached immediately by production employees within the work cell.

Case Study Example: Propulsion Shaft Remanufacturing

Case Study Context: Type II Lean Remanufacturing (High-Moderate Variability):

Remanufacturing Context: Propulsion shaft remanufacturing is a Type II remanufacturing process, as it is a long-lead time process with low volumes (initially 300 days lead time, approximately 15 components per year), with low-moderate condition dependability (many failure modes and machined to extremely tight tolerances), resulting in every component repair being unique. Each component must complete roughly 115 independent work processes for completion.

Work is done on a variety of large industrial equipment, including machining lathes, sophisticated welding machines (both manual and computer-numerical controlled (CNC)), and other specialized equipment. Components are extremely large, requiring a team of sophisticated riggers to coordinate a complex lift anytime a piece needs to be moved. Therefore, efforts are made to reduce the number of moves per component; however, a coordinated plan of component moves has not been attempted. Teams of approximately 12 workers are employed on three shifts to execute this process.

Pre-existing conditions: Prior to lean methods being employed in the remanufacture of propulsions shafts. Each component was tracked independently as it progressed through 115 milestone processes. Each component was subject to a significant number of starts, stops, and interruptions in production. Little effort had been made to tie these processes together into work cells or to optimize flow through any aspects of production. Priorities shifted regularly as a function of "what can be worked on today" and often a dozen or more components would be in some state of progress at any time. Significant imbalances and bottlenecks existed in the production process, highlighted most significantly by a requirement for a 4-6 week technical review and sign-off by a technical expert located in another city. Remanufactured products were regularly plagued with an assortment of quality problems and "fire drills" would often occur every 6-8 weeks when a particular component was badly needed to meet macro-schedule constraints on an entire ship overhaul and repair.

Post-lean remanufacturing conditions: Once lean methods had been applied to the remanufacture of propulsion shafts, the greatest benefit was in production lead time, as this was reduced from 6-8 months per component to 6-8 weeks per shaft. The concept of 11 work cells and a pulsed production line brought tremendous stability and process flow to production, as well as a dramatic decrease in time required to obtain technical approval. Long-term demand rates were identified and required takt time was identified for each shaft. Workers would regularly utilize kaizen (continuous improvement) methodologies to further reduce the cycle time for work cells not consistently performing to takt. Additionally, significant gains came in the reduction in moves per component.

Production was optimized to reduce the number of lifts, which are time consuming, expensive, and very risky from a quality perspective as components are machined to extremely tight tolerances and can be damaged in handling. A summary of lean methods as applied to propulsion shaft remanufacturing is shown in Figure 2.12.

Observed Lean Methods to Develop:	*Context:* *Type II Lean Remanufacturing (High-Moderate Product Variability)* *Case:* *Propulsion Shaft Remanufacturing*
Internal Process Stability	**- Series of work cells created (11 total).** **- Standard work scoped and created for each work cell.** **- Level-loaded key machines, relieving bottleneck at new lathe.** **- Shadow boxes created for management of disassembled parts.** **- Tool cart developed for each work cell.** **- Cycle time and output metrics consistently tracked and updated visually.** **- Visual metrics board created for tracking progress to takt at each cell.** **- Established long-term demand and takt time.**
Just-In-Time Production	**- Redesigned process layout for flow, moving several large pieces of equipment.** **- Created one-piece pulsed production line.** **- Work-in-process controls established.** **- Material kits created and associated with each work cell.** **- Established specialized lifting & handling equipment for speed and safety.** **- Established engineer as full-time member of production team.** **- Initiated several projects to reduce set-up time.** **- Worked with customer to achieve long-term production leveling.**
Built-In-Quality	**- Implemented job rotation and production in cross-functional teams.** **- Simplified technical paperwork.** **- Developed a grid system for communicating condition.** **- Modernized process with new lathe and automated welding process.**

Figure 2.12 – Lean Methods Applied to Propulsion Shaft Remanufacturing

<u>Lean methods to develop internal process stability:</u>

- *Series of work cells created:* The shaft remanufacturing process was originally thought of as 115 discrete steps which need to be completed. The processes were grouped into eleven “buckets” of work, which became the work content for each of the cells. Many of the boundaries for work cells were selected based on the equipment required for processing. The components are extremely large, and the idea was to do as much work as possible without physically moving the component. This had a significant impact on the production process as the objective then became to optimize flow through each of the 11 work cells, and not push each component through all 115 steps.

- *Standard work was developed at each work cell*: Once the work content was identified for each cell, standard work instructions were developed by the mechanics and machinists for each work cell. This incorporated required tooling, materials, external support (engineering, lifting & handling), and a visual representation of each process.
- *Optimized utilization of all equipment*: A primary bottleneck in this process was the unavailability of a recently installed high-capability lathe, as a result of imbalance in utilization for the five key machines used in shaft remanufacturing operations. Many functions currently performed on the new lathe could have been performed on less capable equipment. All 115 process steps were evaluated with regards to which machines were capable of the process and balancing of equipment, greatly improving utilization by freeing up the key resource of the new lathe. This played a significant role in defining the eleven work cells, and resulted in relieving workload at the constraint machine.
- *Shadow boxes were used for disassembled parts*: Similar to the concept of a shadow board being used for tool control, shadow boxes were used for part control during disassembly. A disassembly kit was complete when all parts of the box were full. A specialized cart was also created for these parts. Movement of these carts did not require specialized material handling.

- *Tool cart developed for each work cell*: Required tools were identified for each of the 11 work cells, tools were acquired, and tooling carts were developed. These tool carts were not permanently located at each piece of equipment, but could be wheeled to the work depending on which tasks were being performed. All personal tools were removed from the work area and new tools and gages were acquired and labeled to complete each of the tool carts.
- *Cycle time and output metrics consistently tracked:* Cycle time metrics are now actively tracked and posted on the visual metrics board in the work area. A long-term takt time was established. Cycle time per each component is tracked, so employees can have a better understanding of their performance relative to achieving customer demand (takt).
- *Visual metrics board:* A visual metrics board was created to highlight performance with regards to number of units completed and cycle time performance per unit production relative to takt time.
- *Set long-term demand and takt time:* Process capability, historical process performance, and customer demand were reviewed to identify a realistic and appropriate long-term demand profile. Once this was created, takt time was identified for key components and a balancing of work content was attempted among the 11 work cells.

<u>Lean methods to develop just-in-time production:</u>

- *Redesign process layout for flow*: Initially equipment used in remanufacture of propulsion shafts was in several locations in various parts of the machine shop with haphazard process flow. At significant expense, the production process was redesigned to lay out the equipment to support flow in the production layout. Two large pieces of equipment were moved and one was added so that all equipment could be arranged according to the flow of the product.

- *Created a sandblast satellite work cell:* A satellite work cell was created, at a serious investment, for shaft refurbishment in the same physical work area as other repairs. Previously, components had to be shipped to another building for sandblast at a central facility. This greatly improved service, quality, and communication between work teams and enabled one-piece flow.
- *Created one-piece pulsed production line:* Eleven process cells were created. Process cycle time for each work cell was determined, as well as takt time for the entire production line. Components could move through the system at the same time, similar to a pulse of a non-continuous assembly line. This organization into work cells created challenges; cycle time, and particularly cycle time variability, had to be reduced. This reduction became the focus of improvement initiatives.
- *Work-in-process controls established*: WIP was limited to one component per work cell. The policy was that if that component was completed but the next workstation was not ready to start work on it, production would stop and workers would go help relieve the bottleneck.
- *Material kits created*: Material kits were created for all mandatory replacement parts (which were most of the parts that were not being remanufactured), and staged near the machining area for use. Shadow boxes accounted for components

that were to be disassembled and remanufactured. The two systems together provided a highly successful design for material flow.

- *Established specialized lifting & handling gear*: As previously mentioned these components are very large, heavy, and difficult to move. A railroad line was set up going right into the work cell for movement from the outside. Additionally, specialized rigging gear was established to better transport components without damaging them during a move.
- *Established engineer as full-time member of production team:* The product is remanufactured to precise technical specifications. An engineer is required for validating the product and checking for any deviations from the print.
- *Initiatives to reduce set-up time:* Activities reduce the time required to set-up components in machines at each work station. Tooling and material kits were created, as well as special fixtures and lifting & handling rigs for safe and quick component movements.
- *Production leveling:* As previously mentioned, process capability, historical process performance, and customer demand were reviewed to identify a realistic and appropriate long-term demand profile. Once this was created, takt time was identified for key components and balancing of work content was attempted among the 11 work cells.

<u>Lean methods to develop built-in-quality</u>

- *Implemented job rotation and cross-functional teams:* In addition to the primary mechanics and machinists in the work area, engineers and planners were assigned full-time to the propulsion shaft production support team. All employees spent time learning to complete each task and operate each machine. This led to tremendous knowledge sharing and cross-training as employees learned to better appreciate and communicate tasks to their peers, and to flexibly reallocate personnel when one station was ahead and another behind in production.

- *Developed a grid system for communicating condition:* A tremendous technical advance came when a team of engineers and mechanics developed a standardized grid system for communicating the exact condition of the component in various physical locations. This grid system was identified on the component using chalk and was used to communicate conditions in writing to the engineering analysis team, along with digital photographs.
- *Technical paperwork simplified:* The grid system mentioned above served to greatly simplify the technical paperwork, as well as a set of standard checklists and critical measurement sheets which were established by the workers in the area.
- *Modernized with automated welding process:* Quality increased significantly when a new automated welding machine was acquired and then modified to be placed on a rail line adjacent to a large lathe. This allowed for automated welding to occur on multiple axes of the component.

Case Study Example: Large Valve Remanufacturing

Case Study Context: Type III Lean Remanufacturing (Low-Moderate Variability):

<u>Remanufacturing Context:</u> Large valve remanufacturing is a Type III remanufacturing process, which is processed in higher volumes (approximately 200 components annually),

with few major products (six families of valves, each with multiple configurations), and moderate condition dependability (failure can occur on several surfaces, all with relatively standard repairs). Remanufacture of large valves is conducted in a large machine shop by a dedicated workforce of ten personnel; six personnel who disassemble, evaluate, reassemble, and test valves; three personnel who machine and repair worn or corroded valve surfaces; and one supervisor for the team. Support services such as engineering, logistics support, and epoxy coating are not dedicated, but are available upon request. Apprentice valve mechanics became senior valve mechanics, and the best mechanic was typically selected to be the supervisor. The supervisor's primary responsibilities were to elevate process problems, interpret instructions, complete paperwork for tracking components, and to ensure work for each mechanic.

Pre-existing lean remanufacturing conditions: Large valve remanufacturing was averaging 180 days turn around from receiving the valve to shipping the valve and had remained largely unchanged for decades. Finding work was not a problem for large valve mechanics; at any time approximately 80 valves were in some stage of disassembly or assembly in the system, most of them stored on large pallet racks on the shop floor (large shelving units that held pallets of valves or components). For many months the line had been operating with mandatory overtime for all employees, yet schedule dates were never met, despite expediting many components, and performance to planned cost was very poor.

The area consisted of eight work benches: each mechanic was assigned a work bench, which would be used for a variety of processes including disassembly, analysis, reassembly, and test & certification. Valve components would get routed to other machining sections for processing: a cleaning station, a milling Section, a lathe work section, and an epoxy coating section, each with unique supervisors and work priorities. There was not a clear process flow or shop layout. The primary management objective was to keep workers engaged on the highest priority component. When the next step for a component could not be performed, typically awaiting parts, technical instruction, or attention from a support process, the next highest priority valve was taken from the pallet rack and worked on.

Four engineers supported large valve remanufacturing for technical considerations. However, these engineers supported the entire mechanical production shop. They always had a large backlog of condition reports (from the analyze valve condition process) to answer. Frequently the engineers were not located in the production shop, but instead were in their home engineering department (mechanical, electrical, structural, etc.). The technical reporting process was cumbersome for many mechanics that were required to write long paragraphs identifying existing conditions, and interpret engineering responses also written in long paragraphs.

At the machining stations, long setup times existed for each component (on the order of hours), leading to incentives to batch multiple valves of the same type in sequence, regardless of priority. Tools were frequently horded, and hard to find. Significant quality problems occurred at each step of the process, particularly with the epoxy repair process completed in another building at the facility. Valve parts and sometimes the valves themselves were hard to find. Mechanics spent hours looking for them, often using parts scavenged from another valve that was eventually replaced when the lost piece would be found.

Post-lean remanufacturing conditions: At the completion of a two-year focused effort to apply lean methods to this process, the average cycle time, per component, was reduced from 180 days to 40 days, overtime was eliminated, and cost & schedule goals were regularly achieved. Quality was significantly improved, particularly items related to paperwork and effective communication of component condition. A summary of lean methods as applied to large valve remanufacturing is shown in Figure 2.13.

Observed Lean Methods to Develop:	*Context:* *Type III Lean Remanufacturing (Moderate-Low Product Variability)* *Case:* *Large Valve Remanufacturing*
Internal Process Stability	**- Four work cells were created (receiving, disassembly/assess, repair, assembly/test)** **- Standard work was developed at each work cell.** **- Contingent repair instructions developed for each valve.** **- Machining work cell created and aligned to large valve management.** **- Epoxy work cell created (new equipment in the cell)** **- Tool kits created for common processes.** **- Cycle time metrics consistently tracked and posted weekly.** **- Visual metrics board to track and communicate production.**
Just-In-Time Production	**- Co-located equipment (test, repair, epoxy)** **- Redesigned process layout for flow.** **- Work-in-process controls established and continuously reduced.** **- Pull systems and buffers developed between each work cell.** **- Visual control board for flow.** **- Material kits created for all parts, some contingent, others mandatory.** **- Lifting & handling integrated into production with small hoist.** **- Production Leveling through WIP controls and additional non-ship-specific work.**
Built-In-Quality	**- Andon system (visual andon board) located in high traffic area.** **- Machining-epoxy fixtures created, significant quality improvement resulted.** **- Technical paperwork simplified and key dimension sheets created.** **- Implemented job rotation and cross-functional training.** **- Daily stand-up meeting of production team to discuss process abnormalities.** **- Engineer assigned full-time to the shop floor.**

Figure 2.13 – Lean Methods Applied to Large Valve Remanufacturing

Lean methods to develop internal process stability

- *Work cells were created*: Valve remanufacture was originally considered as approximately twenty unique steps and individual work stations performed everything they could, as in the old days of building a Model-T car in one place. By organizing a flow line and through process improvements these were consolidated to four production cells in a flow layout (receiving, disassembly, repair, and reassembly/test).
- *Standard work was developed at each work cell*: Mechanics and machinists worked together to develop standard work instructions, checklists, and set-up sheets for each work cell.
- *Visual management implemented:* Extensive visual management was instituted in the work area as work areas were cleaned and work cells and work stations were marked. A central production control board illustrated the status (red/yellow/green) and location (work cell or buffer) of every component, as well as associated process problems. This lead to tremendous improvements in communication, organization, and general workplace cleanliness, including disposing of large quantities of excess and retired parts.
- *Contingent repair instructions developed for each large valve*: The technical instructions were expanded to included appendices for common failure modes and repair instructions. They acted like recipes for standard meals. This empowered a mechanic to initiate repairs without engineering signature, effectively removing a bottleneck from the process. This improved quality, particularly quality of paperwork, and assisted in training new employees.

- *Satellite epoxy work cell was created in the process flow*: Repair work cells were created and co-located for mill machining, lathe machining, and epoxy repair processing. In the instance of epoxy repair, where it had previously been located several buildings away, a satellite work cell was created in the valve repair area. Machinists that operated these machines were incorporated into the valve repair team and reported to the valve repair supervisor, with dotted-line responsibilities to their functional supervisor. This created tremendous teamwork, synergy, and joint learning between the mechanics and machinists; leading to significant improvements in quality and communication.
- *Tool kits created*: Tool kits were developed for a variety of applications. In some instances, a core tool set was identified, acquired, and maintained at a particular work site. In other instances, specialized tool kits, specific to a complex repair and/or component were identified, stored in a central location, and brought to the job as needed. Improvements in tooling made a significant impact on quality and scrap rates as all mechanics were now able to consistently use correct tooling for a job.
- *Cycle-time metrics consistently tracked:* Cycle-time metrics had never been utilized before. Key performance metrics included the number of units completed, percentage of on-time delivery, and average cycle time per component. This created a sense of camaraderie and a great deal of motivation to set challenging objectives and meet them. Previously all metrics had been cost-related, largely preventing mechanics and machinists from relating to their impact on the metric.

- *Visual metrics board:* A visual metrics board was established in the work area to track daily performance on the cycle-time metrics.

<u>Lean methods to develop just-in-time production</u>

- *Co-located equipment:* In addition to the epoxy machine mentioned above, several other pieces of equipment were co-located in the production area.
- *Redesigned process layout for flow:* Once all work processes were co-located in the primary work area, work benches and two lathes were moved to better support flow between work cells. The result was a logical u-shaped flow between the four work cells of receiving, disassembly, repair/machining, and assembly/test.
- *Work-in-process controls established*: Each work cell and each intermediate buffer was capped with a maximum number of components permitted. This buffer improved level-loading of production and prevented a large build-up prior to valve machining (the process bottleneck).
- *Pull systems developed between work cells*: The WIP controls acted as a pull system. Once the maximum for each buffer was reached, work on the preceding process would stop, and then proceed when a component was moved or completed. As the buffers filled up, workers were expected to find other useful activities, including continuous improvement. Components waiting processing in buffers were not required to adhere to strict FIFO restrictions; each buffer allowed for a re-shuffling of component priorities.
- *Material kits created*: Material kits of "mandatory replacement parts" were created for each component. A system was developed for contingent material

items to be acquired from a secured “supermarket” in the valve repair work area, or were standard stock items that could be provided in a timely manner by the supply system. Much effort was placed on applying lean methods to the supply chain, resulting in a significant increase in flow as parts became more readily available. Having a limited number of valves in process allowed for clearer prioritization to expedite needed parts.

- *Lifting & handling integrated into production*: Specialized large valve pallets were created for safely wheeling components around the factory, while keeping materials, instructions, and tooling, together. Additionally, low-capacity jib cranes were acquired and strategically placed within the production area. High-capacity overhead cranes (and supporting lift team) were not required for handling heavy components.
- *Production leveling*: Large valve remanufacturing had traditionally had significant variation in production demands over time. A set of non-urgent valves for remanufacture were identified (to be placed in finished good inventory). These components support production during low demand periods. Buffer management and WIP controls enabled the production system to function more efficiently during times of peak production and emergency component repairs.

<u>Lean methods to develop built-in-quality</u>

- *Andon system created*: A crude, but effective communication system was developed by attaching red tags to components that were waiting for external assistance to continue processing. Similarly, on the visual control board, a small red magnet (with the required support identified) was placed next to the component and located where senior management would see the andon signal regularly.

- *Machining fixtures created:* Fixtures were created for machining set-up and machining of components in lathes, mills, and epoxy ovens. Machinists in the work area established a visually managed set-up instruction guide for every component. Many of the fixtures incorporated turntables, flexible fixture plates, and rotating capabilities in each axis. Machinists in the area ingeniously designed and manufactured these fixtures, which created less scrap and less machining downtime for part changeover and setup.
- *Technical paperwork simplified:* Efforts to develop pre-engineered repair instructions reduced writing and simplified technical instructions. The development of pre-engineered repair instructions additionally reduced variability between engineers in repair recommendations. Mechanics in the work area developed an assortment of set-up guides, assembly/disassembly "cheat sheets" and checklists.
- *Implemented job rotation and cross-functional training:* All valve repair employees were required to spend several days cross-training with fellow workers, even if this involved crossing production trades. This resulted in improved teamwork and learning throughout the entire production team.
- *Daily discussion of abnormalities:* The valve remanufacture work team assembled each morning for five to fifteen minutes to address abnormalities, quality defects, and lessons learned from the previous day.

- *Engineer on the shop floor:* A technical engineer was assigned full-time to the production shop, his desk permanently located in the middle of production. This location allowed for quick resolution of minor technical issues as well as teamwork and joint learning between the engineer and production workers.

Case Study Example: Transponder Remanufacturing

Case Study Context: Type IV Lean Remanufacturing (Low Product Variability):

<u>Remanufacturing Context:</u> Transponder repair is considered a Type IV remanufacturing process for its combination of high-volume (1500 components per year), high standardization of components (2 similar components processed), and high condition dependability (most components go through the same set of mandatory replacement processes). This remanufacturing application is the most similar to a Toyota assembly line. Two types of transponders are remanufactured on one production line of 12 employees. Each transponder weighs approximately 30 pounds. The repair process requires disassembly, cleaning, component replacement, component repair as needed, reassembly of electronic and mechanical systems, and test.

<u>Pre-existing lean remanufacturing conditions:</u> For years the transponder remanufacturing process had struggled to meet demand, a demand expected to increase significantly in the coming years. The work was generally performed by apprentice-level mechanics paid at a lower rate than experienced mechanics. Work on components occurred in batches of approximately 20 transponders - the quantity received from the supplier. Quality problems were not significant, but did exist due mainly to incorrect processing and a

particularly cumbersome plastic repair process. The bottleneck production process was the test phase, which was performed in a test facility at the opposite end of the shipyard.

<u>Post-lean remanufacturing conditions:</u>

As a result of the lean methods applied, the transponder remanufacturing line was able to nearly triple production throughput. This line became one of the most impressive examples of lean transformation as an inefficient batch production shop became a high-performing mass production-like assembly line within less than a year. The start-and-stop batch production was replaced with two parallel flow lines of production; one specialized for each of the two types of components. A summary of lean methods as applied to transponder remanufacturing is shown in Figure 2.14.

Observed Lean Methods to Develop:	*<u>Context:</u>* *Type IV Lean Remanufacturing (Low-Product Variability)* *<u>Case:</u>* *Transponder Remanufacturing*
Internal Process Stability	**- Two parallel production lines created, one for each major component.** **- Highly specific standard work developed at each work station.** **- Workstation-specific tooling identified.** **- Cycle time and output metrics consistently tracked.** **- Visual metrics board tracked daily, weekly, and monthly production.** **- Pre-screening of components to identify those not worth remanufacturing.** **- Acquired specialized lifting & handling devices for each production line.**
Just-In-Time Production	**- Redesigned process layout for flow.** **- Work-in-process controls established with little buffer between work stations.** **- Created one-piece flow production line.** **- Acquired satellite test tank and co-located.** **- Initiated many efforts to reduce (and ultimately eliminate) set-up time.** **- Developed specialized material handling cart.** **- Worked with customers to develop long-range production leveling.**
Built-In-Quality	**- Acquired component & process specific gages.** **- Developed specialized mold for plastic repair process.** **- Implemented job rotation and cross-functional training of employees.** **- Simplified technical paperwork, eliminating all together in standard production.**

Figure 2.14 – Lean Methods Applied to Transponder Remanufacturing

Lean methods to develop internal process stability

- *Two parallel production lines created*: Pre-existing conditions had work processes begin work cells spread around a machine shop. Processes were lined up in two parallel production lines, one for each of the two transponders being remanufactured. The production lines shared resources for the clean and test stage. Each production line had eight work stations (disassembly, clean, repair (x2), reassemble (x3), test)
- *Standard work was developed at each work station*: Visual standard work instructions were developed by mechanics at each of the eight work stations. These instructions included pictures of the layout, pictures of acceptable and unacceptable components, and pictures for assembly. The pictures showed the steps to be followed, in sequence, and with standard times for each step. These work instructions were regularly reviewed and updated by the production team.
- *Workstation-specific tooling identified*: Mechanics identified their exact needs for each production step and tool requirements for each workstation were standardized. Tools were acquired to meet needs, color-coded for each work station, and ergonomically placed at each work station. All personal tools were removed from the work area, and mechanics identified their exact needs for each production step.
- *Cycle time and output metrics consistently tracked:* Weekly output and cycle time metrics were tracked and posted in the work area. Key performance metrics were the number of units completed, percentage of on-time delivery, and average

cycle time per components delivered. Previously, performance metrics had not been communicated to employees. These metrics now became a weekly challenge to improve upon the previous best.

- *Visual metrics board:* A visual metrics board was established and placed in the production area to display the metrics.
- *Pre-screening of components for remanufacture*: These components are generally considered an easily replaceable commodity. A cost benefit analysis determined that discarding excessively damaged components for parts was more cost effective than to attempt remanufacture. An initial visual inspection is now conducted on all components and a very small percentage of components are set aside for later disassembly and utilization as spare parts.
- *Acquired specialized lifting & handling device:* A specialized scissor lift was acquired and placed along the conveyor. The lifting device could be used to ergonomically lift components into a key machining process. This also significantly reduced the lifting requirements associated with each component. The device was set on a track roller system such that it could service both production lines.

<u>Lean methods to develop just-in-time production</u>

- *Co-located equipment:* A new test tank was acquired and co-located with the rest of the production processes. Previously, testing processes occurred in another building, far from the primary production operations.

- *Redesigned process layout for flow:* An extremely significant improvement in the remanufacture of transponders came when two parallel flow lines were established to achieve continuous production. Nearly every machine was moved to support this production and batches were broken from their original size of 20, down to a single-piece flow.
- *Work-in-process controls established:* Inventory controls throughout the production lines were tightly controlled and buffers were very small. Workers were easily able to shift from one production process to the next as needed to maintain production.
- *Created one-piece flow production line*: The new production lines were set up to support one-piece flow and FIFO by utilizing a single long roller-conveyor for movement of each component. This flow allowed processes to be tightly coupled visually, and allowed workers to shift workstations as necessary to support the workload.
- *Acquired satellite test tank*: A smaller testing apparatus was acquired that could be co-located with the production process and was always available to support the transponder remanufacturing line.
- *Initiatives to reduce set-up time*: The new smaller testing apparatus did not have the capacity (20 components) of the previous facility. With the use of a smaller test facility it became critical to load and unload parts for testing very quickly. Standard work was developed for test set-up. Specialized material handling devices were created. The output of testing increased the number tested, while at any one time decreased.

- *Developed specialized material-handling cart:* A small cart with rollers to rotate the piece was developed for each component. Specially-sized carts were established for each of the two sizes of components. These carts were designed and produced by mechanics in the work area and were very simple constructed out of wood, ball bearings, and small casters. This simple design significantly reduced the amount of handling required per component.
- *Production leveling:* The production team worked with customers and suppliers to develop a long-term demand profile, and to establishing a level production schedule to meet demand. This level schedule enabled a steady flow of components through the parallel lines and a daily understanding of cycle time as compared with takt time.

Lean methods to develop built-in-quality

- *Acquired component & process-specific gages*: Required measurement and test gages were identified for two of the work stations. Only one set of gages had existed, and they were not ideally sized for the components. An appropriately sized set of component and process gages were acquired, with the existing set serving as a backup when gages were being calibrated.
- *Developed mold for plastic repair process*: One process repaired plastic molding and removal of excess plastic. A new mold was designed that significantly reduced excess plastic and injected plastic through a non-critical surface such that the time required for removal of excess material was reduced.

- *Implemented job rotation and cross-functional training*: All production employees became proficient at each work station. They were able to surge as needed depending on demand for each of the two components. Additionally, engineers, quality control and logistics personnel took turns on the production line. This experience improved communication, cross-training, and ultimately quality for the overall production.
- *Technical paperwork simplified*: The technical paperwork for transponder repair was practically eliminated. Paperwork was only required if an exception to standard work was identified – a rare occurrence.

LEAN REMANUFACTURING CASE STUDY DISCUSSION

Do lean production tools and techniques apply within the remanufacturing context? The four case studies illustrate effective application of lean methods in the remanufacturing context. Detailed cost-benefit analyses were not presented, but the benefits overwhelmingly paid for any costs of implementation. This paper has highlighted there is not simply one best lean solution that applies in this context, but many. Just as manufacturing a small industrial pump differs from manufacturing a large airplane, the remanufacturing of these such products is equally diverse. This discussion will highlight ways in which lean solutions were modified to address different remanufacturing contexts. The discussion also addresses whether lean is a new paradigm of remanufacturing or simply maturation to the appropriate methods that would be suggested by scholars like Woodward, Wheelwright and Hayes.

Breaking the Tradeoff Between Flexibility and Efficiency with Lean Methods:

In The Machine that Changed the World (Womack, Jones, and Roos, 1990), the term lean production was introduced to describe a new "paradigm" of manufacturing that broke many of the rules of traditional mass production. It was more than"maturation" - actually a new way of looking at old problems. The original frameworks reviewed here, including the product-process matrix, suggest a clear tradeoff occurs between flexibility and efficiency, and that the efficient frontier is fixed and rigid.

Remanufacturing needs flexibility. Variability is inherent in the technical process performed. The original component must be inspected and different tasks performed depending on findings of the mechanic. Craft-like methods such as the job shop would seem as far as one could get for the more highly variable products and processes

The lean remanufacturing case studies addressed in this paper suggest that lean thinking can move remanufacturing beyond their current placement within the PPM space. As seen in Figure 2.15, the four cases illustrate four unique remanufacturing contexts. Prior to application of lean methods to each of these cases, they would have been considered well "above the diagonal", an inefficient process even in the normative model determined by authors of the product-process model. The cases of ships hull, propulsion shaft, and large valve remanufacturing would have been considered as job shop production; the case of transponder remanufacturing would have been considered as batch processing.
Yet, in all cases the shipyard was able to move beyond the limits of a jumbled job shop. Lean efforts focused on getting as close as possible to one-piece flow. The ability to

approach one-piece flow was limited in three of the four examples. The case of transponder remanufacturing, with low-product variability was able to approach one-piece flow, similar to an assembly line process - or in this case disassembly, inspection, and reassembly. The other three cases all moved closer towards the diagonal of efficiency suggested by the product-process matrix.

Figure 2.15 illustrates how each process moved closer to achieving the PPM models diagonal of manufacturing efficiency, even though in the precondition they were thought to represent a less mature job-shop production. What appeared to be a Type I process moved toward a Type II solution and so on. In a sense the paradigm of the product-process matrix was challenged by viewing the product and process in a different way. While this chapter talked about the before-and-after conditions as snapshots, in reality the post-lean solution was the result of an evolution. This evolution was a progression moving toward continuous flow. Significant opportunity for improvement remained in the “post-lean” state.

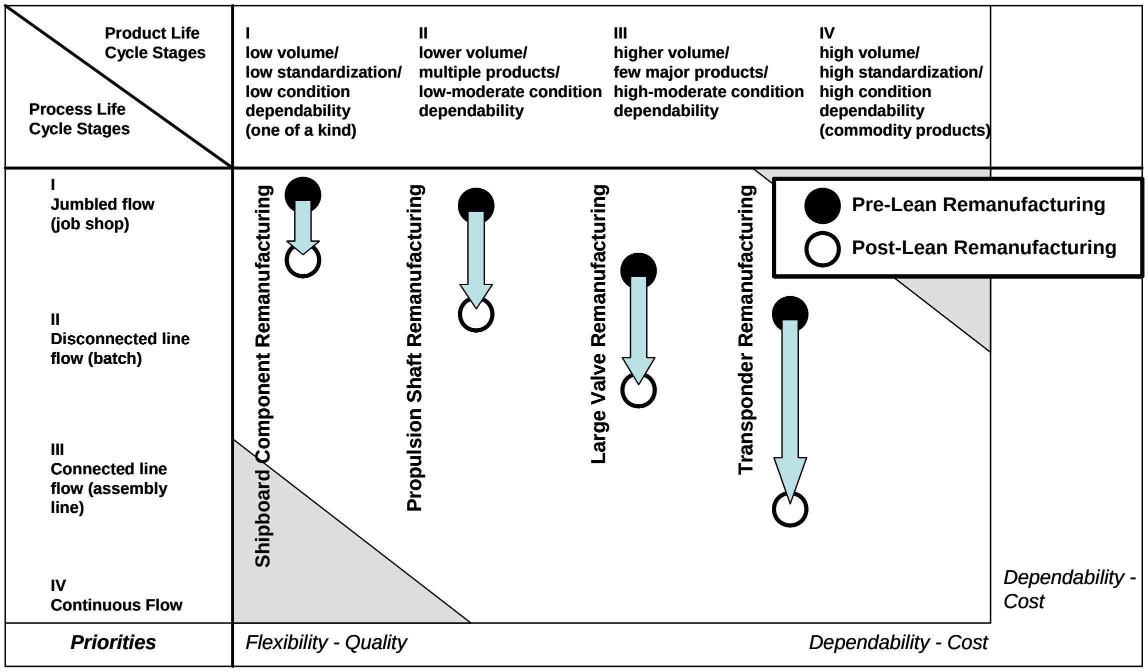


Figure 2.15 – PPM Impact of Lean Remanufacturing Implementation

Adaptation of Lean Methods to the Lean Remanufacturing Context:

The application of lean methods to the four case studies discussed here are as unique as the four case applications themselves. The highly flexible and robust lean methods developed in the Type I context of high variability production contrast with the highly structured and specific lean methods applied in the Type IV context of low variability. On the whole, the appropriate application of lean methods paralleled to the production process. Importantly, all four cases used the same process and the same principles to move in the direction of continuous flow. This discussion will focus on the application of lean methods in each of the four contexts, focusing on key dimensions of developing internal process stability, developing just-in-time production, and developing built-in-quality.

Lean Methods to Develop Internal Process Stability in the Remanufacturing Context:

In considering the application of lean methods to develop internal process stability, the lean concepts of standard work instructions, creation of work cells, use of visual management, and consistent presentation of tools and materials were considered in all cases. Figure 2.16 summarizes application of lean methods to develop internal process stability in the four cases examined.

<u>Standard Work Instructions:</u> The most identifiable characteristic of standard work instructions to the four applications of lean remanufacturing was the detail associated with the instruction. In the case of high-variability (Type I), work instructions were developed as generic operator instruction sheets and a checklist of steps to be completed, at the same time placing significant reliance on the technical drawings accompanying the mechanic. Standard work instructions were seen to develop greater detail and precision with Type II and Type III applications, to the Type IV application, which had detail down to the point of standard process times for each step.

<u>Work Cells:</u> In the Type I lean remanufacturing case; the work cell was defined virtually, as a geographic zone where a cross-functional team of workers would converge for production. In the Type II instance it was one of 11 distinct phases of production, with boundaries of production largely based on the desire to reduce the number of complex moves for the large components. Type III work cells were defined by the more natural phases of component remanufacturing: receiving, disassembly, machining/repair, and re-

assembly/test. In the Type IV application, a single flow line was created, like an assembly line.

Visual Management: Visual management differed in the level of detail it portrayed. In the Type I case, visual management identified the physical zones in which production was taking place, and a few very macro-level metrics. In the Type II and Type III cases, metrics became more detailed. In the Type IV case, metrics also became more detailed as performance to takt time was maintained throughout the day. In the Type IV case, the status of production was visual at all times as a result of the highly standardized linear flow of production.

Tool & Material Presentation: In a Type I remanufacturing context the tool and material presentation is generic to the trade of the worker and has little to do with the actual work being conducted. All necessary tools and materials can be acquired, as necessary. In the Type II context, tools are specific to the work station, in Type III, both tools and materials are kitted, per specific component. In a Type IV application, point-of-use tooling and material is utilized, while tools are fixed at each workstation and materials are located in bins.

Lean Methods for Developing Internal Process Stability				
Lean Tools & Techniques:	*Type I* *Ships Hull Remanufacturing*	*Type II* *Propulsion Shaft Remanufacturing*	*Type III* *Large Valve Remanufacturing*	*Type IV* *Transducer Remanufacturing*
Standard Work Instructions	- Generic operator instruction sheets. - Checklist of steps to complete. - Reliance on technical sketch of component.	- Operator instruction sheet specific to work cell. - Detailed checklist of steps. - Component set-up instructions.	- Operator instruction sheet specific to work cell & component. - Contingent repair instructions. - Set-up sheet with fixtures.	- Detailed standard work instructions with standard process time. - Set-up sheets with fixtures.
Work Cells	- Work cells defined according to geographic zone of the boat. Cross-functional work teams established to work in unique work cells.	- Develop 11 distinct work cells. - Identified as phases of production; dictated by lifts.	- Established based on major process breakdown of receive, disassembly, repair, reassembly.	- Assembly line: Incorporates entire production process (assembly, repair, disassembly). - Full job rotation, employees able to move within production line, as necessary.
Visual Management	- Map of current work zones. - Performance Metrics: percent-complete curve, # of jobs completed.	- Labeling of distinctive equipment comprising work cells. - Performance Metrics: # units completed, cycle-time per component (relative to takt).	- Labeling of distinctive work cells. - Performance Metrics: # units completed, % on-time delivery, cycle-time per component (relative to takt).	- Linear flow of entire shop. - Performance Metrics: # units completed, % on-time delivery, cycle-time component (relative to takt).
Tool & material presentation	- Transportable trade-specific tool kits. - All material special-order.	- Transportable machine-specific tool kits. - Required material kitted. Contingent material ordered.	- Transportable machine & job specific tool kits - Required material kitted. Contingent material in local supermarket.	- Fixed machine & job specific tool kits at work station. - Required and contingent material in local supermarket.

High-Variability Lean Methods ⟷ **Low-Variability Lean Methods**

Figure 2.16 – Lean Methods for Developing Internal Process Stability

Lean Methods to Develop Just-in-Time Production in the Remanufacturing Context:
In considering the application of lean methods to developing just-in-time production, the lean concepts of redesign of process for flow, pull systems, production leveling, set-up reduction, and work-in-process controls are examined. Figure 2.16 summarizes application of lean methods to develop just-in-time production in each of the four cases.

