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This research investigated the role of management support, organizational culture, and organizational structure in a lean implementation. The impact the lean implementation made on communication and employee problem resolution skills within the organization was also examined. A qualitative case study methodology was used to investigate the research questions. The case study was performed at an electronics manufacturer in the northwestern United States. Data was collected over a three month time period. The data was coded employing an evolving coding scheme. The coding allowed the data to be organized into manageable units for analysis purposes. Significant findings were found for each of the research variables of interest. Due to the design of the research, the results of the case study are not broadly generalizable, but they do provide strong justification for further research. Additional research at organizations of differing sizes in a variety of industries would strengthen the findings and allow for wider generalizations to occur.

Evidence of the positive impact of culture on the lean implementation was found, but ingrained cultural assumptions were also found to have a negative effect on the adoption of

lean practices. No evidence was found of organizational structure making a positive impact on the lean implementation. Instead, the lack of support staff and minimal structure seemed to inhibit a persistent adoption of lean practices. Evidence was found to indicate that management support made a positive impact on the lean implementation, but a lack of communication about the lean effort and minimal material support by the executive management team was also found. Some evidence of improved communications attributable to the lean implementation was found, but the majority of the evidence involved examples of poor communication between work areas. Evidence of the lean implementation making a positive impact on employee problem resolution skills was also found, though difficulties still existed when seeking root causes to problems.

Though this research explored five very different propositions related to lean manufacturing, the implications from the propositions often shared similarities. In particular, this research underscored the need to involve the entire organization in the implementation, educate the employees thoroughly, and create a work group that can effectively manage the lean effort.

The Role of Sociocultural Factors in a Lean Manufacturing Implementation

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

Figure | Page

LIST OF TABLES

LIST OF APPENDICES

Appendix Page

THE ROLE OF SOCIOCULTURAL FACTORS IN A LEAN MANUFACTURING IMPLEMENTATION

1. INTRODUCTION

Many organizations operating in today's economy find themselves constantly under pressure to cut operating costs while continuing to maintain high levels of customer service. In the electronics industry of the Pacific Northwest, this has become critical as revenue levels have dropped precipitously. More electronic manufacturers are turning to lean manufacturing as a tactic to increase profits and cut expenses.

1.1. MOTIVATION

Lean manufacturing, also known simply as lean, came from the Toyota Production System (TPS) in Japan, but it has evolved to encompass many ideas and concepts. As organizations in the United States have struggled to compete, many have embraced lean as a method that will allow them to remain competitive. As with many improvement programs, lean implementations have not succeeded universally in their application. This research focused on increasing understanding of how culture, organizational structure, and management support impact a lean implementation. Additionally, how a lean implementation impacts communication and employee problem resolution skills was also studied.

1.2. CONTRIBUTION

The literature contains a great deal of information on lean implementation successes, both anecdotal (Ahls, 2001; Alavi, 2003) and empirically evaluated (Krafcik, 1988; Spear & Bowen, 1999; Womack, Jones & Roos, 1990; Womack & Jones, 1994; Womack & Jones, 1996). Similarly, the literature contains examples of failures, both anecdotal (Parks, 2002;

Stamm, 2004) and empirically evaluated (Bamber & Dale, 2000; Emiliani, 2001; Womack & Jones, 1994). The literature, however, lacks few formal research studies that link sociocultural variables such as organizational culture, organizational structure, management support, communication, and employee problem resolution skills with lean outcomes. The literature also lacks empirical research investigating the impact a lean implementation makes within the organization. Without empirical research, managers and organizational leaders do not have a strong basis for determining whether or not lean is an appropriate tool for their organization.

A lean implementation, as with many transformational programs, impacts more than just the manufacturing floor. Being made aware ahead of time of the potential impact (both positive and negative) a lean implementation may make will allow organizational leaders and managers to anticipate change and plan for the future.

1.3. RESEARCH PROPOSITIONS

Successful change of any kind in an organization is very difficult to achieve (Jarrett, 2003; Lawson & Price, 2003). Not only is it problematic to successfully implement change, but the results may not always be as expected. Very often, the outcome of a new program may depend on numerous sociocultural variables. Three propositions were developed to study the impact of culture, organizational structure, and management support on a lean implementation. Two additional propositions were developed that explored the impact of the lean implementation on communications and employee problem resolution skills. The five research propositions that guided the study are summarized in Table 1.

Table 1.1. Research Propositions

Research Propositions
1. What is the impact of organizational culture on a lean implementation?
2. What is the impact of organizational structure on a lean implementation?
3. What is the impact of management support on a lean implementation?
4. What impact does a lean implementation have on organizational communications?
5. What impact does a lean implementation have on problem resolution in an organization?

For this research, organizational culture is defined as a group's shared basic assumptions that in turn determine how the group perceives and solves problems (Schein, 1992). Few research studies exist in the literature that examine the critical role of culture in a lean implementation. It may be difficult to sustain a lean implementation in a culture that values rigid procedure over the ability to adapt to changing circumstances. The culture of an organization may impact not only the ease of implementation, but the outcome itself. As Krafcik (1988) noted in his study of automobile assembly plants in Japan, Europe, and North America, culture strongly influences performance of the organization. Want (2003) agreed, noting that organizational culture impacts every aspect of an organization's performance. The first research proposition focused on understanding the impact of organizational culture, on a lean implementation.

The second research proposition investigated the role of organizational structure in a lean implementation. Organizational structure can make it difficult to implement changes to improve productivity (Kotter, 1995). As an organization grows in size, an increasing number of management levels between senior management and line employees is not uncommon. As an organization adds more levels to its hierarchy, positions may be created for activities that provide little value to the customer (Barker, 1994). When this occurs, an organization may experience difficulty fostering open communication and decentralizing authority. Both open communication and delegation of authority are necessary for a successful lean implementation (Alavi, 2003; Bamber & Dale, 2000; Jordan & Michel, 1999; Spear & Bowen, 1999; Storch & Lim, 1999).

While culture and organizational structure may impact a lean implementation, the investment of upper management in the lean implementation is also thought to be critical to the outcome of a lean implementation (Alavi, 2003; Bamber & Dale, 2000; Boyer & Sovilla, 2003; Emiliani, 2001; Moore, 2001a; Parks, 2002; Stamm, 2004; Womack & Jones, 1996). Additionally, an organization that has members of the management team unwilling to

legitimize a lean implementation may unwittingly sabotage the efforts (Boyer & Sovilla, 2003; Stamm, 2004). A middle management team that feels threatened by a lean implementation may exhibit a lack of enthusiasm that may lead line employees to feel the lean effort is a waste of time. If line employees feel that the executive team does not respect their efforts, discouragement and disillusionment may take hold, and the lean effort will fail (McNamara, 1983; Kotter, 1995). In order to realize the potential of lean, it must be embraced by all levels of management in the company (Bamber & Dale, 2000; Emiliani, 2001; Moore, 2001a; Parks, 2002; Womack & Jones, 1996). The third research proposition explored how the support of top-level leaders within the organization for the lean initiative impacted the lean implementation.

The fourth research proposition investigated the relationship between the lean implementation and communications within the organization. By necessity, a successful lean implementation requires well defined communication lines with minimal impedance (Spear & Bowen, 1999; Storch & Lim, 1999). Communication must flow easily and directly. A clear method for sending and receiving responses to problems should exist (Spear & Bowen, 1999). This study assessed the impact of the lean implementation on communications within the case study site.

A lean environment not only requires free flowing communication, it also requires that all employees become involved in effective problem resolution (Alavi, 2003; Bamber & Dale, 2000; Emiliani, 2001; Panizzolo, 1998, Spear & Bowen, 1999). While previously published literature identifies problem resolution skills as important to a lean implementation, little empirical research exists to link lean with an improvement in problem solving skills. The fifth research proposition focused on the role of the lean implementation in improving the problem resolution skills of employees.

1.4. METHODS

A case study was used to provide the context-rich data needed to explore these propositions. This research is well-suited for a case study. When a researcher is delving into the how and why of a set of events, the case study offers advantages not found in more quantitative research tools (Yin, 1994). Qualitative data allows the researcher to more fully study a topic and discover complexities that would not be revealed by quantitative methods alone (Miles & Huberman, 1994).

A single site case study design was used. The subject of the case study was a contract electronics manufacturer in Vancouver, Washington. Electronics assembly is a key part of the electronics manufacturing industry. This industry has become a vital part of the economy in the Pacific Northwest. In Oregon and Washington, the value of printed circuit board shipments grew from $160 million in 1992 to $385 million in 1997 (U.S. Department of Commerce, 1999). The economic downturn experienced by the United States in 2001 hit the electronics industry especially hard. In Washington state alone, sales associated with electronics assembly declined from $379 million in 2000 to $117 million in 2002 (Washington State Department of Revenue, 2004). The electronics manufacturing industry in the Pacific Northwest is still struggling to maintain operations and profitability.

The organization participating in this research is referred to as CompX for confidentiality purposes. CompX was founded in 1971. The organization employed 64 employees at the time of the study. The management team consisted of a president and a vice president, a production manager, a manufacturing engineer (who served as a senior engineer for the management team during the lean implementation), and several key production personnel who served as points of contact within each department. The company designed and manufactured products to meet customer needs, but also manufactured products based on customer specifications. It provided a full array of services including prototyping, testing and quality assurance.

At the time of data collection the company manufactured over 1,800 different products with an approximate annual income of $6.5 million. The lean implementation began in late 2001, in response to a customer's request. The implementation began with some training of key production personnel. In late 2002 the company attempted to move the implementation forward with a lean activity involving all production personnel.

Data was gathered over a three month period in early 2003 from multiple sources, using different data collection methods. Fourteen formal interviews were conducted. Informal interviews and observations were conducted in 16 different work areas within the organization as part of a value stream mapping activity. Internal documents and manufacturing production data were also collected from the organization.

All field notes from the case study site were transcribed, resulting in over 80 pages of notes. The field notes were coded using a framework based on the research propositions. A database was created to facilitate storage, organization, and retrieval of the coded data. The database was used for grouping purposes and provided a reliable mechanism for analyzing the data.

1.5. FINDINGS

The database allowed the evidence contained in the field notes to be evaluated and analyzed. Some of the evidence could not be directly linked to any of the propositions, but examination of this evidence provided contextual background and illustrated the impact the lean implementation had made on the organization.

A strong link was found between culture and its impact on the lean implementation. The culture did positively impact the lean implementation, but more evidence was found of ingrained cultural assumptions negatively affecting the adoption of lean practices. The culture evidence also illustrated the need for the organization to align cultural assumptions

about priorities to encourage personnel from the manufacturing floor to place more focus on the customer.

No evidence was found of organizational structure making a positive impact on the lean implementation. Most of the evidence linking organizational structure to the lean implementation involved the lack of focus the implementation was given. Some of the evidence suggested that the lack of support functions and the small management team could be hindering the lean implementation instead of helping it.

Some evidence was found for the role of executive management support in the lean initiative. This support was found to have both a negative and a positive impact on the lean implementation. Evidence suggested that leaders needed to work on increasing employee understanding of lean and providing more material support for the lean effort. Positive evidence of a link between the lean implementation and a more positive attitude towards management was found, indicating management's commitment to the lean effort was visible.

Some evidence was found of improved communications that could be attributed to the lean implementation, but counter evidence also existed. Most of the communication difficulties involved the flow of information between work areas. This is not an unexpected result as most of the lean activities at the time of data collection had focused on specific work areas. Cross functional activities had not yet been introduced within the organization.

Evidence of an increase in employee problem resolution skills was found, as well as evidence of difficulties despite the lean implementation. Many of the employees seem to have basic problem solving skills, particularly when solving problems within the work area. A good deal of the evidence was related to difficulties in problem solving and stemmed from a lack of recognition of the root cause of the problem. As the work areas continued to function as individual units, this result was also not unexpected.

1.6. CONCLUSION

The results of this case study are not generalizable, but they do provide evidence that top-level management support, organizational structure, and organizational culture have an impact on the implementation of lean. Evidence also exists of the impact a lean implementation makes on communications and employee problem resolution skills. Further research at other case study sites would allow the findings to be generalized to a larger population. Extending the research to include organizations of differing sizes from a variety of industries would strengthen the findings even further.

2. LITERATURE REVIEW

The literature reviewed for this study was specifically chosen for its content. Many of the papers reviewed were selected because of their coverage of management support, culture, communication, organizational structure, and employee problem solving and their link to lean manufacturing. A vast amount of literature exists on lean manufacturing. A targeted selection of the most relevant literature streams was used to identify potential studies for inclusion in this review. Some of the key words used in the literature search included organizational culture, leadership, communication, organizational structure, employee problem solving skills, lean failures, benefits of lean, and lean history. Many of the studies were selected because they provided a current perspective on the topics under study. Several of the studies, however, such as those by Womack and Jones (1994, 1996) and Krafcik (1988) were chosen for their early involvement in the lean manufacturing movement. Some articles, such as those by Spear and Bowen (1999) and Lathin and Mitchell (2001) were selected because of their unique perspective on lean manufacturing. Both empirically evaluated research papers and practitioner oriented articles were included to provide a broad foundation for the research. After an analysis of the more general literature on lean manufacturing, it was determined the selected journal articles provided sufficient and adequate background material to also be used in a general review of lean manufacturing. General, non-engineering journal articles on the topics of management support, culture, communication, organizational structure, and employee problem solving were also reviewed to provide background and depth to the research.

2.1. LEAN

Though lean is often thought of as a recent paradigm, its roots can be found in early automobile manufacturing history. Toyota has been perfecting the method for over 50 years. Some may think of lean as a simple recipe to be followed, but it actually has many different practices associated with it. Equally diverse are the number of suggested steps to a successful lean implementation. Though lean has many proven benefits, there are also some individuals who feel lean has its limits. For an in-depth understanding, it's important to explore all of these aspects of lean. It's also important to realize that lean pertains to more than just the manufacturing floor – it involves all of the processes of the organization and all areas of an organization may be involved in lean (Maskell, 2000).

2.1.1. History

Prior to Henry Ford's idea of the moving assembly line, master craftsmen built automobiles individually (Krafcik, 1988; Womack, Jones & Roos, 1990). As a result, cars were not affordable to the average person. Henry Ford consolidated the work range of each employee, increasing efficiency and making cars more affordable (Krafcik ; Womack, Jones & Roos). The Ford system, referred to normally as Fordism, divided the assembly process into 30 second tasks performed almost a thousand times a day by individuals on the line (Krafcik). Assembly tasks were analyzed and stripped of all wasted motion, enabling standards to be set and efficiencies to increase even further (Krafcik). In contrast, craftsmen were much slower to create a car but had a wider range of knowledge and skills (using both their minds and their hands) (Krafcik; Womack, Jones & Roos).

In the 1950's Eiji Toyoda and Taiichi Ohno merged the knowledge and skill range of craftsmen with the assembly line and standardization of Fordism and added the concept of teams, creating the Toyota Production System (TPS) (Womack, Jones, & Roos, 1990).

Employees were trained in a variety of tasks, not just on the factory floor, but in other areas as well such as maintenance, record keeping, and quality control (Krafcik, 1988; Womack, Jones, & Roos). Employees were also given the responsibility of standardizing their work and continuously improving it. The benefits of such a system became quickly noticeable, not only in terms of efficiency, but also in the ability of the new system to flexibly meet customer demand (Krafcik).

John Krafcik introduced the term lean production system in 1988 during his comprehensive research of auto assembly plants and Womack, Jones, and Roos (1990) further elaborated on the Toyota Production System in the book The Machine that Changed the World. Since the publication of this book, organizations in both the east and the west have attempted to replicate and implement lean. Some of these organizations have met with success while others have only achieved partial success. One difficulty in implementing lean may stem from the lack of agreement about what constitutes a lean implementation. Equally as difficult is finding agreement in the literature on the definition of lean itself.

2.1.2. Definition

Though Toyota is generally recognized as the birthplace of lean, it is difficult for employees at Toyota to define the Toyota Production System. Toyota does not have any of the tenets of the system written down (Spear & Bowen, 1999). Employees do have a common goal, however, and a shared sense throughout the organization of what an ideal system would be (Spear & Bowen). In an ideal system the output of a person, a group of people, or a machine is defect free, can be delivered in batch sizes of one, can be delivered immediately in the version required, can be produced without waste, and can be produced in an environment that is safe physically, emotionally, and professionally for every employee (Spear & Bowen). Womack and Jones (1994) provide a similar definition of lean production, though with more specifics as to the manufacturing process. Womack and Jones contend that lean production

entails the elimination of unnecessary steps, aligning the steps so the production process flows continually, employing cross-functional teams dedicated to a specific product stream, and continuously striving to improve the production process.

Other researchers employ a more general definition of lean that focuses on one aspect of the definitions provided by Womack and Jones (1994) and Spear and Bowen (1999), agreeing that organizations implementing lean seek to eliminate waste from the entire value stream (Alavi, 2003; Emiliani, 2001; Jordan & Michel, Moore, 2001b, Storch & Lim, 1999). Womack and Jones (1996) define the value stream as product definition (conceptualizing, designing, and launching production of the product), information management (order taking, scheduling, and delivery), and physical transformation (transforming the raw material into a finished good). Defining waste involves examining the value stream from the customer's perspective (Storch & Lim). Any activity that does not add value for the customer must be investigated as to its necessity. Some activities do not add value, but are required functions in the value stream. Eliminating waste involves removing all non-value added activities that are unnecessary. Organizations may implement lean on only the manufacturing floor, but to enjoy the full benefit of lean, organizations must include all facets of the value stream when eliminating waste (Womack & Jones, 1994).

Other definitions of lean take an organizational view. Jordan and Michel (1999) classify a lean organization as an enterprise that can flexibly respond to market demand, competition, and economic conditions while minimizing waste. Storch and Lim (1999) note that lean requires flexibility when utilizing resources in order to respond to changes in production. Katayama (1996) contends that while fewer resources are required by a lean organization, lean puts pressure on the organization for higher performance in terms of quality and product variety. Lean is also defined as work that is highly specified with no variability. All employees complete a task exactly as specified and variation in the process is reduced (Knuf, 2000; Spear & Bowen, 1999).

Definitions for lean vary from descriptions of the lean processes to descriptions of the affect of lean on the workforce. For this research lean will be defined as the systematic removal of waste, by all members of the organization, from all areas of the value stream. In addition to defining lean, it's also important to understand why organizations might wish to implement lean. The benefits of a lean implementation may include both quantitative and qualitative returns.

2.1.3. Benefits

The benefits of lean described in the literature are numerous. While lean is often associated with reduced inventory or better manufacturing times, lean should, above all else, reduce the cost of doing business (Allen, 2000). Some of the common benefits of lean such as reduced build time, increased quality, increased customer satisfaction, reduced inventory, increased workplace safety, and reduced set-up times for machinery are cited frequently (Ahls, 2001; Alavi, 2003; Emiliani, 2001; Ross & Francis, 2003; Womack & Jones, 1994; Womack & Jones, 1996). Of the literature selected for review, eight studies provided evidence or discussed specific benefits. The benefits of lean detailed in these eight studies are summarized in Table 2.1.

Table 2.1. Benefits of Lean

Author	Reduced Build Time	Increased Quality	Increased Customer Satisfaction	Reduced Inventory	Increased Safety in the Workplace	Reduced Set-up Times
Ahls (2001)	X	X		X		
Alavi (2003)		X	X		X	
Barker (1994)	X	X		X		
Emiliani (2001)						X
Ross & Francis (2003)	X	X	X	X		
Storch & Lim (1999)			X			
Womack & Jones (1994)			X			
Womack & Jones (1996)	X	X		X	X	

Womack and Jones (1996) assert that by implementing lean, labor productivity will double the amount of work through the system and build times and inventory will decrease by 90%. The initial conversion to lean will also cut in half the number of errors in the finished product, the scrap caused by errors within the manufacturing process, on the job injuries, the time needed to get a product to market, and the effort needed to develop new products. By making continuous improvements, productivity can be doubled again in two to three years while cutting inventories, errors, and the amount of time needed for manufacturing in half (Womack & Jones, 1996). A simulation of the reorganization of two work environments employing some of the concepts of lean found improvements in machine utilization, personnel utilization, and lead time (Zuelch, 1994). Ross and Francis (2003) assert that organizations using lean have typically cut inventory and building times by 50% in each wave of the lean

program. While some may question how an organization can improve year after year, Emiliani (2000) contends productivity can be continuously improved without limit by identifying and eliminating waste.

Lean also provides a foundation upon which organizations can respond more quickly to customer orders, allowing the organization to increase sales (Alavi, 2003; Ross & Francis, 2003). Lean plays a large role in customer satisfaction by providing the organization with the ability to respond to specific customer requests related to product customization (Ross & Francis; Womack & Jones, 1994). Though not often the primary catalyst for a lean implementation, lean can help to satisfy customer needs while providing the organization with a competitive edge (Storch & Lim, 1999).

Lean does not only produce quantitative benefits that can be immediately measured, but it also produces some important benefits that are more qualitative in nature. If lean is applied correctly, the organization is able to learn (Emiliani, 1998). Mistakes may still be made, but they are learned from and not repeated which is in contrast to traditional organizations that make the same mistakes repeatedly (Emiliani, 1998). Employee satisfaction and morale also increases (Alavi, 2003). Employees become empowered in the lean process as decision making is pushed to the lowest levels of the organization (Barker, 1994). Employees become knowledge assets instead of physical assets (Jordan & Michel, 1999).

Lean provides many benefits, both quantitative and qualitative. The literature provides insight to the common benefits of lean as well as a perspective on some of the intangibles that may be positively impacted by a lean implementation. While researchers are generally in agreement as to the benefits of lean, there are a number of differing viewpoints on the specific practices an organization may employ during a lean implementation.

2.1.4. Practices

The literature offers definitions and examples of many lean practices. As Spear and Bowen (1999) note, the practices many organizations consider vital to a successful implementation are not seen as a fundamental part of the Toyota Production System. Spear and Bowen contend that organizations often confuse the tools and practices of lean with the Toyota Production System. Organizations are also unable to grasp the paradox of the Toyota Production System: activities at Toyota are highly scripted, but operations remain flexible and adaptable. It is the rigidity that makes the flexibility possible.

The use of lean practices does not indicate an organization is applying Toyota's rules (Spear & Bowen, 1999). Toyota believes that practices are a specific response to a problem. Toyota calls such practices countermeasures. Countermeasures work until a better solution is found or the conditions surrounding the problem change. The countermeasures are not permanent fixtures within the organization. For example, at times Toyota may build up inventory as a countermeasure to deal with a problem at that time (Spear & Bowen). This is counterintuitive for those that associate lean with limited inventory.

The practices of lean are numerous. Some of the most prevalent include kanbans, kaizen events, Five S events, one piece flow, quick changeovers, mistake proofing, reduced cycle time, value stream mapping, and reduction of inventory. Brief definitions of these more common practices are included in Table 2.2.

Table 2.2. Definitions of Lean Practices

Lean Practice	Definition
Five S Events	Defined as the five dimensions of workplace organization. The events are designed to organize and clean. Five S events are often incorporated with Kaizen events. The Five Ss are defined as sort (identify unnecessary equipment), straighten (arrange and label the area so all tools have a specified home), shine (clean the area and maintain equipment daily), standardize (establish guidelines and standards for the area), and sustain (maintain the established standards).
Kaizen Events	Defined as continuous improvement in small steps (Womack & Jones, 1990), organizations typically use kaizen events of varying time lengths to focus on improving a process.
Kanban	Defined as a system which uses a card or other visual cue to signal a need to produce or transport a container of raw materials or partially finished goods to the next stage in the manufacturing process (Nicholas, 1998).
Mistake Proofing	Characterized by built-in methods within the system that prevent defects from happening (Nicholas, 1998).
One Piece Flow	Characterized as a methodology that allows the work to flow through the manufacturing process and to the customer with minimal impedance.
Quick Changeovers	Characterized as a method for minimizing the amount of time it takes to change a machine's setting or to prepare an area to begin processing a new product.
Reduced Cycle Time	Defined as the amount of time it takes for a product to transform from raw material to finished good. The goal is to evaluate the flow of the material and minimize the amount of time (i.e. cycle time) it spends in the transformation process.
Reduced Inventory	Characterized as a practice for receiving materials just as they are needed by manufacturing and only manufacturing products as customer orders are received to reduce the amount of finished goods held in inventory.
Value Stream Mapping	Defined as looking at the flow of material through the manufacturing process and improving the whole process, not just optimizing pieces of the process (Rother & Shook, 1999).

Some of the lean practices should be used with caution. Parks (2002), for example, warns against starting with the Five S activity as future activities may involve moving machines and changing work methods, leaving employees to feel their previous work in straightening and standardizing the area was wasted. Allen (2000) cautions against introducing lean practices that are not used properly to avoid confusing employees.

As Toyota has shown, not all practices must be implemented to achieve lean. Bamber & Dale (2000) contend that tools and techniques must be tailored to each organization. Lean

is also not a randomly chosen set of practices to be implemented as a means to improve production statistics. Alavi (2003) warns that many organizations fail because they see lean practices as something to be incorporated into current working practices to quickly "fix" the organization. As Boyer and Sovilla (2003) note, viewing lean as just a set of tools and techniques does not agree with the philosophy of lean.

The literature has illustrated the variety of lean practices an organization may utilize. A formula for which practices to implement, however, does not exist. The practices an organization chooses to employ will depend on a variety of factors specific to the organization. The steps an organization may follow when implementing lean also vary considerably. The literature provides many differing viewpoints on the steps an organization may take when implementing lean.

2.1.5. Implementation

Just as it is difficult to precisely define lean, finding agreement on the steps needed to implement lean is equally difficult. Every lean implementation is unique; a formulaic approach to an implementation does not exist (Allen, 2000; Bamber & Dale, 2000). A successful lean implementation, however, does seem to require a methodical transformation with each phase of the implementation building on the previous phase (Allen; Boyer & Sovilla, 2003).

Of the literature selected for review, several authors have discussed the steps required for a lean implementation, with some of the authors offering very different perspectives. Womack and Jones (1996), for example, defined five generalized steps towards becoming lean with a focus on manufacturing. Alavi (2003), however, outlines more qualitative requirements for a lean success. Spear and Bowen (1999) contend that lean is not a formula, but is based on four rules. Lathin and Mitchell (2001) provide a socio-technical perspective on

the steps needed to successfully implement lean. All interpretations are worth exploring and comparing as all may be used to successfully implement lean.

2.1.5.1. Lean Implementation – Womack and Jones

Womack and Jones (1996) define five generalized steps for implementing lean. The first step involves defining value through the eyes of the customer. In the second step, the value stream, defined as the entire manufacturing process from the point of product order to the shipment of the product, is evaluated for waste. Identified waste is subsequently eliminated. During the third step, activities of the new value stream such as product definition, information management and physical transformation are evaluated for flow. All of the activities must flow to minimize waiting. In the fourth step, a product is designed and manufactured only when the customer requires it. Emiliani (2000) identifies this step as important in helping to eliminate waste. The fifth step is defined as a virtuous circle – pursuing perfection by completing the previous four steps continuously.

Of the literature selected for review, four of the authors also supported at least some of these steps or included these steps in their own descriptions of how to implement lean. Those papers aligned with a particular step are noted in Table 2.3 with a supporting quote.

Table 2.3. Summary of Literature Aligned with Womack and Jones

Steps to Lean	Allen (2000)	Hancock & Zayko (1998)	Jordan & Michel (1999)	Knuf (2000)
Step One- Define Value from Customer Perspective	"The role of the supplier is to satisfy the customer by delivering value."		"Focus on the customer continuously."	"Value is everything for which a customer is willing to pay."
Step Two – Identify & Eliminate Waste	"For lean manufacturing, eliminating waste must be a driving force."		"Reduce waste by using processes that reduce process time, human effort, defects, inventories, space requirements, and financial commitments."	
Step Three – Maximize Flow	"One process must not deliver to the next process in line until the process after that has pulled the product into its workspace."	"This is accomplished by introducing a pull system and, wherever possible, one-piece flows."	"Identify and optimize enterprise flow."	"The work itself is done in a well-studied, precisely formulated, and disciplined manner, so that variance in the quality of the product is reduced."
Step Four – Manufacture to Customer Need	"A lean organization only produces what the customer requires, at a rate which satisfies the customer."	"Lean production enables one to respond to orders much more quickly than under large lot production."	"The right thing at the right time in the right quantity."	"The lean enterprise seeks to satisfy customer needs in the shortest response time."
Step Five – Continuously Perfect the Process			"Challenge existing processes for continuous improvement."	"Nothing is ever done well enough-new opportunities always beckon just around the corner."

Allen (2000) notes that defining value from the customer perspective involves providing a product that meets the specifications of the customer in terms of form, fit, or function. It's

important the organization recognizes how the customer defines value (Allen). Knuf (2000) notes that providing value to the customer may result in complex consequences for the organization as it usually involves realigning machines, equipment, tools, human labor, leadership, planning, sales, purchasing, and supply chains. If an organization does not know how the customer defines value, but tries to provide it anyway, difficulties will usually surface, resulting in poor quality and wrong quantities (Allen).

Allen (2000) notes that every process has waste. Toyota identifies seven wastes: waste from producing defects, waste in transporting the product, waste from excessive inventory, waste from overproduction, waste of waiting time, waste in processing, and waste in motion (Nicholas, 1998). Emiliani (2001) contends that an organization must understand its business processes before waste can be eliminated, though for many organizations this may be difficult. Emiliani (2001) also notes that behavioral waste is another waste that should be considered. Knuf (2000) notes that arranging work areas to minimize transportation of the product during manufacturing, not only minimizes waste, it also maximizes flow.

Maximizing flow involves scheduling manufacturing so the rate of production equals the number of hours available for manufacturing divided by the number of products required by customers. Products should flow from work area to work area with minimal variation in the process at each work area (Allen, 2000). Maximizing flow also involves having reliable equipment, minimizing set-up times, and preventing defects (Hancock & Zayko, 1998). If equipment is not reliable, large volumes of finished products must be stored in order to meet customer requirements. Most organizations manufacture multiple products which require different set-ups on the manufacturing equipment. Lengthy set-up times justify the use of large lot sizes during the manufacturing process to make more efficient use of employee and equipment time. Minimizing set-up time is a necessary requirement for lean manufacturing in order to manufacture in the smaller batch sizes more likely to meet customer needs. Defects during set-up of the machines can lead to errors that delay manufacturing. Defects occurring during the manufacturing process require stopping the manufacturing process and

investigating the cause of the defects. Without reliable equipment, minimized set-up times, and processes in place to prevent defects, it will be difficult for organizations to achieve maximized flow.

Manufacturing to customer needs involves producing only what the customer requires when the customer requires it (Allen, 2000). Building more than the customer requires is a form of waste because of the need to store the product. Not only does the organization have to pay to store the product, a financial loss may be incurred if the product is not required before it decays or becomes obsolete. Organizations frequently struggle with the idea of having few finished products in inventory as other employees in the organization mistrust the manufacturing floor's ability to reliably provide the products needed (Hancock & Zayko, 1998). Often deliberate intervention by management is required to reduce inventories of finished products. Satisfying customer needs in the shortest time possible may suggest to many organizations the need to stockpile resources, but this adds cost, not value (Knuf, 2000).

Employees must continually strive to improve processes (Knuf, 2000). Womack and Jones (1996) assert that reducing labor, time, space, cost, and defects does not ever end. It is a continual process to create a product that is more closely aligned with what the customer actually desires. Excellence is more important than perfection (Boyer & Sovilla, 2003).

Allen (2000) agrees with four of Womack & Jones' steps, but suggests that an additional step be included in the implementation - the involvement and empowerment of people within the organization who add value. Knuf (2000) concurs, contending that employees in the organization should complete their work with a minimum of supervision and control. Holden (2003) also agrees, maintaining that staff must be empowered to take a view of the whole process, not just their own department. Jordan and Michel (1999) include all five of the Womack and Jones steps in their work describing lean implementations, but they also suggest four other steps. These four additional steps are: designing products for manufacturability and quality, promoting lean leadership at all levels, making decisions at the lowest possible level, and nurturing a learning environment.