<u>Redesign of process for flow & co-location of equipment:</u> Redesigning the process for flow was an equally important aspect of lean remanufacturing in the case studies of Type II-IV. In each instance, co-located external processes, establishing satellite work cells and overall reorganization for flow was a significantly enabling step for all other lean methods. In Type I remanufacturing, where work was completed aboard the ship in a seemingly virtual work environment, significant efforts were being made to redesign the technical process for work flow. This, however, has proved to be far more difficult as it must be done on a job-to-job basis. In the longer-term the ideal solution would be to consider work flow for remanufacturing in the original design of the equipment, for example, considering modular designs of component systems.

<u>Pull systems:</u> Pull systems were important in establishing control of the production process in the context of Type I-IV remanufacturing. The Type I case pulled materials and tools as they were needed to the work cell. In the Type II case, pull systems were used to establish a pulsed production line, and in Type III case, pull systems at each buffer were used to manage the variability in different component sizes, conditions, and

type of repairs. In the Type IV case pull systems were used to initiate the flow line with a regular demand schedule.

Production leveling: In the remanufacturing context, production leveling was a totally new concept for each of the four cases examined. Production leveling and pull systems were of particular importance in each case due to the tendency within remanufacturing to disassemble each component as soon as it is received. Production leveling, in each instance, served to decrease the urgency of component induction to the process reducing WIP.

Set-up reduction: Set-up reduction played a significant role in Type I-III remanufacturing. In the Type I case, set-up was the time required for an employee to get to the job site with all tooling, materials, and instructions to complete a task. In the Type II and Type III cases, set-up reduction was applied in traditional contexts to reduce the amount of time required to set-up a component for processing. Results were significant for each case. In the Type IV case, setups were able to be eliminated completely

Work-in-process controls: As previously mentioned, pull systems and work-in-process controls were critical to gain process control in each case examined. Within remanufacturing, the tendency is to disassemble components as soon as they become available, creating a glut of WIP through all lead and support processing. WIP controls serve to maintain priority and focus on the key tasks to be completed.

Lean Methods for Developing Just-In-Time Production

Lean Tools & Techniques:	*Type I* *Ships Hull Remanufacturing*	*Type II* *Propulsion Shaft Remanufacturing*	*Type III* *Large Valve Remanufacturing*	*Type IV* *Transducer Remanufacturing*
Redesign of process for flow & co-location of equipment	- Working to redefine job task and work breakdown structure.	- Moved several major pieces of equipment. - Created sandblast satellite facility. - Installed train rails in shop.	- Creation of machining cell - Created epoxy repair satellite cell. - Created definitive work stations/cells.	- Co-located major test facility. - Align process to two parallel flow lines.
Pull systems	- Established pull system for job prioritization, per supervisor.	- Established a pulsed production line with 11 work cells.	- Established 4 work cells controlled with buffers between each.	- Established discrete-flow flow line with small buffers between work processes.
Production leveling	- Identified critical chain (and lead/support) for all work, established resource constrained level schedule.	- Attempted to balance job content of work cells - Worked to long-term takt time.	- Identified non-urgent workload to fill valleys. - Better management of WIP for emergent-jobs.	- Developed long-term commitment contracts, fixed demand per time period, and established takt time for combined line capacity.
Set-up reduction	- Kitted tools, emphasis on daily kick-off. - Shorter briefings and longer work hours for less turnover of jobs between shifts.	- Kitted tools and materials. - Set-up fixtures, and specialized lifting & handling rigs.	- Machining fixtures and detailed set-up instructions.	- Dedicated flow lines, set-ups eliminated with use of permanent fixtures.
Work-in-process controls	- Establish WIP limits for number of open jobs per supervisor.	- Established WIP limit of 11 components for pulsed production line.	- Established WIP limits with strict buffer capacities.	- Physical limitation to WIP allowable between production processes.

High-Variability Lean Methods ⟷ **Low-Variability Lean Methods**

Figure 2.17 – Lean Methods for Developing Just-in-Time Production

Lean Methods to Develop Built-in-Quality in the Remanufacturing Context:

In considering the application of lean methods to developing built-in-quality, the lean concepts of simplified technical instruction, error-proofing, integration of technical support, and andon were examined. Figure 2.18 summarizes application of lean methods to develop built-in-quality in each of the four cases.

<u>Simplification of technical work instructions and processes:</u> In Type IV remanufacturing, lean methods effectively eliminated technical instructions, except in rare instances of irregularities from standard work. In Type III remanufacturing, the most impressive simplification of technical instructions, contingent repair instructions were created, authorizing immediate technical resolution to common failure modes. In the Type II case, the zone coordinate system what was established was transformational to the condition assessment process with its ease of communicating existing condition.

<u>Error-proofing; fixtures to achieve improved quality in processing:</u> Fixtures were created for both machining and material handling purposes. In Type II-IV applications, fixtures were created that significantly improved the overall quality of machining and reduced the likelihood of accidental damage during transport. In Type I applications, variability of product and process was so high that error-proofing efforts did not make a significant impact beyond methods to better handle components in shipment.

<u>Integration of engineer to production process:</u> Integration of the engineer into the production process is seen as the counterpart to simplification of the technical

instructions. In Type III and Type IV applications, paperwork was simplified to the point the engineer does not play an integral part of production. However, in Type I and II applications, the engineer was considered of vital support to production. In the Type I case, the engineer carried a pager at all times and was to be able to provide near immediate support to any production team.

Andon system: Andon support systems played a major role in Type I and Type III case studies, yet each was very different from what would be seen on a Toyota assembly line. In the Type I case, andon existed as phones strategically placed throughout the work site with a direct line to an engineering support desk. In the Type III case, andon took the form of a simple flag in a highly visible part of the shop, identifying the requested support. In the Type IV case, the production process was so visual and engineering and planning support was so close by, that an actual andon system was not used.

Lean Methods for Developing Built-In-Quality

Lean Tools & Techniques:	*Type I* *Ships Hull Remanufacturing*	*Type II* *Propulsion Shaft Remanufacturing*	*Type III* *Large Valve Remanufacturing*	*Type IV* *Transducer Remanufacturing*
Simplification of technical work instructions and processes	- None, working towards a computerized tablet to simplify contingent instructions.	- Developed critical dimension worksheets and established zone coordinate system for component surfaces.	- Established critical dimension worksheet and pre-engineered contingent repair instructions.	- Eliminated technical paperwork entirely, unless exceptions found to standard work.
Error Proofing: fixturing to achieve improved quality in processing	- Fixtures created to improve material handling of components.	- Fixtures created to improve material handling and setup accuracy.	- Fixtures created to improve accuracy in assembly and machining processes.	- Fixtures established to error proof machining and assembly processes.
Integration of Engineer to production process	- Engineer always in the work zone with pager for instant access, as needed.	- Engineer assigned directly to small work team, available upon request.	- Engineer on the shop floor, supporting multiple product lines.	- Engineer assigned to shop, primarily working process improvement initiatives.
Andon System	- Phone "hotline" to engineering trouble desk located at several points in work area.	- Process manager and planner available for support, as needed.	- Visual signal located in highly traversed area identifying specific support needed.	- None. Workers see WIP build up and surge to resolve issues immediately. Shop engineer and planner dedicated and available.

High-Variability Lean Methods ⟷ **Low-Variability Lean Methods**

Figure 2.18 – Lean Methods for Developing Built-in-Quality

CIM REMANUFACTURING CONCEPTUAL ANALYSIS

The discussion thus far has focused on the application of lean production tools and techniques in the remanufacturing context. Yet, for the tremendous benefits lean has produced in a number of industries, it is not the only modern production methodology recommended for its dramatic improvement over traditional mass production. Computer integrated manufacturing (CIM) and flexible manufacturing systems (FMS), are additional techniques which have been popularized in recent decades. (Daft, 2004)

This section chronicles one example of application of lean production and CIM to the same product and process - large valve remanufacturing. The large valve (Type III) lean remanufacturing case study occurred between 2002 and 2005. In 1995 a high-technology government research facility approached the shipyard about deployment of CIM to the same process of large valve remanufacturing. The research facility had experts in CIM and had successfully deployed these techniques with other clients. A detailed implementation proposal was written, however, the CIM implementation (projected at $2M in cost) was never funded.

Interestingly, the 1995 proposal discussed the [then] current conditions of excessively long cycle times, inability to meet schedules, and challenges associate with poor quality. The researchers highlighted bottlenecks of technical instructions in response to condition assessment and machining due to non-dedicated resources. From this report, as well as interviews with employees in the work area, the process experienced little change in the seven years between the CIM proposal and lean remanufacturing implementation.

In studying the CIM implementation proposal, the primary objectives were to: 1) improve processing speed and quality of information at the condition assessment process, and 2) utilize information technology systems to improve decision making and data storage throughout the entire valve repair process. Elements of the proposed implementation included:

- *Computerized technical work documents*: Laptop computers were to replace paper technical work documents. Computerized technical instruction would hold all checklists, procedures, and additional required information such as technical drawings and blueprints associated with large valve remanufacturing. Data would be input by mechanics and uploaded daily to a central database.
- *Coordinate Measuring Machine:* A coordinate measurement machine (CMM) would be acquired and utilized to improve the accuracy of the measurement process (part of the condition assessment procedure), which was currently done by hand.
- *Parts tracking via bar code system:* A bar code scanning system was to be established for tracking all parts used in large valve repair.
- *Automated parts storage system:* A large storage system was to be built in the large valve production area to store all valves and associated parts, e.g., replacing the manual pallet rack system.
- *Automated machining:* Valve data from the CMM was to be input and large pallet fixtures were to be created such that setup in the CMM and for machining could be improved.

- *Pre-engineered repair instructions:* Historical failure modes and common repairs were to be evaluated and analyzed so that standard repairs could be prescribed and mechanics could be empowered to execute.
- *Rapid manufacturing part production cell:* Utilizing a CNC Lathe, unique parts could be rapidly manufactured to support assembly.

The overall objectives of the study were identified as cutting cost and cycle time, while improving quality and overall efficiency. These initiatives would likely have improved performance in large valve remanufacturing. Interestingly, the CIM improvement methodology differed significantly from that of lean remanufacturing, which also dramatically improved upon current performance at far less cost.

Ultimately, the lean application was implemented effectively, and became very successful. This is not to say that lean better than CIM, and in fact CIM could be part of a lean solution. It does suggest that when a particular technical solution is forced onto a process it can actually do more harm than good.

CIM REMANUFACTURING CONCEPTUAL ANALYSIS DISCUSSION

The conceptual analysis of proposed CIM and actual lean production in the large valve remanufacturing context provides an interesting opportunity to compare two popular production methodologies. This discussion will review differences in lean, CIM, and traditional mass production along several operations management dimensions, and earlier research conducted with regards to CIM and the previously discussed product-process matrix.

Comparison of Large Valve Remanufacturing: Mass, CIM, Lean Perspectives

The proposed methodology of CIM and actual implementation of lean production in large valve remanufacturing are compared with conditions before introduction of lean methods in Figure 2.19. The rows in this figure are dimensions of operations management, including: production strategy, inventory strategy, process flow, utilization of technology, employee engagement, and inter-departmental communication. Many dimensions of operations management could have been used in the comparative study; however, it was believed these dimensions would best illustrate key differences in production philosophy and implementation.

Dimensions of Operations Management	Traditional Mass Production (2002)	Computer Integrated Manufacturing (Proposal - 1995)	Lean Manufacturing (2005)
Production Strategy	Optimize utilization of resources.	Optimize processing speeds. Leverage information for better and faster decisions.	Create continuous flow. Reduce WIP.
Inventory Strategy	Inventory strategy is subservient to optimize utilization of resources	Utilize automated retrieval system for interchangeability	WIP reduction is a methodology for pressuring production process.
Process Flow	Stove-piped as they evolve over time	Production Cells developed around equipment and technology.	Production Cells developed around process flow.
Utilization of Technology	"technology" exists with skilled laborers	High "technology" leveraged to improve processing time and information flow	"technology" utilized at points to enable flow
Employee Engagement	Workers execute instructions per engineer instruction or manual	"Experts" brought in to deploy technology	Cross-functional teams engaged to improve processes
Inter-Departmental Communication	Stove-piped, confrontational communication	Improved communication through IT tools	Improved communications through templates & visual controls

Figure 2.19 – Mass, CIM, and Lean Large Valve Remanufacturing

The traditional mass production perspective has the strategic objective of optimizing the utilization of resources, particularly the valuable time of production mechanics and expensive equipment and an emphasis was placed on management to keep production going at all times. Inventory strategies were secondary to the need to maintain full-utilization of resources. Process flow was highly stove-piped, particularly in recognition to the evolution of the physical plant over time. New machines had largely been placed where there was available space, with little thought for sequential process flow, as long as each machined could maintain high utilization. High technology was used sparingly in the process; rather, technology was inherent in the craftsman skills of the experienced mechanics. Production workers in the large valve remanufacturing process were not engaged in improvements, nor had they ever been engaged. Historically, process engineers, process planners, shop process managers, had worked as technical subject matter experts in all improvement initiatives. Inter-departmental communications, primarily communications between the production shop, technical engineering, and support production shops (quality, lifting & handling, etc.), were functionally stove-piped and at times confrontational. Each group was measured independently using a unique set of measurement criteria. In some instances these measurement criteria were not in full alignment with resource needs of the large valve remanufacturing operation.

The CIM proposal was centered upon the production strategy of optimizing processing speeds with advanced robotics and leveraging information technology systems for better and faster decisions in the component analysis process. The inventory strategy for CIM implementation was based on the utilization of the automated retrieval system. The automated retrieval system had an extremely large storage capacity, such that large quantities of valves and valve parts could be stored for possible utilization in the future. The proposed automated retrieval system was state of the art in its capacity and ability to rapidly store large quantities of inventory. The new system was designed by the experts from the external government agency and internal manufacturing engineers, with little input from production employees. It was anticipated that inter-departmental communications would have been improved as a result of information technology tools, specifically in that less face-to-face interactions between engineering and production would need to occur as the data exchanges were done electronically.

The implementation of lean methods within large valve remanufacturing focused on the production strategies of reducing work-in-process and creating continuous flow of components. During this deployment, inventory levels were seen as a mechanism for pressurizing the production process and driving process improvement. Production cells (receiving, disassembly, machining/repair, and re-assembly/test) were developed around the process flow. High-technology was not used in implementation; however, new technology was used in the form of an upgraded wash machine and epoxy repair process. Improvements and redesigns of the process were conducted by cross-functional teams of production employees, technical engineers, external lean experts, and other support personnel. Inter-departmental communications improved dramatically through a simplification of information to be communicated, the use of standard work instructions and templates, and visual control boards.

Lean and CIM in the Product-Process Matrix:

In earlier discussions the Product-Process Matrix was used to link production methodologies, on various degrees of technical complexity and context. It was suggested PPM trade-offs between flexibility and efficiency have become somewhat outdated in today's environment of point-and-click design of laptops and customized clothing at low costs. A 1988 study by Paul Adler identified that CIM, developed long after the PPM model was first published, broke away from the assumptions of the PPM required trade-offs. According to Adler, CIM offered new production possibilities capable of marrying efficiency and flexibility at the same time. This occurred through the use of highly flexible robotics, advanced information systems, and automation of equipment. In his study, Adler proposed a new efficiency frontier of the PPM for firms utilizing CIM; one "flattened or bowed out to the left". This failed adherence to trade-offs was similar to the discussion earlier in this paper regarding lean production. As shown below in Figure 2.20, lean manufacturing and CIM offer a similar new operational efficiency frontier to the PPM. The implications of this discussion for an organization utilizing production principles of lean manufacturing or CIM is to suggest that low-volume, standard parts can be produced efficiently with near continuous flow.

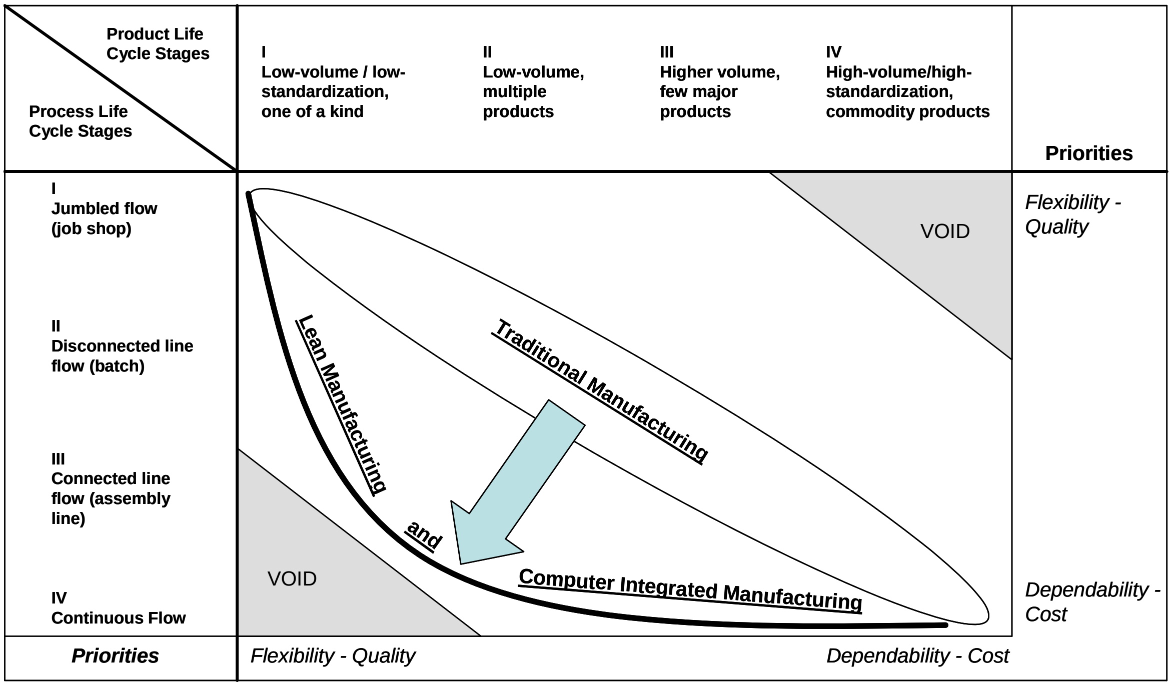


Figure 2.20 – New PPM Efficiency Frontier created by Lean and CIM (Adler, 1988)

Comparison of Organizational Design Characteristics:

Taking a broader look at characteristics of organizational design between mass production, CIM, and the Toyota Production System (lean), a summary of organizational characteristics is shown in Figure 2.21.

	Mass Production	Computer Integrated Manufacturing	Toyota Production System
Span of Control	Wide	Narrow	Narrow
Hierarchical Levels	Many (Coercive)	Few	Many (Enabling)
Tasks	Routine, Repetitive	Adaptive, Craftlike	Routine, Repetitive
Specialization	High	Low	Moderate-High
Decision Making	Centralized	Decentralized	Decentralized with Clear Boundaries
Overall Structure	Bureaucratic, Mechanistic	Self-Regulating, Organic	Bureaucratic, Organic
Interactions	Stand Alone	Teamwork to Operate Machines	Teamwork to Continuously Improve
Training	Narrow, One Time	Broad, Frequent	Broad & Specialized, Frequent
Expertise	Manual, Technical	Cognitive, Social, Solve Problems	Cognitive, Social, Technical, Solve Problems
Technology Investment	Medium	High	Medium (Simple, Slim, Flexible)
Ideal Batch Size	High	High	Low

Source: Mass Production, Nemetz & Fry, 1988; CIM, Adler, 1988.

Figure 2.21 – Organizational Design Characterization of Mass, CIM, and Lean

As previously discussed, CIM and lean each enable the production of low-volume components with efficiencies approaching assembly line flow. However, their organizational design methodologies are very different. TPS and CIM encourage a narrow span of control by each level of management, while mass production proposes a wide span for extensive control. CIM promotes few hierarchical levels of organization; TPS and mass production propose many. However, as documented by Adler and others, TPS has successfully achieved an enabling infrastructure of hierarchical bureaucracy, as opposed to a traditionally coercive organization. Within TPS and mass production, tasks are generally routine and repetitive, while CIM recommends adaptive and craft-like tasks to promote learning and teamwork.

Specialization of production is low in CIM, moderate-high in TPS, and high in mass production. In parallel, decision making is decentralized with CIM, centralized with traditional mass production, and decentralized with an emphasis on clear boundaries within TPS. CIM encourages a self-regulating and organic organization structure; mass production recommends a mechanistic bureaucracy, and TPS successfully creates an organic bureaucracy. Both CIM and TPS encourage teamwork, though in TPS the objective of teamwork is for processes to continually improve, in CIM teamwork is intended to effectively operate machines.

Training within CIM is broad and frequent, while mass production generally deems training as unnecessary, recommending it be narrow and one time only. In a TPS environment, training should be frequently given, and both broad in terms of general technique and specialized for particular application. TPS values cognitive, social, technical, and problem solving expertise. Mass production values manual and technical expertise. CIM values cognitive, social, and problem solving expertise. CIM promotes investment in technology, while TPS and mass production do not place specific emphasis on this. TPS in particular encourages technologies that promote simplicity and flexibility in production. The ideal batch size for efficient operation is high in both CIM and mass production; lean is built upon the concept that small batch size is ideal to promote flexibility.

CONCLUSIONS

This chapter began by asking whether lean production tools and techniques apply in the remanufacturing context. The answer, "yes." However, this discussion and the case studies from four unique lean remanufacturing contexts reveal complexities underlying the original question and in answering it. The remanufacturing industry is complex and diverse, defying simple generalizations of one problem or one best solution. In some instances, such as that of the Type IV case study, remanufacturing has many close parallels to a traditional high-volume manufacturing process. In some instances, such as the Type I case study, remanufacturing is as complex and variable as any process found in original manufacturing. However, a key to effective application of lean methods in remanufacturing is to understand the operational context under consideration.

This chapter examined assumptions underlying the product-process matrix, and implications of new production methodologies such as lean manufacturing and computer integrated manufacturing. Comparing applications of CIM and lean to large valve remanufacture provided a unique comparison of two popular "transformational" methods of production. The following conclusions can be drawn from the four case studies of lean remanufacturing, conceptual analysis of lean and CIM, and their discussion:

- *The remanufacturing context is very broad and diverse*: when discussing advanced manufacturing concepts with leaders in the remanufacturing industry, leaders may say these concepts do not apply in their industry due to inherent variability of every component as a result of incoming conditions. This response over simplifies the remanufacturing context as a whole. Remanufacturing exhibited extreme diversity across the four specific case studies. In the same ways contingency theorists adapted economies of scale and mass production thinking to applications varying from job shop production to continuous flow production, we must offer the remanufacturing industry the same considerations.

- *Lean methods do apply in all instances of remanufacturing, but specific solutions must be tailored to specific context regarding characteristics of product variability:* In the case of high-variability lean remanufacturing: the buffers will be bigger, parts supermarkets will get broader, engineers will be more integrally involved, fixtures will be less specialized, and cross functional teams will support each other to address variability in production processes. In the case of low-variability lean remanufacturing, the process may closely resemble applications of lean tools found in a traditional manufacturing organization: technical instructions will be simplified, one-piece flow will occur, materials and tools will be kitted to precision, andon signals will be responded to immediately, specialized fixtures will improve quality and reduce setups, and multi-skilled workers will continuously improve processes to achieve takt time.

- *Lean actually moves a production process within the PPM space; mainly along the process axis, allowing flexibility and efficiency simultaneously*: the product-process matrix has been a highly valuable tool for examining the alignment of an organizations production methodology to the application context. However, this model has generally been used as a static descriptor of an organizations alignment with technology and product, with little explanation of how to move towards a more appropriate "fit" between product and process characteristics. These case studies show that implementation of lean methods can move a production process within the PPM space, in the direction of continuous flow.

- *Lean manufacturing mitigates the production trade-off between quality and cost; volume and variety; efficiency and customization:* The PPM is grounded in economies of scale production paradigm, suggesting a required tradeoff exists between quality/customization and output/efficiency. However, in examining the PPM, lean methods offer a new set of efficient production options, such that a tradeoff is not required between the key variables.

- *Lean manufacturing techniques work effectively to create improved performance in the remanufacturing context*: The four case studies represent a much larger number of remanufacturing processes to which lean tools were applied. In each of the four cases the application of lean methods produced significant performance improvements, particularly in developing internal process stability, just-in-time production, and built-in-quality. It is further believed that despite the tremendous improvements that were recognized in each of these cases, still far greater opportunity for increased efficiency and productivity exists.

- *Lean, CIM, and advanced mass production are different "production paradigms:"* Today's operations management theory teaches the tremendous benefits from modern production techniques such as advanced mass production, CIM, and lean manufacturing. In some instances, particularly that of CIM and lean, the resultant flexibility and quality of production may lead to improved results. Yet, these methodologies diverge in application, so much so that they must be considered as different production paradigms, and possibly even divergent production paradigms. In considering the case study of lean and CIM in large valve remanufacturing, it is not believed the thinking behind these paradigms, while each effective in their own right, and could have complemented each other successfully. Figure 2.22 illustrates the divergent paths of lean, CIM, and advanced mass production. While each is considered an improvement upon traditional production paradigms, the slope of improvement differs. It should be noted that this is an observation based on a few case studies and not a rigorous large scale study. Moreover, there are many examples of companies like Toyota that deploy lean methods and use advanced manufacturing technologies as one would see in CIM implementations. The difference is the way Toyota focuses process improvement on first simplifying the process and eliminating waste with minimal new technology, then applying the technology very selectively where it fits the best. It is an experimental, learning process (Liker, 2004).

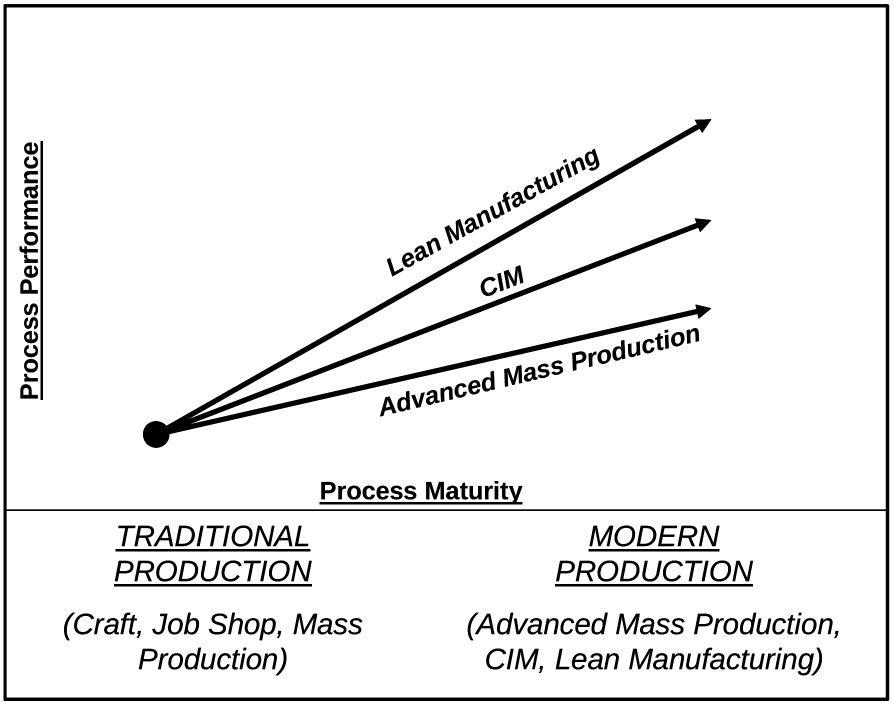


Figure 2.22 – Traditional and Modern Methods of Production

- *Mass production and CIM take a mechanistic view, while lean takes an organic view:* as previously discussed the modern production methodologies of lean, CIM, and advanced mass production offer improvements and efficiencies over traditional production. However, a closer examination of the structural characteristics used to achieve these improvements suggest a mechanistic application (and perhaps over-reliance) on technology in CIM and advanced mass production, while lean is more organically driven by production employees.

- *A tremendous opportunity exists to apply lean production methods to the generally immature remanufacturing industry:* The introduction noted that remanufacturing has been considered as "the next great opportunity for boosting U.S. productivity" and "the ultimate form of recycling." This paper has shown the potential for lean production methods to play a significant role in this important environmental and economic opportunity.

ACADEMIC CONTRIBUTIONS

This chapter has sought to answer the specific question of lean production design in the remanufacturing context. As a result of this study, several key contributions have been made to the academic literature in the areas of lean manufacturing, organizational design, and organizational change. The following contributions to academic literature in these areas have been made:

- Improved understanding of the mechanics by which organizations are able to use processes and technology to move within the PPM space and achieve greater efficiency.
- Modified the PPM to create a framework for characterization of remanufacturing processes, this enables a theoretical linkage between OEM and remanufacturing.
- Utilized the PPM to develop an advanced understanding of the ways in which new production paradigms of CIM and lean manufacturing relate with regards to both process and outcome.

FUTURE RESEARCH

This chapter analyzes the application of lean production tools and techniques within the remanufacturing context. The perspective has been a largely static perspective, simply considering ways in which lean methods apply to the specific remanufacturing context.

Lean remanufacturing has been shown to exhibit tremendous flexibility and potential. Following socio-technical contingency theorists who suggest an organization must first define its technical core and subsequently develop the organizational structure to support technology; this paper has initiated a study of lean production techniques in the remanufacturing context by examining the application of lean production tools and techniques. However, the mechanisms by which an organization can effectively deploy these techniques have not been studied.

Future research must examine techniques by which an organization can effectively deploy these concepts with equal appreciation for social and technical considerations. Additionally, future research should explore the mechanisms by which a large multi-site bureaucracy (similar to most large U.S. enterprises) can develop and sustain an organizational transformation aligned to the tenets of lean production. Finally, remanufacturing is an interesting and unique context to apply lean production tools and techniques. Other similar context exist, such as the health care industry, research and design environments, and lean methods as applied in daily living.

CHAPTER 3

COMPARATIVE CASES OF LEAN MANUFACTURING DEPLOYMENT: ORGANIC VERSUS MECHANISTIC APPROACHES

INTRODUCTION

Many organizations worldwide are pursuing deployment of continuous improvement strategies aligned to the principles and practices of lean manufacturing, based on the Toyota Production System. Many have had some success in attempts to emulate practices of waste elimination, empowerment of employees, and continuous improvement, however, far more have struggled in their attempts to deploy lean manufacturing. Many organizations have experienced early successes at deployment, but little long-term growth and sustainment. This chapter seeks to understand this specific phenomenon by analyzing organizational deployment of lean manufacturing at two large industrial organizations over a six-year period. The two organizations started out with very different approaches to lean deployment, one which is characterized as "mechanistic" and the other "organic." Each organization experienced a mix of successes and failures, ups and downs, crises and regrouped successes. Ultimately, the approaches began to converge as the two learned from each other. For this paper, the level of analysis is an individual industrial facility; specifically two naval ship remanufacturing depots are compared and contrasted. This level of analysis would be similar to comparing two automotive production plants, the field activity offices of a larger organization, or independent divisions of a large corporation. Chapter four of this dissertation looks at the transformation of the larger, connected enterprise of which these two cases are a part.

One common reason organizations struggle in their efforts to implement lean manufacturing is a failure to understand and appreciate both the social and technical aspects of successful deployment. Lean manufacturing is identified for its socio-technical nature; effective implementation is shown to require a change of both organizational processes (technical) and organizational culture (social). The culmination of this socio-technical deployment is the learning paradigm of lean manufacturing, which has led it to be defined by some as the "thinking production system." (Liker, 2004)

This chapter builds on distinctions in organizational design between organic and mechanistic structures. These terms were first used by Burns and Stalker (1961) in their studies of formal structure and control within organizations. Organic is flexible and free-flowing in nature, while mechanistic is rigid and controlling. Their study identified environmental characteristics favoring different mixes of internal organic and mechanistic characteristics. Burns and Stalker addressed the static state of an organization, not the dynamic deployment process for a change in management methods. This paper extends the conceptual distinction between mechanistic and organic approaches of management structure to the organizational deployment of lean manufacturing.

An organic and mechanistic approach to organizational design exists at the very heart of how an organization makes decisions, and how it reacts to internal and external changes. Mechanistic management thinks of the organization as a technical entity with simple cause and effect relationships; find the right levels of inputs and the desired outputs will follow. Management structure, strategy, and organization could be considered as gears of a machine to be measured, adjusted, altered, and realigned within an organization. A mechanistic approach to lean deployment would be characterized by rules, procedures, and a clear hierarchy of authority. This would involve formalized organizational rules and structures to implement lean based on centralized, top-down decision making. Lean would be perceived as a set of tools to be deployed, and would create a bureaucratic process for deployment driven by training, close measurement of results, and formal process controls. Implementation would likely involve a rigid implementation strategy, comprehensive roles and responsibilities, certifications of training capability, and metrics associated with speed of deployment. Outcomes would be measured to assess return on investment for specific lean tool deployment. Since specific lean tools are taught to a small number of "experts" and deployed broadly across the organization, a mechanistic deployment could quickly disseminate the tools to a wider audience (Liker and Meier, 2006).

An organic organization seeks to learn, evolve and adapt to internal challenges and the external environment. This type of organization considers internal "workings" as living, breathing cells that constantly grow and adapt inside of the larger body, as opposed to the rigidity of gears and optimization. Organic organizations do not assume that any one formula for management is optimal. Rather, they continuously search for growth and balance at all levels of the organization. An organic deployment of lean manufacturing would be loose, free-flowing, and adaptive in nature. In this type of organization, rules and regulations are often not written down, and when written they are selectively interpreted and adopted. In this type of deployment individuals are given more freedom to experiment and learn what works and does not work. Organizational hierarchy is less structured, and decision-making authority is decentralized. These characteristics may manifest themselves in a lean deployment based in equifinality (more than one path to success, an element of Open Systems analysis) and evolutionary learning. (Nadler and Tushman, 1997) As opposed to the rank or certification of the individual as a "lean expert," individual expertise and skill sets are likely to be more valued as the organism takes advantage of unique talents of personnel. Lean deployment would focus on deep learning team by team, rather than on rapid deployment of tools based on a preset formula. Compared to mechanistic deployment, organic deployment would be slower and more methodical, quickening in pace as the organism strengthens its internal "muscles" of change.

Both the mechanistic and organic approaches to lean manufacturing deployment have advantages. A mechanistic approach includes an internal strength of infrastructure and rapid deployment of top-down goals; whereas an organic approach results in an ability to adapt and learn in a changing environment. Is one approach to deployment better than the other? In their study of formal structure within an organization, Burns and Stalker argue the answer to this question is contingent upon environmental uncertainty. Organizations become more organic as environmental uncertainty increases and more mechanistic as it decreases. This paper seeks to understand lean manufacturing policy deployment in order to distinguish between an organic and mechanistic deployment strategy, to understand the benefits and challenges of each, and to identify the most appropriate fit for different environmental circumstances.

RESEARCH METHODOLOGY

This paper is a comparative case study, the culmination of six years of research and observation of lean remanufacturing deployment within the naval ship overhaul and repair industry. Over the six years, a total of four large industrial organizations were observed in this industry. This paper will focus on two of these organizations. The cases were selected for their contrasting methodologies of lean manufacturing deployment, as well as accessibility of data. (Yin, 2002) These two organizations, referred to here as "Small Ship" and "Big Ship," are loosely aligned as industrial entities in a large naval ship repair organization, REMAN. Their association relative to each other is as both partners and competitors within the same extended organization. They are partners in that they are aligned to the same organizational management hierarchy and serve the same mission, including teaming, sharing of resources and lessons learned. They are competitors in that they are judged as individual entities and each desires to be regarded as the leading ship repair depot. Thus, when they developed different strategies and ideologies of lean, they each struggled to win in pushing their approach to become the standard for the extended organization. Figure 3.1 summarizes the research methodology: the study design, data and interview sources.

	Research Methodology
Study Design:	*Comparative Case Study of Two Organizations*
Data Sources:	*Participant Observation, Direct Observation of Lean Deployment, Extensive Interviews with Key Personnel, Review of Documentation and Reporting, Archival Records of Implementation*
Interview Sources:	*Corporate Management, Site Management, Shop Management, Line Management, Production Workers, Production Analysts, Lean Manufacturing Deployment Team*

Figure 3.1 Research Methodology

Data presented in these case studies are collected from multiple site visits over a six year period. Data sources include direct observation, extensive interviews, and review of documentation and archival records. A total of more than 50 site visits to Small Ship and Big Ship contributed to the development of this paper. Participant observation was facilitated by the author being an employee with responsibility for lean deployment. In addition, about 40 hours of formal interviews were conducted with personnel from "REMAN" (corporate management), site management, shop management, line management, production workers, production analysts, and the lean manufacturing deployment team at both Small Ship and Big Ship. The support of the REMAN in this study is acknowledged, however, for the sake of confidentiality, no specific organizations or individuals are identified.