2.1.5.2. Lean Implementation – Alavi

While the steps offered by Womack and Jones provide a practical, manufacturing oriented viewpoint of a lean implementation, it is also important to explore some of the steps offered by other researchers. A recent paper by Alavi (2003), for example, offers a slightly different perspective on lean. Alavi identified some of the sociocultural factors that may affect a lean implementation and lists five steps to follow to a successful lean implementation.

Alavi defines step one as securing commitment from senior management for the lean implementation. Step two is the selection of an internal employee to drive the implementation, as well as the formation of a self-directed team to help guide the implementation. Members of the team should include employees from various departments. Outside consultants may be used for educational purposes, but should not be relied on to maintain the momentum of the implementation. During step three, personnel are thoroughly educated in lean. For step four, Alavi recommends a quick, initial success to give the team confidence and to provide good publicity for the lean implementation. During step five, tracking and measuring of progress occurs. Alavi recommends results be published for all employees to see. Results should be presented so they are easy to grasp and understand. Examples could include before and after pictures or statistics on productivity gains, cost reductions, quality improvements, or on-time deliveries.

Of the literature selected for review, four papers emphasized or supported Alavi's first four steps. Those papers aligned with a particular step are identified by a supporting quotation in Table 2.4.

Table 2.4. Summary of Literature Aligned with Alavi

Steps to Lean	Bamber & Dale (2000)	Boyer & Sovilla (2003)	Hancock & Zayko (1998)	Parks (2002)
Step One – Commitment from Senior Management		"Gaining top commitment is key, because this is where the common future is cultivated and deployed."		"With lean thinking comes significant change in corporate culture, change that necessitates strong project leadership, visible support from top management, and patience."
Step Two – Drive Lean from within	"There was no fundamental mind-shift and commitment to lean production, and as soon as the Price Waterhouse consultants left, interest in the concept evaporated."			
Step Three – Educate Thoroughly	"The second biggest stumbling block to the adoption of lean practices was the lack of employee education."		"Lean production encompasses a number of concepts and associated details that must be studied and mastered in order to be implemented."	
Step Four – Have Quick Initial Success				"What you need is commitment and a successful short-term project that will make people true believers."

Boyer and Sovilla (2003) emphasize the importance of the commitment of senior management. They note that organizations are not often able to transform business and operating systems with changes driven from the bottom up. Parks (2002) contends that

motivating employees to change requires a strong leadership strategy and that senior management must require the change directly from the employees affected. Boyer and Sovilla further advise that management should provide information to all levels of management to prevent misunderstandings and fear from developing. Without proper understanding of the proposed change, managers may begin to act in terms of self-preservation, which may undermine the lean effort. It is also important that the implementation have a system-wide perspective to facilitate the change (Boyer & Sovilla, 2003).

The importance of driving lean from within is supported by a case study completed by Bamber and Dale (2000). The case study followed a lean implementation at an aerospace organization in the early 1990s. The organization hired three consultants from an outside firm to implement lean manufacturing. The consultants remained at the case study site for the implementation. The case study found, however, that the practices initiated and employed during the implementation halted when the outside consultants terminated their consulting roles.

Bamber and Dale's (2000) case study also supports the need for education. Bamber and Dale contend that the lack of employee education was a contributing factor to the failure of the implementation. In particular, the lean classes offered in this organization were not available to the employees working on the manufacturing floor. The lack of education offered little opportunity for employees on the manufacturing floor to commit to the lean program. Bamber and Dale also argue that the classes themselves were inadequate as they did not teach the underlying tenets of lean manufacturing. This resulted in many poor decisions by the managers. One example cited a logistics manager who paid overtime to his staff to ensure all raw manufacturing materials were obtained for production with no regard as to the date they were needed. This is a contradiction to the concept of buying materials as they are needed to maintain low inventories.

Hancock and Zayko (1998) also supported the need for education, noting that though lean is a complex topic, it is not taught in many engineering and business schools. Educating employees in lean should be done through in-house courses rather than conferences or professional meetings (Hancock & Zayko, 1998). In-house courses offer the advantage of allowing enough time to teach in detail and it allows students to learn from examples within their own organizations. Education should not be limited to management or production, but should include union leaders and employees from engineering, finance, human resources, maintenance and process engineering (Hancock & Zayko, 1998). Emiliani (2001) considers the lack of education a major cause of lean failures and notes that in college or graduate schools, it is often treated as a peripheral topic. Emiliani (2001) also notes that colleges fail to teach students to look at the root cause of problems. Parks (2002) agrees education is important, but cautions against attempting to train everyone before an implementation. Parks also notes that most adults will only retain training pertinent to their current job, so it is advised that training should be limited to current tasks to maximize learning.

Parks (2002) supports the need for initial success by noting that projects often die due to the lack of results. Jarrett (2003) advises any program implementing change should initiate small changes quickly to test potential boundaries and lower the risk associated with the change. A quick success will also provide an example for employees in other areas of the organization and will generate excitement about the transformation efforts (Kotter, 1995; Parks).

While Alavi advises tracking and measuring the success of the lean implementation, Boyer and Sovilla (2003) caution against using traditional measures to evaluate the status of a lean implementation. Too often, the use of traditional measures may encourage inappropriate decisions. Barker (1994) agrees, noting that financial measurements do not help justify the transition of the organization to lean. Emiliani (2001) contends that bad performance measurements driving incorrect behaviors are a key component to lean failures. Knuf (2000) recommends using benchmarking as a tool to compare performance of an area with other

areas on a yearly basis and then using the best performance as a standard for the next year. Knuf contends benchmarking will not only encourage improvement, but also offers a vital strategic tool that is necessary for radical organizational transformation.

2.1.5.3. Lean Implementation – Spear and Bowen

Though many of the authors provide some very specific steps to lean, very few manufacturers have been able to successfully duplicate Toyota's efforts (Spear & Bowen, 1999). Spear and Bowen dissected the Toyota System in an attempt to understand how it worked. They formulated four rules based on their observations. Rule one says that all work must be defined as to content, sequence, timing, and outcome. This step is consistent with Womack and Jones (1996), but it is more specific as to the mechanics of maximizing flow. In rule two, all customer-supplier connections, both internal and external, must be direct, with no question as to who to contact. Rule two ensures problems are solved directly. Problems do not follow a convoluted path from employee to supervisor to manager and then back down again. Employees with a difficulty know who to contact immediately. Rule three states that the path for every product and service must be defined and direct. Rule three provides a different perspective from traditional manufacturing. In the Toyota Production System, work doesn't just flow to the next available machine or employee, it flows to a specific machine or employee. Rule three also applies to services, such as requests for help. This seems counterintuitive for traditional manufacturing organizations, but it allows the organization to see that every person in the organization is connected to the manufacturing system in some way. Any person that is not connected to the manufacturing system would be considered unnecessary and a target for waste elimination.

Rule four directs that all changes or improvements must be made using the scientific method, guided by a teacher at the lowest possible level within the organization. Spear and

Bowen identify this learning environment at Toyota as a particularly important factor in Toyota's success. All mangers, from the first line supervisors to senior executives are expected to be able to perform the tasks of all employees they supervise as well as teach them how to solve problems using the scientific method. Teaching and learning at Toyota is an active process; employees discover the rules as a consequence of problem solving. The supervisor teaching the rules to the employee will ask the employee questions during the work process, enabling the employee to develop deep insight into the process. Spear and Bowen contend that only those organizations using this teaching method have been successful in transferring the Toyota Production system to their own organizations.

2.1.5.4. Lean Implementation – Lathin and Mitchell

While the other authors offered detailed steps pertaining to production or offered advice involving sociocultural factors, Lathin and Mitchell (2001) offer a slightly different perspective. Lathin and Mitchell recommend using the sociotechnical systems method when introducing lean to facilitate a faster and more complete implementation of lean. Lathin and Mitchell contend that many organizations make the mistake of attempting a lean implementation without observing the social issues. Lathin and Mitchell recommend completing a value stream map to identify waste within the processes of the organization. This is consistent with Womack and Jones (1996), but the value stream map is used to design a preliminary technical system. In the second step suggested by Lathin and Mitchell, the preliminary technical system is tested against a social system. The testing phase may utilize instruments such as questionnaires, surveys, interviews or focus groups. In the third step, the information from the testing phase is used to design a final system. The final step involves creating the implementation plan for changes to both the social and the technical systems.

2.1.5.5. Lean Implementation– Conclusion

The literature contains many recommendations for the implementation of lean, from specific tools and practices for the manufacturing process, to more generalized tenets for introducing lean to the entire organization. Such a wide variety of ideas on implementation provide further support to the idea that a lean implementation cannot be transferred from one organization to another in exactly the same way. Each implementation depends on a wide variety of organizational and sociocultural factors, fostering a unique implementation in each organization.

Just as the steps to lean vary, so do the challenges facing each organization when attempting to implement lean. It is important to explore some of the challenges facing lean manufacturing to provide awareness of some of the errors that may fatally impact a lean implementation.

2.1.6. Challenges

Many challenges to lean manufacturing exist. Jordan and Michel (1999) recommend organizations consider the costs involved before undertaking any change. Costs such as time, development of the lean implementation, operations expenses, education and training, product acceptance risks, customer alienation risks, and supplier risks should be evaluated to determine if the potential gains justify the expense. For some organizations, the costs may outweigh the benefits. Studying the limits of lean as well as the challenges facing an organization may also help an organization decide if lean would is even appropriate.

2.1.6.1. Limits to Lean

Some of the literature provides a sobering counterpoint to the enthusiasm exhibited by many about lean manufacturing. Katayama (1996) argues that the research conducted by Womack, Jones, and Roos was conducted during an economic bubble and is questionable as a result. Katayama contends that the economic bubble pressured organizations to expand market share through price competition, resulting in reduced profits and further pressure on organizations to reduce costs by using lean. It also required an increase in sales volume which organizations pursued by offering more diversified products. This required more indirect labor that increased the point at which a profit was made. It was possible for Japan to maintain this kind of pace during the bubble, but with the economic decline, revenue through larger sales volumes could not be sustained.

The diversified product offerings also became a liability in terms of customer satisfaction. Customers became annoyed because of the frequency of the release of new products. New purchases became obsolete as soon as the customer left the store. It also caused manufacturing problems. The large variety required small batches and constant changes to machine settings (Cusumano, 1994). As a result, many Japanese organizations have focused on reducing product variety to the 20 percent of the models that generate 80 percent of the profits (Cusumano). The increased number of products is also causing problems in terms of waste. In Japan, government regulations and fees encourage the public to replace vehicles every four to five years, which creates steady demand, but also creates a disposal problem for all of the old vehicles (Cusumano).

Katayama (1996) also argues that the Japanese automobile industry may not be as competitive as many believe. When Womack, Jones and Roos conducted their study, Japanese autoworkers worked 2,200 hours a year versus a more typical European or American work year of 1,800 hours. Using a standard 40 hour work week as a comparison

basis, each Japanese autoworker works ten more weeks per year than their counterparts in the United States or Europe. Such an edge in terms of labor could skew measurements of competitiveness.

Japan is also facing another problem caused by the move to lean manufacturing. A key component of lean is the idea of maintaining a small inventory and only bringing materials into the factory as the materials are needed on the manufacturing floor. Toyota, for example, reduced average inventories to those materials needed on the manufacturing floor in just a few hours (Cusumano, 1994). This pressure for smaller and subsequently more frequent deliveries has increased traffic in urban areas and has increased automobile pollution (Katayama, 1996; Cusumano). In the 1990s, the Japanese government began an advertising campaign to encourage less frequent deliveries of parts (Cusumano)

Many proponents have hailed lean as the manufacturing paradigm that will help save any organization struggling to remain competitive in the changing world economy. Some limits to lean do exist, however, and some thought must be given as to how the problems associated with lean can be addressed.

2.1.6.2. Contributing Factors to Lean Failures

A discussion of the limits of lean should also include a study of the factors that may contribute to the failure of a lean implementation. The literature provides some examples. Bamber and Dale (2000) attribute the lean failure at an aerospace organization to one major factor - the threat of layoffs or job loss. The organization saw a reduction of over 900 jobs after the implementation. Much of the job loss stemmed from a poor economy, but Bamber and Dale contend the failure of the lean implementation stemmed from this threat of layoff. Moore (2001a) points out that lean doesn't mean fewer employees, but that fewer employees is a result of applying lean – laying off employees will not necessarily make the organization

lean. A survey by the American Management Association of several hundred organizations that actively reduced work forces over a five year period supports this assertion (Wysocki, 1995). The reduction in the work force resulted in only 50% of the organizations showing a productivity improvement and 33% showing a profit improvement. Employee morale, however, declined in 88% of the organizations. Another study conducted by The Conference Board in 1996 found that share price increased six months after a layoff, but after three years, share prices had declined relative to market indices (Moore, 2001a).

Though lean may increase efficiency and organizations may find areas of the manufacturing process require less people, organizations do not always reduce their workforce. Womack and Jones (1996) discuss the case of Lantech, an organization based in Kentucky that manufactured devices to stretch-wrap pallets with plastic film. When Lantech undertook their lean initiative, the management team promised employees that no jobs would be lost. Instead, the organization assigned the extra employees to a company-wide team that employed lean to plan the improvement of other areas within the organization. After every improvement, the organization assigned the best employees from the newly re-organized area to the team to make it clear that the new assignment was a promotion. Employees remained on the team until growth or new projects required them in other areas. Such an approach not only cements the commitment of the employees to the lean initiative and fosters creativity and employee empowerment, it avoids some of the sabotage, both intentional and unintentional, that employees may use if they feel their jobs are threatened.

The implementation of lean may just be a matter of simple mechanics, but a crucial aspect of the implementation is the need to convince management and employees to think in ways that are foreign (Ahls, 2001). This is a problem that must be addressed. All organizations employing the Toyota Production System consider people the most valuable asset of the organization (Spear & Bowen, 1999). Without the support of the employees, successfully fostering the lean implementation will be difficult. A common problem stems from the degree to which the mass production methods of manufacturers in the western economies

are so ingrained in the minds of employees (Emiliani, 2001; Lathin & Mitchell, 2001). It's very difficult for employees to grasp some of the concepts of lean such as the need to sit idly while waiting for new work and the reduction in inventory (Ahls).

Changing this mindset just because management orders it may prove difficult. Some of the employees may choose not to support the lean implementation for various reasons including the belief that it is just the latest fad, they don't agree that any changes are necessary, or they are going to retire (Hancock & Zayko, 1998). Hancock and Zayko recommend defining a specified time period for each employee to meet a necessary performance level. Anyone not meeting the performance level should be reassigned.

Lathin and Mitchell (2001) also note that some of the major roadblocks to lean include the employees' need for independence and the need to feel like an individual within the corporate structure. Parks (2002) concurs, noting that it's hard to sell the concept of standardized work methods to employees who are also being told their corporate culture values employee empowerment and involvement. The standardized work methods may seem like a restriction or a contradiction to employee freedom. These roadblocks are reinforced by the lack of alignment within the corporate structure. For example, the corporation may be implementing lean, which requires teamwork, but still rewarding individual performance or encouraging competitiveness between areas on the manufacturing floor (Lathin & Mitchell, 2001).

Another difficulty encountered in a lean implementation is the transition to dedicated work cells which focus only on one product stream. Organizations implementing dedicated work cells may assign professional employees from functions such as engineering, purchasing, and accounting to work with manufacturing personnel. Lathin and Mitchell (2001) noted that a lean implementation may be problematic in an organization where the autonomy of functional departments was valued. Problems will occur when the organization tries to re-organize across the functional barriers. Womack and Jones (1994) discussed the conflict that dedicated work cells may cause as professional employees find their career path diverted

from their functional area to focus on a particular product line. Womack and Jones (1994) advise organizations to create a career path that offers alternating sequences of employment. A period of time should be spent on a cross-functional team dedicated to a specific value stream. Another period of time should be spent in a functional department, building new knowledge to allow the employee to continue to grow intellectually. Womack and Jones (1994) contend that such an arrangement will help synchronize the needs of the individual with the needs of the organization.

Some failures of lean stem from how lean is implemented within the organization. Stamm (2004) notes that many organizations make changes that are comfortable without really trying to address the fundamentals of lean itself. Organizations may implement programs to deploy lean, but don't implement the changes needed to sustain the programs (Stamm). Womack and Jones (1994) agree, noting that many managers are able to understand the individual practices of lean, but have difficulties combining the practices into a system. Even when managers were able to implement practices, they had a difficult time introducing them to mature organizations (Womack & Jones, 1994).

The reality of the manufacturing process itself may also hinder an organization's ability to implement lean. Machines and equipment at many organizations are sized to manufacture products in batches to meet sale forecasts (Emiliani, 2001). Western manufacturers also tend to fix problems with expensive technology, resulting in high fixed costs (Emiliani, 2001). The high cost of the equipment makes it difficult for managers and employees to allow the equipment to sit idly, encouraging overproduction and subsequent stockpiling of finished products (Ahls, 2001; Lathin & Mitchell, 2001). Lathin and Mitchell note that it also difficult to implement lean when organizations do not have timely information for production and inventory management, a common problem for many organizations. Without this information, it is difficult to manage the manufacturing process.

Perhaps one of the most difficult challenges facing organizations implementing lean is the management of the external relationships with customer and suppliers. Panizzolo (1998)

found in a survey of 27 organizations that the most critical factor necessary to fully implement lean was the management of external relationships. Womack and Jones (1994) documented an organization in Great Britain that saw its efforts to implement lean halt after several years because key customers failed to adopt lean. Those customers that failed to adopt lean continued to place orders unpredictably, causing the factory to retain high inventories of finished goods to meet demand.

Some of the difficulties in managing relationships with suppliers may be blamed on the belief by many organizations that larger quantities equate to supplier discounts and lower prices (Emiliani, 2001). In order to attain the lower prices, organizations in Japan work with suppliers to minimize the set-up times of the suppliers (Emiliani, 2001). Bamber and Dale (2000) noted that at their case study site, the lack of internal expertise in lean meant the organization was not able to provide any expert consultation to their suppliers. Bamber and Dale contend that an organization can only become as lean as its suppliers. The lack of management of the supplier relationship at the aerospace case study site limited the supplier activities and efforts to maintain lean practices with the suppliers. Womack and Jones (1994) also noted the difficulty Chrysler was having in managing its supplier relationships. While successfully minimizing their supplier base, Chrysler still paid too much for parts because they were not able to persuade their suppliers to adopt lean manufacturing.

2.1.7. Conclusion

Lean manufacturing is a complex topic that has many facets to it. Though lean manufacturing is a relatively new paradigm in the western economy, it has already spawned many unique perspectives. Exploring the influences that created lean, as well as the many definitions, limits, and challenges documented in the literature provides a solid foundation that can be used to guide this research study of the role of organizational culture, organizational

structure, and management support in a lean implementation and the impact of a lean implementation on communication and employee problem resolution skills.

2.2. ORGANIZATIONAL CULTURE

Organizational culture is a growing field of study. Though an organizational culture will develop in an organization of any size, it is usually associated with larger organizations. Development of multi-national organizations did not occur until after the railroad and telegraph were developed (Ouchi & Wilkins, 1985). Ouchi and Wilkins contend that though large corporations are new entities, they are really just an extension of large and complex social structures. Many fields such as anthropology, sociology, and psychology have studied organizational culture, including, most recently, behavioral scientists from management schools (Ouchi & Wilkins).

The literature provides a definition for culture as well as background on how culture develops within an organization. The literature also offers many differing perspectives on defining the types of culture. It is important to understand the definition of culture, the types of culture, and to explore which types of culture are ideal for a particular organization. Want (2003) notes that many organizations mistakenly believe their organizational culture is invisible to the customer, but organizations with cultures characterized by indifferent employees will drive customers away. Understanding which types of culture are ideal also provides information on which cultures are most likely to foster a successful lean implementation. Recognizing the cultural characteristics most conducive to a lean implementation will aid executive management in deciding if implementing lean will be beneficial for their organization.

2.2.1. Definition and Development

Culture has many definitions (Schein, 1992). Many of the definitions, however, emphasize the same aspect of culture - certain objects within a group are shared or common to the group (Schein, 1992). Some of the more common categories of objects includes behavior used when interacting, language, customs, traditions, rituals, group norms, publicly announced values, formal philosophy, and implicit rules for interacting within the organization (Schein, 1992). The existence of a culture implies that all of these objects bind together to form a coherent entity that implies a group has some structural stability (Schein, 1992). Large organizations may contain subcultures, but there will often be common assumptions shared throughout the organization, particularly during times of crisis or when a common enemy causes unity within the organization. For this research, culture is defined as a group's shared basic assumptions which in turn determine how the group perceives and solves problems (Schein, 1992).

Culture develops when leaders impose their own values and assumptions on an organization (Schein, 1992). A study by Sarros, Gray, and Densten (2002) supports this contention, noting that leadership impacted the culture more than the culture impacted the leaders. Chang and Wiebe (1995) also agree, noting that the value system of an organization is molded by the business environment and the beliefs of the organization's founders and executive management team. The value system provides guidance for competing externally and managing operations internally. What gives rise to different organizational cultures is not a different sets of values but the same set of values prevalent within the larger society with different emphases on specific values (Chang & Wiebe, 1995).

2.2.2. Types of Culture

The literature contains many perspectives on the types of culture that exist in organizations today. The literature reviewed does not represent all of the viewpoints on the types of culture, but were selected to illustrate the variety of perspectives. Though the defined types of culture presented here differ considerably in perspective, some underlying similarities do exist.

Want (2003) defines seven types of culture - predatory, frozen, chaotic, political, bureaucratic, service, and new age. A predatory culture has a short term focus and is not able to anticipate the consequences of its actions. The predatory organization does not pay attention to the needs of its stakeholders and responds only when a crisis requires it to. Frozen cultures are characterized by their aversion to risk-taking, innovation, and long-term planning. Strict adherence to the chain of command is required. Chaotic cultures are unfocused; they rarely have a sustainable strategy and more energy is spent on internal politics than on external customers. Political structures are characterized by internal competition for influence, resources, position, and career advancement. Rules and implicit limits do exist to referee the political maneuvering, but resources are again focused more on internal in-fighting than on external customers. Emiliani (2000) notes that corporate politics is one of the most potent forms of behavioral waste because the employees are forced to spend time to ensure their own survival instead of focusing on the customer. Bureaucratic cultures value the needs of the organization before the needs of the customer. Bureaucratic cultures are characterized by their adherence to rules, policies, and regulations and rigidity. Service cultures place a priority on filling customer needs to be able to serve the organization's needs. All strategies, systems, and policies are created around the customer, and employees are empowered to solve problems for the customer. New age cultures are characterized by their combination of innovation with an attention to the needs of their customers and employees.

Employees are encouraged to give feedback and decisions are reached through consensus. Want identifies service and new age cultures as high performing cultures.

Schein (1996) has a slightly different perspective on the types of culture that exist. Schein contends that three types of culture exist within each organization- operator, engineering and management. The operator culture is based on human interaction. The employees on the manufacturing floor find they need to work together to complete their goal. The engineering culture and the management culture both have roots outside of the organization, in the general functional culture of their profession. Both the executive and engineering cultures see people as resources that only generate problems. They view people as a means to achieve efficiency and productivity, not as a resource that can be used to help achieve these goals.

Chatman and Cha (2003) define an ideal culture as "strong." A strong culture is one that has high levels of agreement among its members about what's valued and high levels of intensity about the values. By providing less formal direction on executing strategy, a strong culture forces more ownership on the part of employees, resulting in increased employee performance. It is also important that the employees are free to deliver on the organization's objectives and the culture is aligned with the organization's strategy (Chatman & Cha, 2003). Want (2003) agrees, noting that culture should support the organizational strategy. Firms with strong, strategically appropriate cultures must also have cultures that accept innovation and change to remain effective (Chatman & Cha, 2003).

Nordstrom is an example of an organization with a strong culture where customer service is highly valued. Employees of Nordstrom work to satisfy the customer at all costs, even if it requires directing the customer to a competitor. Employees censor each other when lapses in customer service occur. Strong cultures will increase organizational performance by shaping and coordinating employee behavior (Chatman & Cha, 2003). The norms accepted by a group have more influence over employee behavior than monetary rewards or the physical work environment (Chatman & Cha, 2003). Another example of a culture fitting the

description of a strong culture may be found at Toyota. As Spear and Bowen (1999) discovered in their research, the Toyota Production System relies on a shared sense within the organization of what the ideal system would be. None of the rules are written down. The Toyota System thrives by remaining flexible, adaptable, and requiring employees to participate in the learning process while continually improving every aspect of the organization.

When an organization experiences inconsistencies between intensity and agreement, then less than desired cultures result. Those cultures exhibiting high levels of intensity and low levels of agreement have difficulty agreeing on priorities, increasing tension and competition between departments and employees. Those cultures exhibiting high levels of agreement but low levels of intensity are characterized by employees that agree on what is important, but are not willing to put forth any extra effort to attain the goals of the organization.

Chang and Wiebe (1995) define four types of culture - group, developmental, hierarchical, and rational. Chang and Wiebe define the different cultures using a quadrant framework. They contend, however, that all organizations have different characteristics from all four cultures. When one quadrant becomes overemphasized, then the organization may become dysfunctional. Chang and Wiebe found that the characteristics from the group and developmental cultures were ideal for organizations trying to implement Total Quality Management (TQM) programs.

The characteristics of a group culture emphasize openness, participation, discussion, and concerns about other members. The organization is committed to its employees and strives to keep employee morale high. Flexibility and individual differences are emphasized, with decision making accomplished by the employees performing the work. Developmental culture focuses on resource acquisition and growing the organization through insight, innovation, and adaptation. Expansion and transformation are valued in the developmental culture. Emphasis is on innovation and flexibility of the structure. The organization focuses on "achieving legitimacy" with external stakeholders. Employees are encouraged to be entrepreneurs and risk takers. Hierarchical cultures are based on consolidating and achieving

equilibrium. This culture is commonly associated with bureaucracies. The organization values stability, control, and continuity and strives to achieve these goals by measuring, documenting, and managing information. The maintenance of the internal system is important. Employees are given well-defined roles and expected to follow the rules and procedures of the organization. The rational culture values maximizing output. The organization is decisive about what needs to be completed. The organization values accomplishments, productivity, and making a profit. The rational culture is competitive and values what it can achieve in the market.

Though the four definitions of the types of culture vary, some similarities do exist. Five of the desirable types of culture share several characteristics. These similarities are summarized in Table 2.5.

Table 2.5. Summarization of Characteristics Shared by Different Types of Cultures

Characteristic	Service Culture (Want, 2003)	New Age Culture (Want, 2003)	Strong Culture (Chatman & Cha, 2003)	Group Culture (Chang & Wiebe, 1995)	Developmental Culture (Chang & Wiebe, 1995)
Focus on customer needs	X	X	X		X
Employees empowered to solve problems	X		X	X	
Innovation is prized in employees		X	X		X
Participative atmosphere (employees encouraged to give feedback)		X		X	
Organization is concerned about employees		X		X	

The shared characteristics of the "ideal culture" illustrate the importance of these particular characteristics. The lean literature also contains several viewpoints on the ideal characteristics in a culture implementing lean. Many of the characteristics of an ideal culture for lean are similar to the characteristics of the ideal types of culture defined above.

2.2.3. Ideal Culture for Lean

Many of the characteristics of an ideal culture identified by Want (2003), Chatman and Cha (2003) and Chang and Wiebe (1995) are also mentioned in the lean literature when defining lean or discussing the steps necessary to implement lean. Table 2.6 provides support for the role of these characteristics in implementing lean.

Table 2.6. Ideal Cultural Characteristics for Lean

Characteristic	Jordan & Michel (1999)	Womack & Jones (1990, 1996); Allen (2000); Knuf (2000); Storch & Lim (1999)	Spear & Bowen (1999)
Focus on Customer Needs	"Focus on the customer continuously."	Define value from the customer perspective	"..the output of an ideal person, group of people, or machine can be supplied on demand in the version requested."
Employees Empowered to Solve Problems	Make decisions at the lowest level possible.	"..employees need encouragement to think actively, indeed proactively, so they can devise solutions before problems become serious."	
Innovation is Prized in Employees	"An innovation culture is one that encourages and supports continually striving to use new knowledge (or old knowledge) in new ways...".		
Participative Atmosphere (Employees Encouraged to Give Feedback)			"...[the] system actually stimulates workers and managers to engage in the kind of experimentation that is widely recognized as the cornerstone of a learning organization."
Organization is Concerned about Employees			"...the output...can be produced in a work environment that is safe physically, emotionally, and professionally for every employee."

Though much of the lean literature discusses desirable cultural characteristics when defining lean, some of the literature also directly discusses the role of culture in a lean implementation. Organizations may find that implementing lean often requires a company-wide cultural transformation to adapt to the new business strategy (Alavi, 2003; Parks, 2002).

Stamm (2004) agrees, noting that lean is not compatible with a traditional environment. Filson and Lewis (2000) interviewed several individuals at different organizations before attempting to implement a new lean practice. Many of the individuals interviewed said changing the organizational culture was the biggest hurdle they faced when introducing a new procedure or project. The cultural characteristics of an organization play a vital role in implementing changes of any kind (Filson & Lewis, 2000).

Other researchers provide more specific advice on the ideal type of culture for lean. Boyer and Sovilla (2003) note that lean requires an organization's culture to be proactive, not reactive. Often, in a reactive culture, employees will act as personal heroes to solve difficult problems. Such behaviors do not foster the teamwork necessary for a lean implementation to flourish. The organization must align rewards with the desired behavior by not providing praise when employees act as heroes (Boyer & Sovilla, 2003). It is also important that departments not be allowed to blame each other for difficulties (Alavi, 2003; Boyer & Sovilla, 2003). Shifting of blame prevents the organization from focusing on finding solutions.

Latin and Mitchell (2001) contend that lean is more likely to yield favorable results when the existing social system is capable of supporting and sustaining the new system. As an example, Lathin and Mitchell note that organizations with a history of collaborative problem solving and teamwork are already well poised to accept the lean concepts of dedicated work cells. Alavi (2003) contends that those organizations with a favorable environment for change are the most successful when implementing lean.

Just as it is important to investigate the cultural characteristics that enhance the probability of a lean implementation success, it is also necessary to explore some of the characteristics in a culture that may contribute to the failure of an attempt to introduce a new procedure or project to the organization, including lean. Such an investigation provides valid information that can be used to avoid potential failures.

2.2.4. Failures Attributed to Culture

Parks (2002) contends that each lean failure can be attributed to either the corporate culture or the manner in which the change to lean was managed. Schein (1996) contends that when the three cultures (operator, engineering, and management) within an organization lack alignment, it contributes to the inability of the organization to implement new programs. For example, in some organizations, the status between professional employees (such as engineers and management) and manufacturing personnel may cause difficulties. Too often, the three cultures work against each other. When implementing cross-functional teams, a common lean practice employed to focus on specific value streams, the members of the different cultures have a difficult time communicating, reaching consensus, and implementing changes (Schein, 1996). Lathin and Mitchell (2001) agree, noting that sometimes roadblocks to lean occur because technical specialists feel superior to the employees on the manufacturing floor and fail to cooperate with them.

A case study involving two organizations attempting to implement cellular manufacturing (a practice often associated with lean) identified seven cultural factors that negatively impacted the implementation (Yauch & Steudel, 2002). The seven factors were identified as underorganization, avoidance, lack of mutual respect and trust between employees and management, crisis urgency, complacency, rigid group boundaries, and overemphasis on core activities. Underorganization was defined as the lack of a structured system, policies, or procedures. Avoidance occurred when employees shifted responsibility to others to avoid being blamed for potential difficulties. Crisis urgency was defined as working at a leisurely pace until a crisis occurred. Complacency was characterized as an organization that was content with current working conditions and policies and accepted long standing problems. Rigid group boundaries were defined as boundaries that occurred between functional or departmental groups. Rigid boundaries made it difficult for employees from differing groups to communicate and work together effectively. Overemphasis on core activities was defined as

using employee time on routine activities instead of focusing on improving processes or systems. Yauch and Steudel (2002) also identified external customer focus as a cultural factor that positively impacted the implementation. A focus on customer needs has been identified in other papers as a characteristic present in ideal cultures (Chang & Wiebe, 1995; Chatman & Cha, 2003; Want, 2003).