THEORETICAL DISCUSSION

Lean manufacturing, the principles and practices of the Toyota Production System, is a production system identified worldwide for its ability to efficiently deliver customer value by the reduction of process lead time and elimination of waste. The Toyota Production System was first brought to the forefront of manufacturing strategy in the landmark study of global automotive manufacturing by the International Motor Vehicle Program at MIT, documented in The Machine that Changed the World. (Womack, Jones, and Roos, 1990) In this study, lean Producers were noted for their ability to produce with roughly half the human effort in the factory, half the manufacturing space, half the tool investment, half the engineering hours, and half the time to develop new products as compared with non-lean competitors. Today, lean manufacturing is being deployed in industries as diverse as health care, defense, home construction, restaurants, and rental cars as a methodology for achieving greater efficiencies, cost reductions, quality improvements, and flexibility of workforce. (Womack and Jones, 1996)

Lean manufacturing has been interpreted in light of the socio-technical systems approach to manufacturing (Liker, 2004). It integrates technical tools (waste elimination, just-in-time production, standardized work, workplace organization, pull systems) with social organization tools (problem solving, built-in-quality, teamwork, voice of the customer, continuous improvement). With research beginning in the mid-1980s, the Toyota

Production System has been studied extensively as a manufacturing system. Through follow-on research lean manufacturing has been shown to apply successfully in a wide variety of non-traditional manufacturing, service, and “white collar” applications. Despite an extensive understanding of the principles and practices of lean manufacturing, a majority of companies have failed to successfully deploy the methodologies. Deployment strategies for lean manufacturing have not been examined in great detail, in large part due to the difficulty of obtaining data over an extended deployment. In light of many failed organization-wide attempts at deployment of lean manufacturing, deployment is a critical element that must be examined further.

Organic and Mechanistic Deployment Methodology

One dimension that can be used to characterize the methodology for deployment of lean manufacturing is that of organic and mechanistic, borrowed from theories of organizational design. This theory identifies organizations by their degree of formal structure, characterizing them as either “mechanistic” (rigid, high formalization, machine-like) or “organic” (flexible, low formalization, living-evolving organisms). (Burns and Stalker, 1961) A similar construct can be used for classifying deployment of lean manufacturing. Organic and mechanistic deployment approaches to lean manufacturing are summarized in Figure 3.2 with a set of six variables describing the scope and objective of deployment.

Scope and Objective of Lean Deployment:

The scope and objectives of lean deployment are described by a set of variables addressing how the organization defines success and how this definition translates into the initial deployment approach. Mechanistic or organic tendencies lead to divergent perspectives on how an organization should be structured. These perspectives underlie different reasons for implementing lean manufacturing. Mechanistic and organic deployment strategies to lean manufacturing are summarized below according to the dimensions: key to successful deployment, scope and objectives for both initial and long-term deployment, and key performance indicators of success.

	Mechanistic Deployment	Organic Deployment
Key to Successful Deployment:	*Efficiency*	*Effectiveness*
Scope of Initial Deployment:	*Broad, Shallow*	*Narrow, Deep*
Scope of Long-Term Deployment:	*Broad, Shallow*	*Broad, Deep*
Objective for Initial Deployment:	*Bottom-Line Results*	*Organizational Learning*
Objective for Long-Term Deployment:	*Sustainable Lean Results*	*Learning Organization*
Key Performance Indicators:	*Cost Reduction*	*Waste Reduction*

Figure 3.2 Scope and Objective of Lean Deployment

Mechanistic deployment seeks to achieve success through the overall efficiency of deployment. In other words, a strategy and structure for deployment are created and a successful deployment is one that deploys resources to the strategy and structure efficiently. Due to the highly-structured nature of deployment and focus on overall efficiency of deployment, a mechanistic approach is able to touch a broad cross-section of the organization. However, it tends to be shallow in depth as resources are so widespread. A mechanistic approach to deployment seeks consistency across the organization. For an organization with an existing mechanistic infrastructure, a mechanistic deployment of lean manufacturing would seek to “grease the gears” of its internal workings not to change the internal workings, but to make them operate more smoothly and efficiently. In a mechanistic deployment bottom-line results are the initial objective for lean deployment, with sustainable efficiency and cost reduction as the long-term objective. In considering a mechanistic deployment, key performance indicators of cost reduction are tracked closely. As previously mentioned, efficiency among the gears of a mechanistic organization is the primary objective for deployment and therefore the primary measure of success.

Organic deployment of lean manufacturing seeks to create a living, learning-organization. An organization with this perspective would consider a successful deployment to be achieved through the effectiveness of each interaction, the success or failure of each unique project. An organic deployment would start off far narrower in focus than a mechanistic deployment. Therefore, it is critical that each focused project be a success, since success cannot be gained through average results of a large number of projects. An organic deployment would initially seek a deep, focused penetration of Lean tools and techniques, initially narrow in focus, as a pilot or model of lean manufacturing, followed by a growing deployment to the larger organization in the long-term. An organic deployment of lean production would seek the short-term goals of organizational learning, developing a greater sense of internal operations and structures within. Whereas the short-term objective for organic deployment is organizational learning, the long-term deployment objective would be a "learning organization", as defined by Peter Senge (1990). The juxtaposition of "organizational learning" and a "learning organization" is compared with the focus on cost reduction and sustainment of those benefits in a rigid deployment.

A mechanistic deployment of lean manufacturing seeks rapid, widespread engagement of a broad organization, focusing on efficient delivery of the change implementation. An organic deployment on the other hand, seeks deeper understanding through focused pilot projects and models, with eventual diffusion of learning to the broader organization, with a focus on effectiveness of each unique project. One element of this deployment, reflecting back to the socio-technical nature of lean manufacturing, would be the depth of understanding of the social and technical principles of lean manufacturing. The depth of an organization's experience with lean over time is illustrated in Figure 3.3, considering both technical tools and techniques and social tools and techniques.

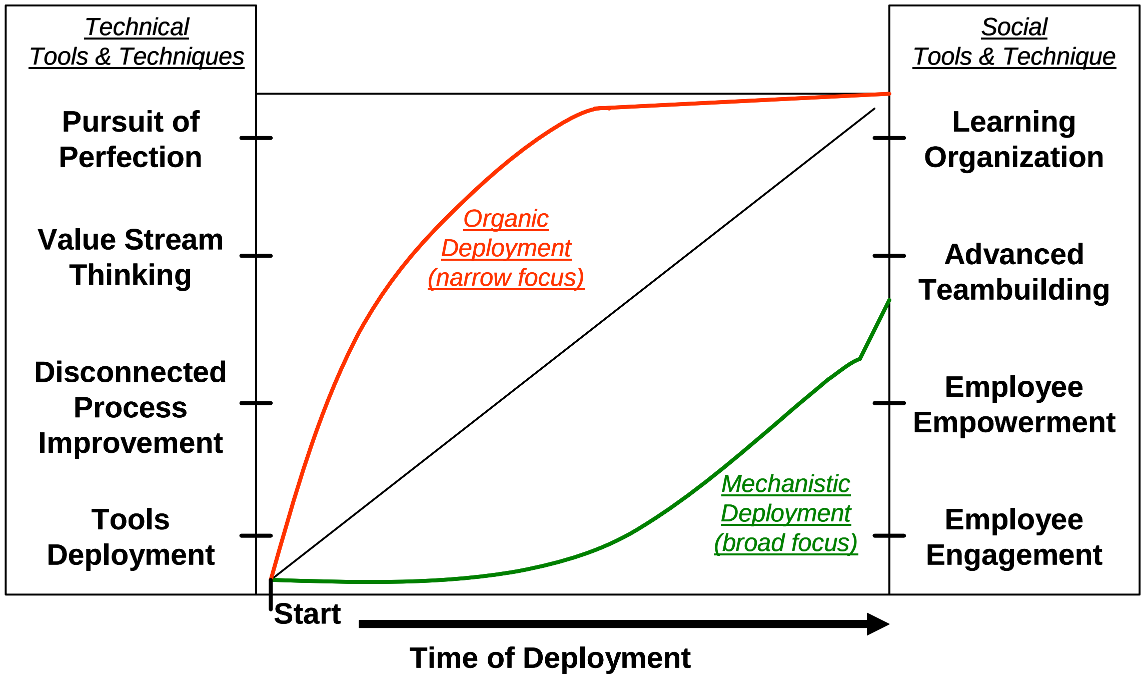


Figure 3.3 Depth of Deployment with Socio-Technical Tools & Techniques

The above figure considers depth of experience to technical and social tools and techniques of lean manufacturing for both an organic and mechanistic approach to deployment. The technical dimension of tools and techniques ranges from:

- *Tools Deployment*: a concerted effort to widely deploy 5S, standard work, production cells, or other singular concepts of lean manufacturing.
- *Disconnected Process Improvement*: an emphasis on kaizen events or rapid improvement workshops, improvement projects that are wholistic in their utilization of technical tools and techniques of lean, but disjointed in their overall focus to the organizational deployment or higher-order value streams.
- *Value Stream Thinking*: application of technical tools and techniques of lean manufacturing to re-orient processes and align all process improvements to improving end-to-end value stream processes.

- *Pursuit of Perfection* : the most mature application of lean tools and techniques; occurs as organizations are aligned to value creation along value streams and all individuals are working to improve strategic and non-strategic initiatives, all tied to a higher order policy deployment or hoshin planning.

The social dimension of tools and techniques ranges from:

- *Employee Engagement*: the first dimension of social transformation is the process of introducing employees to lean manufacturing and getting them involved, whether directly or indirectly, in the change process.
- *Employee Empowerment*: as the social constructs of the organization evolve, leadership becomes more trusting of employee ideas and feedback; employees take ownership of improvements and feel empowered to make continuous improvements.
- *Advanced Team Building*: the social evolution to where groups of employees are working productively as a unit for continuous improvement and synergistic production capabilities. A team lead would evolve, to build the truly embedded social organization for improvement and sustainment of lean deployment.
- *Learning Organization*: the evolution of an organization to the social evolution of employees at all levels working individually and in teams to learn and evolve improved processes aligned to higher order policy deployment or hoshin planning objectives.

As illustrated in Figure 3.3, mechanistic deployment, with an emphasis on rapid and widespread engagement, would ultimately lead to a shallow profile of depth of experience to both social and technical tools and techniques. Organic deployment, with a narrow and deep engagement, would have a steeper profile of experience to tools and techniques. However, they would be limited in scope in the early stages eventually broadening out across the organization.

The dimensions of social and technical experiences are not believed to be inter-connected. Rather, they follow the same deployment profile and would therefore be parallel in nature. As time progresses, an organic deployment would level off in experience, while a mechanistic deployment would deepen as select projects became more advanced and mature in their development. Shifting from a focus on the depth of organizational experience, we now consider the effects of organic and mechanistic deployment on the breadth and scope of organizational deployment. Figure 3.4 illustrates the breadth and scope of lean deployment over time/depth of deployment using each approach.

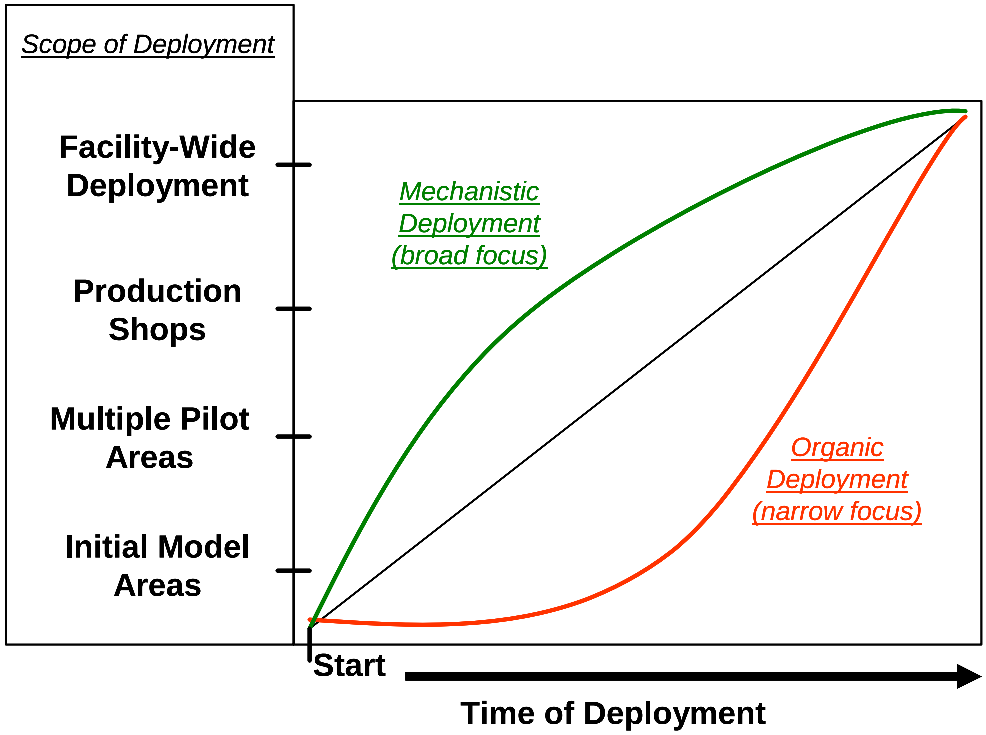


Figure 3.4 Breadth of Lean Deployment

Scope of deployment is characterized over time, moving from initial model areas of deployment, to multiple pilot areas, to production shops in entirety, and ultimately the entire organization. A mechanistic deployment rapidly impacts a broad scope of the organization with its rigid, consistent, and ideally efficient deployment strategy. An organic deployment on the other hand, is slower to impact a broad scope of the organization, yet over time will achieve a large segment. In some instances it may achieve the same breadth of a mechanistic deployment. Interestingly, the two figures of depth (figure 3.3) and breadth (figure 3.4) of deployment are inverted models of each other: mechanistic deployment achieving a shallow curve in depth, a steep curve in breadth; organic deployment achieving a steep curve in depth, a shallow curve in breadth.

Bureaucratization of the Lean Deployment:

A second set of key variables to lean manufacturing deployment is associated with the bureaucratization and formal infrastructure of lean deployment. Tied closely to the mechanistic and organic discussions of Burns and Stalker, the bureaucratization of lean deployment addresses the extent of written rules, policies, and guidance of the deployment, the ability of a deployment strategy to be tailored for specific environmental conditions, the location of lean expertise within an organization, strategies for deployment of lessons learned, and ultimately the organizational sustainment strategy in response to organizational entropy. Figure 3.5 summarizes both mechanistic and organic lean deployment along these dimensions.

	Mechanistic Deployment	**Organic Deployment**
Formalization of Infrastructure:	*High*	*Low*
Autonomy to Customize Process:	*Low*	*High*
Location of Lean Expertise:	*Centralized*	*Disbursed*
Strategy for Deployment of Lessons Learned:	*Audited Compliance*	*Knowledge Sharing*
Response to Organizational Entropy:	*Rules & Regulations*	*Continuous Improvement*

Figure 3.5 Bureaucratization of Lean Deployment

In mechanistic deployment, formalization of infrastructure is high, often in terms of written rules, regulations, procedures, roles and responsibilities, metrics, and deployment strategies. This would create a very rigid infrastructure and model of implementation. Autonomy of the customized process is low because success in a mechanistic deployment is considered to be achieved through efficiency of deployment. Therefore deployment is tightly controlled and monitored, with little autonomy granted for specific external conditions. The source of lean expertise is often centralized in a small change management group that oversees the deployment. This group of "experts" controls the training and deployment mechanisms for lean deployment; a challenge can be created in a mature deployment when the depth of understanding of the organization begins to eclipse that of the "experts." Strategies for deployment of lessons learned are rapidly deployed through written compliance letters with follow-on audits. The response to organizational entropy is the organization seeks to counter organizational entropy (an element of Open Systems Theory) through rules and regulations to maintain the new level of performance. (Nadler and Tushman, 1997)

An organic deployment is low in formalization of infrastructure - much flexibility exists in deployment to fit the specific environmental conditions and unique skill sets of the deployment team. Written rules and regulations are not common. If they exist, they are often ignored. A high degree of autonomy is vested with the change agent to tailor implementation needs to the specific environmental circumstances. Lean expertise within an organic deployment is dispersed amongst the broader workforce and learning of the organization and change agents involved in the model deployments. Lessons learned are not recognized so much as benefits to be replicated, as they are of lessons to be shared. Ultimately, an organic deployment seeks to consistently evolve to achieve continuing growth and learning. As such, organizational entropy is overcome through establishment of continuous improvement initiatives to continually drive performance, processes, and people forward.

Organic and Mechanistic Deployment: Visual Metaphors for Deployment:

The organic and mechanistic deployment approaches can be illustrated visually using concentric circles (mechanistic) and spirals (organic). Consider an organization where key organizational processes, work areas, or departments, are identified by the nodes shown below in Figure 3.6. Each node represents an opportunity for process improvement; the entire square represents the entire organization. The overall success of each initiative is illustrated by the area encompassed by a concentric circle or spiral.

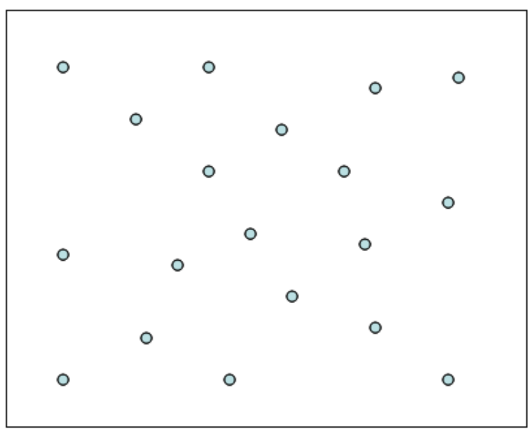


Figure 3.6 Key Organizational Processes

Mechanistic deployment as concentric circles: In Figure 3.7, mechanistic deployment is illustrated by concentric circles, each radiating outwards from a key organizational process or target area for improvement. As initiatives are successful, the size of the circle radiates out from the initial node. Concentric circles were selected for this illustration because a mechanistic approach would deploy a standardized set of specific tools with each initiative. It is simply a matter of success for each initiative. As can be seen in Figure 3.7, a mechanistic approach, with its broad scope, colloquially termed “inch-deep, mile-wide”, will impact many key processes at a time. As initiatives are successful, the size of the concentric circle will increase or decrease as a representation of the impact from deployment.

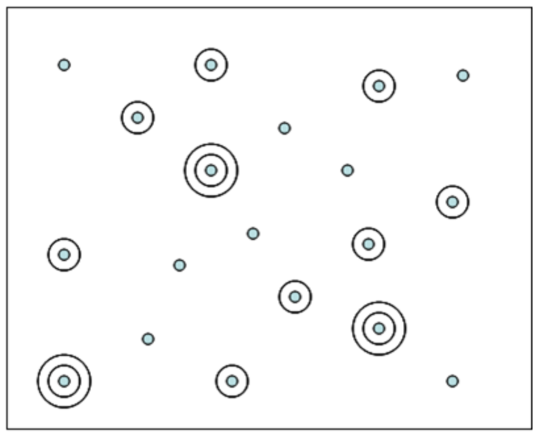


Figure 3.7 Mechanistic Deployment as Concentric Circles

Organic deployment as spirals: Organic deployment is illustrated in Figure 3.8 by spirals growing outwards from key organizational processes (as opposed to the concentric circles of mechanistic deployment). As the spiral grows outward it will impact more entities within the organization, resulting in knowledge sharing. Each turn of the spiral leads to an advanced level of implementation and learning. The organic deployment initiates with a small number of nodes, which are established as “models” of lean for the entire organization. This approach is colloquially termed “inch-wide, mile-deep”. As the success of the penetration of each model initiative goes deeper and deeper, the impact and benefit from those initiatives, and organizational learning gained from them, will have a direct and indirect impact on surrounding key organizational processes. At some point a broader cross-section of the organization begins to learn value stream thinking in pursuit of perfection as represented by the broader spiral that cuts across multiple processes.

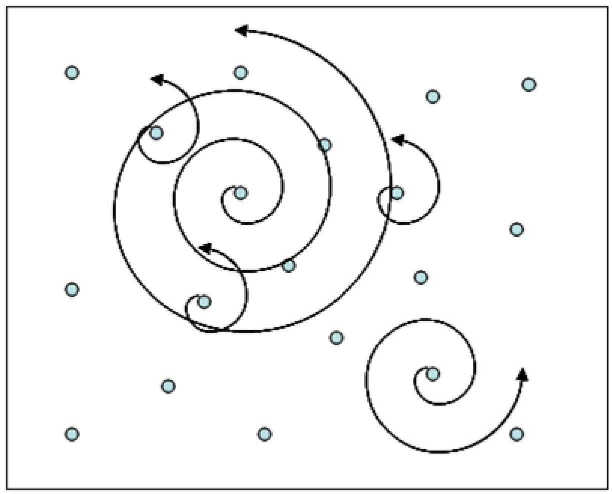


Figure 3.8 Organic Deployment as Spirals

Organizational Entropy: A final element of these illustrative models is the concept of organizational entropy, a core concept of open systems theory. Entropy suggests an organization, in the absence of a positive force, will seek its level of lowest energy. In many instances, this is identified by the pre-existing process conditions. Entropy is a force against which all change management and continuous improvement programs must battle in sustaining improvements. The specific parallel to the models of lean manufacturing deployment as spiral implementation (organic) or concentric circles (mechanistic) is that they are capable of collapsing to the original node. Even in a successful deployment of lean manufacturing, the laws of Entropy will apply. Without energy, commitment, and resources, the deployment can regress to a lower-energy state. In many instances, the regression can lead to original conditions, unless a new baseline level of organizational homeostasis can be developed by the socio-technical implementation. Achieving this new level of homeostatic requires continual energy from leaders who are deeply committed to developing a lean culture.

CASE STUDY ANALYSIS – A TALE OF TWO SHIPYARDS

Organizational Profile:

The two organizations compared in this chapter are large naval ship remanufacturing depots, identified here as Small Ship and Big Ship. The mission of these organizations is to maintain operational condition of a large fleet of super-sized naval vessels. Each of these organizations has a long and proud history, has an experienced and unionized workforce, a technically-expert management team, and an overall risk-averse culture. As previously mentioned, these two organizations are loosely aligned as both partners and competitors within the same operational arm of REMAN, their parent organization. They are partners in that they are aligned to the same organizational management hierarchy, serve the same organizational mission, and share resources and lessons learned. They are competitors in that they are judged as individual entities and each desires to be regarded as the leading shipyard. With regards to lean implementation, each organization had the same introduction, and their paths have fully paralleled each other chronologically. However, it has not always been a relationship of teamwork in deployment. Each organization has a different strategy and ideology with regards to lean. To some degree they are each a manifestation of the overall shipyard culture, but each organization has struggled to win out in pushing its approach to become the standard for the extended organization.

The first organization to be profiled in detail is the smaller of the two shipyards, referred to in this case study as Small Ship. Small Ship was an organization of roughly 4500 employees, and dedicated and to one major product line. The company is known for its independent thinking and entrepreneurial perspective to work. Small Ship had established itself as the expert within the naval ship repair environment in one focused product line. The shipyard has been shaped and hardened by multiple threats of closure due to a perceived excess capacity within REMAN. The shipyard has survived multiple close calls for closure, and this possibility constantly looms for the workforce, especially because REMAN leadership has shown a tendency to consider site closings roughly every ten years. The shipyard has survived largely based on its past performance and specialization, but powerful political powers exist both for sustaining the shipyard and closing the shipyard. Lean manufacturing was viewed as one strategy to better ensure their longevity. However, the organization is ultimately not trusting of outsiders and external initiatives.

The second organization profiled is the larger of the two shipyards, Big Ship. At the beginning of this case study Big Ship was an organization of approximately 7500 employees, and was dedicated to two major product lines. Big Ship is known for its progressive management strategies. Prior to lean, it had invested significantly in training of managers along tactics of Stephen Covey (leadership), Mark Graham Brown (metrics), and Malcolm Baldridge (quality). The organization, which is large and influential, has not experienced threats of closure such as Small Ship, or the distrust of external influences. Big Ship is closely aligned to REMAN's corporate initiatives and has regularly sought to exert influence over cross-shipyard directives and guidance. At the time of kick-off to lean deployment, the most significant management influence at Big Ship is that of the Baldridge Criteria and its use for management by corporate measurement and assessment as part of their "organizational effectiveness cycle".

Case Study Phases of Implementation:

Deployment of lean manufacturing at Small Ship and Big Ship differs greatly, and is captured in this comparative case study, which encompasses six years of deployment. The timeline for these two case studies is identical, beginning in 2001 and concluding in 2007. And while their paths are mostly unique and parallel, they do intersect at several points through communication, resource sharing, occurrences of joint-learning, and engagement of corporate management. These points are highlighted in the case study. In each instance, what began as a grassroots effort to become more efficient through deployment of lean manufacturing was transitioned to a corporate mandate to do so. The deployment methodologies of the two organizations differed greatly, as did their response to corporate guidance on deployment.

The deployment methodologies of Small Ship and Big Ship match the overall culture of the shipyards. Small Ship is "entrepreneurial and rebellious," tending towards an organic approach, while Big Ship is “button down corporate,” leaning towards a mechanistic approach. In writing the comparative case study, six distinct phases of lean manufacturing deployment were identified:

- *“Phase One - Early Awareness”*: In phase one, the shipyards are first introduced to the concepts of lean manufacturing through training and one-week exposure from external consultants.
- *“Phase Two – Grassroots Deployment*”: In phase two, the first major steps towards implementation of lean manufacturing are undertaken at both Small Ship and Big Ship.
- *“Phase Three – Growing the Deployment - Spreading Lessons Learned”*: In phase three, the shipyards have moved beyond initial deployment, and seek to spread lean manufacturing to broader elements of the organization.
- *‘Phase Four – Corporate Engagement and the Next Level of Deployment”*: As Small Ship and Big Ship mature in their deployments, corporate leadership becomes engaged in the improvement initiatives. As part of this, external influences and guidance are now applied to the organization.
- *“Phase Five - Crisis in Lean Manufacturing Deployment”*: In phase five of deployment, both Small Ship and Big Ship face crises in deployment and must respond to challenges that could undermine continuing deployment.
- *“Phase Six - Regrouping & Redefinition”*: In the sixth phase of deployment, the final phase studied for Small Ship and Big Ship, the organizations must regroup from crisis and successfully move forward in deployment.

This case study will analyze both Small Ship and Big Ship as they evolve through the six phases of implementation. At the conclusion of phases two and four a detailed analysis of implementation will be conducted to better illustrate the cases. Finally, a summary of mechanistic and organic characteristics will be provided.

Case Study Phase One – Early Awareness:

Both organizations, Small Ship and Big Ship, were introduced to lean manufacturing in July of 2001. At this time a small contingent of REMAN VIPs, including senior leaders from both Small Ship and Big Ship, toured the site of a successful lean manufacturing implementation in western Michigan, an automotive parts supplier to Toyota. On this tour, managers received an introduction to the concepts of lean manufacturing, attended a five-day seminar on the subject, and discussed the prospects for lean manufacturing deployment in the naval ship repair industry.

Within six months of the initial offsite, both Small Ship and Big Ship were kicking off their lean manufacturing deployment. Kick-off for lean at each organization occurred when a lean consulting firm, hired by the headquarters management group for the REMAN, arrived at each shipyard to conduct a one-week kaizen event (also know as a rapid improvement event). A kaizen event is a change management tool used by many organizations as a primary driver of lean manufacturing deployment. It is a one-week "blitz" of an area, specifically intended to bring all perspectives to the table, identify desired changes, and implement changes immediately, in accordance with lean manufacturing principles and practices. This is a valuable tool for continuous improvement, specifically designed to overcome organizational and bureaucratic inertia associated with “paralysis by analysis,” general inactivity from over-analysis. The five-day, expert-led event was intended to provide training and an illustration for each organization on the potential for lean manufacturing. The targeted projects for Small Ship and Big Ship were large valve repair and project management of shipboard valve repair, respectively. These projects were selected for their importance as constraints in the overall execution of ship overhaul and repair.

At Small Ship, the kaizen event selected for an initial target area was the machine shop process of large valve repair. In one week the team of approximately ten workers was able to clean up the workspace, organize tools, and establish basic visual management in the workplace. Equipment was moved to improve work flow and a capital investment was initiated to procure a parts-cleaning machine, which was identified as a bottleneck process. Despite initial skepticism, the improvement effort was well received within the work area and positive energy was created. However, Small Ship did not maintain energy beyond the one-week kaizen event and lean manufacturing deployment failed to take hold. In time, the work area regressed to previous process and performance levels, as well as a growing skepticism among employees in the area associating lean with a “flavor of the month” and un-kept promises by management.

At Big Ship, the kaizen event focused on the project management processes associated with onboard valve replacement, specifically work sequencing, readiness of support services, and overall resource allocation. This was a particularly challenging project to undertake as the work is done in a crowded non-dedicated area onboard the ship. To complete the process, specialized mechanics bring their materials, tools, and instructions to the worksite. This was later termed as “bringing the worker to the work” as opposed to “bringing the work to the worker” (classic assembly-line thinking). An additional challenge to this effort was that the consultant was not able to visit the actual worksite, due to security restrictions. In the five-day kaizen event, the team developed a process plan to change the methodology for repairing the component. Ultimately, only pieces of the new process were implemented, elements that had been previously identified prior to the kaizen event. This project was particularly challenging as a kick-off for lean manufacturing. It was identified years later that significant forces existed within Big Ship at the time to repress lean manufacturing deployment since it did not fully align with their existing paradigm for improvement based on the Baldridge approach.

Case Study Phase Two – Grassroots Deployment - First Major Steps:

The Early Awareness Stage of lean deployment at Small Ship and Big Ship was an illustrative example, but largely a failure at each organization due to a lack of follow-up and organizational commitment. Deployment could have ended at this initial stage, if not for interest of corporate management, REMAN, and a general belief lean could be a tool to alleviate growing budget pressures. Small Ship began to commit well-respected, if limited, resources to the deployment, while Big Ship overcame strategic alignment issues and folded lean into the continuous improvement strategy along with the Baldridge approach of measurement and control. In this phase, which lasted approximately twelve months, Small Ship revisited the site of the initial kaizen event in attempts to develop a model of lean manufacturing. Meanwhile, Big Ship developed a lean six sigma continuous improvement program and a lean six sigma academy for training “black belt” experts.

The first major step at Small Ship was to place a highly-respected senior leader, a production-oriented ex-project manager, as the director of lean manufacturing implementation. A lean manufacturing expert was then hired to guide implementation on the Shop Floor. With a lean manufacturing staff of only two, Small Ship attempted to rejuvenate implementation by revisiting the original kaizen event in large valve repair. Shipyard management acknowledged their failing to support outcomes of the initiative, and the lean manufacturing staff was dedicated and fully focused on this specific area to determine whether or not the tenets of lean manufacturing could be successful at Small Ship. A follow-on kaizen event was held to rejuvenate ideas and initiatives from the Early Awareness Stage that had not been implemented. This second kaizen event was followed-up with daily activity from the lean manufacturing staff. Small Ship made a significant commitment of resources, both financial and managerial, to a small group of employees and their process of large valve repair over an extended period of time. At the time, large valve repair was performing significantly above cost, beyond cycle time, and with significant quality problems. This became identified as the organization’s “model line” for lean manufacturing, and it was decided that Lean success or failure at Small Ship would be dependent upon the success and lessons learned at the large valve repair model line. The organization received criticism, both internally and from leadership at Big Ship, as to why they were not working faster and applying lean manufacturing in more areas at once. Senior leadership at Small Ship, convinced they were on the right path, weathered the criticism and stayed the course. Small Ship brought in consultants to assist, and hired two industrial engineers to support the lean manufacturing deployment, doubling the team to four personnel. In the course of twelve months, Small Ship made many iterative improvement passes at the model line in large valve repair. It took time, but within twelve months the process was transformed greatly, both in terms of people and process. Average cycle time for large valve repair was reduced by 83%, schedules were being maintained, costs were reduced (e.g. overtime eliminated), quality was improved, employees were fully engaged, and the team was achieving continuous improvement through daily initiatives, both large and small.

At the same time as model line implementation was occurring at Small Ship, Big Ship was aggressively training black belt experts and senior managers through a newly established lean six sigma academy. Similar to lean manufacturing, six sigma is a process improvement strategy intent upon continuous improvement of performance, though principles, tools, and techniques are divergent. The strategy for deployment at Big Ship was to implement lean manufacturing and six sigma jointly via four to six month projects, led by the internal experts. Big Ship hired a six sigma black belt from an automotive OEM as their internal expert. This individual played a vital role in developing a lean six sigma academy, a training program for green belt and black belt change agents and facilitators. Big Ship hired many talented industrial engineers fresh from large universities to serve as these internal experts. These facilitators were trained to follow a highly regimented five-step process and were assessed by supervisors based on their adherence to the process and overall cost reductions from their projects. Big Ship, successful in building a large infrastructure to support lean manufacturing and six sigma deployment, was lauded by REMAN for development of their lean six sigma academy.

Case Study Deep Dive Profile - Large Valve Repair at Small Ship and Big Ship:
Through the first eighteen months of lean manufacturing deployment at Small Ship and Big Ship, no process illustrated the differences in implementation strategy more than that of large valve repair. At Small Ship, large valve repair was identified as the model line for implementation, and was therefore the narrow focus of implementation. At Big Ship, large valve repair was selected as one of several processes to be worked in the first set of six-month projects for implementation, in part to share best practices and lessons learned with Small Ship.

At Small Ship, the large valve model line was developed over eighteen months. During this time a fully-dedicated lean expert worked in the area, all necessary resources were committed to the initiative, and senior management was fully engaged to understand and learn from the implementation. The initiative was a success, though not over night or without setbacks. From a technical perspective, many of the lean tools were used such as standard work instructions, 5S (workplace organization), kanban, andon, takt time, work-in-process reduction, rapid changeover fixtures, visual management, and point-of-use materials and supply. Paperwork was streamlined or eliminated, tool kits were developed, teamwork became enhanced, and work cells were created to support work previously done off-site. Average cycle time was reduced from 270 days per component to 45 days per component. The team on the shop floor, which had initially been very skeptical and resistant to change was now embracing the process, taking ownership, and making small, but daily continuous improvements. The level of commitment and understanding grew with each continuing success. Much like how a sports team will gain momentum in a competition, the team was building momentum in lean manufacturing deployment. As a result of the improvements, overtime in the area was completely eliminated, productivity tripled per employee, and many managers at Small Ship would regularly tour the large valve repair section. Later, many outside visitors including high level leaders of REMAN toured the large valve area. Ultimately, this represented a small and seemingly insignificant element of the total business at Small Ship, yet it was invaluable in demonstrating the concepts of lean manufacturing to management and the workforce.

At Big Ship, the large valve repair area was worked as an accreditation project for a recent graduate of the lean six sigma academy. For six months the individual worked in the large valve repair area, deploying lessons learned in the training. The initial task in deployment of large valve repair at Big Ship was to benchmark processes at Small Ship. There was much resentment at Big Ship over the notoriety Small Ship was receiving from their efforts in large valve repair. Big Ship felt they had never had performance problems in that specific work area, and were therefore as efficient as Small Ship (ultimately, this was identified as incorrect when considerations were made for type of work, volume of work, and employee productivity).

At Big Ship, the six-month benefits were generally shallow in nature. Implementation was directed by the black belt as part of that individual's accreditation project, most benefits were identified through visual management and implementation of 5S. The work area was cleaned, color coding systems were established and overall organization and appearances were improved significantly. No changes were made to the process flow, but paperwork improvements were attempted (but ultimately not supported by the engineering team). Only minor equipment expenditures were allowed. At the conclusion of six months, the black belt change agent presented results of the initiative, as well as planned follow-up tasks. The black belt expressed frustration from the lack of overall management engagement, particularly from groups outside of the production responsibility. Overall, the initiative was deemed a success. Unfortunately, after a few months of inattention the initiative had regressed to pre-existing conditions. Setbacks in the area were not due to a lack of knowledge on behalf of the change agent, or lack of enthusiasm from the workers. Rather, employees became busy and could not support the initiative and closure of follow-up tasks. Managers did not understand the significance of what the change agent was attempting to achieve, and many simply viewed the individual as an annoyance that would go away; they were largely correct. Though, to be fair in comparing the large valve repair case studies, it is important to recap that Big Ship had ongoing projects in many work areas, while implementation at Small Ship had been limited only to the process of large valve repair.

Case Study Pause for Analysis - Mechanistic vs. Organic in "Early Awareness" and "Grassroots Deployment":

In the initial stages of deployment, we identify Big Ship for its tendencies towards mechanistic deployment. Big Ship has placed tremendous emphasis on widespread deployment (though shallow in nature), training, and emphasis on cost reductions. The emphasis at Big Ship has been to build an infrastructure to support a long-term sustained deployment and they have been very successful at this. They are placing all expertise in the central office, with little opportunity for those outside of the "lean team" to shape the lean deployment process.

At Small Ship, the organic deployment tendencies are clear. They are focusing on only one area for the purposes of organizational learning. Management attention is focused on this area and they have an extremely concentrated deployment. They are emphasizing the organic evolution of learning amongst the employees as they seek to understand how classic lean tools and concepts apply in their environment. Expertise of the lean process is taught at a basic level and is delegated to shop floor employees to lead the process. Little infrastructure was developed in the lean deployment team, though. Perhaps this simply illustrates an overall lack of management support. Figure 3.9 summarizes both Big Ship and Small Ship in phases one and two for characteristics of mechanistic/organic and for indications of success/failure.

	PHASE ONE: "Early Awareness"	PHASE TWO: "Grassroots Deployment"
Illustrations of Mechanistic & Organic Deployment *Big Ship*	Big Ship rejected Lean Manufacturing due to failure of initial Kaizen to deliver significant ROI.	Big Ship began investment in infrastructure and training, tool deployment of 5S implemented in multiple sites.
Small Ship	Little Ship failed to benefit from Kaizen, due to lack of sustainment, but seeds of organizational learning were planted.	Little Ship attempted to "just do something and learn", established an implementation pilot. Organization was very informal.
Indications of Success or Failure of Lean deployment *Big Ship*	Outcomes of initial Kaizen had already been planned, little credibility given to this effort.	Big Ship was building an effective change management team and training capability.
Small Ship	Kaizen was well received and produced immediate impact, though, organization failed to sustain changes.	Little Ship developed a very successful pilot, worked to "show Lean" to the entire organization.

Figure 3.9 Analysis of Big Ship & Small Ship in Phases One and Two

Case Study Phase Three - Growing the Deployment and Spreading Lessons Learned:
Phase three of deployment represents the growth and maturation of lean manufacturing deployment, growing the deployment and spreading lessons learned. At this point, each organization has established a firm foundation for their moving forward. In phase three of lean manufacturing deployment, each organization sought to expand and elevate lean manufacturing to a more significant deployment strategy.

At Small Ship, multiple model lines began to develop across the organization and "spontaneous lean" initiatives began to develop as work leaders embraced the tools they saw demonstrated in the model line area. Small Ship spread the model line concept to multiple production shops within the organization. Transponder repair, motor generator repair, ball honing, and hatch repair were selected. Each of these had similar experiences to the large valve model line implementation; however, they were able to move much faster as senior leadership began to further understand the implementation process and overall vision for lean manufacturing. Additionally, the application of tools such as value stream mapping, workplace organization, standard work instructions, andon, and setup reduction began to "pop up" spontaneously throughout the organization as management began to understand the vision for lean manufacturing. These spontaneous attempts at deployment were now considered in the screening process to select future areas to focus lean deployment resources. That is, focus areas for deployment models were being developed in areas that had shown significant commitment and personal investment in the lean manufacturing deployment.

At Big Ship, black belt and green belt experts were deployed to each major department of the organization. A growing number of black belt change agents were trained; all senior managers were trained on lean six sigma principles; and lean six sigma objectives were placed in managerial performance appraisals. At Big Ship, lean manufacturing was becoming ingrained in the vocabulary and organization structure of senior management. As additional employees were selected for the lean program, they were trained as black belt and green belt facilitators and were embedded in the line organization. Green belts reported directly to the line organization, black belts reported to either the line organization or the director of the lean program. All senior managers were trained on lean six sigma principles and lean six sigma objectives were placed in managerial performance appraisals. Lean six sigma briefings became commonplace at senior management meetings. In terms of execution, many experiences were similar to that of the Big Ship large valve repair effort from Phase Two. Improvements were being made, but they were often limited in scope to the particular shop/function being engaged. Consequently they did not pull in extended partners (customers and suppliers) from other work functions.

Deep-rooted experience and understanding of lean manufacturing was beginning to take hold in Big Ship's machine shop. This area was the home of large valve repair, and several other projects that had been in the first round of black belt accreditation projects. Additionally, at this point many managers were visiting other organizations to see examples of lean manufacturing deployment, including the one at Small Ship, to gain a greater understanding. Several of the most experienced black belts were working in the machine shop and were learning from their prior experiences at deployment. An external consultant was hired and assisted in developing a value stream map of key processes in the machine shop, which highlighted twelve areas to focus energy. A building-wide 5S was conducted (reportedly removing more than 35 tons of waste and excess material) and the organization proceeded to conduct kaizen events in each of the twelve work areas identified in the value stream map.

At this time a rift began to exist between experiences of the seasoned change agents in the machine shop and the training occurring in the lean six sigma academy. As the most senior black belt change agent said, "employees go to the six-week training program and when they get back, the first thing I have to do is retrain them." This rift began to exist as a divergence between textbook knowledge of the instructors and “deck plate” experience of seasoned change agents occurred. This rift was only to grow as the two organizations moved into *Phase Four of Lean Manufacturing Deployment and Corporate Headquarters* became engaged.

Case Study Phase Four - Corporate Engagement and Next-Level of Deployment:
Phase Four of lean manufacturing deployment within the two organizations was a significant turning point in deployment, highlighted by two external influences: (1) a planned closure of Small Ship and (2) the engagement of REMAN with a rigid implementation strategy similar to that at Big Ship. This phase of deployment was characterized by each organization making an effort to apply lean to the central core business function of ship overhauls. During the first two years of lean manufacturing deployment at Small Ship and Big Ship, the efforts had been bottom-up, grassroots efforts. Each organization had a similar objective, but the roadmap was unclear and no guidance was being given from a corporate headquarters.

REMAN saw the positive impact lean manufacturing was having at Small Ship, Big Ship, and other facilities that had undertaken grassroots efforts. REMAN established a special task force to oversee lean implementation at all sites. This task force hired a lean consultant who had been supporting Big Ship with guidance and assistance. Desiring a common approach to lean across the entire enterprise, a rigid implementation plan was developed, with a formula for implementation, roles and responsibilities, methods, and metrics for capturing the savings.

At Small Ship, the organization was marked by site closure process. The specter of this event, along with the nearing departure of their charismatic shipyard leader, created significant energy for process improvement. The thought was they needed to "take it to another level" in order to "show what we are capable of." The corporate task force had little impact on lean at Small Ship during this period as they simply ignored corporate guidance. With the impending base closure, REMAN was not about to step in and mandate compliance.

Senior leadership at Small Ship held a two-day offsite to strategize about the next level of lean manufacturing deployment. The particular challenge faced by leadership was the lack of standard and repetitive work during a ship overhaul. They had learned how to apply lean in higher-volume and lower-variety work processes, but a ship overhaul, with its low-volume and high-variety presented a unique challenge. Approximately 10,000 tasks were executed on a ship overhaul, with nearly every one of those tasks being unique. How could techniques such as process flow, pull systems, work-in-process reductions, andon, and visual controls work in this environment?

An important revelation for the organization came when it was revealed that, while each of the 10,000 tasks is unique in work content and complexity, a common method and approach existed in the planning and follow-up of work. Utilizing the same tools used in the original model line, the organization developed a value stream map and a strategy for managing the 10,000 tasks in a systematic approach. This involved a wide array of lean production tools and techniques. With a focus on continuous flow and cycle time per unit, the organization was able to make tremendous strides in a short time. They established a supermarket for incoming work, visual communication boards, standard work instructions, and significantly improved workplace organization, work-in-process inventory controls, andon systems, and pull systems. The deployment included all production shops, and required significant communication across multiple trades and functions. In many instances, as the strategy was both being developed and implemented, comments were made such as “well, we had a similar situation in the large valve model line, this is what we did and this was the outcome… let’s try that here.”

The entire shipyard management team rallied around the single mission, vision, and objective. Ultimately, the strategy was recognized to have flaws in implementation, yet the new strategy had allowed for the organization to complete one of their most complex ship overhauls at a twelve percent cost reduction over a previous best. The way ahead for lean manufacturing was clear. Largely due to their innovation and process improvement initiatives, Small Ship was successful in being removed from the base closure list, the charismatic leader was promoted to Admiral and all energy was riding high at Small Ship.

At Big Ship, energy was also riding high as the corporate task force offered an opportunity for it to broaden its influence with lean deployment, and consolidate its efforts locally under the guidance of a corporate directive. At Big Ship a feeling existed that the organization could now “take lean deployment to the next level.” Big Ship now placed one of their brightest and most respected managers to oversee the lean manufacturing deployment. This individual, who brought tremendous credibility to the position, proceeded to implement and oversee the rigid implementation strategy laid out by REMAN. Quotas were established for each manager and department in terms of the number of improvement events, participants, and initiatives to be achieved. All departments at Big Ship were deploying lean in order to meet their management quotas and each was building internal examples and expertise. However, the departments at Big Ship were working independently and not always willing to share resources; top-notch personnel rarely participated in lean events outside of their particular department. An additional change came at Big Ship when the lean six sigma academy broke from the shipyard and aligned directly with the REMAN task force. This resulted in Big Ship losing control of the overall curriculum and vision of the academy.

Similar to Small Ship, Big Ship also worked to tackle the tremendous challenge of successfully applying lean to the entire ship overhaul. The approach taken at Big Ship included aligning lean deployment on the overall ship overhaul with existing accounting mechanisms and focusing efforts on reducing the overall cost and variability of cost to major line items, with responsibility falling to the individual departments who executed the work. This strategy produced positive results, but they were largely constrained by the existing accounting measures, producing sub-optimized results to the overall initiative of improving performance.

Case Study Deep Dive Profile - Ship Overhaul Maintenance & Modernization:

At both Small Ship and Big Ship, the greatest opportunity and challenge for improvement existed in applying lean to the core business capability of ship overhaul and repair, known as a ship overhaul. As previously discussed, this could be comprised of upwards of 10,000 individual tasks, each unique and subdivided further by requirements for material, engineering services, direct labor and indirect labor services. This was complicated by the extreme low-volume and high-variety of each task, as well as the size (potentially upwards of one-thousand personnel each day), duration (potentially longer than two-years in execution), lack of consistent work environment (each task was completed at a unique location aboard ship) and overall technical complexity of each overhaul.

During the first two years of lean implementation, both Big Ship and Small Ship took “baby steps” to understand how lean concepts could apply in this non-repetitive remanufacturing environment. In a previous chapter we addressed the technical challenges and analysis of applying lean in the remanufacturing context. These baby steps taken at the two organizations shaped their full-blown application of lean to the overall ship overhaul. However, it was the unique experiences and lessons learned in the large valve model line that ultimately allowed Small Ship to change their frame of reference and truly revolutionize their way of doing business.

With pressures to impress decision makers in the shipyard closure process, the best analogy for the Small Ship experience with lean is they jumped into a swimming pool rather than cautiously dipping a toe in the water. As previously mentioned, the leadership at Small Ship held a two-day off-site meeting to develop a strategic plan for applying lean to the complete ship overhaul. During this off-site meeting a complex value stream map of the complete two-year overhaul was created. The leadership team developed a high-level plan, emphasizing continuous flow of work, work-in-process controls, and improvement of team structures and worker communication. Kaizen events were scheduled for teams to develop details of the plan. As a result of taking a step back to study the work and by applying lessons learned during model line implementation, Small Ship was able to shift the paradigms of production management to account for seeming paradoxes of lean such as work-in-process controls and emphasis on individual cycle time reduction. The team developed new sets of metrics to measure daily and weekly performance, production schedules and work hours were shifted, and “rules of thumb” were challenged. The team even went as far as to request variance from corporate policy as they felt it promoted non-lean behaviors. The entire ship overhaul was nearly treated as a science experiment. The entire management team met once a week to look at, discuss, and debate the meaning of their new set of metrics. “Lean advocates” were assigned to the production team to police adherence to new processes and provide immediate and direct feedback on process changes. As part of the shift in production paradigms, the management team began to rethink rules on meeting performance milestones and even the importance of metrics in one production area as opposed to another. As one senior production manager at Small Ship said:

> “It used to be that we would think of ourselves as one team, but we were a baseball team. We [the Shipyard] would achieve success if we [each production shop] were all .400 hitters and hit a lot of homeruns. Now, we still think of ourselves as a team, but now we’re a football team. We have blockers [support shops], running backs and receivers [primary production shops]. We

> don’t care if our blockers are performing great individually, just that our running backs and receivers are moving the large downfield for the entire team to be successful”.

Significant changes were occurring at Small Ship, including the formation of a single team, but little emphasis had been placed on improving performance in the value-added functions of production. Rather, most energy was spent removing roadblocks to value-added production and improving or eliminating the non-value-added functions. In order to quantify improvements, the organization decided to simply target the overheard management costs for the ship overhaul. Aggressive targets of 20% cost reduction were not achieved, but schedule was improved by more than a month and a solid 12% cost reduction was achieved. Ultimately, many lessons were learned as to how future overhauls could be managed and improved.

At Big Ship, the application of lean manufacturing to the entire ship overhaul was much less pronounced, than at Small Ship. In maintaining their “corporate and button-down” demeanor, management at Big Ship considered the task at hand to be a natural progression of their deployment strategy for training the workforce and conducting kaizen events throughout the entire organization. REMAN, the corporate management group, pressured Big Ship to deliver significant improvement results on their next ship overhaul. Because of this, Big Ship leadership felt pressure to increase their pace of training and kaizen events. At Big Ship, the ship overhaul was dissected according to cost and cost variance. Additionally, each manager was asked to target high-cost jobs and use lean manufacturing to cut the costs.

These factors created three significant challenges for leadership at Big Ship: 1) Each department was challenged to work independently to improve cost, thus attacking the value-added functions one at a time. It is believed the most significant opportunities existed in improving the non-value-added functions, specifically the coordination between departments. 2) Other than the machine shop, few of the departments within Big Ship had any deep-rooted experiences and learning to draw upon in applying lean to the challenging applications of shipboard production. 3) An extreme emphasis was placed on cost reductions, which made it particularly challenging for managers to achieve short-term cost objectives while enabling the needed investment in kaizen events.

Using the analogy offered by Small Ship, Big Ship was a team of individuals [departments] each working to improve their batting average and home run hitting prowess. As a result of these efforts, many improvements were made at Big Ship, however, the improvements were largely disconnected and potentially sub-optimizing. Reporting of improvement results was conducted one job order at a time, and while some were reduced others were increased (with justifications addressed). Minimal reductions were made in the overall schedule or cost of the next ship overhaul. Ultimately, performance was improved, but no significant lessons were learned or paradigms challenged. Any organizational learning that occurred was on the individual level.

Case Study Pause for Analysis - Mechanistic vs. Organic in "Growing the Deployment" and "Corporate Engagement and Next Level of Deployment":

Phases three and four highlight the growing divergence between the largely organic deployment at Small Ship, and the largely mechanistic deployment at Big Ship. Small Ship's actions and decision for deployment strategy were based almost entirely on their own learning and do-or-die perspective to performance. Big Ship's actions were based largely on a desire to build favor with the REMAN task force and maintain consistent progress along their internally developed lean deployment journey.

At Big Ship, they are becoming more mechanistic in response to the challenges of a growing deployment and the alignment with the REMAN task force implementation strategy. Ultimately, the metrics and implementation strategy of Big Ship align perfectly to the mechanistic strategy and values of the corporate implementation. Big Ship is successfully training and engaging large numbers of employees and the effort is receiving great visibility within the organization.

At Small Ship, a clash was occurring between the mechanistic rigidity of directives, forms, training, and accounting as prescribed by the REMAN task force and the flexible organic deployment that had been successful. As a result, Small Ship is ignoring corporate direction regarding deployment strategy, yet they are delivering results held by the REMAN task force as a model for deployment opportunities. The organic learning occurring at all levels of Small Ship was very dynamic and exciting to observe. Figure 3.10 summarizes both Big Ship and Small Ship in phases three and four for characteristics of mechanistic/organic and for indications of success/failure.

	PHASE THREE: "Growing the Deployment"	PHASE FOUR: "Corporate Engagement and Next Level Deployment"
Illustrations of Mechanistic & Organic Deployment *Big Ship*	Widespread deployment, development of standard methodology, extensive training, shallow deployment.	Organization-wide deployment, owner of the corporate training program, written implementation methodology and metrics.
Small Ship	Deep-rooted model line, multiple additional pilot sites, little organizational structure to deployment.	Entire management team focused on new pilot implementation project which seeks to learn at a new level. Significant pushback to corporate deployment.
Indications of Success or Failure of Lean deployment *Big Ship*	Big Ship is beginning to develop successful initiatives in the Machine Shop area, extensive change management team and training capacity.	Organization-wide deployment, owner of the corporate training program, many managers becoming trained.
Small Ship	Multiple sites engaging in deep Lean deployment, established models in a variety of applications, management team building deeper understanding.	Primary Lean initiative has become the focus of the entire management team and the cornerstone of defense against Base Closure

Figure 3.10 Analysis of Big Ship & Small Ship in Phases Three and Four

Case Study Phase Five - Crisis in Lean Manufacturing Deployment:

Lean manufacturing deployment within the naval ship repair community had been growing rapidly, bolstered by an urgency to survive and desires to use the corporate directive as a mandate at Small Ship and Big Ship, respectively. However, in phase five each organization began to recognize growing pains in deployment. Both organizations faced tremendous, though unique, crises to the long-term success of lean deployment.

At Small Ship the lean deployment was met with five significant changes at one time, each highlighting a single failure point in their deployment; Small Ship was removed from the base closure list, removing the perceived urgency for improvements. The charismatic leaders, both the shipyard leader and the head of the lean deployment team, were promoted to more prestigious positions as a result of their successes. Four of the most experienced lean change agent facilitators, some of the key players in development of the new strategy, left within a six month period for personal reasons. Problems were surfacing in the implementation plan established for the ship overhaul model line, some senior leaders felt this was proof the concept of lean manufacturing in this environment was flawed. Finally, conflicts continued to grow between Small Ship and the increasingly influential corporate Task Force.

Each of these changes pointed to the failure points that Small Ship (1) had become overly dependent upon charismatic leadership and (2) could not sustain the unusually high energy level for lean deployment. The progress of lean deployment slowed tremendously and regressed in certain areas. The characteristics that allowed Small Ship to be flexible and learning-oriented at the start became the same characteristics that challenged them as they sought to continue growth of their deployment. The extraordinary energy and focus that was driving lean Manufacturing deployment at Small Ship was removed and the organization had not built an infrastructure of systems, processes, and people capable of maintaining the deployment.

At Big Ship, the crisis was nearly opposite that of Small Ship. The organization became overextended in their drive to achieve the REMAN quota of kaizen events and number of employees trained. This was a form of event overload. Managers were pushing hard to achieve their numbers. As a result, many initiatives were unprepared and poorly selected, leading to a failure to deliver the expected results and value. This was not a problem during times of extra manpower, but resources were becoming extremely constrained and work was not being completed on schedule. Drawing resources away from direct labor to use in process improvement grew increasingly difficult. As part of this, many managers were growing increasingly skeptical of the benefits being realized through the shallow, yet widespread deployment of lean at Big Ship. Managers were struggling to believe the return-on-investment (ROI) claimed by the corporate task force, believing this was simply “paper money.” Unfortunately, the “good stories” of waste elimination were not yet quantifiable at this point. Additional pushback to the lean manufacturing deployment occurred when REMAN mandated that Big Ship deploy the same strategy and lessons learned as Small Ship on their next ship overhaul. This led to resentment of Small Ship and a strong reluctance to adopt ideas that were perhaps not their own.

Case Study Phase Six - Regrouping and Redefinition:

A return to basics is now the goal at both Big Ship and Small Ship for lean implementation. Both organizations have pushed themselves to the point of internal crisis and now they are both forced to rebalance themselves and their lean efforts for long-term sustainment.

At Small Ship, they have recognized the challenges of pushing implementation far beyond the infrastructure they had developed to support it, only to realize they do not have the internal strength to sustain the pace. Relying upon what has made them successful; Small Ship is refocusing its improvement priorities. At the same time they are now requiring all senior managers to attend training and go on regular “waste walks” with the lean management team. The original charismatic leader of the lean deployment team has returned to lead the office. New industrial engineers have been hired and they are being trained in the corporate lean six sigma academy, as well spending time in each of the model line initiatives at the shipyard. Ultimately, Small Ship has pockets of deep models and illustrations of lean manufacturing. They have a management team, which has experienced the evolution and adaptation of their improvement initiatives, and now they must build the infrastructure of their lean organization and continue to build support among managers for long-term continuing success.

At Big Ship, a return to basics suggests a more significant re-baseline to the fundamentals of lean manufacturing. The lessons learned thus far have largely been associated with infrastructure development and deployment, not deep Lean learning. The organization is pulling back in the number of ongoing initiatives and becoming more focused as they attempt to develop deep examples of learning. One focus of this effort is in the machine shop, which had been moving ahead with models of lean implementation and organic learning. They are acting largely as an independent sub-culture within the larger organization. Several similar production areas are now using concepts from the machine shop to build lean manufacturing models throughout the organization. The organization is beginning to push back on the REMAN task force by resisting pressures to continually do more and more initiatives and becoming more strategic in selection of initiatives and deployment of resources. Their ultimate challenge is to develop an internal culture of understanding that effective lean manufacturing provides the opportunity to develop a learning organization – it is not simply an issue of resources and internal efficiency.

Case Study Pause for Analysis - Mechanistic vs. Organic in "Crisis in Lean Deployment" and "Regrouping and Redefinition":

In phases four and five, Big Ship showed weaknesses of a predominately mechanistic deployment (lack of deep learning). In phase five, Big Ship focused on the "activity metrics" of number of kaizen events conducted and employees trained, and their overall efficiency in running those events. Ultimately they overestimated their own infrastructure and outran their internal capability to support Lean initiatives. They attempted to conduct too many initiatives (with a leadership team that lacked a deep understanding of lean) and the preparations and follow-up were not completed successfully. Consequently, initiatives began to fail at higher rates. In Phase Six, Big Ship became more focused on deeper deployments and models within the organization, ultimately becoming more organic in nature.

Small Ship showed weaknesses of a predominately organic deployment and ultimately became more mechanistic in nature (lack of deployment infrastructure). During the crisis stage, Small Ship lost the energy and momentum created by the potential base closure and found itself lacking in the necessary infrastructure to be successful over the long run. They had been overly dependent upon dynamic personalities and enthusiasm created by an organizational crisis. As it regrouped, Small Ship ultimately became more mechanistic as it built a more robust infrastructure to support continuing deployment. Figure eleven summarizes both Big Ship and Small Ship in phases five and six for characteristics of mechanistic/organic and for indications of success/failure.

	PHASE FIVE: "Crisis in Lean Deployment"	PHASE SIX: "Regrouping and Redefinition"
Illustrations of Mechanistic & Organic Deployment *Big Ship*	Lean Office focused on running a particular number of events and overall efficiency of implementation, management not understanding or engaged.	Big Ship is becoming more organic in its attention to deeper projects, maintaining infrastructure to support.
Small Ship	When the management attention was removed, lacked a significant infrastructure to support sustained implementation.	Little Ship is becoming more mechanistic, building an infrastructure to support long-term deployment.
Indications of Success or Failure of Lean deployment *Big Ship*	Big Ship had outrun its own infrastructure, attempting to do too many initiatives, management not fully onboard and not seeing results.	Big Ship backing off pace, beginning to develop deeper implementations and understanding.
Small Ship	Pressure of potential base closure removed, management did not sustain energy, little infrastructure to support. Recognized as being too dependent upon personalities.	Little Ship building a stronger infrastructure for sustainment, re-focusing efforts after attention had been lost to deep implementations.

Figure 3.11 Analysis of Big Ship & Small Ship in Phases Five and Six

CASE STUDY DISCUSSION

This chapter has defined two distinct strategies for lean manufacturing deployment: organic and mechanistic. Which methodology of deployment is preferred, organic or mechanistic? In order to address this question, the case studies have been characterized according to 1) the degree to which they illustrate organic and/or mechanistic characteristics of deployment, and 2) the degree of success for each methodology throughout the deployment.

Organic and Mechanistic – Understanding the Case Studies:

Figure 3.12 summarizes the case studies of Big Ship and Small Ship through the six phases of deployment according to their degree of organic and mechanistic approach to implementation. Ratings on the scale of organic and mechanistic were assessed according to the organization's actions and emphasis in deployment and the extent to which they followed the definitions of organic and mechanistic identified earlier in this chapter.

	"Early Awareness"	"Grassroots Deployment"	"Growing the Deployment"	"Corporate Engagement and Next Level"	"Crisis in Lean Deployment"	"Regrouping and Redefinition"
Primary Influence:	External Introduction to Lean Manufacturing	Need to build understanding of Lean Manufacturing	Need to expand energy for Lean Manufacturing	Need to produce results for Corporate	Need to produce results for Corporate	Need to re-balance deployment
Mechanistic/Organic at Big Ship:	Uncertain	Mechanistic	Moderately Mechanistic	Extremely Mechanistic	Extremely Mechanistic	Mechanistic
Mechanistic/Organic at Small Ship:	Uncertain	Extremely Organic	Organic	Organic	Moderately Organic	Moderately Mechanistic

Figure 3.12 Big Ship & Small Ship as Mechanistic/Organic in Six Phases of Deployment

In the Early Awareness phase of implementation, each organization was introduced to lean manufacturing by REMAN and initial kaizen events were conducted. Yet, while the two organizations responded differently in acceptance of the new concepts, it is difficult to characterize either as having an organic or mechanistic approach. Each deployment, therefore, is characterized as *uncertain*.

In the second phase of deployment (Grassroots Deployment) the tendencies of each deployment first emerge as they seek out the first steps in implementation. Small Ship, with its committed focus to a lean manufacturing model line in large valve repair and relatively unstructured implementation strategy is characterized as *extremely organic*. Big Ship, with its focus on widespread training, curriculum development, and structured implementation, is characterized as *mechanistic*.

The third phase of implementation (Growing the Deployment) brings both organizations closer to the center. Small Ship attempts to replicate successes of the initial model line in multiple areas, creating a small portfolio of model lines that vary in their implementation. Their deployment is characterized as *organic*. At Big Ship, they continue to use a mechanistic implementation strategy, but become more moderate as their advanced deployment area, the machine shop, takes root. A relatively organic implementation emerges in that environment, and overall the deployment is characterized as *moderately mechanistic*.

The fourth phase of implementation (Corporate Engagement and Next Level) is highlighted by the aggressive engagement of corporate deployment and the full-speed push at Small Ship to produce results in order to avoid closure. At Small Ship, the aggressive attempts at transforming operations on an entire ship overhaul using lean would qualify as extremely organic. Despite the use of extensive rules, regulations, and roles & responsibilities of deployment in order to rapidly deploy, the deployment is characterized as *organic*. At Big Ship, the mechanistic tendencies of the organization are greatly enhanced by the extreme mechanistic approach being deployed by the REMAN task force, which uses an extremely rigid implementation plan, metrics, and expectations of engagement at all levels of management. The deployment is characterized as *extremely mechanistic.*

In the fifth phase of implementation (Crisis in Lean Deployment) each organization struggles to achieve the aggressive pace and expectations of REMAN, particularly after the fears of base closure at Small Ship subside. Big Ship, with the continuing push for further and faster deployment within the existing infrastructure, is characterized as an *extremely mechanistic* deployment. At Small Ship, charismatic leadership and expertise has been removed and it has become more dependent upon the infrastructure for improvement. The deployment is characterized as *moderately organic*.

In the final phase of implementation (Regrouping and Redefinition) both Big Ship and Small Ship sought to regroup from the crisis in implementation. Big Ship recognized the crisis was partially caused by shortcomings of their rigid implementation structure and lack of a deep understanding throughout the organization. Despite the continuing pressure from REMAN for a rigid and highly mechanistic approach, they are becoming more moderate in their approach and are characterized as *mechanistic*. While Big Ship's crisis involved too much infrastructure, Small Ship experiences a crisis due to too little infrastructure. Small Ship, while largely resistant to this point, is becoming more aligned with the rigid implementation strategy of REMAN and is continuing to introduce infrastructure in order to bolster the long-term feasibility of their implementation. The deployment is characterized as *moderately mechanistic*.

Efficiency, Effectiveness, and Success – Understanding the Case Studies:

Many quantitative indicators were examined to define the deployments at Big Ship and Small Ship as successes or failures. Unfortunately, the size and scope of projects was different enough so that it was not possible to compare the two organizations on precise quantitative measures. Instead the data are qualitatively summarized in Figure 3.13. It was previously discussed that success in a mechanistic view of deployment involves a highly structured process for deployment and then efficiency in delivering resources to execute that strategy and structure. An organic deployment is focused more on the overall effectiveness in developing buy-in and understanding within the entire workforce to grow a new culture, as opposed to efficiency of deployment. Figure 3.13 characterizes the success of each organization through the six phases of deployment for efficiency of deployment, effectiveness of deployment, and overall success of deployment. In conducting this subjective analysis, the following definitions are used:

- *Efficiency of Deployment* – the degree to which large segments of the organization are introduced to lean manufacturing with the least number of resources.
- *Effectiveness of Deployment* – the degree to which an organization is able to successfully transform specific work processes and get buy-in and understanding for a deep and lasting implementation of lean manufacturing.
- *Success of Deployment* – the degree to which the entire organization is on a path towards a deep and lasting implementation of lean manufacturing.

		"Early Awareness"	"Grassroots Deployment"	"Growing the Deployment"	"Corporate Engagement and Next Level"	"Crisis in Lean Deployment"
Big Ship:	Efficiency of Deployment:	Low	Medium-High	Medium-High	High	Medium-High
	Effectiveness of Deployment:	Low	Low	Medium-Low	Medium	Medium-Low
	Overall Success of Deployment:	Low	Low	Medium-Low	Medium	Medium
Small Ship:	Efficiency of Deployment:	Low	Low	Medium	Medium-High	Medium-Low
	Effectiveness of Deployment:	Low	High	Medium-High	Medium-High	Medium
	Overall Success of Deployment	Low	Medium	Medium	High	Medium

Figure 3.13: Efficiency, Effectiveness, and Success at Big Ship and Small Ship

Ratings of high, medium, and low for each element of figure thirteen were developed from qualitative analysis of actions, outcomes, and intent for each organization during the first five stages of deployment. Stage six has not been assessed because it is too early to tell the results of their response to crisis. Efficiency and effectiveness are considered independently. However, overall success is considered a combination of the two categories. In considering success, more emphasis is placed on effectiveness than efficiency. While it is true both efficiency and effectiveness must exist for success, effectiveness is considered a closer indicator.

The results in Figure 3.13 are complex when we compare all the indicators for both yards during the five phases. Some patterns of note are:

1. The two organizations took very different paths. However, each began with low overall effectiveness, and both concluded with medium overall effectiveness.
2. As expected, Big Ship was more efficient across all phases compared to Small Ship. Small Ship was more effective than Big Ship in the early stages of lean deployment, but both exhibited moderate effectiveness in the long run.
3. At Small Ship, efficiency generally increased, but effectiveness slightly decreased (with the exception of the crisis stage) as efforts became more widespread.
4. The highest performing period was in phase four at Small Ship, largely due to the medium-high efficiency of deployment while maintaining medium-high effectiveness. This success is largely a result of charismatic leadership and the overall organizational drive towards being removed from the base closure list. Big Ship was also most successful at this point. They were ramping up their deployment while exerting internal controls (or simply, organizational inertia to change) in order to proceed at an internally desired pace.

Organic and Mechanistic Deployment – Benefits and Shortcomings:

To suggest that either mechanistic or organic deployment is always superior would not be appropriate. Each approach has benefits and shortcoming, summarized in Figure 3.14.

Mechanistic Deployment	Organic Deployment
Benefits: Provides clear expectations for deployment Builds widespread awareness throughout organization Better infrastructure to support long-term sustainment Quick to engage all managers	**Benefits:** Provides clear examples of deployment. Builds deep understanding throughout organization Better opportunity for long-term sustainment Better enables organizational learning
Shortcomings: Shallow, potentially superficial deployment Potential discontinuity between training and deployment Hinders true organizational learning	**Shortcomings:** Slower, more methodical approach Slow to engage all managers Requires change agents with advanced knowledge and understanding

Figure 3.14 Benefits & Shortcomings of Mechanistic and Organic Deployment

Mechanistic deployment provides clear expectations for deployment, builds widespread awareness throughout the organization, builds an infrastructure to support long-term sustainment, and is quick to engage all managers in deployment. The shortcomings of Mechanistic are that it can be shallow and potentially superficial, creates a potential discontinuity between training and deployment, and may hinder true organizational learning through adherence to a rigid strategy.

Organic deployment on the other hand, provides clear examples of deployment, builds a deeper understanding of lean manufacturing throughout the organization, creates a better opportunity for long-term sustainment through deep learning, and better enables organizational learning through a flexible and evolutionary deployment strategy. The shortcomings of organic include a slower and more methodical approach, a slowness to engage all managers, and requirement for change agents with more advanced skills due to the flexibility of implementation strategy.

One might conclude that it is better to choose one deployment approach based on what strengths are more important to the organization and live with the shortcomings. However, the result may not be satisfying to anyone. For example, in the case of a truly mechanistic deployment, the lean program may be superficial, and the actual implementation will be weak compared to what the training suggests lean should be. Because of this, the organization will not learn or progress. Instead, they will efficiently deploy tools superficially that have little staying power and limited effectiveness. That certainly is not satisfactory. A truly organic deployment will provide a deep understanding and allow the organization to learn and grow. That certainly sounds better. Unfortunately, the organic approach is sometimes hard, slow going at times, and in need of real expertise to guide an organization through the learning process. It seems that the organic approach may be more effective overall if the organization is willing to put in the effort and both obtain and develop the expertise.

So why did Big Ship end up just as successful overall as Small Ship if Big Ship was implementing superficial tools with little understanding? Had Big Ship continued upon their initial course of textbook training and little external influence, the lean deployment likely would have ultimately stalled due to being superficial, spread too thin, and lacking significant learning and results. The deployment could have been extremely efficient, but a superficial tool delivered efficiently would still be considered ineffective. The reason for Big Ship's success is that Big Ship slowly developed internal expertise, particularly in the machine shop, developing individuals who understood lean organically. These individual deployment champions began to focus on model line projects, as Small Ship had done, and achieved the same great successes as Small Ship had earlier. These deployment champions began to develop a deeper understanding of lean to the point, as previously mentioned, they found themselves at odds with the mechanistic strategy of the REMAN task force, the textbook learning of the lean six sigma academy, and their organization's traditional mechanistic management structure on the whole. The combination of Big Ship's mechanistic infrastructure and Small Ship's organic learning led to something stronger than either the mechanistic or organic approach by itself.

The rest of this chapter will elaborate on these two approaches and explore how they can be blended to a hybrid that exploits that best of mechanistic and organic approaches to deployment.

Organic and Mechanistic Deployment – Stages of Technology Acceptance:

The deployment of lean manufacturing within an organization can be likened to adaptation and acceptance of a new technology. In his study, Rogers (2003) identified five groups of individuals associated with acceptance of a new technology. They are as follows:

1. Innovators - venturesome, educated, multiple information sources, greater propensity to take risk
2. Early adopters - social leaders, popular, educated
3. Early majority - deliberate, many informal social contacts
4. Late majority - skeptical, traditional, lower socio-economic status
5. Laggards - neighbors and friends are main info sources, fear of debt

If we are to consider lean manufacturing as a new technology that must be accepted by individuals, particularly managers, it is reasonable to assume the profile of management acceptance would look similar to Rogers' profile of these five groups. One of the strategies of the organic approach is to develop the initial model in an area where there is a leader prone to be an innovator or early adopter. Getting early "wins" is important. This individual is often developed to then sell and teach others. This type of targeting and then developing depth of knowledge in the innovators and early adopters is more difficult in a mechanistic implementation that blankets the organization with more superficial training. Overall the mechanistic approach does not recognize the human dynamics of change and does not align well with Rogers' model of the adoption process.

Technical and Cultural Change – Understanding the Interconnected-ness:

These case studies reveal the interconnectedness of social and technical change in building a lean-learning organization and developing the lean technical systems. The balance between social and technical aspects of deployment is something missing from the mechanistic approach, which is overly focused on technical change. In both cases technical change was easier than social change. Process changes, such as a redesign of process flow, reduction of work-in-process, or implementation of pull systems can be driven by management to create immediate change. On the other hand, those same technical changes, if implemented using team problem solving and employee engagement may create a resultant social change within the team, diminish skepticism, improve morale, empower employees, and encourage more fundamental problem solving.

As illustrated in Figure 3.15, with the initial impetus of a technical process change, the resultant social change may enable (but not create) a greater technical change as the employees gain greater understanding of the goals and overall attitudes towards change are improved. As an iterative process, if change continues to be implemented in a positive, empowering way, greater technical/process changes will lead to further social/cultural changes, enabling still-greater technical/process changes, and so forth.

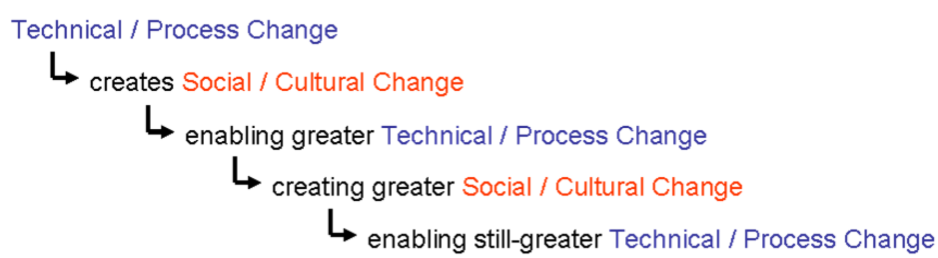


Figure 3.15 Positive Relationship Between Technical and Cultural Change

Based on observing Big Ship and Small Ship over six years, with each iterative cycle of improvement (technical change -> creating social change -> enabling technical change) the benefits increase exponentially. With each implementation of process improvements the organization becomes more emboldened and enlightened to the true capabilities of a lean producer. The first few kaizen events in an area may be focused on removing "monuments" to the old way of doing things, whether by moving equipment, establishing customer/supplier relations, or simply changing the existing attitudes towards change. Follow-on kaizen events would likely become more focused on improving daily process-related issues.

However, it is also noted that impacts of not sustaining a technical/process change will have social/cultural implications. In the event a team develops a positive change, but it is not sustained, the team may become disenfranchised with lean, skeptical of the benefits and unkept promises, or outwardly hostile towards management or the lean deployment team. This is illustrated in Figure 3.16.