Another study of an organization attempting to implement concurrent engineering (another concept associated with lean) identified six cultural characteristics that negatively impacted the implementation (Filson & Lewis, 2000). Filson and Lewis (2000) identified the six characteristics as lack of functional cooperation, conflicting goals between production and supporting departments, concentration on quickly supplying customers with new, low volume products, the tendency for departments to blame each other, lack of commitment to the new procedures by senior management, and lack of support from the engineering management team. The lack of functional cooperation, and the tendency for departments to blame each other agree with characteristics identified by Yauch and Steudel (2002). Both case studies, though implementing only facets of lean, provide pertinent insight into some of the real problems facing organizations. These insights can be extended to an organization attempting to fully implement lean, providing valuable information on the potential problems facing organizations with less than ideal cultures.

2.2.5. Conclusion

Organizational culture is a complex topic impacting many aspects of every organization. Though the literature provides many definitions on the types of culture, some of the characteristics of an ideal culture are similar across these definitions. These characteristics are also similar to the traits of an environment suited for a successful lean implementation. s identified by three of the four authors share many common characteristics. Project failures, which have been attributed to organizational culture, are important to study as they provide

crucial information on the challenges facing organizations when implementing lean. Though culture is often overlooked in favor of management fads or quick fix strategies, it is a critical element of every organization's success (Want, 2003).

2.3. ORGANIZATIONAL STRUCTURE

Organizational structure can be defined in many ways. One definition focuses on the structure defined by organizational charts and the number of management levels within the organization (Senge, Kleiner, Roberts, Smith, & Ross, 1994). A second view of organizational structure is based on the flow of work throughout the organization (Senge, Kleiner, Roberts, Smith; & Ross). For this research, organizational structure was defined as the number of management levels within the organization.

The structure of an organization can vary immensely. Very large corporations, for example, may have as many as twelve to eighteen levels of management between the board of directors and the employees manufacturing the product (Jaques, 1965). The impact of a large number of management levels is predictable. Communication becomes distorted and employees utilize tactics to work around obstacles created by the large number of management levels (Jaques, 1965).

A case study of 128 savings and loan associations studied the relationship between efficiency and organizational structure (Armandi & Mills, 1982). The study defined efficiency as organizational efficiency and managerial efficiency. Both types of efficiencies were measured using a variety of quantitative measures. The study found that efficiency increased when stratification (differences in income and prestige between levels of the organizational hierarchy) increased (Armandi & Mills). The authors proposed that when employees were given the opportunity to move to different positions within the organization, employee productivity would improve to increase opportunities for promotion (Armandi & Mills).

The study also found that the more formalized the organization is in terms of definition of roles, the less efficient it is (Armandi & Mills, 1982). The formalization of the organizational roles may have decreased personal interest, discouraging efficiency (Armandi & Mills). Efficiency also decreased as the complexity of the organization in terms of the number of job titles, number of departments and number of branch offices increased (Armandi & Mills). No correlation between an increase in the centralization of decision making and efficiency, however, was found by the authors.

Some of the findings of the savings and loan study offer important insights into the role of organizational structure in a lean implementation. The savings and loan study would suggest that an organization with less complexity, fewer formally defined roles, and a decentralized decision making structure would be more efficient. An organization with these characteristics may also find it easier to implement lean because the organizational structure is conducive to increasing efficiency. The existing lean manufacturing literature does provide some support for two of the findings of the savings and loan study. Table 2.7 provides a summary of the literature with findings similar to those in the Armandi and Mills (1984) study.

Table 2.7. Lean Literature Aligned with Findings of Organizational Structure Study

Author	Study: More Complexity Leads to Decreased Efficiency.	Study: Centralization of Decision Making does not Lead to Increased Efficiency.
Alavi (2003)	"Lean organizations tend to be much more flat in terms of organizational structure"	
Bamber & Dale (2000)		"Rigid hierarchies are replaced with more flexible hierarchies that are solution focused."
Barker (1994)	"Removing complex systems means removing people."	

In those organizations that have successfully implemented lean, the organizational structure may evolve continuously. Spear and Bowen (1999) contend that organizations

adopting the Toyota Production System will experience shifts in the organizational structure as the organization adapts to various problems. At Toyota, the organizational structure may not be the same from one work area to another, even within the same manufacturing site (Spear & Bowen, 1999). At one Toyota plant, for example, the production employees in one machine division reported to shop heads while the process engineers reported to the head of the division. In another machine division at the same manufacturing site, the process engineers were assimilated into cells with the production employees and all employees reported to the shop heads (Spear & Bowen, 1999).

Organizational structure has not been well-studied within the context of a lean implementation, but organizational research has shown that efficiency and organizational structure are correlated. The impact of lean on the organizational structure has been discussed in the literature, but no documentation of the impact of organizational structure on the lean implementation has been found. This research will address this area by studying the impact of organizational structure on a lean implementation.

2.4. MANAGEMENT SUPPORT

For this research, management support was defined as the participation of the executive management team in leading or supporting the lean implementation. The executive management team is a crucial aspect of any business. Not only is the executive management team responsible for financial performance, but it must also carefully guide the organization towards a profitable future. Many times, the mechanism for remaining profitable includes crafting change efforts within the organization.

It is widely recognized that any change initiative program requires the commitment of the top executive team (Kotter, 1995; McNamara, 1983). It is true that not every executive manager will support the new program, but in order for the change initiative to be successful, the group of executives that do support it must form a powerful coalition (Kotter, 1995). While

a change initiative may start out small and grow to involve more managers and non-management employees, a successful change initiative must retain the support of a core group of senior managers (Kotter, 1995). In a lean implementation, it is vital that the effort to transform the organization to a lean enterprise be driven by the executive management team (Boyer & Sovilla, 2003). It is rare that an organization would be successful in its transformation efforts if the lean initiative is driven from the factory floor (Boyer & Sovilla, 2003).

Anecdotal evidence from the lean literature supports the importance of management in a successful lean implementation (Alavi, 2003; Boyer & Sovilla, 2003; Moore, 2001a; Parks, 2003, Stamm, 2004, Womack & Jones, 1996). The executive management team must not just give tacit approval to the implementation - they must be visibly committed to it (Alavi, 2003, Bamber & Dale, 2000; Boyer & Sovilla, 2003; Emiliani, 2001). The executive management team must communicate its support by participating in the lean events (Alavi, 2003; Boyer & Sovilla, 2003). Those organizations that fail in their efforts to implement lean may have an executive management team that does not understand lean (Emiliani, 2001).

Any kind of transformational effort is often difficult for employees to grasp. In a lean effort, employees often fall into one of three categories: those that adopt and advocate (3-5%), those that are open to the idea but require strong leadership to completely adopt the new concepts (90%) and those that will directly oppose the idea (3-5%) (Boyer & Sovilla, 2003). The executive management team must provide the necessary support by supplying the strategy for achieving lean, giving employees the necessary tools to achieve the goals, and creating an organization aligned with the new lean concepts (Boyer & Sovilla, 2003; Moore 2001a).

Sometimes, the executive management team needs to take on different roles in an implementation. One theory proposes that an organization needs three types of leaders (Womack & Jones, 1996). One leader would be the person committed to the business for the long term. Another leader would have enough power to destroy the internal barriers

constructed by departments or department heads not wishing to change to the new system. The third leader would be someone with an in-depth knowledge of lean.

Management support is a vital factor in any organization, but the role of the executive management team in leading a lean implementation is critical to its success. The executive management team must provide guidance and be actively involved in the implementation. Employees need to know that the executive management team is committed to lean so they also feel comfortable committing to the new program (Alavi, 2003; Bamber & Dale, 2000; Parks, 2003). Without an executive management team that truly understands lean and provides the necessary support for the implementation, success would be unlikely.

2.5. COMMUNICATION

Communication may be defined in a number of ways. A communication event is considered to be rich when it provides "substantial new understanding" (Barry & Crant, 2000: 651). Communication channels are ranked by their richness, with face-to-face communication considered the medium with the best potential for transmitting information (Barry & Crant, 2000). Telephone communication is considered the next richest medium, with personal written messages, formal written messages, and numeric reports following (Barry & Crant, 2000). For this research, communication was defined as a method, usually verbal or written, by which employees in the organization transferred work related information to other employees.

Communication is considered one of the principles of lean production (Spear & Bowen, 1999; Womack, Jones, & Roos, 1990). To be lean, it is vital that the organization have efficient communication within and between value streams (Storch & Lim, 1999). Communication is important as it not only facilitates the flow of work between areas, it also allows ideas for improvement to be exchanged between functions and work areas. Empirical evidence from studies of communication supports this supposition. The studies indicate that a

link between higher levels of communication and innovation in an organization does exist. One study of research and development groups found a higher level of performance in research and design project groups associated with a higher level of communication (Monge, Cozzens, & Contractor, 1992). One explanation given by the authors for the increase in innovation is that employees who are better informed about innovations and the implications of innovative ideas can more easily connect ideas.

Evidence from the literature suggests that lean will be a catalyst in improving communications within the organization. In a lean implementation, organizations develop effective internal and external communication channels to process the large flow of information necessary in a lean organization (Jenner, 1998). Forming cross functional teams is one method that facilitates communication by allowing employees to understand activities outside of their own work area. Cross functional teams also break down barriers that may exist between functions or work areas and places everyone on an equal basis, allowing communication and ideas to flow more easily (Alavi, 2003). One case study found that the process of pushing decision making to the lowest possible level as part of a lean implementation also improved communications between functions (Bamber & Dale, 2000).

Communication is widely acknowledged as a crucial part of a lean enterprise, but little empirical evidence exists that measures the impact of the lean implementation on communications within the organization. High levels of communication, however, have been associated with general organizational success (Barry & Crant, 2000). In the Toyota Production System, every customer-supplier path is direct, with no ambiguity when sending requests and receiving responses (Spear & Bowen, 1999). Most organizations do not have this type of communication system in place. To achieve lean will require the creation of broad and efficient communication pathways (Jenner, 1998).

2.6. PROBLEM RESOLUTION

For this research, problem resolution was defined as the ability of personnel to define a problem and seek root cause solutions to resolve the problem. Many organizations have recognized that in order to survive and remain profitable, it is vital that the human resources within the organization be used more effectively. An early case study at a electronics manufacturer found that involving employees in resolving a persistent problem with injuries on the job not only led to a decrease in the injuries, but also increased employee productivity, material usage efficiency, and attendance (Pasmore & Friendlander, 1982). This study found that given the responsibility, employees were able to act in the best interests of the organization and recommend effective courses of action for solving serious organizational problems. A later survey confirmed these findings. A comprehensive survey of managers from several high-performing European organizations found that involving employees and expanding their level of responsibility was considered a crucial factor for improvements in the performance of the organization (Panizzolo, 1998).

Employee problem resolution skills are widely acknowledged as an important aspect of lean manufacturing. Lean organizations typically have employees that are multi-skilled and able to recognize and research problems as well as formulate and implement solutions at little cost (Alavi, 2003, Emiliani, 2001). Employees are encouraged to look for potential problems as a tool for finding and eliminating waste (Bamber & Dale, 2000).

In the Toyota Production System, the employees are taught the scientific method, which consists of formulating a hypothesis and then testing it under the guidance of a teacher (Spear & Bowen, 1999). If an employee experiences a problem on the manufacturing floor, the employee is to call for help immediately. This allows the problem to be addressed at that time, while the root cause is visible. While this system would seem to discourage problem resolution skills, in reality the employees are also responsible for improving their own work. The Toyota Production System allows people to make effective changes using the scientific

method. Another advantage to this level of problem solving is the "nesting" that occurs. Resolving problems at the lowest possible level allows people to implement design changes without negatively or haphazardly affecting others parts of the organization (Spear & Bowen, 1999).

Some initial work has been undertaken to identify mechanisms to improve problem resolution skills. Typically, training operators in problem solving at a lean organization involves using job rotation and on-the-job training (Allwood & Lee, 2004). Job rotation in particular is advocated to provide the organization with flexibility. A simulated case study, however, found that job rotation did not improve overall problem solving skills or productivity (Allwood & Lee, 2004). The authors theorized that if distinct problems occur in specific work areas or work stations more often, it is more efficient for the employee to develop a specialization in solving the particular problem. If the problems are uniformly distributed then job rotation offers no advantage in problem solving as the employees will experience the same problems in each area (Allwood & Lee, 2004).

While the literature supports the importance of employee problem resolution skills in lean manufacturing, there is not wide agreement about how to increase those skills. This research is focused on investigating how a lean implementation impacts the development of employee problem resolution skills.

2.7. CONCLUSION

Lean manufacturing is an increasingly important area of study. Previous research of lean implementations in a variety of industrial sectors has led to many divergent views about lean manufacturing and lean implementations. It is important to understand the existing literature, including the differing viewpoints, in order to provide a sufficiently broad theoretical foundation for the research propositions that have been developed. While lean is widely acknowledged to benefit most organizations, many challenges to implementing lean have

been identified. Research that explores both the benefits and limitations of lean provides organizational leadership with the information that is needed to make informed decisions about lean implementations.

The variables included in the research propositions created for this research can vary widely in both scope and context. The foundational literature review has provided the basis for defining each of the key variables included in this study. In addition, this literature review has also been used to develop a common platform from which to present the results. Finally, both empirical and anecdotal findings from previous relevant research streams has been used to provide a contextual background to enable a more in-depth understanding of the appropriate methodologies for evaluating the variables focused on in this research. The next chapter will explore the relevant literature related to methodological issues pertinent to this research and develop the methodological framework used to explore the research propositions.

3. METHODOLOGY

3.1. QUALITATIVE RESEARCH

Variables that are difficult to measure quantitatively can be studied empirically, but require the use of qualitative research methodologies. Qualitative data is usually in the form of words and involves focusing not only on the research questions of interest, but also the circumstances in which the observations took place to provide context. Many qualitative researchers employ a case study design for their research. A case study focuses on a phenomenon within a bounded context (Miles & Huberman, 1994). Qualitative research is often faulted for the subjectiveness of its nature, but techniques do exist to increase validity of the results and negate the subjectivity that may occur from researcher bias.

3.1.1. Qualitative Research Methodology

Some researchers describe qualitative data as "thick description." Examples of thick description could include detailed descriptions of the physical environment, the characteristics of the people involved, and the nature of the group or community in which the research is being conducted (Guba & Lincoln, 1981). This level of detailed description allows those reviewing the results of the research to understand the context of the research and evaluate the interpretation of the data for themselves (Patton, 1990). Qualitative research methods allow an in-depth exploration of complex relationships between variables that are both quantitative and qualitative. Complex interactions, such as those involving human subjects and multiple variables, can also be difficult to capture in a wholly quantitative study. A

qualitative model allows the interactions between variables to be studied more fully in their natural setting.

Qualitative research produces a great deal of information for a small population, but due to the limited population, the results may not be generalized to a larger population. (Patton, 1990). Though it may be more difficult to generalize results, qualitative research still offers advantages. Studying "naturally occurring, ordinary events in natural settings" offers a perspective on "what real life is like." (Miles & Huberman, 1994: 10). Qualitative research allows the "how" and "why" of a question to be explored and preliminary conclusions on cause and effect to be drawn.

Qualitative research in organizations is conducted over a period of time in a real world setting resulting in the capture of raw data within the organization (Miles & Huberman, 1994). Through systematic capture of background data the unspoken beliefs or rules associated with the organization can be studied (Miles & Huberman). The researcher will also purposefully collect perceptions of employees and study how people in the organization understand and manage everyday activities. As opposed to using the quantitative tools of surveys, the researcher is the main measuring device (Miles & Huberman). Similarly, analysis is completed with words instead of statistics. (Miles & Huberman)

A case study is often employed in qualitative research. A case study is an empirical inquiry that "investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 1994: 13). A researcher defines a case to clearly outline what is being studied and what is not being studied (Miles & Huberman, 1994). Examples of cases can include an individual, a role, a small group, a community, or a nation (Miles & Huberman).

Case study research is often associated with qualitative research, but case studies may utilize a combination of qualitative and quantitative data (Yin, 1994). A case study is the best type of framework when researching contemporary events, but when behaviors are not being manipulated. A case study will answer "how" and "why" questions over which the researcher

has little or no control (Yin). A single case study is analogous to a single experiment. A single case study may be useful in testing theory, representing an unusual case (outlier), or when the researcher has an opportunity to observe a situation not previously accessible. (Yin) Evidence gathered from the single case study helps determine if further research is warranted.

3.1.2 Data Collection Methods

For this research a data collection method is defined as how the data is gathered. In a qualitative study, data is typically gathered using three collection methods: interviews, observations, and company documents (Patton, 1990). A data source is defined as the supplier of the information. Sometimes a data source may be a person, a group, a computer file, or a piece of paper. Figure 3.1 illustrates the difference between data methods and data sources as well as some examples of data sources. A data source may contribute data through more than one data collection method. For example, it is common to observe a line employee perform a work process and have a conversation with the employee, as well as formally interview the employee using a structured format.

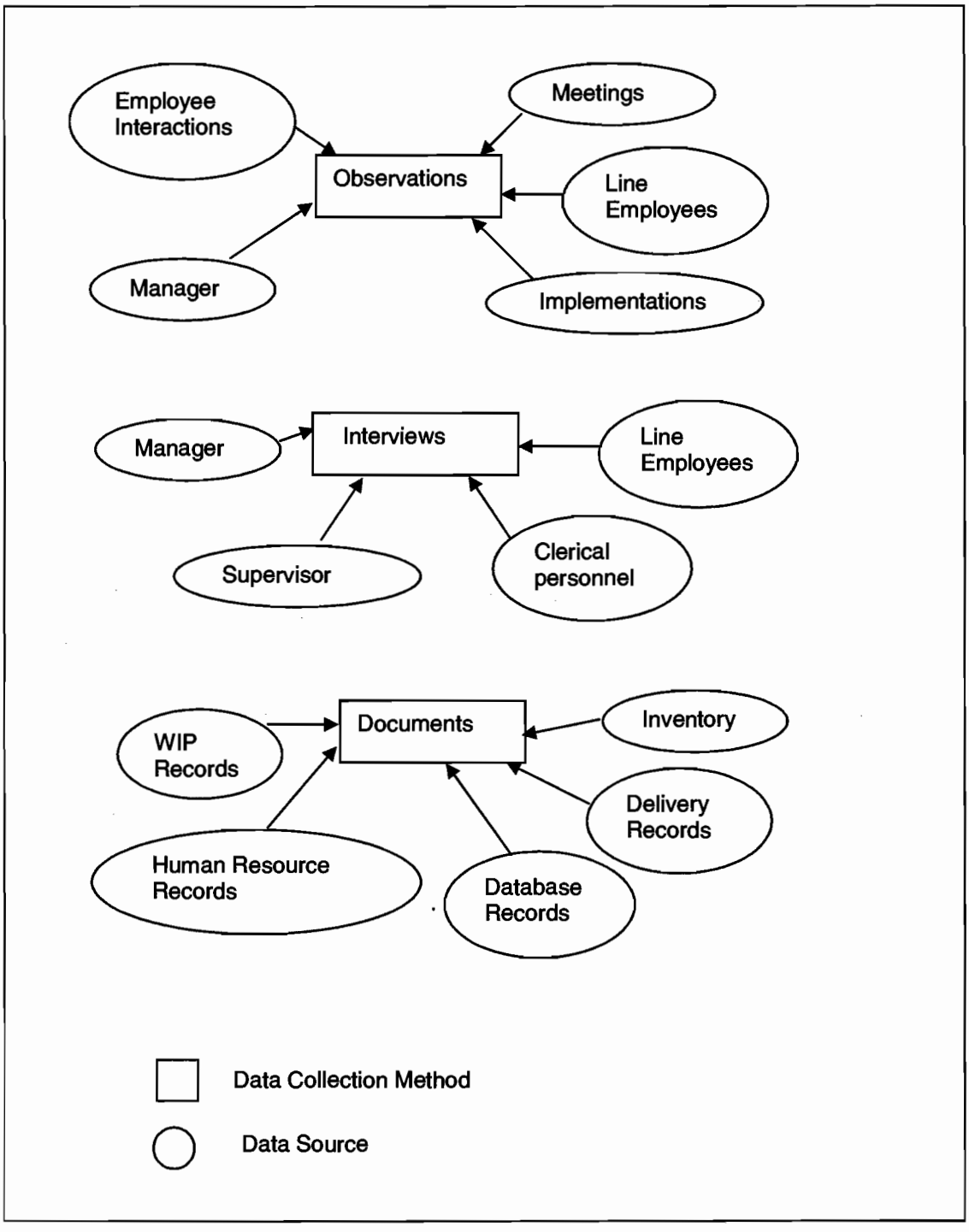


Figure 3.1. Data Collection Methods

3.1.3. Misconceptions of Qualitative Research

Qualitative research does rely on data collection methods that are subjective. This possibility of error is "more than offset by the flexibility, insight, and ability to build on tacit knowledge that is the peculiar providence of the human instrument." (Guba and Lincoln, 1981: 113). Some of the common forms of bias typically associated with qualitative research include researcher bias and over reliance on one source within the case study. While subjectivity is a potential hazard of qualitative research, it also exists in quantitative research (Guba & Lincoln, Patton, 1990). Patton argues that "numbers do not protect against bias; they merely disguise it." (Patton: 480).

Critics of qualitative research feel too much of the data collection process has the potential for researcher bias as data collection relies on the researcher's perception of what is important and relative to the research. During the typing of data collection notes bias is also possible as the researcher begins to filter out important details from irrelevant data. This viewpoint implies the data is based on opinion, rather than fact, which leads many to view this form of research as imprecise and incapable of being replicated. To overcome these potential pitfalls the researcher must develop a systematic, documented approach to data collection (Patton, 1990). Good documentation of procedures will allow other researchers to assess the potential bias of the data collection methods used. The researcher must also use techniques such as multiple sources for data collection and triangulation to increase the robustness of the research (Patton).

Triangulation occurs when multiple sources from different data collection methods support the same conclusion or, at the least, do not contradict it (Miles & Huberman, 1994). Triangulation strengthens the validity of research findings (Patton, 1990). The concept of triangulation is illustrated in Figure 3.2.

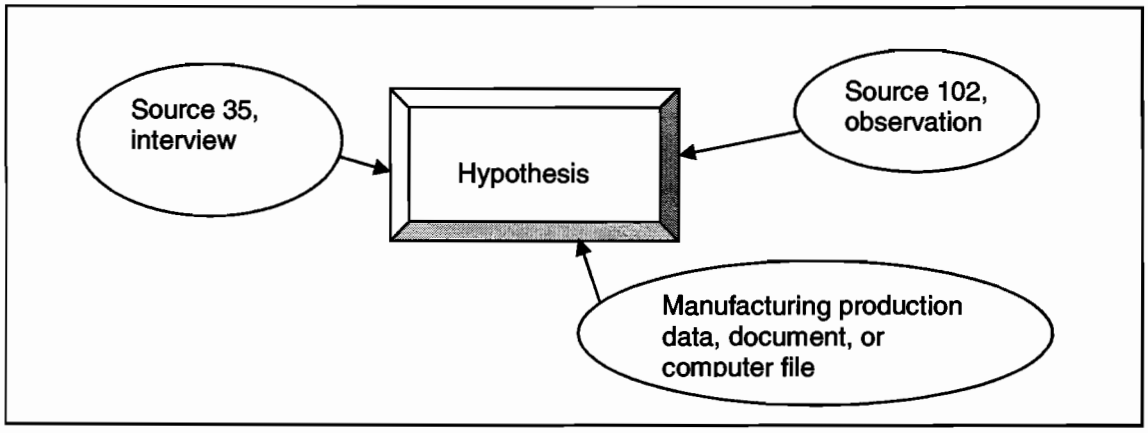


Figure 3.2. Example of Triangulation

Four types of triangulation are commonly identified: data triangulation, investigator triangulation, theory triangulation and methodological triangulation (Miles & Huberman, 1994; Patton, 1990). Data triangulation is defined as the use of different data sources. In Figure 3.2, two unique data sources (source 35 and source 102) provided supporting evidence for the hypothesis. Data triangulation will not typically provide definitive proof to support a hypothesis or proposition, but it will provide some boundaries (Miles & Huberman). Investigator triangulation occurs when several different researchers or evaluators collect the data and the data from different researchers supports the hypotheses. Theory triangulation involves analyzing the data employing a framework of unique or competing hypotheses. This triangulation method may introduce problems if two incompatible theories predict the same result (Miller, 1983). Methodological triangulation collects data using several different collection techniques. In Figure 3.2, data is collected employing three unique techniques: formal interview, observation, and document collection. Miles and Huberman (1994) define a fifth type of triangulation as data type. Data type is defined as the collection of different types of data and could include examples such as qualitative data, quantitative data, or archival records. For example, in Figure 3.2, qualitative data (interviews and observations) and

quantitative data (manufacturing production data) were collected. If triangulation provides conflicting or inconsistent results, further study may be needed to explain the lack of agreement among the results. Though this may not provide the desired support for the hypotheses, the conflicting results may help develop a new perspective on the problem (Miles & Huberman).

Triangulation also helps to reduce some of the common forms of bias associated with qualitative research. Researcher bias may occur, for example, when a researcher rigorously adheres to the hypotheses and discounts any data that may contradict the hypotheses. A case study design employing multiple investigators will help to negate the potential bias one researcher may bring to the research. Another form of bias may occur when a researcher fails to establish multiple sources of data and allows one source to unduly influence the outcome of the research. Incorporating multiple data sources into the case study design will reduce this possibility. Triangulation should not be considered a separate task to be completed after data collection. Triangulation techniques should be built into the study, with conscious decisions to seek unique sources and unique types of data, and to employ unique data collection methods (Miles & Huberman, 1994).

Other techniques for increasing the validity of qualitative research findings include rigorous training on data collection techniques and external reviews of data (Patton, 1990). The collection of data for qualitative research is not routine or predictable. The researcher must maintain an open mind and be flexible in pursuing new opportunities or new avenues of thought. The researcher must also maintain self-awareness and be vigilant about potential bias during data collection (Yin, 1994). At all times the researcher must be aware of the possibility of bias and work purposefully to manage it. Any potential sources of bias should be documented within the research (Patton). The qualitative researcher must adopt a neutral mind set and a commitment to understanding the "world as it is, to be true to complexities and multiple perspectives as they emerge, and to be balanced in reporting both confirming and disconfirming evidence" (Patton: 55).

To maintain neutrality it is important that observations be recorded as factually as possible, without embellishment or speculation. Other researchers should be able to confirm the data collected in the study (Guba & Lincoln, 1981). The researcher should focus on who, what, where, and when. Any personal opinions of the researcher should be specifically noted. Observations should take into account all points of view, not just those that support the hypotheses. Qualitative researchers are similar to investigative journalists and as such must strive to be fair and balanced in investigation and presentation of all viewpoints (Patton, 1990).

Neutrality, however, does not imply detachment. Qualitative research is dependent on the researcher's experiences, insights, and empathy. Patton (1990) argues that empathy is important as it allows the researcher to "understand the stance, position, feelings, experiences, and worldview of others" (Patton :56). As human beings are unique in not only their thinking and reasoning skills, but in their emotions and group behaviors, they cannot be studied in the same way as other research subjects (Patton).

This research employed a single case study design that served as a test case for the research propositions. Data for this research was collected using four different methods (formal interviews, unstructured interviews, observations, and value stream mapping) from multiple sources. Unique sources were purposely sought, not only to increase validity of findings, but to also provide a wider perspective on the research propositions. Manufacturing production data and documents from the organization were also collected, but were not used extensively in the analysis phase. The manufacturing production data and the organizational documents, however, did offer important details about the lean implementation that provided contextual background for the case study.

3.2. VARIABLES

The variables of interest in this research have been studied across a variety of disciplines. As a result, various definitions and contexts exist for each one. To increase

preciseness, it was critical to operationalize each variable for the purposes of the case study. Definitions were developed for each variable and were used to guide the analysis of the data.

3.2.1. Definitions

Some of the variables in this research could have been defined as both independent and dependent variables. Organizational culture, for example, may impact the lean implementation, but the lean implementation may also make a positive impact on the culture, creating an environment more open to change. For the purpose of this study, however, organizational culture was defined as an independent variable. Organizational culture was defined as the shared basic assumptions held by the employees that in turn determined how organizational personnel perceived and solved problems.

Organizational structure and management support were also defined as independent variables. Organizational structure was defined as the number of management levels between the manufacturing personnel and the executive management of the organization. Not only may the number of management levels significantly impact a lean implementation, but the number of people supporting those management levels may also serve as a barrier to the implementation (Barker, 1994). Management support was defined as the participation of the executive management team in leading or supporting the lean implementation.

Communication is a variable that could also be defined as an independent or a dependent variable. It may be argued, for example, that in an organization that has strong communication pathways, a lean implementation may be more successful. For this research, however, communication was defined as a dependent variable. Communication was defined as the method, usually verbal or written, by which employees in the organization transfer work related information to other employees. Problem resolution was also defined as a dependent variable. Problem resolution was defined as the ability of personnel to define a problem and seek root cause solutions to resolve the problem.

3.2.2. Independent Variable Evaluation

Analyzing the impact of the lean implementation on the dependent variables was completed by examining the field notes for a link between the lean implementation and any impact on communication or employee problem solving skills. Investigating the role of the independent variables (culture, organizational structure, management support) in the lean manufacturing implementation was a more complex task as it was possible that multiple aspects of the lean implementation could be impacted. In order to thoroughly investigate the impact of the independent variables on the lean implementation, a balanced scorecard framework was developed for this portion of the analysis.

The balanced scorecard concept, first introduced by Kaplan and Norton in 1992, was created to give senior executives a measurement system that provided a system-wide perspective. While some organizations preferred to focus on particular areas of the organization, such as finances or operations, other organizations found such measures lacking and incapable of providing a clear picture of the performance of the entire organization and its processes. Kaplan and Norton developed the balanced scorecard from their work with 12 organizations practicing advanced performance measurement. The goal of the scorecard is to provide information from different perspectives, and to also limit the number of measures to avoid information overload. Many organizations institute new measures on a regular basis to gather information organizational personnel deem critical. The balanced scorecard forces managers to focus on the finite set of measures that are the most critical (Kaplan & Norton, 1992).

Kaplan and Norton (1992) identified four perspectives in the balanced scorecard: customer, internal, innovation and learning, and financial. The customer perspective is concerned with how customers view the organization. Customer concerns typically revolve around four categories: time, quality, performance and service, and cost. Organizations using

the balanced scorecard must set goals for these four categories and then develop specific measures for the four categories

The internal perspective involves translating the expectations of the customers and determining what must be done internally to meet those customer expectations (Kaplan & Norton, 1992). The internal measures should be developed for those business processes that most impact customer satisfaction (Kaplan & Norton, 1992). Factors that may be measured include the amount of time to manufacture a product, the quality of the product, and the productivity of the manufacturing process.

The innovation and learning perspective is necessary to enable the organization to remain flexible and open to change. An organization's ability to introduce new products, provide more value for customers, and improve efficiencies within operations enables the organization to increase revenues and profit margins (Kaplan & Norton, 1992). An example measure might be the percentage of sales from new products.

The financial perspective is the perspective most familiar to managers. Financial measures by themselves, however, may be inadequate. Financial measures are often backward-looking and may not improve customer service, quality, manufacturing time, or employee motivation (Kaplan & Norton, 1992). Kaplan and Norton contend that financial measures are a critical part of the balanced scorecard. If an improvement in operations does not result in financial improvement, then senior executives must re-think their strategy (Kaplan & Norton, 1992). Example measurements are profitability, growth, and shareholder value.

Since its introduction, the balanced scorecard has been adapted and expanded upon. It has been linked with strategy development and strategy execution (Kaplan & Norton, 1996; Kaplan & Norton, 2000; Kaplan & Norton, 2004). Stewart (2001) introduced a balanced scorecard for projects. Other research has expanded or modified the balanced scorecard for other purposes (Emiliani, 2000; Jordan & Michel, 1999).

One example of an expanded scorecard included two additional perspectives: innovation and globalization (Jordan & Michel, 1999). The innovation perspective measured

performance in areas such as the organization's investment in research and development or the earnings attributed to implemented innovations. The global perspective measured market share by geographic market or share of total market potential (Jordan & Michel, 1999).