Technical / Process Change
↳ creates Social / Cultural Change
↓ energy / commitment to change not sustained
disenfranchisement occurs with Social / Cultural Change ↵
Technical / Process Change reverts to initial condition ↵

Figure 3.16 Negative Relationship Between Technical and Cultural Change

Recognizing the interconnectedness of technical/process change and social/cultural change suggests a further enhancement to the illustrative models introduced earlier in the chapter for organic and mechanistic deployment. These models used illustrative metaphors of spirals and concentric circles, respectively. Figure 3.17 illustrates a technical change enhancing subsequent social change and so forth. As previously discussed, if energy for continuous improvement is not sustained, it is feasible for a spiral or concentric circle to collapse inward to the original process state.

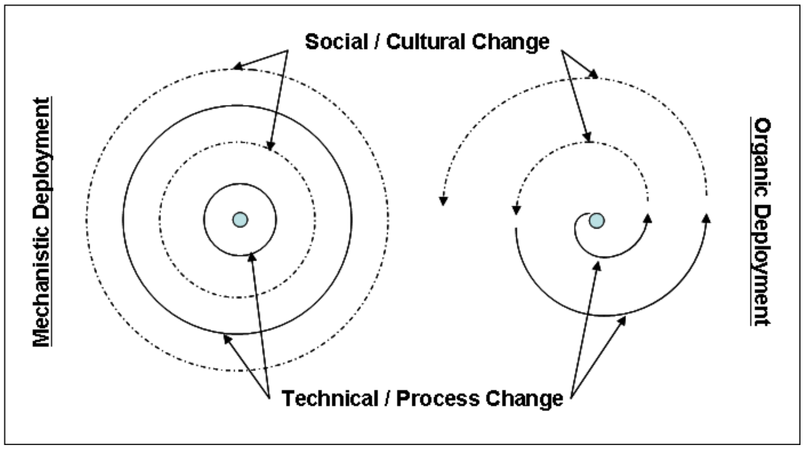


Figure 3.17 Understanding Technical and Cultural Change Metaphors

A Broader Perspective - Small Ship as "Model Line" for Corporate Deployment:

For the purposes of this comparative case study, analysis has focused on Big Ship and Small Ship as mostly separate entities. However, a broader frame of reference could more closely link the two organizations within the extended naval ship repair enterprise. It could be concluded that Big Ship could not have achieved its success, or the potential for longer-term improvements, if Small Ship were not the "model-line shipyard." Small Ship had a more flexible and aggressive organization, while Big Ship was much larger and command-control focus. It can be argued that Big Ship, and the extended enterprise as a whole, had too much to risk by Big Ship being as innovative and exploratory as Small Ship was in phase four of implementation. This broader frame of reference does not change the short-term or long-term outlook for Big Ship or Small Ship. However, shifting to a broader frame of reference may lead to a revision in characterizing individual sites as successes and failures when viewed in the context of contributions to a larger corporate structure.

CONCLUSIONS

The comparative case studies of Small Ship and Big Ship present a complex picture of successful lean deployment. One over simplified conclusion is that a mechanistic approach is preferred, especially when one examines the success of Big Ship in building widespread awareness and large infrastructure to support lean deployment in the long-term. Another over simplified conclusion is that an organic approach is preferred if one looks at Small Ship’s ability to quickly gain a deep understanding and learning of lean through a model line implementation. While reasonable, each of these conclusions fails to grasp the deeper understanding of the case studies. The following conclusions can be drawn from this case study:

- *Need for Balance*: The case study set out to determine the “one best way” of deployment between organic and mechanistic. However, the cases suggest a long-term successful deployment requires a blending of both organic and mechanistic approaches. An organic approach is required for deep understanding and organizational learning, but it fails if it is not supported by appropriate infrastructure (as seen in the case of Small Ship). A mechanistic approach will enable widespread awareness and implementation, yet, it must be augmented with deeper change at the technical and cultural level and organizational learning. It is worth noting that Big Ship and Small Ship have attempted to become more balanced in their deployment between organic and mechanistic in their response to deployment crises.

- *Existence of Equifinality*: A construct of Open Systems Theory, equifinality is the belief in multiple paths to achieving the same outcome. It is illustrated in the case studies of Big Ship and Small Ship. Both organizations observed in this case study have an opportunity for a successful long-term deployment of lean manufacturing. Big Ship has achieved this through a highly mechanistic approach, subsequently is balanced with an organic approach through inter-organizational knowledge sharing and response to crisis in deployment. At Small Ship, crisis in deployment brought them to a similar position of a more balanced approach of mechanistic and organic deployment, as they increased their infrastructure for deployment over time, and the over-reliance on charismatic personalities required them to institute a more structured approach to deployment. Ultimately, there is no "one best way" to deploy lean manufacturing, but a long-term balance between organic and mechanistic strategies is required for continued successes to occur.

- *Begin with Organic deployment:* while it was just stated there is no "one best way" to deploy lean, these case studies do seem to suggest advantages to leading with an organic deployment in order to achieve deep, immediate, and illustrative examples. This conclusion is also partly aligned to the original distinction of organic and mechanistic by Burns and Stalker. An organic approach seems more appropriate when uncertainty exists regarding the deployment, specifically questions about the objective, longevity, benefits, scope, timeline, etc. As the deployment begins to take hold within an organization, and the idea of "lean deployment" is better understood and embraced, uncertainty regarding the deployment is reduced and the infrastructure of a more mechanistic approach can begin to take hold. This conclusion proves true both at the model line (large valve repair) scope of analysis, as well as the model organization (Small Ship) scope of analysis.

- *Technical and cultural change go hand-in-hand*: As was discussed early in this chapter, many organizations will develop strategies for implementing specific technical and/or social change. Yet, in many of the case studies, particularly those with deeper implementations and multiple iterations of improvement, technical changes created social changes. Social changes in turn enabled greater technical changes. Therefore, deployment strategies that limit engagement to only a social or a technical change is shortsighted and do not appreciate the interconnectedness of the two. Long-term success is defined by achieving a lean learning organization, which is knowledgeable of the appropriate technical tools and the social infrastructure for implementation.

- *Exponential benefits with depth of deployment*: In case studies at both Big Ship and Small Ship deeper deployment, with multiple passes on a specific project, yielded greater benefits. As the organization deployed advanced social and technical tools of lean (e.g. flow of value, flexible/interconnected processes, WIP reduction, and a team construct) the benefits were more significant than in initial tool implementation (e.g. 5S and brainstorming). This is represented by the expanding surface area of the spirals and concentric circles in the illustrations of organic and mechanistic deployment, respectively.

- *No wasted failures, only failures to learn*: This adage, attributed to a senior leader with Toyota, is relevant when one looks at the evolution in both the organic and mechanistic approaches of the two shipyards. Small Ship, with the organic approach, was certainly more dynamic and evolutionary with their learning of lean manufacturing, but both organizations learned over time and adapted their strategies.

- *There is no crystal large*: The case studies of Small Ship and Big Ship produced one definite outcome. In large, complex organizations it is hard to predict the long-term future for lean implementation, adoption, and learning. Successful lean implementation requires that organizations challenge their present norms and procedures. Talking about an organization's evolution is simple compared to talking about each organization as a large number of individuals who must similarly challenge their own personal norms, procedures, and successes. One particular element of this is that in a large complex organization, positive energy may be effectively created for lean manufacturing deployment, yet, if the message is not closely preserved the energy and enthusiasm behind that message may be distorted by a manager looking to advance his/her own ideals. An examination of the Small Ship and Big Ship case studies after phase three or four of implementation would have suggested a very different set of analyses and conclusions than at the completion of six years. Successful lean deployment requires significant focus and energy for an extended period of time. Success and failure cannot be easily predicted.

ACADEMIC CONTRIBUTIONS

This chapter has sought to answer the specific question of how to begin a lean deployment, and to better understand the methodology and mechanisms by which lean deployment occurs. As a result of this study, several key contributions have been made to the academic literature in the areas of lean manufacturing, organizational design, and organizational change. The following contributions to academic literature in these areas have been made:

- Adapted organizational design concepts of an organic and mechanistic structure to develop a detailed dynamic model of organizational change; one of organic and mechanistic methodology of transformation. Strengths, weaknesses, and appropriate application of each concept are identified.
- Developed a socio-technical organization change model to describe the ways in which social and technical transformation must build upon each other for sustained transformation.

FUTURE RESEARCH

This chapter addresses lean manufacturing deployment on the scope of a specific organizational entity. In the comparative case study of Big Ship and Small Ship, it is acknowledged they are both partners and rivals in a larger enterprise. Yet, this study does not examine lean deployment at the enterprise level. Further study is planned regarding how enterprise deployment of lean manufacturing occurs over an extended lifecycle and how the organizations of enabling bureaucracy and coercive bureaucracy respond to efforts at creating the proper environment for successful lean manufacturing deployment. Additionally, it is recommended the model of organic and mechanistic deployment be studied over a larger set of organizations to understand the long-term strengths and weaknesses of each methodology. Finally, it is recommended that these concepts be applied in a retrospective look at large organizations that have successfully deployed lean production techniques, to determine the ways in which their experiences align to either Big Ship or Small Ship.

CHAPTER 4

DEVELOPING A LEAN BUREAUCRACY: ENABLING VERSUS COERCIVE TRANSFORMATION FROM AN ORGANIZATIONAL LIFE CYCLE PERSPECTIVE

INTRODUCTION

> Lean (adj.) – containing little excess, fat, or waste; efficient; see-also: lean muscle, Toyota production System.

Lean manufacturing, lean thinking, lean culture, lean product development, lean supply chain - these are descriptive characteristics sought by many of today's largest and most successful companies around the world to connote industry-leading efficiency. The term "lean" was coined by MIT scholars to mean "fragile with strength" in an attempt to describe what they observed in studying the Toyota Production System (TPS). (Vasilash, 2005) It is meant to describe an organization that does "more with less" by empowering employees towards continuous improvement and learning, and building upon a technical foundation of concepts such as stable production processes, workplace safety and organization, just-in-time production, and built-in quality. (Liker, 2004) Many companies have sought expertise from a lean sensei (Japanese term for "teacher") to internally learn, teach, and deploy lean thinking throughout their organization.

> Bureaucracy (n.) – management or administration marked by hierarchical authority among numerous offices and by fixed procedures; the administrative structure of a large or complex organization.

Bureaucracy, described by Max Weber (b.1864 - d.1920) as an idealized form of organizational governance for its rational control, clearly defined hierarchy, span of control, roles & responsibilities, and division of labor, is the predominant management structure for large complex organizations worldwide. Weber studied the largest organizations of his time (the government, military, and church) to appreciate the relative effectiveness of the bureaucratic governance form across broad and diverse organizations. (Weber, 1990) However, while in Weber's day a "bureaucrat" may have been praised for service to the organization, today the term has largely given way to negative perceptions of ineffectiveness, self-preservation, "red tape," and mindless adherence to procedures.

> Lean bureaucracy (n.) – 1. an efficient, large and complex organization, operating with minimal waste and excess in the system; see-also: lean manufacturing. 2. an internal agency within a large or complex organization, created as a deployment unit of lean management throughout an organization, highlighted by rules, procedures, and reporting metrics; see-also: red tape, institutional theory.

A play on words, lean bureaucracy is meant to represent the ideal of transforming a large, complex, inefficient bureaucracy into an efficient and well-run organization as Weber had envisioned. It was first coined by Paul Adler (1996) in an article that described what he observed at New United Motor Manufacturing Incorporated (NUMMI), Toyota's joint venture with General Motors in Freemont, California. He observed many structural characteristics of a bureaucracy, but found they enabled employee performance, instead of stifled employee-driven innovation and improvement, which was expected.

Unfortunately, for many organizations and senior leaders, this ideal of transforming their organization is replaced with another type of lean bureaucracy, a politically powerful, yet inefficient internal bureaucracy to deploy tenets of lean production. As seen in many organizations, the lean deployment team can quickly become a negative function of an inefficient bureaucracy, and not a mechanism to positively change an inefficient bureaucracy. In some instances, the rules and procedures used to efficiently deploy lean can ultimately become counter, even oppressive, to the overall message of learning and empowerment that are characteristic of a successful lean organization. This chapter seeks to better understand this specific phenomenon, the unintended double-meaning of lean bureaucracy. It will examine (1) why this phenomenon occurs, (2) why many attempts to transform an organization can become overwhelmed by self-inflicted red tape, and (3) will further consider how a bureaucracy can be formed through lean deployment, that is, has the best of both worlds - highly efficient and empowering within a bureaucratic framework, as envisioned by Adler.

The term lean bureaucracy has been used thus far to highlight the potential double-meaning of this terminology. To clarify discussions, for the remainder of this paper the term "lean bureaucracy" is used to represent a large, complex bureaucracy that has been transformed through tenets of lean production. The internal bureaucratic organization with the mission to deploy lean production is hereby termed a “lean deployment unit.” To use these terms in context: if the lean deployment unit is successful in its mission an organization may transform to a lean bureaucracy.

In a previous chapter, “Comparative Case Analysis of Lean Manufacturing Deployment: Organic vs. Mechanistic Approaches,” a distinction was made between an “organic” and “mechanistic” lean deployment within an organization. Two contrasting methodologies for deployment were identified (organic and mechanistic) and the benefits and shortcomings of each were identified. Organic lean deployment was noted for its deep learning and application of tools as systems, as well as its relatively slow pace of implementation. Mechanistic lean deployment was noted for its rapid and broad deployment, yet relative shallowness of implementation.

This chapter considers a broader scope of analysis - that of lean deployment across a large, complex, and geographically diverse organization, a multi-site bureaucracy. Many organizations attempting lean deployment today would be characterized as large, complex, and mature bureaucracies. Perhaps it is because these organizations are advanced bureaucracies that enterprise-wide transformation is attempted. This chapter seeks to explain the process by which a lean bureaucracy, the organizational unit, is created.

This discussion of organizational transformation will build upon two significant theories of bureaucracy: that of the organizational life cycle (Greiner, 1972) and the distinction between enabling and coercive bureaucracy (Adler, 1996). The most prominent theory on the organizational life cycle proposes four stages of organizational growth and maturation evolving to a "very bureaucratic" organization and ultimately to an elaboration stage, a form of post-bureaucracy, that breaks down the stranglehold of a rigid management structure.

Theory on enabling and coercive bureaucracy distinguishes between two types of bureaucracy, both of which may exist within a single organization. Coercive bureaucracy is a negative form of bureaucratic governance, or a system of rules and procedures intent upon measuring and controlling the individual. It is typically associated with inefficiency, mindless adherence to rules, and oppressive management control. By contrast, enabling bureaucracy, first observed in a Toyota-run plant, also has extensive rules and procedures, but they exist to support and empower the individual to higher levels of creativity and performance. (Adler, 1996)

Discussion of developing a lean bureaucracy integrates these two theories of organizational life cycle and enabling/coercive bureaucracy, to suggest a life-cycle development by which an organization may take alternative paths to an end state of enabling (positive) or coercive (negative) bureaucracy. In considering lean implementation across a large, multi-site organization, a model for life cycle stages of lean deployment is developed to define a sequence by which a positive lean bureaucracy is created.

To illustrate these theoretical constructs, this paper examines the life cycle of lean deployment within a large, complex, and mature bureaucracy, REMAN. Like many organizations, lean deployment at REMAN was initiated in good faith, to transform the organization through the principles and practices of lean production. Yet, over time it became clear the lean deployment unit within REMAN was far more a function of the bureaucracy than a transformation. The case study of REMAN and its analysis produce recommendations for effective enterprise-wide lean transformation. These recommendations can be used to develop efficient lean bureaucracies.

RESEARCH METHODOLOGY

“REMAN” would be considered as “very bureaucratic” by any definition. It has facilities across the United States, and is heavily influenced by national and international events. REMAN is an organization of more than 50,000 employees at 30 sites across the United States. (The specific agency or industry is not important to case study considerations)

Prior to lean deployment REMAN was a large, complex, mature, geographically dispersed organization with a long and proud history of industry-leading performance. REMAN had a long history of adopting “best practices” as introduced by outside contractors: from total quality management (TQM) to quality circles and quality functional deployment; from Malcolm Baldridge to Stephen Covey, to Mark Graham

Brown; from MRP systems, to ERP, to ERP2, and portfolio management. One could say lean manufacturing deployment is no different from these other initiatives. However, it currently has six years of run-time at REMAN, outlasting all other initiatives and has no sign of slowing. Furthermore, it has been developed and embraced internally. As one senior official stated, “lean has made more impact than any single initiative I have observed in 30 years with the REMAN.” This case study examines the first six years of lean deployment at REMAN.

A number of advantages led to selecting REMAN as the case study for this analysis. First, if implementation of lean production could transform a large bureaucracy from coercive to more enabling, it would be a strong demonstration of the impact of lean deployment, considering the layers and maturity of the REMAN bureaucracy. Second, access was good as senior leadership at REMAN was very supportive of this research. The researcher was a participant observer for part of this study as an entry-level professional helping lead the lean transformation of REMAN. Consequently, there was access to many archival documents, reports, directives, and planning meetings for lean deployment. Numerous interviews were conducted, both formal and informal, with personnel at all levels of the organization. An extended rotation at corporate headquarters, and multiple site visits to nearly half of REMAN’s thirty field-activities offered a well-rounded perspective on enterprise-wide deployment. (Eisenardt, 1989; Yin, 2002)

In order to deepen the learning to be gained from this case study, two specific divisions of REMAN, the two largest divisions, are highlighted for analysis: EarlyAdopter Division and LateToTheParty Division. These two divisions of REMAN are similar in size, geography, workforce demographics, culture, and overall organization structure. They perform diverse missions, yet serve a similar customer. Additionally, each division is subject to the same guidance and policies as outlined by the parent organization, REMAN. The two case studies had different starting points for lean deployment and took somewhat different paths that led to unique outcomes and understanding. Figure 4.1 outlines the research methodology for this paper.

	Research Methodology
Study Objectives:	*To better understand the phenomenon by which efficient lean bureaucracy is created*
Unit of Analysis:	*Extended enterprise - large, mature, and complex bureaucratic organization*
Study Design:	*Case study analysis of a single large organization during six year lean deployment; deep-dive examination of two large departments within this organization for case study comparison*
Case to be Studied:	*REMAN, a large ship remanufacturing agency, through six years of lean deployment*
Data Sources:	*Direct observation of lean deployment, extensive interviews with key personnel, review of documentation and deporting, archival records of implementation, participant observation*
Interview Sources:	*Corporate management, site management, shop management, line management, production workers, production analysts, lean manufacturing deployment team*

Figure 4.1 Summary of Research Methods

THEORETICAL DISCUSSION – DEVELOPING A LEAN BUREAUCRACY IN THE EXTENDED ENTERPRISE

To be “lean”, to do “more with less” while continuously improving and maintaining focus on customer value is a characterization sought by competitive organizations in nearly every market in the world today. The global marketplace continues to place ever greater emphasis on operating efficiency as organizations search the world over for better and cheaper materials, facilities, labor and intellectual capital. The term “lean” originated in automotive manufacturing, but has since been associated with a variety of industries, including: manufacturing, service organizations, office operations, home construction, management philosophy, organizational culture, product development practices, and supply chain characterization. (Womack, Jones, 1996)

Deployment of lean thinking in any organization at any level is a deliberate effort to promote better performance, with the best known model being Toyota. In some ways the deployment of lean production is no different than any other corporate initiative in that it is intent upon tangible change within the organization. Organizations may deploy lean for a variety of reasons: to impress stockholders; to transform a culture; to improve operational safety, efficiency, throughput, cycle time, quality, customer satisfaction, or a myriad of other measurable objectives. From the perspective of others in the field (e.g., Liker, 2004) deployment of lean is far different from other corporate initiatives. It is not an initiative as much as a transformation to a new way of thinking about and managing the organization.

Many of the organizations working to “deploy lean” are large, multi-site, and even global organizations. These organizations would all be characterized by a high degree of bureaucracy. Bureaucracy has been noted throughout history, as early as the Book of Exodus in the Bible, for highly efficient oversight and control of large organizations through rational control, clearly defined hierarchy, span of control, roles & responsibilities, and division of labor. In a bureaucracy, legitimate control is associated with a position, not an individual, allowing organizations to endure far beyond the tenure of key personnel. (Weber, 1990) However, in a mature bureaucracy, elements of complacency, organizational entropy, and stagnation are commonly found and can erode efficiency within the overall organization. (Greiner, 1972) These sources of decline lead many organizations to attempt to continuously improve their organization through lean deployment.

Lean Bureaucracy and Organizational Life Cycle Development:

In this paper we take a dynamic perspective on lean deployment, considering the natural evolution, growth, and decline of bureaucratic organizations through the organizational life cycle. Greiner (1972) studied numerous organizations over time and began to recognize patterns in organizational development, similar to life cycle development observed in organisms, including humans. Greiner’s organizational life cycle theory suggests the growth, evolution, and maturation of an organization occurs through four distinct and predictable stages of development: (1) entrepreneurial stage, (2) collectivity stage, (3) formalization stage, and (4) elaboration stage. In this theory of organizational life cycle development, a key dimension in distinguishing the stages is the degree of bureaucracy present at each stage. The entrepreneurial stage is characterized as "non-bureaucratic." The organization reaches the peak of bureaucracy in the formalization stage. Then the organization reverses itself to undo some of the strangling bureaucracy in the elaboration stage, which may be considered "post-bureaucratic." The elaboration stage is particularly interesting, both for the fact it is the most ideal bureaucracy, and for the fact it receives the least consideration in Greiner's work (perhaps because strong examples of this type of organization were difficult to find at the time). Today, Toyota may be an example of an organization that successfully grew to the elaboration stage and filled a gap in this literature. (Liker, 2004)

While Greiner provided the initial architecture for organizational life cycle development, understanding of this construct has been further enhanced through follow-on research (Quinn and Cameron, 1983; Lippitt and Schmidt, 1967), characterizing each stage according to a large collection of variables. Figure 4.2 summarizes each of the four stages of life cycle development along the dimensions of:

- *Keys to Achieving Stage*: the characteristic of organizational development which marked the transition from one stage of evolution to the next. Initially, an organization originates from a creative idea in the Entrepreneurial Stage, will develop a clear purpose and direction as it transitions to the Collectivity Stage, develops extensive internal systems of management in the Formalization Stage, and develops effective utilization of teamwork in the Elaboration Stage.
- *Goal of Organization*: the overarching objective for an organization in this stage of maturity. Organizational goals transition from survival to growth, internal

stability, and market expansion, to development of a “complete” organization with efficient and effectives rules and regulations throughout, as it transitions through the stages of development.

- *Structure*: the overall formal infrastructure common to an organization at this level of maturity. Overall structure transitions from an informal one-person show, to a mostly informal structure with some procedures, to a formal structure with division of labor, to extensive teamwork and small-company thinking as an organization matures.
- *Top Management Style*: characteristics of organizational leaders commonly found in an organization in this stage of development. As the organization matures, so do the requirements of leadership, from individualistic, entrepreneurial, and controlling; to charismatic and team building; to the ability to delegate and manage; to a self-managing team approach to attack bureaucracy.
- *Reward and Control Systems*: the formal and informal methods and systems used to award and discipline employees. Reward and control systems evolve from personal rewards which are paternalistic to recognition of contributions to success; to impersonal rewards as elements of the formalized system; and ultimately to rewards which are tailored to the department.
- *Crisis to Overcome*: the specific challenge that develops within the organization at this stage of development and must be overcome for the organization to mature to the next stage of evolution. An organization may suffer from a lack of leadership in the Entrepreneurial stage, a need for delegation with control in the

Collectivity, a need to deal with too much red tape in Formalization, and a need for revitalization to overcome complacency in the Elaboration stage.

	Entrepreneurial Stage *Nonbureaucratic*	**Collectivity Stage** *Prebureaucratic*	**Formalization Stage** *Bureaucratic*	**Elaboration Stage** *Post Bureaucratic*
Keys to Achieving Stage :	*Creativity*	*Provision of clear direction*	*Addition of internal systems*	*Development of teamwork*
Goal of Organization:	*Survival*	*Growth*	*Internal stability, market expansion*	*Reputation, developing a complete organization*
Structure:	*Informal, one-person show*	*Mostly informal, some procedures*	*Formal procedures, division of labor*	*Teamwork within bureaucracy, small company-thinking*
Top Management Style:	*Individualistic, entrepreneurial*	*Charismatic, direction-giving*	*Delegation with control*	*Team approach, attack bureaucracy*
Reward and Control Systems:	*Personal, paternalistic*	*Personal, contribution to success*	*Impersonal, formalized systems*	*Extensive, tailored to department*
Crisis to Overcome:	*Need for leadership*	*Need for delegation with control*	*Need to deal with too much red tape*	*Need for revitalization*

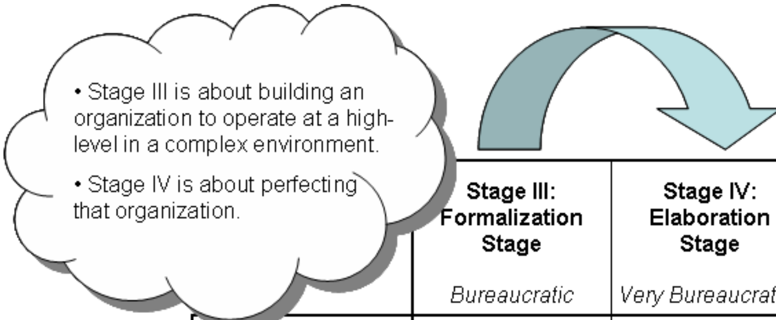
Source: Greiner (1972), Lippitt and Schmidt (1967), Quinn and Cameron (1983)

Figure 4.2 Summary of Organizational Life Cycle Characteristics

As seen through the organizational life cycle, an organization becomes more dependent upon rules, regulations, and formal procedures to exert influence and control as it becomes larger and more mature. As layers of bureaucracy are added to achieve this influence and control, the organization becomes less responsive to internal and external pressures to change. This trend is reversed as organizations achieve the Elaboration Stage (Stage IV) of development, achieving a post-bureaucratic organization. The Elaboration Stage is unique for the high degree of bureaucracy, but relatively low degree of red tape. Greiner (1972) identifies it as rare for this stage to be achieved or sustained by any organization due to a unique balance of the conflicting values of big-organization control and small-organization flexibility. It is largely for this reason most large and mature organizations today would be considered stuck in the Formalization Stage (Stage III), unable to make the transition to Stage IV thinking.

Transition through the first three phases of the organizational life cycle is a largely natural transition for a growing, maturing, and successful organization; transition to an Elaboration-Stage organization is not a natural evolution. As previously mentioned, it is believed that Toyota is a rare organization that has achieved successful elaboration and the positive characteristics of bureaucracy described by an Elaboration-Stage organization. The specific mechanics of this achievement within Toyota are not clearly understood. However, for most organizations the transition to an Elaboration stage organization must occur through a purposeful organizational design. The fear of remaining in a stagnant, Formalization Stage may motivate many to deploy lean production with promises of organizational learning, employee empowerment, reduction in bureaucracy, improved efficiencies, and culture change.

This study of the development of a lean bureaucracy examines the transition from a Stage III organization to a Stage IV organization. Figure 4.3 highlights this specific transformation. Evolution to Stage III allows an organization to operate at a high level in a complex environment, while evolution to a Stage IV organization can be considered as a “perfecting” of that organization.



	Stage III: Formalization Stage *Bureaucratic*	Stage IV: Elaboration Stage *Very Bureaucratic*
Keys to Achieving Stage :	*Addition of internal systems*	*Development of teamwork*
Goal of Organization:	*Internal stability, market expansion*	*Reputation, complete organization*
Structure:	*Formal procedures, division of labor*	*Teamwork within bureaucracy, small company-thinking*
Top Management Style:	*Delegation with control*	*Team approach, attack bureaucracy*
Reward and Control Systems:	*Impersonal, formalized systems*	*Extensive, tailored to department*
Crisis to Overcome:	*Need to deal with too much red tape*	*Need for revitalization*

Figure 4.3 Purposeful Transition to an Elaboration Stage Organization

Relating the Organizational and Individual Life Cycle – Maslow's Hierarchy of Needs:

The study of growth, evolution, and purposeful transition in pursuit of perfection at the organizational level has a striking similarity to Abraham Maslow's theory of motivation at the individual level. Maslow's "Hierarchy of Needs" identifies stages of personal development and growth as our goals and desires in life transition through the following stages: survival, external growth, internal growth, and self actualization, the highest level of achievable performance. Figure 4.4 illustrates the parallels between Maslow's hierarchy of human development and Greiner's life cycle model of organizational evolution.

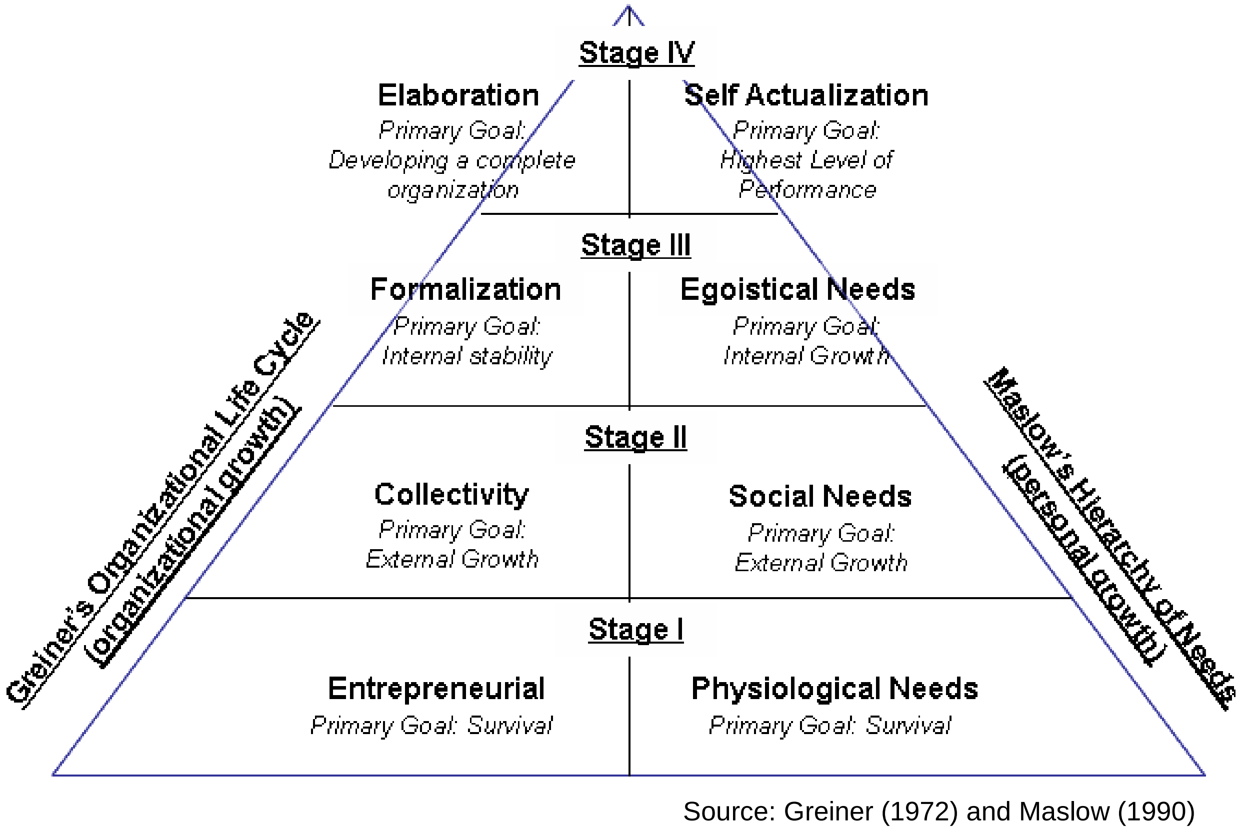


Figure 4.4 Organizational Life Cycles and Maslow's Hierarchy of Needs

According to Maslow (1990), many people will naturally transition through Stages I - III of development. Similarly, many organizations will naturally transition through Stages I-III of development. However, few individuals and organizations are able to achieve the highest levels of performance associated with self-actualization and elaboration. Self-Actualization and elaboration exist as goals sought after by most mature individuals and organizations, but are seldom achieved.

Enabling/Coercive Bureaucracy and the Lean Transformation:

As previously mentioned, Formalization Stage organizations are characterized by extensive internal systems of oversight and control, impersonal formalized systems, and formal procedures, rules, and regulations. Elaboration Stage organizations on the other hand, are characterized by teamwork and their overall attack on wasteful bureaucratic structures and organizations. This stark contrast in organizational characteristics is similar to that of Coercive and Enabling bureaucracies, as identified by Paul Adler (1996). It must be noted that in his recognition of coercive and enabling tendencies, Adler suggests organizations are not homogenous. Rather, Adler argues intention and outcome may blur as systems and governance exist in some areas to control (coerce) an employee, as well as support (enable) him/her.

Adler identifies bureaucracies, not by their maturity as Greiner, but by their internal characteristics of the relationship between the individual and the formal systems. Adler identified coercive bureaucracy by the ways in which they focus on assessing poor performance, measuring costs, keeping employees out of the decision making loop, and controlling actions of the individual through rigid adherence to rules, regulations, and procedures. By contrast, enabling bureaucracy emphasizes: process characteristics, sharing of best practice methodologies, empowerment and customization of procedures as necessary, and emphasis on continuous evolution and improvement. Enabling and coercive bureaucracies are summarized in Figure 4.5

Coercive Bureaucracy	Enabling Bureaucracy
• Systems focus on performance standards so as to highlight poor performance.	• Focus on best practice methods: information on performance standards is not much use without information on best practices for achieving them.
• Standardize the systems to minimize gameplaying and monitoring costs.	• Systems should allow customization to different levels of skill/expertise and should guide flexible improvisation.
• Systems should be designed as to keep employees out of the control loop.	• Systems should help people control their own work: help them form mental models of the system by glass box design.
• Systems are instructions to be followed, not challenged.	• Systems are best practice templates to be improved.

Source: Adler (1996)

Figure 4.5 Summary of Enabling and Coercive Bureaucracy

A unique aspect of Adler's study (1996) is highlighting the potential of bureaucratic organizations to enable the employee. Prior to this research, most work on bureaucratic theory suggested that a high degree of bureaucratization was synonymous with "red tape" and inefficiency caused by excessive controls. Adler's description of enabling bureaucracy aligns closely to Greiner's (1972) characterization of an Elaboration Stage organization and post-bureaucratic organizational development.

Similar to Adler, Steven Spear and Kent Bowen (1999) have closely examined culture and bureaucracy at Toyota. Their findings were similar, specifically their perceived paradox of bureaucracy that "rigid specification (bureaucracy) is the very thing that makes the flexibility and creativity possible" (Spear and Bowen, 1999). How is this possible? Spear and Bowen point to the continuous improvement practices of Toyota.

Any improvement made to an unstable process becomes simply one more way of performing the process. True organizational learning requires stabilizing the process. They use the analogy of scientific inquiry to describe Toyota's approach as running many experiments. For each experiment a certain number of variables must be held constant and standardized, while selective changes are made and the results observed. If the results are favorable, then the new method is standardized until a better way is found. Through alternatively stabilizing and improving through experimentation, a "very bureaucratic" organization becomes efficient and capable of adapting to environmental stressors. (Spear and Bowen, 1999; Adler, 1993, 1996)

Defining a Lean Bureaucracy:

Adler, Greiner, Spear, and Bowen all offer descriptions of very bureaucratic organizations that reveal a picture of what a positive lean bureaucracy may look like. Yet, the descriptions offered by these authors are each intended for a unique purpose and audience. In order to describe a lean bureaucracy more systematically, an adaptation of Open Systems analysis is used to refine descriptive characteristics and parameters (Nadler and Tushman, 1997). Three key areas in organizational analysis are: the formal organization, informal organization, and the organization's orientation to change.

These dimensions are summarized in Figure 4.6. The formal organization has an organizational hierarchy and structure, rules, regulations, and procedures, roles and responsibilities, written communication mechanisms, and decision making processes. The informal organization is considered the "soft stuff", and includes elements of organizational history and culture, leadership styles, physical workspaces, sources of individual power, and verbal communication mechanisms. Orientation to change would consider the organization's overall preparedness and environment for change, including existence of a "burning platform" (pending organizational crisis), history of organizational change, goals for transformation, and the overall strategy and infrastructure for organizational change.

Formal Organization

- organizational hierarchy and structure
- written communication mechanisms
- formal procedures, rules, regulations
- technology and technical systems
- decision making processes
- organizational reward systems
- written roles and responsibilities

Informal Organization

- sources of individual power
- organizational history
- organizational culture
- verbal communication mechanisms
- organizational leadership styles
- physical layout of facilities

Orientation to Change

- goals of organizational transformation
- methods of organizational learning
- history of organizational change
- infrastructure for transformation
- organizational risk aversion
- "burning platform"

Modeled upon Nadler and Tushman (1997)

Figure 4.6 Dimensions of Bureaucratic Analysis

In order to characterize and describe a positive lean bureaucracy, the definitions of Adler's "Enabling Bureaucracy" (1996), Greiner's "Elaboration Stage Organization" (1972), and Spear and Bowen's "DNA of the Toyota Production System," (1999) are compared along the dimensions of formal organization, informal organization, and orientation to change. Each of these illustrates a large, complex, and mature bureaucracy operating efficiently and eliciting the best characteristics of Max Weber's (1990) original declaration of bureaucracy as the "ideal form of organization." An additional source that is added to this comparison is the "Learning Organization" as defined by Peter Senge (1990). The Learning Organization is the result of extensive research on small and large organizations that are able to effectively learn, evolve, and adapt according to past experiences. (Devanna and Tichy, 1990) Toyota and other lean producers are noted for their ability to learn as an organization, and have been referred by Liker (2004) as "lean learning organizations." When combined, these four perspectives, Figure 4.7, create a broad vision, description, and definition of an efficient and effective lean bureaucracy.