Emiliani's (2000) version of the scorecard more evenly distributed measures between external requirements and internal factors. As a result, the innovation and learning perspective became the employees' perspective, the financial perspective became the investors' perspective, and the internal perspective became the suppliers' perspective (Emiliani, 2000). Measures in the employees' perspective of the scorecard may include retention rate, compensation, and gaps in skills between employees (Emiliani, 2000). The investors' perspective may include measures such as earnings per share, net income, inventory turns, and return on invested capital. The suppliers' perspective may include measures such as the quality of products received from suppliers, as well as the number of on-time deliveries by suppliers and a supplier satisfaction rating (Emiliani, 2000).

The scorecard framework is adaptable, both in terms of measures and uses. As a result, this framework was considered an appropriate structure to measure the impact of the independent variables (culture, organizational structure, and management support) on the lean implementation. The framework used in this research utilized concepts from both the scorecard first developed by Kaplan and Norton (1992) and the scorecard developed by Emiliani (2000). As the study organization was privately held, some of the measures in the investor/financial category did not directly apply. The other measures in the investor/financial category involved organizational financial details unavailable to the study. As a result, the investor/financial category was not developed further for this research. The scorecard framework consisted of three categories – customers, employees, and internal. The measures used within each category are detailed in Table 3.1.

Table 3.1. Balanced Scorecard Developed for this Research

Employee Perspective	Customer Perspective	Internal Perspective
Employee Attitude	Ability to meet customer's manufacturing needs through the use of lean practices such as kanbans, or just in time manufacturing	Streamlined processes (elimination of waste)
Improved employee skills	Customer satisfaction in areas such as on-time delivery or quality	Adaptation of lean concepts/tools

The specific measures within each category were developed based on expected outcomes of a lean implementation. For example, a common benefit of lean is an increase in customer satisfaction (Ahls, 2001; Alavi, 2003; Womack & Jones, 1996). Another benefit of lean is an increase in employee skills and morale (Alavi, 2003; Barker, 1994; Jordan & Michel, 1999). The independent variables (culture, organizational structure, management support) were then separately evaluated for their effect on the measures in the scorecard to determine their impact on the lean implementation.

The independent variables in this case study require a different measurement approach. The balanced scorecard framework was developed in response to the difficulty of measuring these variables. Evaluating the case study data from a variety of perspectives provides a framework for examining both supporting and contradictory evidence of the importance of the variable in the lean implementation.

3.3. CASE STUDY SITE

A critical aspect of qualitative research is the need to provide the context of the case study site to enable other researchers to evaluate the validity of the findings. The details of the case study site also provide other researchers with the tools necessary to replicate as closely as possible the findings of the study, an important aspect of any scientific research.

The case study site is located in Vancouver, Washington. The site was physically visited seven times over a three month period in early 2003. The identity of the company will be kept confidential. The company will be referred to in this research as CompX. Contact was made with the case study site through part of a larger research project funded by the National Science Foundation (NSF) and directed by Dr. Toni Doolen, PhD of the Industrial and Manufacturing Engineering department at Oregon State University. The NSF study is also related to lean manufacturing practices and attempts to link specific lean practices and the degree of success of such practices.

Summarized data in the form of a report was provided to the president and operations manager of CompX upon the end of data collection. The report offered suggestions for efficiency improvements in some of the manufacturing departments. Inventory statistics in particular were compiled and shared with executive management with suggestions on possible ways to reduce the amount of inventory held by the company. The results of the interviews were shared in aggregate form after being filtered for confidentiality purposes.

3.3.1. Organizational Structure

CompX was a contract electronics manufacturer. The organization designed and manufactured products to meet customer needs, but also manufactured products based on customer specifications. The organization provided prototyping, testing, and quality assurance services. The organization is privately held and family owned. It has been in business for over 32 years. The current company president is part-owner and the son of the company's founder. The company employed roughly 64 people at the time of data collection. The number of people employed in specific positions may be found in Table 3.2:

Table 3.2. Number Employees by Position at CompX

Position	Number of People Employed	Percentage of work force
Executive	1	1.6%
Managerial	3	4.7%
Human Resources	1 part-time	1.6%
Technical/Engineering	13	20.3%
Manufacturing Operators	31	48.4%
Manufacturing Leads	7	10.9%
Administrative/Support personnel	8	12.5%

The skill level of most employees on the manufacturing floor was moderate, with many employees required to multi-task within their department. Some of the employees were also trained in tasks in other departments and would help in those departments when the work load in their own department was light. The number of employees leaving the company was very low. It was estimated that in the sluggish job market at the time of data collection, turnover was less than 5%. Even when the job market was much better, executive staff estimated employee turnover was less that 10%.

The ratio of managerial/executive positions to manufacturing operators was very high. The company had minimal middle management. Each department on the floor had one lead, but the management duties of these individuals was minimal at the time of data collection. The leads acted as a point of contact for directing work through the department and coordinating the needs of other departments. Typical supervision duties such as writing performance reviews, managing employee scheduling, or reprimanding employees for performance issues were performed by the production supervisor or the operations manager. At the end of the data collection period the leads were being trained in some of the supervisory duties in anticipation that they would be performing them in the future. The reporting structure for the organization is shown in Figure 3.3.

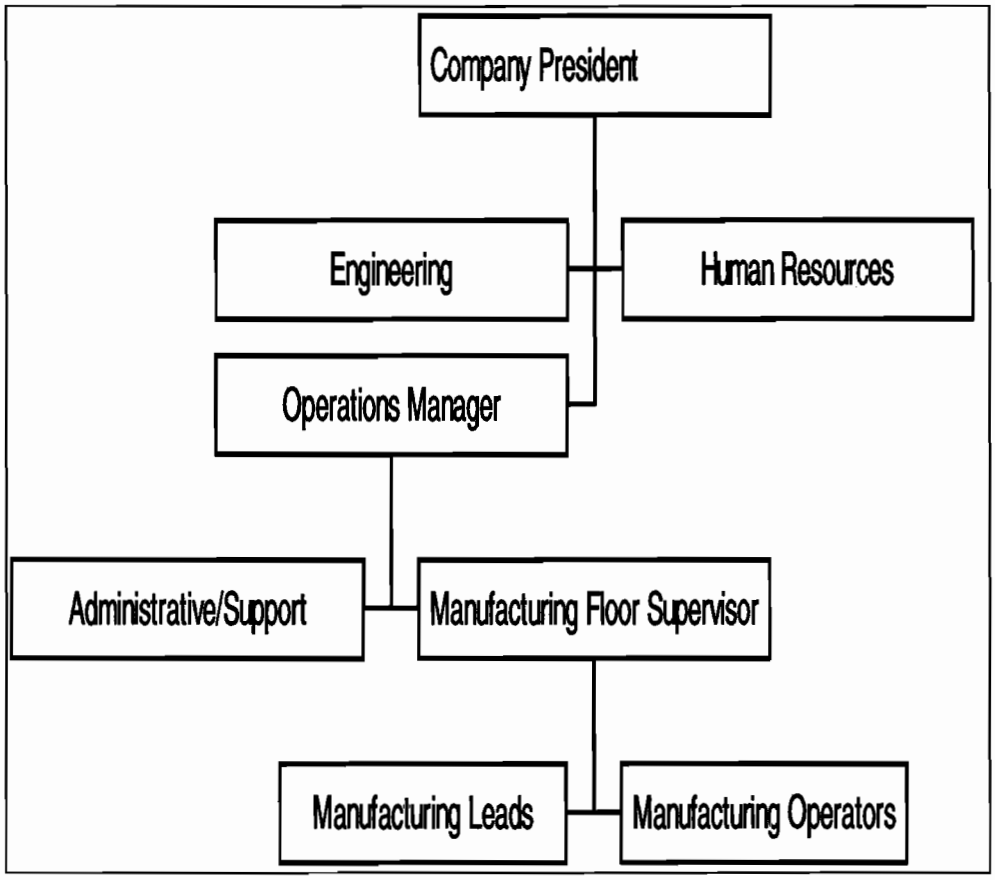


Figure 3.3. Organizational Chart for CompX

The operations manager and company president participated in all aspects of the company. For example, the operations manager and the company president were often observed directing the flow of orders through the line, helping the manufacturing operators, meeting with customers, and helping engineering with technical questions. During the data collection period the floor supervisor was on a leave of absence a majority of the time. Her duties appeared to have been delegated to the operations manager, with some minor aspects of her position now performed by the area leads.

3.3.2. Physical Details of the Organization

CompX consisted of one manufacturing location. All company offices and manufacturing facilities were located in the same building. The building was roughly 17,000 square feet at the time of data collection and was located in a commercial office building. The building was constructed in 1987 and consisted of a front office holding the executive, managerial, administrative, purchasing, and engineering/technical support offices and cubicles. The company president and operations manager shared an office. The production supervisor had an office on the manufacturing floor.

The rear of the building is a large warehouse converted into a manufacturing floor. The shipping and receiving areas are located at one end of the building in the same area as the inventory, with the manufacturing departments laid out sequentially in close proximity to the actual flow of the product as it is built. A sketch approximating the physical layout of the company is included in Figure 3.4.

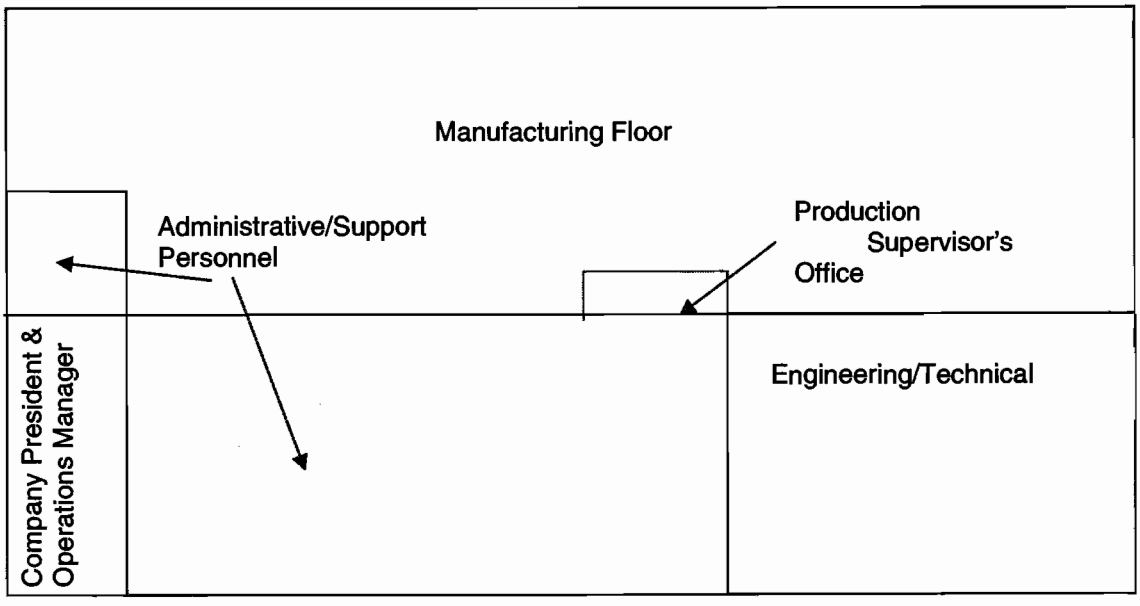


Figure 3.4. Physical Layout of the Manufacturing Floor

The manufacturing floor was divided into functional departments, with an area lead in each department. Table 3.3 details the departments and the number of people in each department. The number of employees listed in each department includes the area lead.

Table 3.3. Summary of the Number of People in Each Department and Department Function

Department Name	Function	Number of Manufacturing Operators
Materials	– Receives in all parts – Tracks part shortages – Assembles kits of raw parts for the floor – Prepares parts for the kits – Stores and tracks finished goods – Ships all finished goods	6
Surface Mount Assembly (SMT)	– Adds components to boards with surface mount machines – Dry boards – Inspect	5
Hand Assembly & Quality Assurance	– Add components to boards by hand – Inspect boards	12
Cables	– Make cable assemblies for use on boards	3
Mechanical Assembly I & Wave Solder	– Assemble boards per specifications – Perform wave solder function for other areas	3
Mechanical Assembly 2	– Secure components with chemical compounds – Wash boards for this area as well as other areas – Perform additional assembly as required	6
Test	– Test various components on board	3

A sketch of the manufacturing floor is included in Figure 3.5. This sketch provides a general layout of the manufacturing area at the time of data collection.

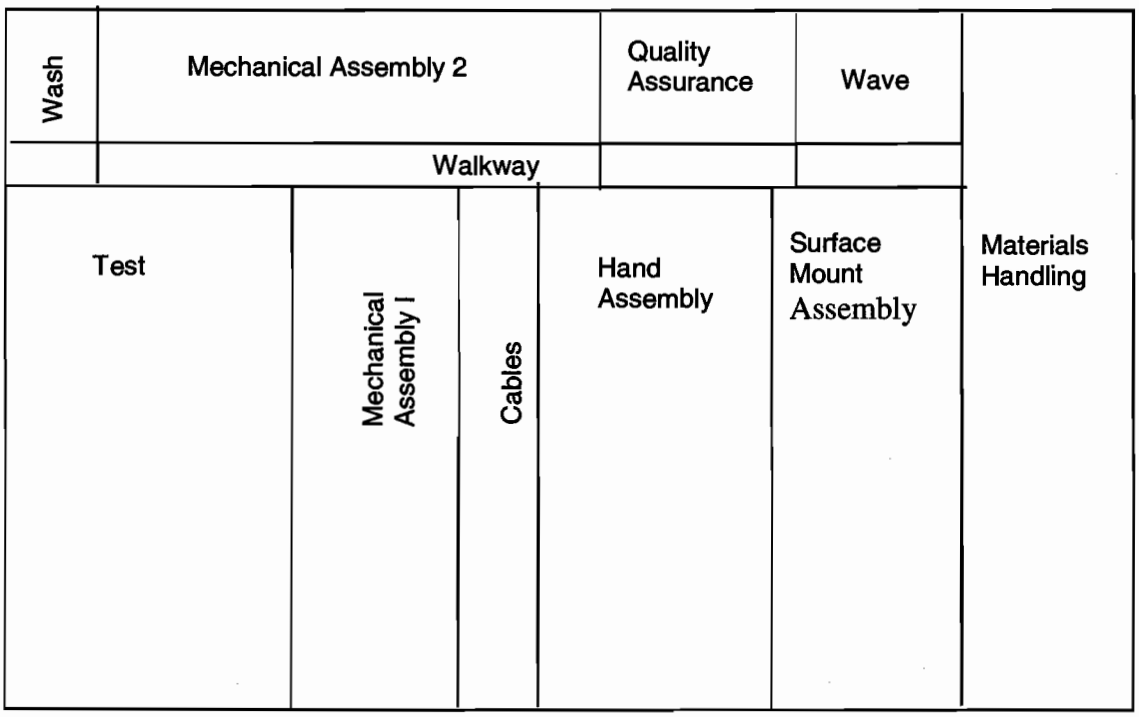


Figure 3.5. Layout of Manufacturing Floor

3.3.3. Manufacturing Information

The company operated using a batch-and-queue manufacturing strategy. A batch-and-queue manufacturing strategy manufactures products in batches, with work flowing from area to area without regard for the next area's capacity. Any excess batches that an area cannot immediately process are put into a queue in each area to wait until employee or machine capacity become available. Batches are taken out of the queue using a variety of strategies. Some areas will take a batch out of the queue based on the oldest batch in the queue while other areas must prioritize the batches based on when the finished product was promised to the customer.

CompX manufactured a large variety of products (over 1,800), but at low volumes. The typical order size was 43 units. The company averaged 210 orders per month, building

approximately 9,000 units each month. The company had no minimum build order and would even build orders of one or two units.

Batch size was typically the same as the order size. Orders occasionally were combined by the production planner to reduce set-up times. A kit consisted of the raw materials and/or subassemblies needed by each work area to complete the processes of that work area on the unfinished product. The unfinished product (known as work in progress, or WIP) was also considered a part of the kit. At the time of data collection, the company had a great deal of WIP on the floor due to a material requirements planning (MRP) program that did not track WIP and a poor process for managing kits awaiting parts from suppliers. The policy of releasing kits to the floor with missing parts, combined with the inadequate MRP system resulted in large quantities of kits stored on the floor awaiting parts. The current MRP software program did have a WIP module available but it was decided the cost of the software was too prohibitive. At the time of data collection an employee was working on developing software in Microsoft Access to work in tandem with the MRP system to track WIP.