	Elaboration Stage of Bureaucracy	Enabling Bureaucracy	"DNA" of Toyota	Learning Organization
Formal Organization	• High degree of collaboration and teamwork among entire organization • Social control reduces the need for additional formal controls • To achieve collaboration, teams are often formed across functions of the organization	• Bureaucratic structures and systems function to support the work of the doers rather than to bolster the hierarchy • Procedures are designed with the participation of the users in order to identify best practices and to identify opportunities for improvement • Bureaucracy will be considered by employees as a tool with which they can better perform their tasks	• Activities, connections, and production flows are rigidly scripted, yet at the same time operations are enormously flexible and adaptable • Rigid specification is the very thing that makes the flexibility and creativity possible • Every internal customer/supplier relationship must be direct, with unambiguous yes-no communications • The pathway for every product must be simple and direct	• The whole is more important than the parts, and boundaries between parts are minimized • Individuals are aware of the whole system, how everything fits together, and the relationships among various organizational parts • A learning organization encourages openness, boundarylessness, equality, continuous improvement, and risk taking
Informal Organization	• Managers develop skills for confronting problems & working together • Managers learn to work with the bureaucracy without adding to it	• Power is endorsed from below rather than authorized from above • Staff function as partners with line employees	• People are most significant corporate asset and investments in their knowledge and skills are necessary to build competitiveness	• A sense of community and caring for one another is created • Managers emphasize honest and open communications as a way to build trust
Orientation to Change	• Organization may have become over bureaucratized and must go through a period of streamlining and innovation • Management may attack the bureaucracy and streamline it **Source: Greiner, 1972**	• Focus on best practice methods, with flexible improvisations for skill/experience • Systems are best practice templates to be improved **Source: Adler, 1996**	• Activities and processes are constantly challenged and pushed to a higher level of performance, enabling the company to continually innovate and improve **Source: Spear & Bowen, 1999**	• A basic value is to question the status quo. Constant questioning of assumptions opens the gates to creativity and improvement • To symbolize the importance of taking risks, a learning organization may also reward those who fail in order to learn and grow **Source: Senge, 1990; DeVanna & Tichy, 1990**

Figure 4.7 Defining a "Lean" Bureaucracy

As a result of this analysis, a more refined definition of a positive lean bureaucracy is created:

- *Formal Organization*: The formal organization of a positive lean bureaucracy is marked by a sense of the whole. The organization would likely be considered as very bureaucratic or post-bureaucratic for its systems, structures, and organization, yet each is carefully crafted and evolutionary to both support the whole and support the individual.
- *Informal Organization*: Teamwork is an important element of the lean bureaucracy. Teams create complimentary units for the individual and work effectively with other teams to avoid politics and sub-optimization within the larger organization. At the same time, the power of the individual is emphasized While red tape connotes the powerlessness of the individual, lean bureaucracy is characterized by an extreme emphasis on the individual as truly the most significant of resources. Indeed, individuals are a source of power within an organization, as they promote problem solving and a sense of community. Servant leadership is an active element of a lean bureaucracy, where the primary role of leadership is to empower and enable the individual within the bounds of the bureaucracy (Liker, 2008).
- *Orientation to Change*: The orientation to change in a lean bureaucracy is recognizable for emphasis on a systematic approach to challenging the status quo, even challenging “best practice” methodologies. Process improvement and change are a mechanism for continually improving the organization, refreshing it, and training employees. A lean bureaucracy will not become stagnant if

continually challenged and refreshed by a well-trained workforce. The orientation to change is a central element to success of the lean bureaucracy, since it provides the energy to combat organizational entropy. However, this is also a tremendous challenge for the organization because it creates a constant sense of urgency and need for change.

Developing a Lean Bureaucracy – A Life Cycle Perspective:

In earlier discussion within this chapter, a positive lean bureaucracy has been defined as a large complex bureaucracy that has effectively deployed tenets of lean production. Further, the context for transformation to a lean bureaucracy has been identified as a purposeful transformation from a Formalization (Stage III) bureaucracy. Discussion now shifts to the lean deployment unit, and its implications to the outcome of transformation.

In a previous chapter, a distinction was made between mechanistic and organic mechanisms of deployment, specifically the ways in which a single organization deploys lean production. Organic was noted for learning and evolutionary deployment, characterized by deep learning and a relatively slow deployment. Mechanistic deployment was characterized by rapid and widespread deployment, yet a relatively superficial understanding of implementation concepts. The characterization of deployment originated from the characterization of organization structure as rigid and "machine like" (mechanistic) as opposed to a living, breathing, evolving organism (organic). (Burns and Stalker, 1961) From the perspective of organizational structure, Adler (1996) suggests enabling bureaucracy has the technical characteristics of a mechanistic structure and the social flexibility of an organic structure. The lean bureaucracy is a hybrid mechanistic and organic organization. This concept can apply at the unit of a single geographical site or across a dispersed multi-site corporation. In this chapter we focus on the extended enterprise for a large and complex bureaucracy.

Transformation of a large extended-enterprise often occurs through a purposeful organizational change program such as lean deployment or other corporate initiatives. Many large and complex Formalization (Stage III) organizations have undertaken a transformation towards a lean bureaucracy. As a result, many have achieved a positive and desirable outcome as defined in the previous discussion, but others have experienced negative outcomes associated with red tape and bureaucracy in deployment.

We can look at the development of the lean deployment initiative in much the same way as we looked at the growth and development of an organization—through the organizational life cycle perspective described by Greiner (1972). An organizational initiative is begun as a largely entrepreneurial venture, evolves over time, and may achieve an elaboration stage. If successful, the initiative is simply thought of as part of the organizational culture and operating norms. Therefore, a parallel model can be created for the lifecycle of a lean deployment as a bridge from Stage III bureaucracy to a Stage IV bureaucracy. Figure 4.8 illustrates the stages by which an organization may transition from a Formalization Stage bureaucracy to an Elaboration Stage bureaucracy through a four-stage purposeful transformation through lean deployment.

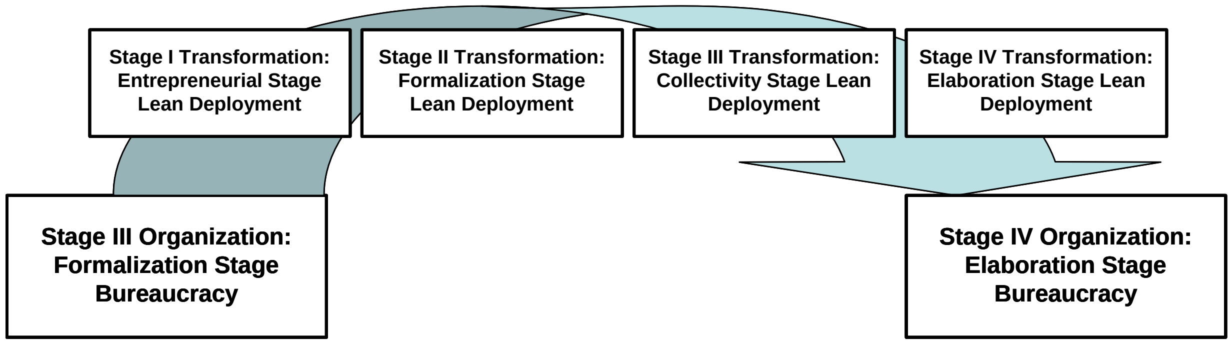


Figure 4.8 Life Cycle Metaphor for Lean Transformation

The parallel between maturation of an organization and that of a purposeful organizational transformation initiative highlights how an initiative, such as lean deployment, evolves through unique stages. The model of organizational maturation is appropriate for comparing the maturation of organizational change programs when the initiative is begun by technology innovators and early adopters. As the deployment grows it will engage a larger element of the organizational population until, ultimately, the change management tools and techniques are simply absorbed by the organization as commonly accepted organizational norms.

In the previous discussion of organizational evolution through stages of development, the transition of characteristics (organizational goals, structure, top management style, reward and control systems, and crisis to overcome) was presented. Figure 4.9 offers a normative model of lean deployment through the same four phases of evolution: entrepreneurial, collectivity, formalization, and elaboration. This normative model characterizes organizations according to: goal of the lean program, perception of the lean program, structure of lean deployment, leadership of the lean program, technical tools and techniques applied, social/cultural tools & techniques applied, lean program results and benefits, and crisis to be overcome in order to move forward in lean deployment.

	Entrepreneurial Stage of Lean Deployment	Collectivity Stage of Lean Deployment	Formalization Stage of Lean Deployment	Elaboration Stage of Lean Deployment
Goal of Lean Program:	*Learn Lean Production, test the waters to see how it applies*	*Growth, develop strategic plan for Lean Deployment*	*Internal stability, "seeding" of entire organization*	*Every worker seeking continuous improvement, every day*
Perception of Program:	*Uncertainty and skepticism*	*"Special projects to fix isolated problems"*	*"Everyone has to get involved!"*	*"Here to stay, part of the day job"*
Structure:	*Informal, few leading individuals*	*Mostly informal, small department for Lean Transformation*	*Formal procedures, Lean capability beginning to develop in each department*	*Teamwork within bureaucracy, small company-thinking*
Leadership of Lean Program:	*A few knowledgeable, Lean individuals*	*Enroll senior management*	*Spread to middle management*	*All levels of the organization*
Technical Tools & Techniques:	*Tools deployment, disconnected Process Improvement*	*Value Stream Thinking by Individual Departments*	*Value Stream Thinking by Entire Organization*	*Pursuit of Perfection, Complete Value Stream Thinking*
Social/Cultural Tools & Techniques:	*Isolated employee engagement*	*Widespread engagement, isolated empowerment of employees*	*Widespread engagement and empowerment, isolated teambuilding*	*Widespread engagement, empowerment, teambuilding*
Program Results and Benefits:	*Isolated waste elimination*	*Many examples of waste elimination, few specific cost reductions*	*Widespread waste elimination, many cost reductions*	*Widespread waste elimination, cost reduction, and redeployment of resources*
Crisis to be overcome:	*Isolated Program or Leadership*	*Failure to develop depth of deployment*	*Failure to develop breadth of deployment, too much red tape*	*Accepting "good enough", possible burnout*

Figure 4.9 Normative Model of the Phases of Lean Deployment in an Organization

Consider each of these characteristics of lean deployment in turn:

- *Goal of the Lean Program*: the overall purpose of the deployment program during this phase of maturation. As the lean deployment takes roots within an organization the primary objective is simply survival of the change management program and understanding the feasibility of lean concepts within the organization. The deployment must overcome significant organizational inertia to current practices simply to exist. As deployment is sustained, the objective becomes one of growth, and in the Collectivity Stage of deployment a need arises for a strategic plan for deployment in order to gain broader acceptance throughout the enterprise. During a Formalization Stage of deployment a primary goal for implementation would be to achieve internal stability for long-term success and effective seeding of the entire organization to culture change of continuous improvement. The ultimate goal of lean deployment in the Elaboration stage is where every worker seeks continuous improvement every day as part of the culture and norms of operation within the organization.

- *Perception of the Lean Program*: a general attitude of employees towards the lean deployment. As lean deployment matures within the organization, the perception of this change management program will also certainly change. At the inception of deployment, the program is likely met with uncertainty and skepticism by employees who may be uncomfortable with organizational change. As lean deployment matures, perception likely shifts to expectation of lean resolving specific issues and process challenges throughout the organization, as this is what most employees are familiar with regarding change management. Employees may finally realize that all aspects of the organization will be impacted by lean deployment as the Formalization Stage is achieved. Finally, during the

Elaboration of deployment all employee's would be confident the program is not simply a short-lived initiative, but a permanent policy for improvement.

- *Structure*: the organizational makeup of the lean deployment. The development of structure in a lean deployment is similar to that of an organization as it matures. Early on in deployment, the structure would be largely informal, with a few individuals assuming leadership roles due to their personal interests. As deployment advances, a small program office for lean deployment is likely to emerge, yet it would remain largely informal in deployment. In the Formalization Stage of deployment it becomes more critical for formal procedures to guide deployment, and the lean capability is established in all major departments. The structure of lean deployment during the Elaboration Stage is an ideal end-state of teamwork within the bureaucracy and small-company thinking and flexibility of deployment.

- *Leadership of the Lean Program*: the role of senior leaders leading the lean deployment. At the inception of lean deployment, it is likely only a few knowledgeable leaders exist in support of deployment as early adopters and/or innovators. As the deployment seeks to grow, it becomes important to effectively enroll senior management in support of deployment. The most difficult level of management to engage in deployment is that of middle management, but this must occur in the Formalization Stage if true culture change is to occur within the organization. Finally, during Elaboration of lean deployment, management at all levels of the organization are effectively engaged in deployment.

- *Technical Tools & Techniques*: technical evolution of lean deployment concepts. Upon inception, the technical deployment of lean would resemble disconnected process improvements and deployment of very specific technical concepts. As deployment matures, this technical deployment would become more strategic in the form of value stream thinking among independent departments, and connected by value stream thinking in the extended enterprise in the Formalization Stage. In the Elaboration Stage of lean deployment, the application of technical tools and techniques is replaced with a simple, committed pursuit of perfection as applied to value stream thinking throughout the entire organization.

- *Social/Cultural Tools & Techniques*: social evolution of lean deployment concepts. Similar to the evolution of technical tools and techniques, deployment of social tools, the other element of the socio-technical nature of lean deployment evolves over time. Socio-technical transformation begins with isolated employee engagement; evolving to widespread engagement with only isolated empowerment of employees. During Formalization an organization is able to achieve widespread engagement and empowerment, but with isolated teambuilding. Finally, a lean deployment would involve widespread engagement, empowerment, and teambuilding throughout the organization during the Elaboration Stage.

- *Program Results and Benefits*: the overall benefit to be recognized through lean deployment. Lean deployment may be initially engaged in each organization for a variety of reasons, but the desire to achieve waste elimination is paramount. As the deployment matures, many examples of waste elimination may arise throughout the organization, as well as a few specific examples of cost reduction may emerge. The Formalization Stage is simply a growth in the number and impact of waste elimination and cost reductions. In the Elaboration Stage, the organization recognizes widespread waste elimination, cost reduction, adaptation to the environment, and redeployment of resources.

- *Crisis to be Overcome*: the greatest challenge to the lean deployment that must be overcome in order to transition to the next stage of development. In order for lean deployment to transition through stages of deployment, an organization must first overcome crises associated with being considered an isolated program. As it matures, the crisis is a failure to develop depth of deployment during Collectivity; a failure to develop breadth of deployment and possibly too much red tape during Formalization; and ultimately, the desire to accept "good enough", along with possible burnout, in the Elaboration Stage.

Lean Deployment Unit – Enabling and Coercive Design:

The normative model of lean deployment is useful to understand the evolution and development of the process by which organizational transformation occurs. However, as previously discussed, not all lean deployments produce the same results. Many efforts that attempt to effectively transform the organization to a lean learning organization become subject to the same rules and regulations of the bureaucracy they are attempting to transform. This is a similar comparison to Adler's (1996) work on enabling and coercive bureaucracy, reminding us there are various forms of bureaucracy. Therefore, whereas Adler's analysis was description of enabling and coercive was a characterization of bureaucracy. This concept is extended to consider the implications of an enabling lean deployment and coercive lean deployment is introduced.

Adler (1996) identified organizational structure as enabling or coercive. Similarly, organizational change can be conducted in an enabling or coercive manner. Adler did not specifically define organizational change as enabling or coercive, but did identify the implementation context by which enabling and coercive organizations could be created. This is summarized in Figure 4.10. Adler considers the dimensions of structure, skills, procedures, culture, and strategy. All of these loosely align to the dimensions of Open Systems Analysis, which has been previously discussed: formal organization, informal organization, and orientation to change.

Formal Organization

Informal Organization

Orientation to Change

	Implementation Context of Coercive Bureaucracy	Implementation Context of Enabling Bureaucracy
STRUCTURE	• fiefdoms • positional authority • top-down control	• mutually supportive specializations • hierarchy of expertise • shared control
SKILLS	• operational know-how • narrow, specialized • training as expense to be minimized	• problem-solving and know-why • both broad and deep • training as investment to be optimized
PROCEDURES	• coercive constraints • provide top-down visibility for supervisors	• enabling disciplines • provide intelligibility for the top down, for the bottom up, and for everyone laterally
CULTURE	• command and control • mistakes are costly	• collaborative control and learning • mistakes are learning opportunities
STRATEGY	• identifies desired results • focuses at business level • autocratic formulation process	• sharing of required capabilities • sharing of functional levels • participative formulation process

Source: Adler (1996)

Figure 4.10 Summary of Enabling and Coercive Bureaucracy in Implementation Context

- *Formal Organization*: the formal organization in implementation context incorporates the variables of structure, worker skills, and procedures. A coercive bureaucracy is developed with an emphasis on rigid constraints, positional authority, top-down control and visibility, and fiefdoms for span of control. An enabling bureaucracy is developed through shared information, broad and deep expertise, emphasis on problem solving during implementation and the consideration of training as an important long-term investment.
- *Informal Organization*: the informal organization in implementation context incorporates the variables of worker skills, procedures, and organizational culture. During the implementation context, a coercive bureaucracy is characterized by fear of failure and change management in which mistakes are costly. Furthermore,

quantifiable results are publicized for the aggrandizement of the individual or specific business unit. The informal organization of the enabling context places significantly more emphasis on mistakes as learning opportunities and the need to progress through collaborative learning across the enterprise.

- *Orientation to Change*: orientation to change in the implementation context incorporates the variables of culture and strategy. Within a coercive deployment the emphasis is placed upon quickly achieving desired business results of cost reductions and reduction in labor force. Improvements focus at the sub-optimized business level, and management is likely to define specific improvements to be implemented throughout the extended organization. An enabling implementation occurs through a sharing of knowledge, resources, and technical expertise for total organization-wide optimization. Improvements are made through a participative formulation, and the average employee is meant to feel a greater degree of ownership to the overall deployment.

Enabling and Coercive Lean Deployment:

This discussion leads to a question: What does the lifecycle of an enabling and coercive lean deployment look like? To answer this question, we theoretically contrast an enabling and coercive deployment through the four phases of the deployment life cycle.

Entrepreneurial Stage of Deployment:

Figure 4.11 illustrates differences between an enabling and coercive deployment during the early entrepreneurial stage when the organization is first being introduced to lean methods. As noted earlier, in this stage of deployment the initiative is met with uncertainty and skepticism, and the overall goal of the program is to learn the basic tools to test the waters to see how they may apply. The structure is informal, the initiative is lead by a few knowledgeable individuals focusing on tools deployment and disconnected process improvements, isolated employee engagement, with a few individual leaders who act as champions.

An enabling deployment at this early stage is characterized by few rules and regulations, so as not to impede learning. An organic and flexible structure would exist with little formal reporting of results. The leadership team would focus on teaching the basics and seek out early adopters within the organization who can take on future roles as leaders of deployment. An environment is created that encourages risk taking and learning from early mistakes.

A coercive deployment at this stage would be characterized by rules and regulations to manage implementation according to a structured plan. A mechanistic structure would exist with rigid roles, responsibilities, and reporting requirements. A management-oriented leadership team would be in place to monitor and measure deployment. A highly structured deployment strategy would be developed and enforced to build a repeatable model of implementation across the entire organization. An emphasis would be placed on short-term cost-reductions, strict procedures, and an identification of key leverage points to optimize return on investment of deployment.

	Entrepreneurial Stage of Lean Deployment
Goal of Lean Program:	*Learn Lean Production, test the waters to see how it applies*
Perception of Program:	*Uncertainty and skepticism*
Structure:	*Informal, few leading individuals*
Leadership of Lean Program:	*A few knowledgeable, Lean individuals*
Technical Tools & Techniques:	*Tools deployment, disconnected Process Improvement*
Social/Cultural Tools & Techniques:	*Isolated employee engagement*
Program Results and Benefits:	*Isolated waste elimination*
Crisis to be overcome:	*Isolated Program or Leadership*

	Entrepreneurial Stage of Lean Deployment	
	Coercive Deployment	**Enabling Deployment**
Formal Organization	rules & regulations developed to “manage” implementation according to structured plan; mechanistic structure with roles, responsibilities, and reporting requirements	few rules & regulations, so as not to impede learning; organic and flexible structure; little reporting
Informal Organization	management-oriented leadership to teach Lean deployment; structured training of organizational leadership team; emphasis on building a repeatable model for success	technically-oriented leadership team to teach Lean deployment; un-structured recruiting of “early adopters” to take on leadership role; emphasis on trial and error, measured risk taking
Orientation to Change	emphasis on capturing short-term cost-reductions; deployment encouraged as “part of the norm”; emphasis placed on identifying “leverage points” for deployment	emphasis placed on overcoming “organizational inertia”, creating illustrative “wins” in short-term; encourage a “new way of thinking” throughout organization

Figure 4.11 Enabling and Coercive Deployment in the Entrepreneurial Stage

Collectivity Stage of Deployment:

Figure 4.12 illustrates differences between an enabling and coercive deployment during the collectivity stage. As previously identified, the overall goal of the initiative is to spread lean methods in this stage of deployment. The overall perception of the program continues to be a “special program to fix isolated problems,” with a mostly informal structure and small department for lean deployment. The role of leadership is to enroll senior management, and value stream thinking begins within isolated processes. At this point, the organization has more widespread engagement, though empowerment remains in isolated islands. Many examples of waste elimination exist, and a few specific cost reductions are achieved. The crisis to overcome at this stage is the failure to develop depth of deployment.

During the collectivity stage of deployment, an enabling deployment would have rules and regulations in place to enable individual learning throughout the organization while forms and reporting evolve to support deployment. A technically-oriented leadership becomes more balanced with a management structure to spread deployment throughout the organization. The organization encourages leadership engagement and encourages leaders who become engaged. The orientation to change is characterized by a centralized deployment team coaching necessary deployment skills at low-levels throughout the organization, with an emphasis and focus on growing lessons learned.

A coercive deployment at this stage would be characterized by rules and regulations to manage implementation according to a structured plan. Standard reporting would be established to assess deployment across the organization, and strategic targets would be set for deployment metrics. Individual performance appraisals would be tied to these metrics. The management-oriented leadership team would consolidate power under a lean program office. Furthermore, employees would be assigned to complete minimum quotas of lean training, and leaders who do not support deployment would be punished. A continued emphasis would be placed on documenting and capturing cost reductions, and expertise would rest with small groups of experts deployed to high-profile initiatives by management.

	Collectivity Stage of Lean Deployment
Goal of Lean Program:	*Growth, develop strategic plan for Lean Deployment*
Perception of Program:	*"Special projects to fix isolated problems"*
Structure:	*Mostly informal, small department for Lean Transformation*
Leadership of Lean Program:	*Enroll senior management*
Technical Tools & Techniques:	*Value Stream Thinking by Individual Departments*
Social/Cultural Tools & Techniques:	*Widespread engagement, isolated empowerment of employees*
Program Results and Benefits:	*Many examples of waste elimination, few specific cost reductions*
Crisis to be overcome:	*Failure to develop depth of deployment*

	Collectivity Stage of Lean Deployment	
	Coercive Deployment	**Enabling Deployment**
Formal Organization	standard reporting established to assess deployment across organization; strategic targets set for deployment metrics; individual performance appraisals tied to deployment metrics	rules & regulations in place to enable individual learning throughout organization; forms and reporting are evolving to support deployment
Informal Organization	Management-oriented leadership consolidates power; employees assigned to Lean training and deployment team to meet quotas; leaders punished who do not support Lean	technically-oriented leadership becomes more balanced with management structure to enable others; organization encourages leadership engagement, rewards leaders who become engaged
Orientation to Change	continued emphasis on documenting and capturing cost reductions; expertise rests with small group of experts deployed to "high-profile" initiatives by management	Lean expertise centralized with deployment team; coaching of necessary deployment skills at low-level throughout organization; focus on growing lessons learned

Figure 4.12 Enabling and Coercive Deployment in the Collectivity Stage

Formalization Stage of Deployment:

Figure 4.13, below, illustrates differences between an enabling and coercive deployment during the formalization stage. In this stage of deployment the overall goal of the initiative is to build internal stability and "seeding" of the entire organization. The program has grown to the point that it is recognized as a serious part of the management system and managers accept that supporting it is necessary to have a successful future in the organization. Formal procedures are aggressively developed for implementation, and capacity to lead lean deployment begins to arise in each department of the organization. Middle managers within the organization become active and connected value stream thinking begins to occur throughout the entire organization. There is an attempt to build wide-spread employee engagement and empowerment. By this point, many success stories have been documented and a cause and effect relationship is accepted between lean deployment and movement of key performance indicators. The crisis to be overcome is now failure to develop breadth of deployment and too much red tape within deployment.

During the formalization stage of deployment, an enabling deployment would have rules and regulations in place to enable sharing of best practices and organization-wide learning. Managers of the lean deployment must achieve a strong balance between technical-orientation of continuing to teach deployment, and a leadership-teaching orientation to facilitate the deployment. The primary leadership challenge is to develop senior managers. At this point, lean deployment is considered a viable mechanism for achieving business objectives, and the infrastructure for deployment is dispersed throughout the organization.

A coercive lean deployment at this stage would be characterized by even more highly developed rules, regulations, metrics, and audits to mandate adherence to best practices. Lean would become part of the company's formal operating procedures supported at the level of the CEO. Lean deployment would still be controlled and managed by experts throughout the organization, with little opportunity for variation from the standard mechanisms. Lean leadership would consolidate power, and an emphasis would be placed on complying with corporate best practices (the net effect of which would stifle continuous improvement efforts). Additionally, the organization would strive for replication of cost reductions throughout the entire organization. In the end, the intent of lean deployment would slowly erode and power players could manipulate the message of engagement and empowerment towards their own desired outcomes.

	Formalization Stage of Lean Deployment
Goal of Lean Program:	*Internal stability, "seeding" of entire organization*
Perception of Program:	*"Everyone has to get involved!"*
Structure:	*Formal procedures, Lean capability beginning to develop in each department*
Leadership of Lean Program:	*Spread to middle management*
Technical Tools & Techniques:	*Value Stream Thinking by Entire Organization*
Social/Cultural Tools & Techniques:	*Widespread engagement and empowerment, isolated teambuilding*
Program Results and Benefits:	*Widespread waste elimination, many cost reductions*
Crisis to be overcome:	*Failure to develop breadth of deployment, too much red tape*

	Formalization Stage of Lean Deployment	
	Coercive Deployment	**Enabling Deployment**
Formal Organization	rules, regulations, metrics, and audits in place to mandate adherence to best practices; Lean strategy controlled and managed by "experts" throughout the organization	rules & regulations in place to enable sharing of best practices and organization-wide learning
Informal Organization	Lean leadership continues to consolidate power; the Lean culture driven by verbatim compliance to corporate best practices, stifling continuous improvement	technically oriented leadership to continue teaching, but balanced with enabling management structure to facilitate deployment; primary role of leadership to develop senior managers
Orientation to Change	Emphasis placed on replication of cost reductions from best practices across organization; intent of Lean deployment slowly eroding as power players manipulate message	Lean deployment considered as viable mechanism for achieving business objectives; infrastructure for deployment dispersed throughout organization

Figure 4.13 Enabling and Coercive Deployment in the Formalization Stage

Elaboration Stage of Deployment:

Figure 4.14 illustrates differences between an enabling and coercive deployment during the elaboration stage. As previously mentioned the goal is to achieve a culture in which every worker is seeking continuous improvement, every single day in this stage of deployment. Lean is considered “here to stay” as part of the day job, and teamwork is achieved with small company thinking. All levels of the organization are engaged through deployment and pursuit of perfection, and complete value stream thinking is sought through the entire organization. Widespread engagement, empowerment, and teambuilding exist, and waste elimination, cost reduction, and redeployment of resources are seen as tangible benefits. The challenge at this phase of deployment is to overcome the notion of accepting “good enough” and possible burnout by the organization.

During the elaboration stage, an enabling deployment would have mechanisms in place so that organizations could “pull” best practices. Furthermore, lean knowledge would be dispersed throughout the entire organization. Senior management would be leading the lean deployment by advocating, teaching, and coaching. Lean deployment would be fully aligned to business objectives. Management would encourage employees to challenge the status-quo, while an organizational sense of urgency must be constantly renewed in a quest for perfection.

A coercive deployment at this stage would involve senior management regularly assessing lean deployment “by the numbers”. Extensive formal procedures would be in place, with emphasis on aligning to structured deployment plan. Lean deployment could quickly be considered as a standardization initiative throughout the extended organization (as opposed to corporate best practices). As lean deployment gained in political clout within the organization, leaders from early stages of deployment could be pushed out by corporate power players. At this phase of deployment, lean could be considered as a destination that has been achieved, and many organizations may be prepared to evolve and transition towards the next corporate initiative.

	Elaboration Stage of Lean Deployment
Goal of Lean Program:	*Every worker seeking continuous improvement, every day*
Perception of Program:	*"Here to stay, part of the day job"*
Structure:	*Teamwork within bureaucracy, small company-thinking*
Leadership of Lean Program:	*All levels of the organization*
Technical Tools & Techniques:	*Pursuit of Perfection, Complete Value Stream Thinking*
Social/Cultural Tools & Techniques:	*Widespread engagement, empowerment, teambuilding*
Program Results and Benefits:	*Widespread waste elimination, cost reduction, and redeployment of resources*
Crisis to be overcome:	*Accepting "good enough", possible burnout*

	Elaboration Stage of Lean Deployment	
	Coercive Deployment	**Enabling Deployment**
Formal Organization	senior management regularly assesses Lean deployment "by the numbers"; extensive formal procedures in place, with emphasis on aligning to structured deployment plan	mechanisms in place for organizations to "pull" best practices from organization-wide learning; Lean knowledge dispersed throughout organization
Informal Organization	Lean deployment now considered standardization initiative across extended organization to corporate best practices; leaders in early stages pushed out by corporate power players	senior management throughout the organization leading deployment by advocating, teaching, and coaching; Lean deployment fully aligned to business objectives
Orientation to Change	Lean considered as a destination to be achieved, evolved and transitioned by power players to next initiative	management enabling all to challenge status-quo; "burning platform" constantly renewed through internal strive for perfection;

Figure 4.14 Enabling and Coercive Deployment in the Elaboration Stage

This discussion has addressed the four phases of lean deployment, with a detailed summary for each. It began with Stage One, where an organization is first introduced to lean. Finally, it concluded with Stage Four, where lean deployment is simply the way an organization now operates. The life cycle model of lean deployment illustrates that an initiative will ultimately become more bureaucratic as time progresses, regardless of how it attempts to address enabling and coercive methodologies. The degree to which Toyota is able to exist as an enabling organization with a high-degree of bureaucratization is ultimately a paradox from the DNA of the Toyota Production System. (Spear and Bowen, 1999) This chapter will now examine a case study of a large, complex, international organization and its lean deployment during the four phases of deployment.

CASE STUDY – LEAN DEPLOYMENT AT REMAN

To further examine the concept of enabling and coercive lean deployment, a case study analysis is conducted of "REMAN," a large naval ship repair organization. While the specific agency or industry of REMAN is not important to case study consideration, the organization is extremely large, geographically dispersed around the United States, and heavily impacted by global events. REMAN is an organization of more than 50,000 employees worldwide and has a well established history as a leader in its specific industry. REMAN initiated a deployment of continuous improvement aligned to the principles and practices of the Toyota Production System in 2001. This case study traces the first six years of this lean deployment. Many other organizations have approached REMAN in order to learn from this model of lean deployment. For these reasons, lean deployment at REMAN is a typical lean production initiative within a large and complex organizational bureaucracy.

To provide greater depth of analysis, the case study of lean deployment at REMAN will provide a comparison of implementation at the two largest divisions of the organization: EarlyAdopter Division and LateToTheParty Division. EarlyAdopter and LateToTheParty are the two largest divisions of REMAN, each representing an organization of roughly 20,000 employees at more than a dozen sites across the country and having multibillion dollar operational budgets. REMAN and each of the two divisions are headquartered in a major east coast city.

Lean deployment within EarlyAdopter and LateToTheParty was heavily influenced by guidance and directives from REMAN throughout the six year period. Initial deployment efforts were largely grassroots and organic at EarlyAdopter and LateToTheParty, the primary difference being EarlyAdopter had roughly a two year head start during the Entrepreneurial Stage of deployment. REMAN initiated an aggressive corporate deployment during the Collectivity Stage of deployment, influencing the methodology and context for lean deployment. During the Formalization Stage of deployment, headquarters management within both divisions became heavily involved to influence the specific content of deployment throughout their divisions. Neither EarlyAdopter nor LateToTheParty Division was able to achieve an “Elaboration” stage of deployment. The primary value in comparing the two organizations is to examine one organization, EarlyAdopter, that was largely pro-active in shaping corporate direction for lean deployment; and one organization, LateToTheParty, that was largely reactive in responding to corporate direction.

Before examining the two departments, the distinction between intended and unintended outcomes should be considered. Robert Merton (1968) identified how an organization would take purposive action to transition from an existing state of performance to a desired future state of performance, similar to lean deployment within REMAN. However, Merton concluded both intended and unintended outcomes occur, which together may result in less than desirable consequences. Unintended outcomes may result from many factors within a bureaucracy. Some of these factors include the degree of: politics, leadership engagement, planning, execution, vested interests, confusion, creativity, and communication. Figure 4.15 illustrates how an organization filter (internal organizational distortions) is applied to the purposive change action to create both intended and unintended outcomes. In examining the EarlyAdopter and LateToTheParty case studies, both what actually occurred and the intended outcomes will be examined. The researcher is able to write about the intended outcome of implementation since he was a participant observer, an entry level professional position in the REMAN bureaucracy in support of corporate deployment.

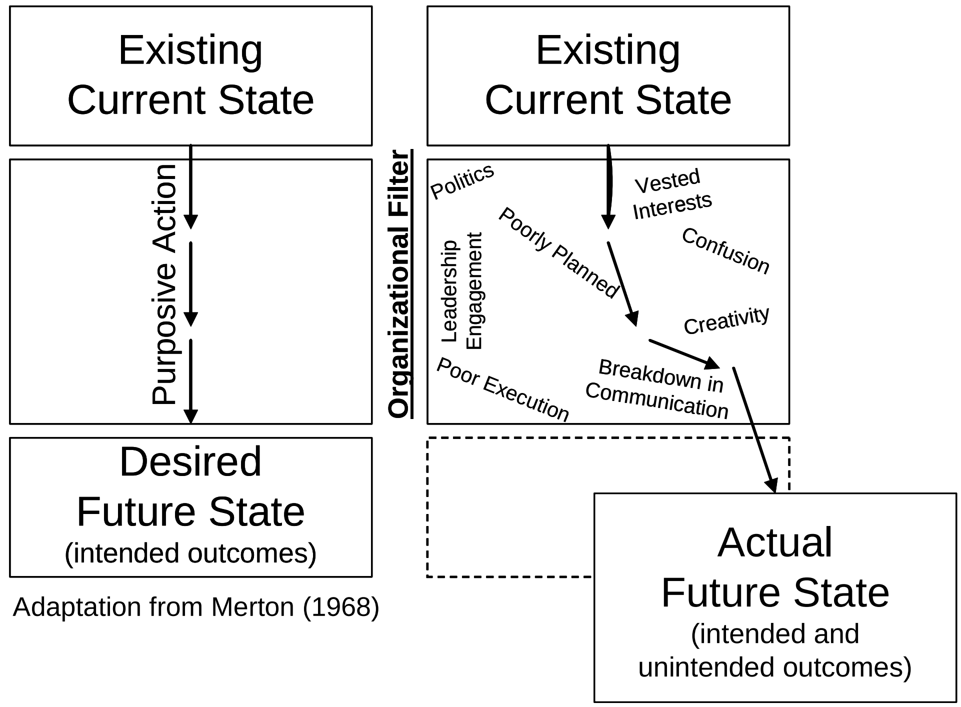


Figure 4.15 Intended and Unintended Consequences of Organizational Change

In considering the divergence between intended and unintended outcomes of lean deployment, it is important to keep in mind the primary difference between EarlyAdopter and LateToTheParty: EarlyAdopter Division initiated deployment two years prior to LateToTheParty. This resulted in EarlyAdopter Division having a deeper knowledge and understanding of lean deployment when the influences of REMAN lean deployment became more bureaucratic in the Collectivity Stage of deployment. Additionally, EarlyAdopter Division was largely proactive in shaping corporate lean deployment, while LateToTheParty Division was more reactive to direction from REMAN.

Case Study Stage I - Entrepreneurial Stage of Lean Deployment:

The primary normative objective in the Entrepreneurial Stage of lean deployment is to learn the basics of lean production. During this stage, the deployment is largely informal, relatively shallow and narrow. Deployment at this stage focuses on the fundamental tools of lean production and disconnected process improvement. It entails isolated engagement of employees and result in isolated waste elimination. As discussed in the comparison to Maslow's hierarchy of needs (1990), the deployment is still in a relatively fragile state where continuation of the lean deployment initiative is not certain. The result of these normative characteristics in an enterprise-wide lean deployment is that each individual site or organization acts largely independently and entrepreneurially in initial stages of deployment. This suggests an opportunity for trial and error methods with limited corporate oversight and governance - essentially low bureaucracy. Implementation at a specific site is likely to become a function of the leadership style of the site deployment leader. As multiple individual sites within a larger organization continue to develop in their lean deployment, they may begin to share techniques and lessons learned with each other. However, their will be a point at which deployment cannot continue to grow unless formal energies and resources are applied, so as to build an infrastructure for growth of deployment and take deeper roots for transformation. Figure 4.16 summarizes the intended outcome within REMAN and the actual outcomes during the Entrepreneurial Stage of deployment at the EarlyAdopter and LateToTheParty Divisions.

During the Entrepreneurial Stage of lean deployment at REMAN, corporate governance was largely non-existent in transformation efforts. The intended outcome was for individual sites and departments to learn the fundamentals of lean deployment and establish a proof of concept within the industry. Corporate management at REMAN supported efforts made by individual sites, but did not wish to officially endorse the effort or commit resources. The intent was for the concept to be proven before corporate energies were placed behind the initiative. Additionally, they wanted sites to take ownership by using some of their own funding. Corporate management did not have expertise in any aspect of lean deployment. The perspective was clearly to "wait and see" before proposing intended outcomes. Beyond lean deployment, corporate management at REMAN was largely mistrusted by the EarlyAdopter and LateToTheParty Divisions for "meddling" in day-to-day operations. It was clear process improvements needed to be made within REMAN since budgets were continually pressurized. However, corporate management was already invested in a "transformation plan" with a few specific targets and initiatives. They resisted endorsing lean deployment to make sure it was not a "flavor of the month," which would quickly subside. The Entrepreneurial Stage of deployment at REMAN lasted approximately 30 months. The transition to the Collectivity Stage occurred when a large number of managers within EarlyAdopter Division petitioned corporate management to become engaged in endorsing a formal lean deployment program.

EarlyAdopter Division was the first within REMAN to engage in lean deployment. This occurred when the executive overseeing EarlyAdopter introduced senior leaders to lean while on a tour of Toyota's Georgetown, Kentucky plant. However, the executive was uncertain of how the concepts would apply in this industry, and simply desired to "plant a seed" for lean (not promote an organizational deployment). Several sites within EarlyAdopter Division made positive strides towards learning lean production. This was truly an entrepreneurial effort with little external pressure applied, and no formal rules or procedures existed beyond those developed internally. Over time, knowledge was extensively shared throughout various sites at EarlyAdopter Division as the lean deployment communities shared lessons learned and examples of success. Leaders considered to be forward thinkers and early adopters of technology (Rogers, 2003) were selected to lead the lean deployment. They were enthusiastic about the opportunity and challenge. Because it was a risk-averse organization, many senior managers resisted continuous and rapid improvement techniques of lean deployment. Each department within EarlyAdopter implemented lean differently, often mirroring the personality of leadership and culture of the department. Many within EarlyAdopter Division were excited about the potential for lean deployment. A need for improvement was recognized within EarlyAdopter, especially since budgets had been shrinking on an annual basis. Ultimately, EarlyAdopter Division pressured REMAN's corporate leadership to become engaged in lean deployment, and an ideological competition arose among the sites of EarlyAdopter Division as to the preferred method of deployment.

LateToTheParty Division initiated lean deployment much later than EarlyAdopter Division. The duration of their Entrepreneurial Stage varied by site, and lasted approximately 6-12 months. As a result, there was much less growth and learning at each site within LateToTheParty Division. The impetus for deployment at LateToTheParty Division was also different from that of EarlyAdopter. Whereas EarlyAdopter had slowly embraced lean internally, the feeling within LateToTheParty was much more of reactive urgency as it became clear REMAN was going to become engaged in enterprise-wide lean deployment. LateToTheParty Division borrowed significantly from learning that occurred at EarlyAdopter Division, including implementation methodologies and training materials. Well-respected managers were selected to lead the lean deployment within LateToTheParty Division, but not individuals who would be characterized by their individual passion or technical knowledge of the processes. By the time REMAN was ready for a transition to the Collectivity Stage of deployment, there was much less personal support, enthusiasm, and proven success for lean at LateToTheParty Division as compared with EarlyAdopter. Budget constraints were not as critical and senior management did not embrace the need to deploy lean. Managers at LateToTheParty Division were embracing lean as the inevitable corporate direction, while management at EarlyAdopter Division were driving REMAN to become engaged.

Entrepreneurial Stage of Lean Deployment at REMAN

<table>
<tr><th colspan="2">Normative Characteristics</th><th>Intended Outcome: REMAN</th><th>Actual Outcome: EarlyAdopter Division</th><th>Actual Outcome: LateToTheParty Division</th></tr>
<tr><td>Goal of Lean Program:</td><td>Learn Lean Production, test the waters to see how it applies</td><td rowspan="3"><u>Formal Organization:</u>
Corporate management at Big Public supported efforts made by individual departments towards Lean deployment, but did not wish to endorse the effort or commit resources. The intent was for the concept to be proven before corporate energies were placed behind the initiative. Corporate management did not have expertise in any aspect of Lean deployment.</td><td rowspan="3">EarlyAdopter Division became engaged in Lean Deployment early on. This was truly an entrepreneurial effort with little external pressure applied, no formal rules or procedures existed beyond those developed internally, there was extensive knowledge sharing throughout EarlyAdopter, and the primary tasking was simply to learn Lean production. Ultimately, EarlyAdopter Division pressured Big Public corporate leadership to become engaged</td><td rowspan="3">LateToTheParty Division initiated Lean deployment much later than EarlyAdopter Division. Overall, there was much less individual growth and learning at LateToTheParty as much as it was “catch up with EarlyAdopter Division” as it eventually became clear Big Public corporate was going to become engaged in Lean Deployment. LateToTheParty Division borrowed significantly from learning which occurred at EarlyAdopter Division.</td></tr>
<tr><td>Perception of Program:</td><td>Uncertainty and skepticism</td></tr>
<tr><td>Structure:</td><td>Informal, few leading individuals</td></tr>
<tr><td>Leadership of Lean Program:</td><td>A few knowledgeable, Lean individuals</td><td rowspan="3"><u>Informal Organization:</u>
Big Public did not have an intended outcome for an informal organization with regards to Lean Deployment. The perspective within corporate management was clearly “wait and see” before proposing intended outcomes. Overall, corporate management at Big Public was largely mis-trusted by EarlyAdopter and LateToTheParty Division for “meddling” in day-to-day operations.</td><td rowspan="3">Early Adopters were selected to lead the Lean deployment and were enthused about the opportunity and challenge. Overall, a risk-averse organization, many senior managers resisted continuous and rapid improvement techniques of Lean Deployment. Each department within EarlyAdopter implemented Lean differently, often mirroring the personality of leadership and culture of the department.</td><td rowspan="3">Good managers were selected to lead the Lean deployment within LateToTheParty Division, but not individuals which would be characterized by their individual passion or technical knowledge.</td></tr>
<tr><td>Technical Tools & Techniques:</td><td>Tools deployment, disconnected Process Improvement</td></tr>
<tr><td>Social/Cultural Tools & Techniques:</td><td>Isolated employee engagement</td></tr>
<tr><td>Program Results and Benefits:</td><td>Isolated waste elimination</td><td rowspan="2"><u>Orientation to Change:</u>
It was clear process improvements needed to be made within Big Public, budgets were continually pressurized. However, corporate management was already invested in a “transformation plan” with a few specific targets and initiatives. They resisted endorsing Lean deployment to make sure it was not a “flavor of the month”.</td><td rowspan="2">Many within EarlyAdopter Division were excited about the potential for Lean deployment. A need for improvement was recognized within EarlyAdopter as budgets had been shrinking on an annual basis. An ideological competition arose within departments of EarlyAdopter Division for preferred method of deployment.</td><td rowspan="2">Overall, there was much less personal support and enthusiasm for Lean at LateToTheParty Division as compared with EarlyAdopter. Budget constraints were not as critical and senior management did not embrace the need to deploy Lean, the “burning platform” was not as clear. A major reason for Lean deployment within LateToTheParty was considered to match EarlyAdopter in the eyes of corporate management.</td></tr>
<tr><td>Crisis to be overcome:</td><td>Isolated Program or Leadership</td></tr>
</table>

Figure 4.16 Intended and Actual Outcomes in Stage One Lean Deployment

Case Study Stage II - Collectivity Stage of Lean Deployment:

During the Collectivity Stage of deployment, the normative objective is to grow the deployment in order to achieve a sense of legitimacy and organizational investment. At this stage, the deployment remains mostly informal with a small department leading the lean deployment. Value stream thinking is applied by individual departments, and there is widespread engagement of employees, though perhaps limited or isolated empowerment. In the case study of lean deployment at REMAN, after being encouraged by grassroots successes at LateToTheParty, and particularly EarlyAdopter Division, corporate management became engaged in deployment. A senior official with EarlyAdopter Division was selected to lead a Task Force that had been established to lead leaders from both EarlyAdopter and LateToTheParty Divisions were asked to join a leadership steering committee. A group of four individuals worked with a corporately selected consultant to write a thirty-page formal "Lean Implementation Plan" for REMAN. This implementation plan was endorsed by all senior leaders of REMAN prior to distribution. The plan included terminologies, position descriptions, training modules, performance expectations, a suite of metrics, and formal guidelines on implementation. Figure 4.17 summarizes the intended outcome and the actual outcomes during the Collectivity Stage of deployment at both EarlyAdopter and LateToTheParty Divisions.

The intended outcome during the Collectivity Stage of lean deployment at REMAN was to achieve consistent and results-oriented implementation across the whole of REMAN, 50,000 employees and over 30 sites. This was supposed to be achieved through strict adherence to the formal implementation plan, including its rigid roles and responsibilities, training curricula, management expectations, reporting metrics, and follow-on audits and assessments. Corporate management at REMAN expected rigid adherence to the deployment strategy, and believed that managers at EarlyAdopter and LateToTheParty Divisions would implement the deployment plan as directed. As issues arose that were not covered in the deployment plan, REMAN developed additional guidance and directives. Corporate management at REMAN understood the business case for change and was confident this message would be communicated and embraced by the extended organization. Lean deployment was intended to "overwhelm" the organization as the single largest change initiative in the history of REMAN.

Leaders of the lean deployment initiative at both EarlyAdopter and LateToTheParty Divisions were appreciative of the engagement by REMAN. Particularly within EarlyAdopter Division, it was believed lean deployment had gone as far as it could without endorsement and resource allocation from corporate management. Leadership from EarlyAdopter played a major role in the creation of the corporate deployment plan and welcomed the legitimacy it brought to lean deployment. But later it became resistant to the controls it placed upon them. Leaders in EarlyAdopter Division had several years of knowledge and experience with lean deployment, and became somewhat rebellious to guidance and directives from REMAN when they did not support the direction. At this point a clear division arose within leadership at EarlyAdopter Division. Many leaders sought to execute the REMAN strategy verbatim; however, many of the technically-oriented lean deployment leaders (who had direct experience with implementation) found the guidance rigid and failed to implement the guidance being offered. The divide was also seen in the culture of deployment between what was communicated to the workforce and what was reported to REMAN. The message to the workforce supported first-level employee engagement and empowerment, but reports to corporate management revealed little more than "bean counting" the number of events, employees trained, and dollars saved. The orientation to change at EarlyAdopter Division changed dramatically as REMAN became engaged. What had begun as a grassroots effort and "good idea" had now become a corporate initiative that was mandated. Many managers were now forced to become involved in deployment, while other power players sought to utilize deployment energy to push their desired outcomes.

LateToTheParty Division was now given the guidance for lean deployment, something they had been seeking. Whether a result of desired implementation, a desire to please REMAN, or both, LateToTheParty Division was aggressive in implementing the corporate deployment plan. LateToTheParty Division did not possess expertise in lean deployment consequently sought out guidance from REMAN and the documented strategy of the deployment plan. LateToTheParty endorsed guidance, directives, and assessments from REMAN, performing well in audits and assessments for all areas of deployment. Leadership throughout LateToTheParty was immersed in lean deployment in order to adhere to a corporate directive. The "burning platform" at LateToTheParty came from corporate management at REMAN, which was placing pressure to ramp up deployment to the pace of EarlyAdopter Division.

<table>
<tr><th colspan="5"><u>Collectivity Stage of Lean Deployment at REMAN</u></th></tr>
<tr><th colspan="2">Normative Characteristics</th><th>Intended Outcome:
REMAN</th><th>Actual Outcome:
EarlyAdopter Division</th><th>Actual Outcome:
LateToTheParty Division</th></tr>
<tr><td>Goal of Lean Program:</td><td>Growth, develop strategic plan for Lean Deployment</td><td rowspan="3"><u>Formal Organization:</u>
Corporate management at Big Public developed a written, rigid deployment plan; with roles, responsibilities, training curriculum, pace of deployment, expected results, reporting mechanisms, and formal structure for the Lean deployment organization. As issues arose which were not covered in the deployment plan, Big Public developed additional guidance and directives.</td><td rowspan="3">EarlyAdopter Division was appreciative for corporate engagement by Big Public, support they had been actively seeking. Leadership from EarlyAdopter played a major role in the creation of the corporate deployment plan, and welcomed the legitimacy it brought to Lean deployment, but later became resistant to the controls it placed upon them. EarlyAdopter became resistant, and somewhat rebellious, to guidance and directives from Big Public.</td><td rowspan="3">LateToTheParty Division was now given the guidance for Lean deployment which they had been seeking. Whether a result of desired implementation, a desire to please Big Public, or both; LateToTheParty Division was aggressive in implementing to corporate deployment plan.</td></tr>
<tr><td>Perception of Program:</td><td>“Special projects to fix isolated problems”</td></tr>
<tr><td>Structure:</td><td>Mostly informal, small department for Lean Transformation</td></tr>
<tr><td>Leadership of Lean Program:</td><td>Enroll senior management</td><td rowspan="2"><u>Informal Organization:</u>
Corporate management at Big Public anticipated rigid adherence to the deployment strategy, managers at EarlyAdopter and LateToTheParty Divisions which would implement the deployment plan as directed.</td><td rowspan="2">At this point a clear divide arose within leadership at EarlyAdopter Division, many leaders sought to execute the Big Public strategy verbatim, however, many of technically-oriented Lean deployment leaders became rebellious to the guidance being given. The divide was also seen in the culture of deployment between what was communicated to the workforce, and what was reported to Big Public.</td><td rowspan="2">LateToTheParty Division did not possess expertise in Lean deployment, and sought out guidance from Big Public and the deployment plan. LateToTheParty endorsed guidance, directives, and assessments from Big Public, performing well in all areas of deployment.</td></tr>
<tr><td>Technical Tools & Techniques:</td><td>Value Stream Thinking by Individual Departments</td></tr>
<tr><td>Social/Cultural Tools & Techniques:</td><td>Widespread engagement, isolated empowerment of employees</td><td rowspan="3"><u>Orientation to Change:</u>
Corporate management at Big Public understood the business case for change, and was confident this business case would be communicated and embraced by the extended organization. Lean deployment was intended to “overwhelm” the organization as the single largest change initiative in their history.</td><td rowspan="3">The orientation to change at EarlyAdopter Division changed dramatically as Big Public became engaged. What had begun as a grassroots effort and “good ideas” had now become a corporate initiative which was mandated. Many managers were now forced to become involved in deployment, other power players sought to utilize deployment energy to push their desired outcomes.</td><td rowspan="3">Leadership throughout LateToTheParty was immersed in Lean deployment as an element of “checking off” adherence to a corporate directive. The “burning platform” at LateToTheParty came from corporate management at Big Public which was placing pressure to ramp up deployment to the pace of EarlyAdopter Division, which had a several year head start in Lean deployment.</td></tr>
<tr><td>Program Results and Benefits:</td><td>Many examples of waste elimination, few specific cost reductions</td></tr>
<tr><td>Crisis to be overcome:</td><td>Failure to develop depth of deployment</td></tr>
</table>

Figure 4.17 Intended and Actual Outcomes in Stage Two Lean Deployment

Case Study Stage III: Formalization Stage of Lean Deployment:

During the Formalization Stage of deployment, the normative objective is to develop internal control and stability of the lean transformation. At this point, the initiative should be producing tangible results. Furthermore, the emphasis shifts to developing sustainable internal deployment mechanisms and structure. A shift in deployment infrastructure may be expected from the lean deployment office, to mainstreamed capability within the operational organization. The overall structure and strategy for lean deployment in the Formalization Stage will become more focused on the specific context, goals, and objectives of the operational organization, whereas in the Entrepreneurial Stage the objective was to determine whether the initiative would survive and in the Collectivity Stage the objective was to spread deployment throughout the organization. In the case study of REMAN, this emphasis on driving results and developing internal stability resulted in establishment of specific cross-functional teams to achieve operational objectives throughout the extended enterprise. These cross-functional teams became known as "National Value Streams," each aligned to a specific functional operation of the organization. Each National Value Stream had an independent lean deployment infrastructure, and the team lead for each initiative was accountable to senior executives at REMAN to deliver results. As corporate best practices were identified in the various functional areas by the National Value Stream teams, they were elevated to a "lean release" for mandatory implementation. The "release" concept was similar to the bundling of new technologies in a spiral development of computer software. Figure 4.18 summarizes the intended and actual outcomes during the Formalization Stage of deployment at both EarlyAdopter and LateToTheParty Divisions.

Corporate management at REMAN was enamored with deployment of National Value Stream initiatives and Lean Releases as mechanisms to rapidly deploy lessons learned throughout the organization. Within the various divisions of REMAN, skepticism was prominent anytime another site or department claimed a corporate best practice. The intent of the National Value Stream was to both develop and identify best practices for corporate implementation. The expectation within REMAN was for the knowledge-sharing networks of the National Value Streams to identify these best practices, and for the corporation to adhere to all aspects of the best practice technical solution. Implementation of best practices would be evaluated through regular corporate audits to assess execution.

The National Value Stream and Lean Release approaches at REMAN were initiated with relatively enlightened and enabling intentions. However, as the initiatives continued to develop, what began as an effort to share lessons learned in a learning community of practice became an extremely coercive deployment with audits and assessments. For each corporate initiative, detailed instructions and audit standards on observable characteristics (not the underlying intent) were written. Similarly, the selection of initiatives for “corporate release” was voted on in a largely political manner throughout the extended organization. Further, adherence to the lean release strategy was to be executed along with the corporate deployment plan (which identified the mechanics by which each initiative was to be conducted). Lean deployment at REMAN was to be driven corporately by adherence to change pace requirements and audits to assess adherence to the National Value Stream initiatives and Lean Releases.

Within EarlyAdopter Division, the Lean Release approach was initially implemented with great energy and hope. Leadership within EarlyAdopter had largely become disenfranchised with the corporate deployment practices of REMAN, and they saw the lean release approach as a mechanism to refocus deployment on strategic operational business objectives. EarlyAdopter Division established a small, but powerful bureaucracy to deploy lean best practices and oversee implementation across the department. The division had never before had such specific guidelines for adherence to corporate process standards as those set forth in the lean release. It became clear within EarlyAdopter Division that the original leaders of lean deployment were being pushed out by the management group of the National Value Streams. Over time, it also became clear that this management group consisted of heavy-handed power brokers within EarlyAdopter Division who were able to interpret corporate guidance in their own way and use this mechanism to achieve personally desired outcomes throughout EarlyAdopter Division. Lean deployment within EarlyAdopter Division had become an end unto itself as managers were now able to achieve nearly any desired outcome as long as it was associated with "lean". The original expertise and intent of lean deployment had largely been lost within the bureaucracy. Those seeking truly enabling and empowering continuous improvement, the original leaders of lean deployment within EarlyAdopter Division, were left to work small initiatives under the radar of corporate management.

At LateToTheParty Division, similar to EarlyAdopter Division, knowledge-sharing networks were established to deploy lean lessons learned according to the National Value Stream context. However, LateToTheParty Division lacked the broad experience and deep understanding of lean that EarlyAdopter Division had learned in their early years of the Entrepreneurial Stage. National Value Stream initiatives were more difficult and complex than standard improvement initiatives, both in terms of technical complexity and political savvy required to make them successful. Overall, National Value Stream efforts failed to make any significant impact within LateToTheParty Division. Results were not deployed beyond the original organizations. Central management and oversight of this effort was not nearly as strong as it had been at EarlyAdopter Division. Finally, change agent leaders lacked the technical ability to make them successful. However, corporate management at REMAN was not aware of failure to implement, and the issue went largely unnoticed. With regards to adherence to the Corporate Deployment Plan: LateToTheParty Division, which had initially lagged behind EarlyAdopter Division in overall deployment, began to question guidance from corporate REMAN in much the same way as EarlyAdopter Division had previously. Encumbered by quotas to deployment pace and corporate oversight, LateToTheParty Division no longer enjoyed a “honeymoon phase” and began pushing back on corporate guidance.

Formalization Stage of Lean Deployment at REMAN

<table>
<tr><th colspan="2">Normative Characteristics</th><th>Intended Outcome:
REMAN</th><th>Actual Outcome:
EarlyAdopter Division</th><th>Actual Outcome:
LateToTheParty Division</th></tr>
<tr><td>Goal of Lean Program:</td><td>Internal stability, “seeding” of entire organization</td><td rowspan="3"><u>Formal Organization:</u>
Corporate management at Big Public identified specific initiatives to be implemented as Lean best practices throughout the extended organization. Knowledge sharing networks were established and Divisions were to adhere to all aspects of the best practice technical solution. This was to be executed in addition to the corporate deployment plan as previously developed for all other initiatives.</td><td rowspan="3">The deployment of Lean best practices was closely monitored and assessed by Big Public management. A small, but powerful, bureaucracy was created to deploy Lean best practices as knowledge sharing networks were established and a management board for overseeing implementation was created. This effort received tremendous push back within EarlyAdopter Division and was implemented inconsistently across the organization.</td><td rowspan="3">LateToTheParty Division, similar to EarlyAdopter Division, established knowledge sharing networks to deploy Lean lessons learned. However, the central management and oversight of this effort was not nearly as strong as in EarlyAdopter Division. This effort failed to achieve significant results and best practices were not deployed beyond original organizations. However, corporate management at Big Public was not aware of failures to implement.</td></tr>
<tr><td>Perception of Program:</td><td>“Everyone has to get involved!”</td></tr>
<tr><td>Structure:</td><td>Formal procedures, Lean capability beginning to develop in each department</td></tr>
<tr><td>Leadership of Lean Program:</td><td>Spread to middle management</td><td rowspan="3"><u>Informal Organization:</u>
All employee’s were to become engaged in the Lean deployment. Corporate management at Big Public anticipated rigid adherence to best practice standards and the deployment strategy, as directed.</td><td rowspan="3">Lean deployment had largely become a source of power for certain managers to attain visibility and manipulate the “system” to achieve their desired outcomes within the extended organization. The original leaders of Lean deployment were being pushed out for more significant power brokers within the organization who deviantly interpreted corporate guidance to achieve desired outcomes.</td><td rowspan="3">Lean deployment remained largely unchanged with corporate deployment of Lean best practices.
LateToTheParty Division did not possess expertise in Lean deployment, and sought out guidance from Big Public and the deployment plan.
LateToTheParty endorsed guidance, directives, and assessments from Big Public, performing well in all areas of deployment.</td></tr>
<tr><td>Technical Tools & Techniques:</td><td>Value Stream Thinking by Entire Organization</td></tr>
<tr><td>Social/Cultural Tools & Techniques:</td><td>Widespread engagement and empowerment, isolated teambuilding</td></tr>
<tr><td>Program Results and Benefits:</td><td>Widespread waste elimination, many cost reductions</td><td rowspan="2"><u>Orientation to Change:</u>
Lean deployment at Big Public was to be driven corporately by adherence to change pace as identified by corporate management, audits to assess adherence to Lean best practices, and monthly reporting of deployment activity. Big Public management would review monthly reports; EarlyAdopter and LateToTheParty Division’s were assessed by these monthly reports.</td><td rowspan="2">Lean deployment within EarlyAdopter Division had become an end unto itself as managers were now able to achieve nearly any desired outcome as long as it was associated with “Lean”. The original expertise and intent of Lean deployment had largely been lost within the bureaucracy.</td><td rowspan="2">LateToTheParty Division, lagging behind EarlyAdopter Division in overall Lean deployment and deployment of Lean best practices, began to question guidance from corporate Big Public in much the same way as EarlyAdopter Division had previously. Encumbered by quotas to deployment pace and corporate oversight, LateToTheParty Division no longer enjoyed a “honeymoon phase” and begin pushing back on corporate guidance.</td></tr>
<tr><td>Crisis to be overcome:</td><td>Failure to develop breadth of deployment, too much red tape</td></tr>
</table>

Figure 4.18 Intended and Actual Outcomes in Stage Three Lean Deployment

Case Study Stage IV - Elaboration Stage of Lean Deployment:

The Elaboration Stage of lean deployment was identified earlier as the post-bureaucracy period of deployment. At this stage of maturity, organizational structures, corporate deployment strategies, and new initiatives cease to drive deployment. Lean is simply "here to stay" and "part of the day job," while improvement initiatives are aligned directly to measurable strategic business objectives. Ultimately, a lean deployment that is able to achieve the Elaboration Stage successfully results in a lean learning organization, or a positive lean bureaucracy, in which every worker seeks continuous improvement every day. Neither the EarlyAdopter nor the LateToTheParty Divisions of REMAN were able to achieve the Elaboration Stage of deployment due to coercive influences within deployment and the overall organization, for these reasons it is doubtful they ever will be able to achieve the Elaboration Stage of deployment.

CASE STUDY ANALYSIS

The case study of lean deployment at REMAN, with detailed profiles of two large divisions (EarlyAdopter and LateToTheParty) is an example of how one large complex bureaucracy seeks to transform itself through principles and practices of the Toyota Production System. The case study of lean deployment at REMAN is similar to purposeful transformations at many other large organizations. Whether they are private or government, industrial or service. The intent to transform towards a lean bureaucracy (which has been shown to parallel definitions of a Learning Organization, Enabling bureaucracy, and Elaboration Stage Organization) is characteristic of transition from a bureaucratic stage organization (Stage III) to a post-bureaucratic stage organization

(Stage IV). This case study offers deep understanding of the transition process towards a lean bureaucracy, distinguishing between an enabling and coercive transformation.

As can be seen in the case study, coercive lean deployment became a way of life within REMAN. The well-intentioned initiative to *transform* a large and complex bureaucracy ultimately became a function *of* the bureaucracy. This is not to say lean deployment was a failure, there are many very positive outcomes from six years of lean deployment, so much so that many other organizations looked to REMAN as a model to emulate. However, deployment likely will never achieve a truly transformational effect within the organization. Indeed it may fail to create a positive lean bureaucracy. This discussion will: identify the enabling and coercive nature at each stage of lean deployment within REMAN, offer some understanding to the unique stories of the EarlyAdopter and LateToTheParty Divisions, identify the influences to enabling and coercive deployment, and ultimately attempt to characterize the degree of success at lean deployment at REMAN.

Characterization of Deployment at REMAN - Enabling and Coercive:

The case study of lean deployment at REMAN offers an inside look into the enabling and coercive mechanics by which an organization transforms itself. To support discussion, in Figure 4.19 each stage of deployment at EarlyAdopter Division and LateToTheParty Division is characterized by the degree to which enabling and coercive characteristics are deployment are observed. These characterizations are based on qualitative observations made during deployment, analyzing the frequency and impact of enabling and coercive characteristics defined in earlier discussion; ratings are made on a scale of: low, low-moderate, moderate, high-moderate, and high, for the degree to which enabling and coercive characteristics of deployment are observed. A discussion and detailed description of each rating is included in the following analysis. In general, both organizations experience a decline in enabling characteristics and an increase in coercive characteristics as deployment matures. The shift in implementation from enabling to coercive at LateToTheParty Division was much more rapid and significant than the shift at EarlyAdopter Division.

	EarlyAdopter Division		LateToTheParty Division	
	Enabling Characterization of Deployment	Coercive Characterization of Deployment	Enabling Characterization of Deployment	Coercive Characterization of Deployment
Entrepreneurial Stage	*HIGH*	*LOW*	*HIGH-MODERATE*	*LOW-MODERATE*
Collectivity Stage	*HIGH-MODERATE*	*MODERATE*	*LOW*	*HIGH-MODERATE*
Formalization Stage	*MODERATE*	*HIGH*	*LOW*	*HIGH*

Figure 4.19 Enabling/Coercive Deployment at EarlyAdopter and LateToTheParty

Entrepreneurial Stage of Deployment at REMAN - Enabling and Coercive:

During the Entrepreneurial Stage of lean deployment at REMAN corporate governance and oversight of lean deployment efforts were non-existent. Deployment in this phase was truly entrepreneurial in nature as each organization attempted different methodologies and formulas in order to achieve success. The leaders of the program were largely “salesmen” of the effort as much as they were technical experts trying to push the fundamental concepts of lean production. The Entrepreneurial Stage of implementation lasted approximately three years at EarlyAdopter Division, while it lasted a single year at LateToTheParty Division. The intent of implementation at LateToTheParty Division was more coercive than that at EarlyAdopter. While EarlyAdopter had truly initiated a grassroots effort to improve performance, LateToTheParty desired to impress senior management within REMAN when it became obvious that corporate guidance would soon be offered on lean deployment. In both departments, implementation was largely enabling in nature, which contrasted with the general coercive organizational structure and tendencies of the larger organization.

In considering the degree of enabling characteristics observed in the Entrepreneurial Stage of lean deployment, EarlyAdopter Division would be considered *high*, with LateToTheParty Division considered *high-moderate*.

In both departments the primary task was simply to learn lean production, and forward thinking and enthusiastic leaders were selected to lead the deployment. In the case of EarlyAdopter Division, there existed a general absence of formal rules and procedures for implementation beyond those developed internally for use by implementers. Each department implemented lean differently, often mirroring the personality and culture of the department. There existed significant trial and error of implementation with energies shifting to parts of the organization exhibiting interest and commitment to the changes. Within EarlyAdopter Division, the implementation leaders were technically knowledgeable of lean fundamentals, but were not interested in organization building or required reporting. Significant knowledge-sharing existed within EarlyAdopter Division. Many of these lessons were passed on to LateToTheParty Division as they sought to catch up with EarlyAdopter in implementation.

In considering the degree of coercive characteristics observed in the Entrepreneurial Stage of lean deployment, EarlyAdopter Division would be considered *low*, and LateToTheParty Division would be considered *low-moderate*.

In the Entrepreneurial Stage of deployment, coercive characteristics of implementation were minimal, yet did exist largely as a result of organizational infrastructure. Within EarlyAdopter Division, many senior managers resisted continuous improvement and rapid improvement techniques. In many instances second-tier managers (not the A-players) were selected to lead deployment and an ideological competition rose within EarlyAdopter Division. Within LateToTheParty Division, much less individual growth and learning occurred since they were catching up with EarlyAdopter. This resulted in coercive tendencies of implementation as emphasis was placed upon "deploying lessons learned," and not internal learning.

Collectivity Stage of Deployment at REMAN - Enabling and Coercive:

In the Collectivity Stage of deployment at REMAN, corporate leadership formed a Lean Deployment Task Force and became actively involved in deployment at each division. A Lean Implementation Plan was written, and it quickly became a corporate "program" to be implemented across the enterprise. Individual divisions lost much of their autonomy in technique and reporting of improvement status with the heavy handed approach to cookie-cutter implementation.

In considering the degree of enabling characteristics observed in the Collectivity Stage of lean deployment, EarlyAdopter Division would be considered *high-moderate*, and LateToTheParty Division considered *low*.

Appreciative for REMAN's corporate acknowledgement and involvement, EarlyAdopter Division considered corporate involvement to be a further enabler of implementation and played a major role in the creation of the corporate deployment plan. Early on, leaders of lean deployment within EarlyAdopter Division were able to heavily influence the corporate message, and the message was an enabler to implementation in the way it required senior management's attention. EarlyAdopter division was now able to acquire the resources and management attention it had been missing. However, as time went on, and the REMAN management team became more experienced, the relationship with EarlyAdopter Division changed. What began as a high-powered corporate initiative they could control soon grew to a threat to EarlyAdopter Division as the energies and focus of REMAN shifted. Within LateToTheParty Division, the issuance of the lean Corporate Deployment Plan, a textbook instruction for implementation, created a very coercive deployment - the only enabling characteristics of deployment were the senior leadership commitment it required.

In considering the degree of coercive characteristics observed in the Collectivity Stage of lean deployment, EarlyAdopter Division would be considered *moderate*, and LateToTheParty Division considered *high-moderate*.

The lean corporate deployment plan issued by REMAN scripted a highly coercive deployment strategy. In this document were quotas for the required numbers of personnel to be trained, the number of improvement events to be conducted, the speed at which implementation must occur, amount of dollars to be saved, and metrics to be reported. Adherence to this plan was to be audited by REMAN leadership, with senior managers at EarlyAdopter and LateToTheParty reprimanded if performance levels were not achieved. Within EarlyAdopter Division, this was a significant threat to building on the successes of implementation that had been achieved. Initially, EarlyAdopter leadership was able to shape the corporate implementation and/or ignore guidance, becoming somewhat rebellious. As time went on, this became more difficult to do and they became more heavily influenced by the coercive corporate deployment plan. Within LateToTheParty Division, the corporate deployment plan was endorsed as a document to be carried out with verbatim compliance. LateToTheParty had not experienced any significant learning internally during their brief Entrepreneurial Stage. As such, they appreciated the detailed guidance offered during the Collectivity Stage. At LateToTheParty, the coercive corporate deployment plan (with its guidance, directives, and assessments) was fully endorsed. Little internal assessment or filter of directives occurred at LateToTheParty, and to a lesser degree EarlyAdopter. Lean deployment quickly became a “box to be checked off,” and the only “burning platform” was to appease corporate mandates to increase pace of deployment.

Formalization Stage of Deployment at REMAN - Enabling and Coercive:

The Formalization Stage of deployment within REMAN was dominated by pressures from corporate leadership to reduce costs as a result of improvement initiatives. In order to answer these pressures and develop more standard improvement initiatives, the concept of “deploying best practices” became the rally cry for lean deployment within REMAN. This was also a bit of a reversal to the corporate deployment plan introduced during the Collectivity Stage of deployment. In Stage II, REMAN leadership provided guidance on the desired mechanics of lean deployment. In Stage III, division leadership provided guidance as to the specific topics and high-profile initiatives to be undertaken within both EarlyAdopter and LateToTheParty Divisions.

In considering the degree of enabling characteristics observed in the Formalization Stage of lean deployment, EarlyAdopter Division would be considered *moderate*, and LateToTheParty Division considered *low*.

Within EarlyAdopter Division, a small but powerful bureaucracy was created to oversee deployment and replication of successful improvement initiatives and various “best practices.” This management board was strongly divided into two groups - those who wanted to use this mechanism as an enabling tool to create knowledge-sharing communities of practice and improved communication, and those who desired to consolidate power and control along a functional segment of the business. The extreme dichotomy of perspectives was fascinating to observe, with “lean purists” endorsing (enabling) knowledge-sharing and “traditional managers” seeking the (coercive) control of transformation. The result of this effort in EarlyAdopter Division was a blend of enabling and coercive, dependent upon which personalities impacted that element of the business. Where knowledge sharing networks were created, a powerful tool for cross-functional teamwork, small business thinking, and enabling lean deployment was created. An additional characteristic of enabling lean deployment was the way in which EarlyAdopter Division resisted the influence of the REMAN corporate guidance; EarlyAdopter Division had created a small, but effective barrier between the Division and corporate influences. Within LateToTheParty Division, there were very few characteristics of enabling deployment. Lean had largely become an end unto itself, with the objective to hit the metrics and achieve audit scores.

In considering the degree of coercive characteristics observed in the Formalization Stage of lean deployment, EarlyAdopter Division would be considered *high*, and LateToTheParty Division considered *high* as well.

As previously mentioned, a struggle took place within EarlyAdopter Division as to whether the deployment of best practices would take place in an enabling or coercive manner. In the end, those desiring a coercive power grab under the guise of lean deployment gained greater support. However, for the most part, these efforts at standardization and consistent deployment of initiatives across the Division received tremendous resistance and were implemented inconsistently across the organization. Lean deployment had become a source of significant power for these managers to manipulate the “system” and achieve their desired outcomes in the name of corporate improvement initiatives. Now that lean deployment had achieved significant political capital, original leaders of the deployment were now being pushed out of the power center and replaced with more significant power brokers within the organization who deviantly interpreted corporate guidance to achieve desired outcomes. In this instance, the power brokers had little knowledge and/or interest in enabling lean deployment, but saw this as a tool to achieve organizational change they had previously desired. Within LateToTheParty Division, senior managers had similarly attempted to push for widespread deployment of successful initiatives. However, the deployment techniques within LateToTheParty remained very immature, and they were unable to successfully deploy complex initiatives across organizations. The central management and oversight within LateToTheParty was not strong and did not have a major impact on transforming operations. At this point, LateToTheParty Division also realized the coercive nature of the corporate lean deployment plan and pushed back on quotas for the deployment pace and corporate oversight.

Understanding the Different Outcomes in EarlyAdopter and LateToTheParty Division:
The divergence in outcomes between the EarlyAdopter and LateToTheParty Divisions offers some interesting insights into enterprise transformation through lean deployment. The two divisions operated in similar environments, with similar size, infrastructure, and missions. The most distinctive difference regarding this case study is that EarlyAdopter

Division had a three-year Entrepreneurial Stage of deployment, while LateToTheParty had only one. The key element of the Entrepreneurial Stage is there was little external pressure and/or expectations of deployment. As such, a healthy period of natural growth and evolution of learning could occur. This took place during the three-year period at EarlyAdopter Division when they developed internal expertise on deployment of lean production.

Within LateToTheParty Division, the learning cycle was cut short by external influences. Not only did pressure exist to catch up with EarlyAdopter Division, but guidance from REMAN leadership followed shortly after transformation efforts were initiated. As a result, LateToTheParty was an organization in which few individuals had any knowledge of lean deployment beyond what was presented / mandated to them by corporate leadership.

As previously identified, the primary objective is to "learn lean production" during the Entrepreneurial Stage of deployment. As a result of external influences, LateToTheParty Division was forced to mature beyond the Entrepreneurial Stage without effectively achieving this primary objective. Consequently, LateToTheParty Division lacked internal knowledge and expertise to discern the intent of corporate direction and was easily influence by external coercive influences. This can be seen as enabling characterization of deployment rapidly went from *high-moderate* in the Entrepreneurial Stage to *low* in both the Collectivity and Formalization stages. A similar reversal occurred in the coercive characterization of deployment. Meanwhile, EarlyAdopter

Division was able to maintain enabling characterization levels of *high-moderate* and *moderate* during advanced deployment. EarlyAdopter Division had clearly achieved enough internal lean expertise to counter the coercive external influences of the greater organization, while LateToTheParty Division had not.

Understanding the Influences on Enabling and Coercive Bureaucracy at REMAN:

Significant emphasis has been placed upon external influences to the lean deployment, and the coercive influence they have on the transformation process. Two major sets of external influences occurred in the lifecycle of lean transformation at REMAN:

- The first set of external influences was corporate pressure to create an enterprise-wide transformation effort, which resulted in the creation of the REMAN Lean Deployment Task Force. This first set of external influences had the effect of transitioning lean deployment at the EarlyAdopter and LateToTheParty Divisions from the Entrepreneurial to Collectivity Stages of deployment.
- The second set of external influences was corporate pressure to produce tangible and significant cost reductions, which resulted in division leadership becoming aggressive in prescribing corporate initiatives to be undertaken. This second set of external influences had the effect of transitioning lean deployment at EarlyAdopter Division and LateToTheParty Division from the Collectivity to Formalization Stages of deployment.

Figures 4.20 and 4.21 illustrate the impact these external influences had on the degree of enabling and coercive elements through the stages of the deployment lifecycle. As can be seen each of these external influences had a significantly coercive impact on deployment within the organization. It is believed these coercive influences are largely a function of the overall management culture at REMAN, which would be characterized as a coercive bureaucracy according to Adler (1996).

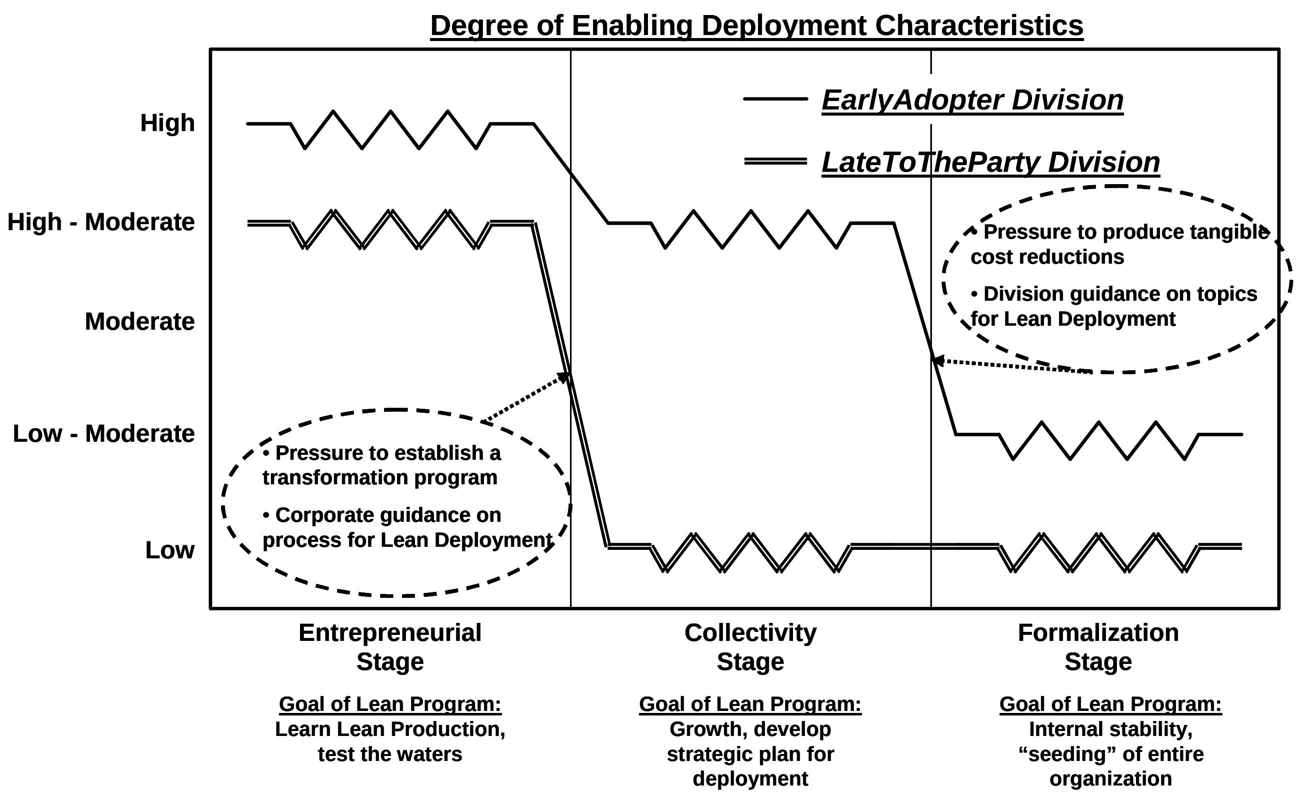


Figure 4.20 Degree of Enabling Deployment Characteristics

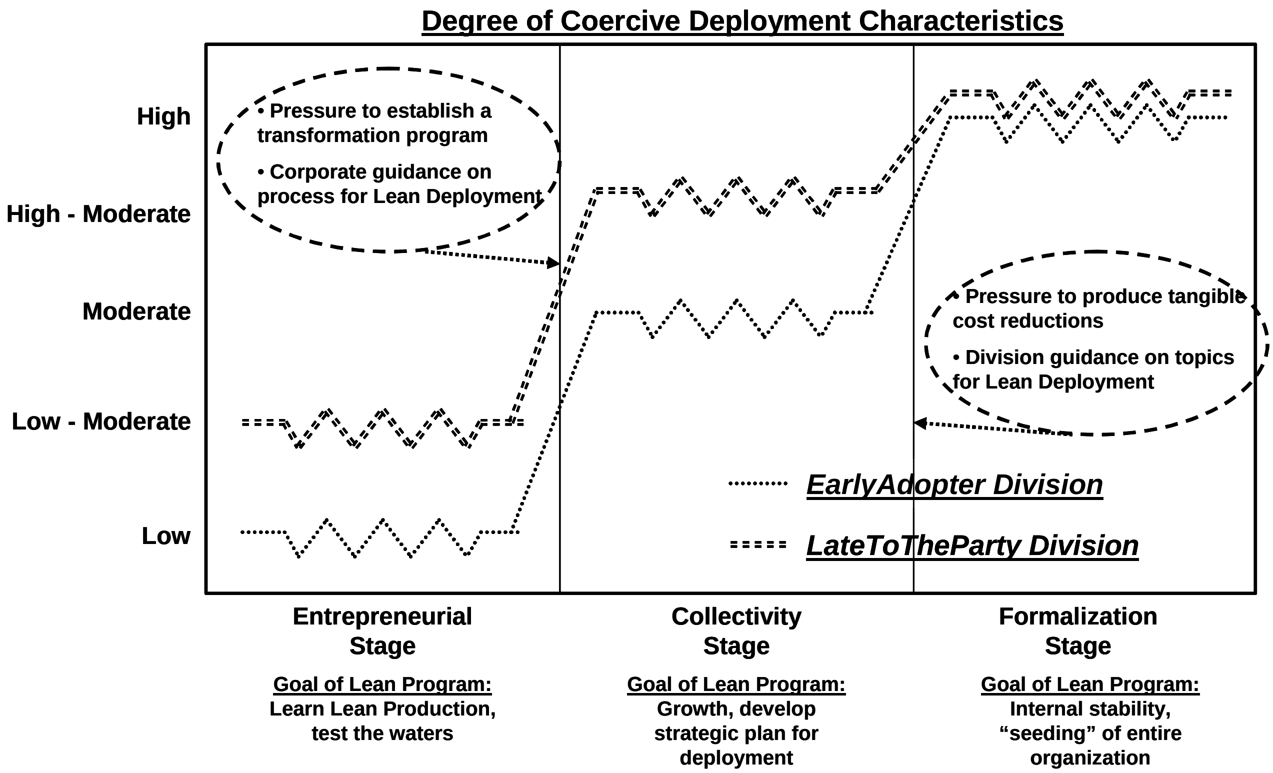


Figure 4.21 Degree of Coercive Deployment Characteristics

Understanding Lean Deployment at REMAN as a Success or Failure:

The case study of REMAN illustrates the way in which an organization sets out to transform the organization, but ultimately does not achieve their desired outcome of positive transformation. The challenge in developing a lean bureaucracy lies in optimizing the positive influences and overcoming the negative ones. For some organizations the objective of culture change and establishment of a learning organization may not be the objective for lean deployment. In some instances, the objective may simply be to reduce expenses at all costs. Many organizations do operate in this way, but the long-term implications of this short-term thinking are likely harmful to the success and longevity of an organization. In terms of REMAN, the objective was not cost reduction at any consequence. In many large bureaucracies this occurs regularly, and is known as a "budget wedge." REMAN had been through many of these arbitrary cost reductions in the past, but management was largely attracted to lean deployment because they felt it offered an alternative to their past behavior and resultant negative implications.

Therefore, if the objective for lean deployment at REMAN was to create a lean learning organization, how and why did they go astray? Was the failure in planning or execution? Was the failure a result of internal or external influences? Was the failure a result of the intended, or unintended, outcomes? The simple answer to all these questions is, yes. REMAN is a large and complex enterprise-wide bureaucracy, with strong tendencies towards coercive management behavior. The lean deployment began with excellent intentions, which were largely observed at EarlyAdopter in the Entrepreneurial Stage of deployment. But, when the program was put under pressure to perform and new decision makers and influencers were introduced to the deployment, the intent of lean deployment passed through the organizational filter, as described by Merton. As the organization sometimes distorted the intended outcome of lean deployment, the unintended outcome of a negative lean bureaucracy was achieved, see Figure 4.22.

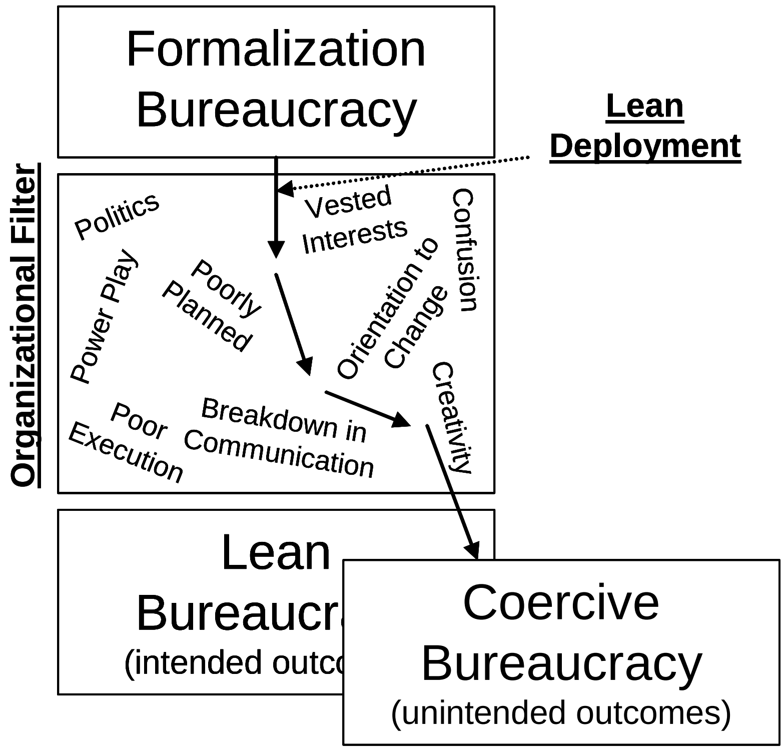


Figure 4.22 Intended and Unintended Consequences of Lean Deployment : Path to Coercive Bureaucracy

In considering the specific case study of lean deployment at REMAN, numerous elements of the organizational filter lead to the breakdown of intended outcomes. These of course, could cause deployment to shift from the intended outcome of a lean bureaucracy to the unintended outcome of a coercive bureaucracy. Among these reasons are the following:

- *Pressure to Create Immediate Results:* As observed in analysis of EarlyAdopter Division and LateToTheParty Division, the most significant shift towards coercive behavior came when external pressures were applied. These external pressures came in the form of a need to rapidly create a corporate transformation initiative and the need to deliver immediate results. When senior management was put under these pressures they responded with coercive organization norms of behavior. Because of this, coercive behavioral characteristics of command-and-control were rapidly infused into the lean deployment.

- *Poor Planning and Execution:* To some degree, lean transformation within REMAN, but particularly LateToTheParty Division, failed due to a lack of technical expertise and knowledge about successful lean deployment. In some instances, improvement initiatives were poorly selected, poorly prepared for, or poorly executed. These are all basic skills which that must be learned by an organization over time.
- *Confusion and Breakdown in Communication:* The message of empowerment, teamwork, and rapid improvement is not part of the underlying culture or DNA of REMAN, a command-and-control bureaucracy. As the message gets further dispersed throughout the organization, it undoubtedly gets twisted and manipulated, leading to possible confusion and inappropriate action.
- *Organizational Politics and Power Play:* Power and politics are alive and well in any organizational transformation or shakeup where there are likely "winners" and "losers." (Roskies, Liker, Roitman, 1988). As observed in the case study of REMAN, many senior managers did not wish to engage in the lean deployment effort until it became clear it would endure. Similarly, once it was identified that powerful political energy did exist for lean transformation, many opportunistic individuals sought to use this energy to achieve their desired outcomes, regardless of whether or not their idea of transformation aligned to the lean deployment.

- *Vested Interests and Orientation to Change:* As previously mentioned, in any significant organizational transformation there will be "winners" and "losers," suggesting a large percentage of the population may be deeply committed to maintaining the status quo. As observed at REMAN, some employees, often low-level managers, may intentionally undermine the message and intent of developing a lean bureaucracy, so they can protect the position they have achieved in the organization.
- *Creativity:* Perhaps the greatest challenge associated with creating a positive lean bureaucracy is that of continually endorsing empowerment and creativity, while maintaining some aspect of control over the extended deployment effort. It is believed this is the reason "culture change" is emphasized in much of the lean transformation literature (Liker, 2007). If the organization culture is pulling the deployment towards coercive ends, as was seen in the REMAN case study, the initiative will become coercive.

As a result of these issues, the deployment that began with very positive intentions became largely coercive, resulting in REMAN's failure to achieve the desired lean learning organization.

CONCLUSIONS

The phenomenon of lean bureaucracy; in which an organization desires to become an efficient learning organization and can achieve this outcome through enabling lean deployment; yet many organizations create a coercive deployment and simply feed the bureaucracy they are trying to transform with added layers of departments, procedures, rules, and regulations. This chapter has sought to better understand this phenomenon by defining a lean bureaucracy; encompassing ideal concepts of organization from multiple social science thinkers; developing a concept of a transformation life cycle, much like the growth and evolution of a bureaucracy itself; and defining the enabling and coercive manner in which that transformation may occur in an organization. All of this, along with the case study of lean transformation at REMAN has highlighted the dynamics of organizational change and lean transformation.

The case study of lean deployment at REMAN (its growth, evolution, and ultimate decline) is not unique. Many organizations undergo similar challenges and opportunities. As seen in these examples, many coercive forces exist that challenge the desired enabling lean deployment. A list of barriers and enablers to lean transformation are identified and discussed below with respect to enabling/coercive deployment. Also included is a framework for relating: positive lean bureaucracy, coercive bureaucracy, organic lean deployment, and cost reduction programs.

Barriers to Lean Transformation – Discussion from Enabling/Coercive Perspective:

The following eight characteristics have been observed in the case study of REMAN and other organizations as barriers to successfully developing a positive lean bureaucracy. Each characteristic is identified for the ways it may impact a lean deployment and make it more coercive.

- *Doing what comes naturally:* To employees in many large and complex organizations, the notion of management by command and control is simply a way of life. From an employee's perspective, if the new "lean program" is rolled out in a coercive manner, it seems like business as usual. They will comply and do what is necessary to check the box that they have "done lean" and go about their business the way they always have. From a manager's perspective, there is a tendency to deploy lean production using the same management tools as any other program. This creates a particular challenge, especially since a major element of successful lean deployment is an enabling and empowering culture, a required shift for most organizations that ultimately require a break from what comes naturally.
- *"Wait for me - I'm your leader":* Many managers, particularly those coming from strong command-and-control organizations, may feel it is a show of weakness among their peers or others to enable employees to make key decisions. Likewise, some employees might question a manager's authority. These managers may feel threatened by this and question whether empowering employees makes them replaceable to the organization. The essence of lean is to distribute leadership broadly to encourage learning and continuous improvement. This requires managers to become teachers, an uncomfortable role for some in a coercive bureaucracy.
- *Feeding the bigger fish:* There are institutional characteristics of a lean deployment by which senior management will want to both review progress in continuous improvement and promote successes to superiors. However, as a lean

deployment matures, and potentially more levels of a hierarchy become engaged, a tendency will exist for metrics to become more coercive in nature (i.e. "bean counting"). Furthermore, metrics may less directly enable transformation within the organization.

- *Supporting the masses:* As previously discussed, perhaps the single greatest challenge to effective enterprise-wide lean transformation is the delicate balance between employee empowerment and "management" of deployment. It is important for consistency in message and methodology of a corporate deployment, but this can become exponentially more difficult as an organization gets larger and more complex. Lean deployment across an enterprise will ultimately require crossing significant organizational, and possibly geographic, boundaries. The broader the deployment, the greater the opportunity for coercive forces to undermine deployment. The minds and hearts of individuals within each subgroup of the organization must be won over to the culture change of an enabling organization. It is for the specific reason of maintaining consistency in "managing" a program that Max Weber (1990) considered bureaucracy so powerful. Yet, despite the best intentions, the enabling aspect of lean deployment may become blurred as the "lean message" and deployment spread throughout an organization.
- *Power grab:* As was seen in the case study of lean deployment at REMAN, some managers may not desire to empower employees, or even implement lean, but they will embrace the deployment and organizational energy it creates as a means to achieve their own ends for organizational change. This is a particular challenge

since these managers are likely to use traditionally coercive management techniques in championing their efforts. As employees observe managers making a power grab under the guise of "lean deployment," the credibility and purpose of the overall deployment will be questioned.

- *Ignore it, and it will go away:* Some managers and employees will intentionally create a coercive environment for lean deployment, simply because they do not believe in it or do not desire to be bothered with a perceived "program of the month." This behavior will create a particularly coercive environment for deployment, an environment that may undermine long-term success of the effort.
- *Common to all, useful to none:* As observed in many organizations, a traditionally coercive deployment strategy for any initiative may involve developing a highly structured and rigid strategy for widespread dissemination of tools and techniques. In some instances, as organizations seek to develop a "system" of deployment, they may create a strategy that becomes so vague, general, and watered down to the point it provides little value to anyone. As seen previously, this belief in a standard strategy may undermine implementation as managers and employees place too much emphasis and faith in "the system," and fail to recognize shortcomings or seek out more appropriate deployment techniques.
- *Justifying a management position when technically ignorant of lean deployment:* In some cases, the lean deployment manager may not be technically knowledgeable of lean and disinterested in learning. This individual must be a champion, spokesman, and teacher for the intent of deployment. If this individual

cannot empower employees in an enabling way through lean deployment, they may revert to long-learned techniques of command-and-control by developing an elaborate bureaucratic management structure for lean deployment.

Enablers to Lean Transformation – Discussion from Enabling/Coercive Perspective: The following list of seven characteristics has been observed in the case study of REMAN and other organizations as enablers to successfully developing a positive lean bureaucracy. To some degree, each of these characteristics could be true of any management-led initiative, but they are particularly important in developing a positive lean bureaucracy. Each is discussed for the way it causes a lean deployment to become more enabling.

- *"How can I help?":* Servant-leadership is a key to developing an enabling lean deployment (Liker, 2008). Many leaders exhibit a common hubris of management that when they put on the "management hat" they become more important and knowledgeable of an organization. From the perspective of creating an enabling lean deployment, the most important characteristic of management is the ability to remove roadblocks to successful transformation.
- *Technical expertise leading the lean deployment:* Lean deployment, as well as any other significant transformation with an organization, is by definition a new way of working and behaving. Leadership for this effort must therefore possess a technical skill-set that is not simply aligned to "business as usual." Management should be able to instruct all levels of the organization on the new way of doing business. Leadership of the lean deployment must represent the thought leadership within the

organization if a lean bureaucracy is to be achieved. Management must constantly be teaching and coaching in order to avoid an organization reverting to traditionally coercive tendencies of bureaucratic command-and-control in deployment.

- *Senior Leadership engagement:* Many senior leaders have shown a propensity to "delegate" organizational transformation with weekly or monthly reports from their deployment leadership. The distinction between senior leadership support ("I support what you are doing") and senior leadership engagement ("I am going to commit my personal time and energy") cannot be understated for the key role it plays in creating a successful transformation and a positive lean bureaucracy. The adage of needing to "walk the talk" by senior management is critical to a successful enabling lean deployment.
- *Support for middle management*: Organizational transformation will typically place tremendous pressure on middle management to maintain execution and performance, while promoting transformation and change at the same time; all while obtaining information second or third hand regarding the details of deployment. It is critical to support middle managers in this challenging period of transformation so they can ultimately support changes and enabling lean deployment may prosper.
- "*What gets measured, gets done":* The adage of "what gets measured, gets done" holds true in considering organizational transformation. Many employees may not understand the overall intent of lean deployment, but they will be able to understand the metrics used by superiors to assess performance. Building the right metrics as an enabler to building the right behaviors is critical for developing an enabling lean deployment in support of leading implementers. This is a particular challenge in

building an enabling lean deployment, since many of the easiest and most common metrics to be gathered are some form of "busy-ness" metrics. These metrics are valuable to senior management so that they understand the activity going on within their organization. However, they are typically coercive from the perspective of front-line implementation. A key to developing an enabling lean deployment is to develop a metrics dash board that can support the needs of both senior management and enable the front-line implementer. In the case of enabling organizations, metrics, metrics goals, and methodologies for achieving those goals are negotiated and agreed upon at each level of the organization. (Liker, 2008)

- *Staying Power:* Perhaps a circular argument, but lean deployment must be enabling to become truly transformational; and it must be truly transformational to be sustained as a long-term shift in culture. Therefore, it must be enabling in order to have staying power. As can be seen in the case study of REMAN, many coercive organizational influences will exist in deployment, including existing organizational inertia and would-be opportunists who align to the transformation program in order to achieve their desired transformational outcomes.
- *Unite the masses:* In order to achieve long-lasting success with an enabling lean deployment, a requirement is to win over the hearts and minds of a majority of employees. An element of this is to enable, empower, and engage front-line workers, not simply technical experts, in the lean deployment. When transformation energies are expended only by a small team of managers or expert change-agents, this may be perceived as a coercive effort by someone else to "improve" an activity of which they have little to no understanding.

Typology of Lean Deployment:

- This chapter has largely focused on distinctions between early-stage and advanced lean deployment, as well as enabling and coercive deployment, all within the context of a large, complex, and mature bureaucracy. A typology of transformation initiatives is created utilizing the dimensions of "change typology," as enabling or coercive, and the point of maturation, nascent or mature. Figure 4.23 illustrates this model, which will be discussed further.

Change Typology

Evolution of Lean Deployment		**Enabling**	**Coercive**
	Early Stages of Lean Deployment	**Organic Lean Deployment**	**Cost Reduction Program**
	Mature Lean Deployment	**Transformation to a Lean Bureaucracy** ***(building through an enabling deployment)***	**Mechanistic Lean Deployment** ***(building a coercive bureaucracy)***

Adaptation from Adler (1996)

Figure 4.23 Typology of Lean Deployment

Organic Lean Deployment: A lean deployment that is in the early stages and is enabling would resemble an organic deployment (as introduced in chapter three of this dissertation). Organic lean deployment is recognized for its evolutionary learning over time and "spiral deployment" as initiatives grow from model areas to impact larger elements of the organization.

Cost Reduction Program: A lean deployment that is in the early stages and is coercive in nature would resemble a traditional cost reduction program. In a traditional cost reduction program, the methodology for improvement is seemingly inconsequential as compared to the outcome of cost reduction.

Transformation to a Lean Bureaucracy: A lean deployment that is mature in the Formalization Stage or beyond, and is characterized as enabling would represent the ideal of developing a positive lean bureaucracy. This deployment, which would effectively impact a large population of the organization in an empowering and enabling way, would suggest that the organization is well on its way to becoming an Elaboration Stage (Stage IV), post-bureaucratic organization.

Mechanistic Lean Deployment: A lean deployment that is mature, yet characterized as coercive in nature, is similar to the deployment observed in the case study of REMAN. This deployment would be considered mechanistic in nature. While it would impact a large segment of the organization it would ultimately lead to the development of a coercive bureaucracy.

ACADEMIC CONTRIBUTIONS

This chapter has sought to shed understanding to the phenomenon by which large and complex bureaucracies are transformed (or not) through deployment of lean production, and the impact an enabling or coercive deployment of improvement initiatives can have on the overall success of transformation. As a result of this study, several key contributions have been made to the academic literature in the areas of bureaucracy theory, organizational change, and lean manufacturing. The following contributions to academic literature in these areas have been made:

- Aligned organization design models of Greiner (Elaboration Stage Bureaucracy, 1972), Adler (Enabling Bureaucracy, 1996), Spear & Bowen ("DNA" of Toyota, 1999), and Senge (Learning Organization, 1990) to relate the close similarities in their description of the "ultimate form" of organization.
- Adapted an organization life cycle model to develop a detailed four-stage normative life cycle model of lean transformation within an organization.
- Adapted organizational design concepts of enabling and coercive bureaucracy to develop a dynamic model for the intended and unintended outcomes of organizational transformation.
- Developed a typology of organization transformation aligned to continuous improvement methods. This framework utilizes key dimensions of "change

typology" (enabling/coercive) and "evolution of lean deployment" (early stages/mature).

FUTURE RESEARCH

In chapter three of this dissertation we examined how deployment occurs within a single organization. In this paper we examine how deployment occurs in a large and extended bureaucracy. Future research should focus on the uniqueness of Toyota as a lean bureaucracy; examining the historical mechanics by which their internal culture was established, and examine the impact rapid growth in North America has had on the lean bureaucracy within the organization. A particularly fascinating study of this could occur by examining Toyota as they set up a factory for initial production, such as their new assembly plant in Mississippi. Additionally, further case studies beyond REMAN of smaller, less-bureaucratic organizations that have made the transformation to a positive lean bureaucracy would make a significant contribution to the literature on organizational transformation.

CHAPTER 5

CONCLUSIONS AND FUTURE RESEARCH

The primary objective of this has been to better understand the opportunities, challenges, and methodologies by which lean production tools and techniques can be successfully applied in the remanufacturing context. This question has been examined from a socio-technical perspective at three distinct units of analysis. Summarized below are the research objectives and key findings for each study at the single process, single facility, and extended enterprise levels.

LEAN REMANUFACTURING: ADAPTING LEAN TOOLS AND TECHNIQUES TO THE REMANUFACTURING CONTEXT

Unit of Analysis: Lean remanufacturing within a single process, shop floor level.

Research Objective: The objective of this research study was to de-mystify the question of if, and how, it is appropriate to apply concepts such a lean manufacturing in the remanufacturing context. This study sought to better understand the appropriate technical design of lean manufacturing tools and techniques in the remanufacturing context.

Key Research Findings:

- *The remanufacturing context is very broad and diverse*: It is important to shift the discussion of lean remanufacture away from one that simply compares OEM and remanufacture; this is an oversimplification of the issue and can lead to misleading generalizations and stereotypes.

- *Lean methods do apply in all instances of remanufacturing, but the specific solutions must be tailored to the specific context according to characteristics of product variability:* In the case of high-variability lean remanufacturing: the buffers will be bigger, parts supermarkets will get broader, engineers will be more integrally involved, fixtures will be less specialized, and cross functional teams will support each other to address variability in production processes. In the case of low-variability lean remanufacturing, the process may closely resemble OEM operations: technical instructions will be simplified, one-piece flow will occur, materials and tools will be kitted to precision, andon signals will be responded to immediately, specialized fixtures will improve quality and reduce setups, and multi-skilled workers will continuously improve processes to achieve takt time.

- *Lean manufacturing techniques work effectively to create improved performance in the remanufacturing context*: In each case study significant performance improvements were recognized through application of lean methods. This is not to suggest all attempted implementations will be successful, but that success is not technically prohibited.

- *Lean is arguably a different "production paradigm" than CIM and advanced mass production*: Lean, CIM, and advanced mass production have been shown to be so divergent in application, it is believed they must be considered as different production paradigms, and possibly even divergent production paradigms.

- *Mass production and CIM take a mechanistic view, while lean takes an organic view:* A close examination of the structural characteristics of lean, CIM, and advanced mass production suggests a mechanistic application of technology in CIM and advanced mass production, while lean is more organically driven by production employees.

- *Lean actually moves a production process within the PPM space; mainly along the process axis, allowing flexibility and efficiency simultaneously*: The implementation of lean methods has been shown to effectively move a production process within the PPM space. Specifically, in each case examined, the application of lean methods effectively moved the process in the direction of continuous flow.

- *Lean manufacturing effectively challenges the concepts of a production trade-off between quality and cost; volume and variety; efficiency and customization:* the PPM is grounded in economies of scale production paradigm, suggesting a required tradeoff exists between quality/customization and output/efficiency. However, in examining the PPM, lean methods have been shown to effectively offer a new set of efficient production options, such that a tradeoff is not required between the key variables.

- *A tremendous growth opportunity exists to apply lean production methods to the generally immature remanufacturing industry:* Remanufacturing has been considered as “the next great opportunity for boosting U.S. productivity” and “the ultimate form of recycling.” This paper has shown the potential for lean production methods to play a significant role in this important environmental and economic opportunity to come to fruition.

COMPARATIVE CASES OF LEAN MANUFACTURING DEPLOYMENT: ORGANIC VERSUS MECHANISTIC APPROACHES

Unit of Analysis: Lean remanufacturing within a single facility/factory.

Research Objective: The objective of this research study was to answer the fundamental question of how to begin a lean remanufacturing deployment, and to better understand the methodology and mechanisms by which lean remanufacturing is appropriately deployed.

Key Research Findings:

- *Need for Balance Between Organic and Mechanistic Deployment*: An organic approach is required for deep understanding and organizational learning, but it fails if it is not supported by appropriate infrastructure. A mechanistic approach will enable widespread awareness and implementation, yet it must be augmented with deeper change at the technical and cultural level and organizational learning.

- *Existence of Equifinality*: Ultimately, there is no “one best way” to deploy Lean Manufacturing, but it is advisable that a long-term balance between organic and mechanistic strategies is required for continued successes to occur.

- *Begin with Organic Deployment:* An organic approach is more appropriate when uncertainty exists regarding the deployment, specifically questions about the objective, longevity, benefits, scope, timeline, etc. As the deployment begins to take hold within an organization, and the idea of "Lean Deployment" is better understood and embraced, uncertainty regarding the deployment is reduced and the infrastructure of a more mechanistic approach can begin to take hold.

- *Technical and cultural change go hand-in-hand*: Technical changes have been shown to lead to social changes. Social changes in turn enable greater technical changes. Therefore, deployment strategies that limit engagement to only social or technical changes are shortsighted and do not appreciate the interconnectedness of the two.

- *Exponential benefits with depth of deployment*: As the organization progresses to advanced social and technical tools of lean, including flow of value, flexible/interconnected processes, WIP reduction, and a team construct, the benefits are more significant than in initial tool implementation like 5S and brainstorming.

- *No wasted failures, only failures to learn*: This adage, attributed to a senior leader within Toyota, is relevant when one looks at the evolution in both the organic and mechanistic approaches. An organic approach is certainly more dynamic and evolutionary, but with mechanistic deployment of tools there is still the opportunity for considerable learning about how to use the tools and their limitations.

- *There is no crystal ball in deployment*: In large, complex organizations it is hard to predict the long-term future for lean implementation, adoption, and learning. Successful Lean implementation requires an organization to challenge their history of norms, procedures, and ways of doing things. While it is simple to talk about an organization evolving, it is much more complex to talk about each organization as a large number of individuals who must similarly let go of their own history of norms, procedures, and successes. One particular element of this is that in a large complex organization, positive energy may be effectively created for lean manufacturing deployment, yet, if the message is not closely preserved the energy and enthusiasm behind the message may be high jacked by a manager looking to advance his/her own ideals. Successful lean deployment requires significant focus and energy for an extended period of time. Success and failure cannot be easily predicted.

DEVELOPING A LEAN BUREAUCRACY: ENABLING VERSUS COERCIVE TRANSFORMATION FROM AN ORGANIZATIONAL LIFE CYCLE PERSPECTIVE

Unit of Analysis: Lean remanufacturing within a complex extended enterprise.

Research Objective: The objective of this research study was to better understand the ways in which a large and complex bureaucracy is transformed (or not) through deployment of lean production, and the impact an enabling or coercive deployment of improvement initiatives can have on the overall success of transformation.

Key Research Findings:

There are many influences within a large bureaucracy which will pull a lean deployment towards coercive characteristics of controlling, yet, some positive influences that can serve to overcome this negative pull are:

- *"How can I help?* Servant-leadership is a key to developing an enabling lean deployment (Liker, 2008). From the perspective of creating an enabling lean deployment, the most important characteristic of management is the ability to remove roadblocks to successful transformation.

- *Technical expertise leading the lean deployment:* Leadership for a lean deployment must possess a technical-skill set that is not simply aligned to "business as usual." Leadership of the lean deployment must represent the thought leadership within the organization. It must constantly be teaching and coaching in order to avoid an organization reverting to traditionally coercive tendencies of bureaucratic command-and-control in deployment.

- *Senior leadership engagement:* The distinction between senior leadership support ("I support what you are doing") and senior leadership engagement ("I am going to commit my personal time and energy") cannot be understated for the key role it plays in creating a successful transformation and a positive lean bureaucracy. The adage of needing to "walk the talk" by senior management is critical to a successful enabling lean deployment.

- *Thawing the "Ice Cream Sandwich***":** Senior management and front-line employees, who are typically supportive of deployment, are the "soft, warm, and chewy chocolate part"; middle management is the "frozen middle." Organizational transformation will place tremendous pressure on middle management to maintain execution and performance, while promoting transformation and change at the same time; all while obtaining information second or third hand regarding the details of deployment. It is critical that first-line level of management support changes so that enabling lean deployment may prosper.

- "*What gets measured, gets done":* Many employees may not understand the overall intent of lean deployment, but they will be able to understand the metrics used by superiors to assess performance. Building the right metrics as an enabler to building the right behaviors is critical for developing an enabling lean deployment in support of leading implementers.

- *Staying power:* Perhaps it is a circular argument, but lean deployment must be enabling to become truly transformational; and it must be truly transformational to be sustained as a long-term shift in culture. Therefore, it must be enabling in order to have staying power. Many coercive organizational influences will exist in deployment, including existing organizational inertia and would-be opportunists who align to the transformation program in order to achieve their desired transformational outcomes.

- *Need to unite the masses:* In order to achieve long-lasting success with an enabling lean deployment, there is a requirement to win the hearts and minds of a majority of employees. An element of this is to enable, empower, and engage front-line workers, not simply technical experts, in the lean deployment. When transformation energies are expended only by a small team of managers or expert change-agents, this may be perceived as a coercive effort by someone else to "improve" an activity of which they have little to no understanding.

FUTURE RESEARCH

This dissertation has examined lean manufacturing applications in the remanufacturing industry. Aspects of this research have served to advance our theoretical understanding of lean production methodologies and challenges in deployment, while other aspects have served to advance our more practical knowledge of lean methods as they apply in the remanufacturing context. Future research to build upon this study would include:

- *Additional study into interesting and unique contexts for lean production methods*: The remanufacturing context is a very unique and colorful context for application of lean methods, but still more unique applications exist. Three particular contexts of interest are the application of lean methods in the health care industry; research and design environments; and lean methods as applied in daily living, to highlight popular methods of eliminating wasted resources in daily life.

- *Additional study of design for life cycle maintenance and methodologies to project life cycle costs in design*: Many long-term decisions for lifecycle maintenance and cost are made very early in product design. The implications of design for life cycle maintenance as well as the life cycle cost implications of integrated and modular product architecture should be examined; as well as the financial and technical implications to closed-loop manufacturing/maintenance/disposal life cycle models.

- *Comparison in the application of lean methods in the manufacture and remanufacture of common components*: This research has highlighted the application of lean methods to the remanufacturing of various components. At the same time, OEM's for those same products are likely making great strides through application of lean methods. It is believed a significant contribution of future research would be a comparative study of lean methods as applied in manufacture and remanufacture of the same product.

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