Analyzing manufacturing production data from the period April 2002 to March 2003, it was found that on average, 480 of the batches on the floor each month were missing parts. The number of batches missing parts exceeded the average number of orders completed each month, providing evidence of the large number of batches in WIP.

3.3.4. Lean Initiative Background

Lean implementation at CompX began in 2001. The operations manager led the efforts in the company, with some help in facilitation from the manufacturing engineer. Both the operations manager and company president expressed some skepticism when interviewed regarding the success of lean in a small company. The monetary benefits had not been made clear when compared to the costs required to undertake some lean projects. Though some doubt as to the ultimate success of lean was voiced, both continued to invest time in

reading and attending training. The operations manager also continued to introduce new ideas to the employees and to plan for future lean activities.

Lean activities were introduced informally to the employees by the operations manager through memos or meetings. Area leads were sent to a three day training session on basic lean concepts in early 2002. The plan at that time was for the leads to disseminate the information to other employees, but this had not occurred uniformly or with great effect at the time of data collection. Some line employees had been exposed to lean through previous employment with other organizations.

In December of 2002 the company initiated a Five S activity within the company. Five S refers to the five dimensions of workplace organization and is a popular practice in lean implementation. The Five S's are defined as sort (identify unnecessary equipment), straighten (arrange and label the area so all tools have a specified home), shine (clean the area and maintain equipment daily), standardize (establish guidelines and standards for the area), and sustain (maintain the established standards). The Five S activity was the first practical exposure for most of the manufacturing personnel to the concept of lean.

Information on the activity was provided to employees in a two page memo that explained the purpose of the activity and the basic philosophy behind each S. The explanation for each S also contained specific instructions and examples to enable each employee to see the steps necessary to successfully complete the activity. The memo also contained a diagram of a continuous circle made up of each S with a brief definition for each S. The activity was designed as a contest, with the operations manager, the manufacturing floor supervisor, and the manufacturing engineer acting as judges. Each area was given a maximum of $50 to complete the activity. Each area had to provide a plan for what the activity was going to accomplish, the number of hours required to accomplish the plan, and a list of the personnel involved within the area. The areas were judged by the degree to which Five S was met, before and after pictures, observations, how well the area adhered to the estimated time budget, and how effectively the budget was used. Judging of the areas was conducted at

the end of January 2003. The judging activity was observed by the researcher and field notes were recorded during the observation.

The company purposefully chose to make participation in the lean implementation voluntary, but most employees on the manufacturing floor did take part. Out of the 31 manufacturing operators, one deliberately chose not to take part. Several others were not directly involved due to time constraints that prevented them from fully participating. This lean initiative was focused only on the manufacturing floor. Support functions such as engineering, purchasing, order entry and human resources did not participate in the Five S activity.

3.4. PHASES OF DATA COLLECTION AND ANALYSIS

Data collection was divided into three phases. Managing and analyzing the data was divided into four phases. In phase one, the research data was collected through formal, structured interviews over a period of three visits. Phase two involved observations and unstructured interviews with line employees, clerical staff, support personnel, and senior management over a period of four visits. Phase one and phase two overlapped. Phase three consisted of analysis of manufacturing production data from mid 2002 through spring of 2003 and the collection of company documents. The analysis of the production data provided background for the research and allowed the researcher to provide suggestions for improvement to the organization. Phase four consisted of the transcription of the notes. Phase five involved the construction of a database for data analysis purposes. Phase six focused on coding the data into appropriate units to facilitate analysis, entering the coded data into the database, and performing preliminary analysis. Some of the data was then re-coded to further refine the data into meaningful units of analysis.

3.4.1. Data Sources

Data was collected from various employees, employing different methods. While the data collected from an employee using multiple methods may differ, if it is similar, it would not provide the data triangulation necessary to demonstrate reliability. For this reason, both the data source and the method by which the data was collected were carefully tracked throughout the research. Employees voluntarily participated in structured interviews, unstructured interviews and observations. Employees were informed that participation (or non-participation) in any or all of the proposed research activities would have no consequence to their employment status. There was no monetary compensation for any employee or for the organization for participating in this research. The organization did receive a report detailing possible ideas for improvement in operations based on the observations conducted.

A participant consent form approved by the Institutional Review Board (IRB) was presented to each employee before a structured interview, and the interview did not proceed until the employee had read and signed the form. The voluntary nature of the interview and the confidentiality of the data obtained through the interview were verbally stressed to the employee before the form was signed. A copy of an unsigned consent form is provided in Appendix A. Employees were permitted to ask questions prior to making a decision regarding their participation in the interview. Employees were advised that they could terminate the interview at any time. None of the employees in this study chose to terminate an interview. Participation in the observations portion of the research was also voluntary.

All individuals interviewed and observed were assigned an identification code to guarantee data source confidentiality and to validate the originality of the source for triangulation purposes. Each person interviewed was assigned a letter of E or L and then a unique number. An E was used to designate a supervisory or managerial employee. An L was used to designate a non-supervisory employee. Individual names were tracked only for the purpose of assigning the generic code. If an individual was assigned a code during the

interview portion of the case study, the same code was used for the observations portion. For both the interviews and the observations, the general position held by the participant was noted when the identification code was assigned.

All interview and observational data and subsequent analysis were summarized at the organizational level. For the purposes of this research, individual responses were not of interest. The primary focus of all data collection in which participants were involved was to provide organizational level data. The human data source population was not limited based upon gender or ethnic background. Some data sources were excluded from structured interviews because of language barriers. These employees all worked in one area. The lead of that area was interviewed and the processes in the area were observed. Based upon the depth of information given by the area lead, and the data collected through the observation, the lack of additional interviews from the area was not felt to have significantly impacted the study.

3.4.2. Phase One – Structured Interviews

Many types of interviews exist. An interview can be a structured questionnaire, a group panel, a covert interview where the interviewee doesn't know the interview is taking place or a loose and unstructured interview with no particular focus (Guba & Lincoln, 1981). Interviews may be inefficient, costly, and difficult to replicate, but they provide the richest source of data for the amount of time invested in the data collection process (Guba & Lincoln). Interviews offer the researcher the opportunity to collect data on the experiences of people in the case study in their own language. The purpose of an interview is to allow the researcher to experience the interviewee's perspective and to find out information not available through direct observation (Patton, 1990). Interviews offer insights into situations and may provide critical background on prior events (Yin, 1994). Interviews may also identify new sources of evidence.

Much of the success of an interview depends on the interviewer. An interviewer must establish a rapport with the interviewee in a short span of time. Building rapport requires the interviewer to convey empathy and understanding without judging the interviewee. Rapport requires the interviewer to respect the interviewee. The interviewee must feel comfortable that he or she will not be judged and their "knowledge, experiences, attitudes, and feelings are important" (Patton, 1990: 317).

Building rapport may be difficult, but it is critical to a case study utilizing interviews. Interviewers who are seen as supportive, interested, and courteous will elicit more information from the interviewees (Lofland & Lofland, 1995). It is important for an interviewer to present a non-threatening presence, so the interviewees feel secure sharing beliefs and thoughts. The interviewee must also feel secure that nothing he or she says will make the interviewer think more or less of them (Patton, 1990). The interviewer must maintain neutrality and avoid exhibiting any show of favor or disfavor, shock, anger, embarrassment, or sadness (Patton).

It is equally important that questions in an interview be structured to avoid any implication of the researcher's opinion (Lofland & Lofland, 1995). Questions that infer a desired response should also be avoided. An interview should not be used to put ideas into the interviewee's mind (Patton, 1990). Sometimes an interviewee may be inadvertently influenced when the interviewer attempts to help the interviewee answer a difficult question or clarify the meaning of a question. It is critical an interviewer does not try to influence the interviewee, but attempts to record the data without reservation (Patton). If an interviewee cannot provide an answer, the event should be recorded as a non-response. When clarifying a question, it is critical to use neutral language that does not imply one answer would be preferred over another.

Sometimes it is also possible that the body language of the researcher gives the interviewee non-verbal cues that will encourage particular responses. If this occurs, the researcher should consciously attempt to modify the behavior (Guba & Lincoln, 1981). It's important to guard against responses of a group of interviewees that seem to deliberately be

the same. Such responses may be part of a conspiracy by the interviewees, and the researcher must thoroughly investigate such responses to ensure they are genuine and not pre-planned or dictated by group pressure (Yin, 1994). It is also important to recognize that interviews may be prone to bias, poor memory on the part of interviewees and poor verbalization (Yin). Triangulation through the use of multiple sources and multiple collection methods will help to minimize the effects of these issues.

A structured interview is defined as a set of specific questions (Guba & Lincoln, 1981). A structured interview may resemble a questionnaire, though the verbal interview format allows more flexibility (Guba & Lincoln). A structured interview allows a researcher to obtain the same information from a number of different people. The tone of a structured interview may be open-ended and conversational. While a structured interview is typically considered more rigid than an unstructured interview, researchers must still take careful note of the non-verbal reactions of the interviewee to providing context or clarity to a response (Guba & Lincoln).

Some disagreement exists among researchers about the format of the structured interview. The standardized open-ended interview advocates an approach that utilizes a more rigid format, with questions asked of all interviewees in the same sequence, with minimal probing to minimize variation (Patton, 1990). Asking the same questions of each interviewee serves to minimize the effect of the interviewer on the responses. Credibility may be jeopardized if different questions are asked of different interviewees, also raising the possibility that more information may be collected from some sources than from others.

Other researchers employ the questions of the structured interview more as a guide (Lofland & Lofland, 1995, Patton, 1990). The order the questions are asked may change from interviewee to interviewee as the researcher allows the interviewee to speak freely (Lofland & Lofland). It is also possible an interviewee may answer later questions on the guide while talking about another subject (Lofland & Lofland). The use of the interview guide allows the

interviewer flexibility to probe different subjects and to follow new lines of inquiry that may not be included in the interview questions (Patton).

This research defined the structured interview as an interview consisting of a predetermined set of questions that were administered in an open environment where little attempt was made to constrain responses. The same questions were asked of all interviewees, but the order of the questions was not always the same for all interviewees. Some of the questions did not apply to the interviewee and were not asked. Some of the interviewees provided answers to later questions and these were noted at the time. If a question was answered in a previous question, it was not asked again. Some sources may have been asked to elaborate in certain areas, whereas other sources were not. If an interviewee offered a unique insight, questions were asked if clarification was necessary. Questions asked that were not included on the interview instrument were recorded in the interview notes with the response. Interviewees were encouraged to speak freely, and their responses were recorded factually, without filtering of content. Some effort was made to direct the interview using the interview questions as a guideline, but some interviews resulted in a large amount of tangential information.

Two sets of interview questions were developed for this research. The first set of interview questions was developed for non-supervisory employees and focused on the details of the lean implementation specific to the data source's area. The questions focused on exploring the impact the implementation made on the data source's work area and how the data source viewed the implementation. Some of the questions on the interview instrument resulted in relatively uniform answers by all employees, but other questions highlighted how differently the implementation impacted specific work areas. Examples of questions on the non-supervisory interview instrument are listed in Table 3.4. The entire interview instrument for non-supervisory personnel may be found in Appendix B.

Table 3.4. Sampling of Interview Questions from the Non-Supervisory Interview Instrument

Sample Questions
1. What kind of training in lean manufacturing practices have you received?
2. What is your understanding as to why lean manufacturing practices were needed? (customer-driven? Competition-driven? Etc.)
3. Which lean manufacturing practices have you implemented or attempted to implement in your area?
4. Have certain practices not performed as expected? If yes, do you know why the practice didn't succeed in your area?

The other set of interview questions was developed for executive or managerial personnel who managed more than one area. The executive interview form was designed to seek out information on the lean implementation from the systems wide or macro viewpoint. Some of the questions on the executive interview form were the same or similar to those on the non-supervisory interview instrument. Sample questions from the executive interview instrument are listed in Table 3.5. The entire interview instrument for executive personnel may be found in Appendix C.

Table 3.5. Sampling of Interview Questions from the Executive Interview Instrument

Sample Questions
1. When was lean manufacturing first implemented in your company/work area? Can you give a schedule of lean implementation by area or department?
2. Who leads the lean manufacturing efforts in your company? (a lean department, HR, a member of management, etc.?)
3. How has lean manufacturing been introduced to the company? (mandatory participation, voluntary, incentives, etc.)
4. How many people are typically involved in your lean manufacturing implementation efforts? (How big are the teams during Kaizen events, etc.?)

Three months before formal data collection began the researcher was given a guided tour of the manufacturing facility. Some introductions to key personnel were made at that time with some brief conversation occurring. For some interviewees, this allowed them to develop some familiarity with the researcher before structured interviewing began. For other

interviewees, however, the structured interview was the first contact between the researcher and the interviewee.

The initial data sources for the interviews were chosen by the operations manager of CompX. Of the seven department leads, six were interviewed employing the structured interview. The seventh department lead was informally interviewed during an observation. Four line employees from three different departments were also interviewed using the structured interview format. The company president, the operations manager, the production supervisor, and the manufacturing engineer were all interviewed in a structured interview. The number of people interviewed from each department and the percent of the population for each job category of the organization is summarized in Table 3.6.

Table 3.6. Summary of Employees Interviewed with the Structured Interview Instrument

Employee Category	Number Interviewed with the Structured Interview	Percentage Interviewed from Employee Category
Executive	1	100%
Managerial	3	100%
Department Leads	6	85.7%
Line Employees	4	12.9%

An attempt to build rapport was initiated by the researcher during the first few minutes of the interview by discussing the purpose of the research project. The interviewee was given an opportunity to ask questions and all questions were answered to the best of the researcher's ability. The interviewees were then given a copy of the Institutional Review Board approved consent form. The highlights of the consent form were discussed with the interviewee and the interviewee was then asked to read and sign it. The interviewee was then provided a copy of the questions with the realization that some subjects process information better visually. At the end of the interview the interviewees were given the option of keeping

the copy of the interview questions. Some did keep a copy of the questions, but most declined the offer.

Interviews for all line employees and area leads were conducted in an open meeting area in the engineering department Privacy was minimal. Some of the sources exhibited a reluctance to answer questions or gave very brief answers. It was difficult to establish rapport with some of the interviewees. The lack of rapport may be attributed to lack of familiarity with the researcher, lack of privacy, and the formal structure presented by the structured interview format. The lack of privacy and the inability to establish an open rapport in the formal meeting structure may have contributed to a lack of participation by some of the interviewees. Interviews of the line employees typically lasted less than 30 minutes. Interviews of some department leads lasted between 30 and 60 minutes.

Interviews for executive personnel were conducted in the open meeting room in the engineering area and in the office of the president and operations manager. Interviews took approximately 60 minutes. This was not the first contact with these data sources. A previous meeting several months earlier with executive personnel had occurred, allowing the establishment of some degree of comfort with the researcher. Executive personnel provided more details related to the lean implementation than line employees. This may be attributed to greater knowledge about the lean implementation on the part of the executive personnel, or the prior meeting may have led to a greater level of comfort and trust.

Some researchers recommend tape recording interviews to allow the interviewer to focus on the interviewee (Lofland & Lofland, 1995). Tape recording allows the interviewer the freedom to think of related questions or follow a new line of inquiry without focusing on the mechanics of writing down all of the data (Lofland & Lofland). This research did not use a tape recorder to record the interviews. Tape recording was discussed at the initiation of the research, but it was rejected as creating a possible barrier to rapport building. It was also reasoned that tape recording may inhibit some interviewees from providing wholly honest responses. All interviews were recorded with paper and pencil. An effort was made to record

the interviews word for word, using abbreviations created by the researcher, but this was not always possible. When the interviewee spoke too fast to allow a word for word transcription, notes were made using abbreviations to record as much of the spoken word as possible and maintain the true intent of the interviewee. After the interview, while it was still fresh in memory, the researcher would make additional notes if necessary.

While the information gathered from structured interviews is invaluable, the approach used in this research may have suffered from a lack of rapport with the researcher. As a result, a different research design was utilized at subsequent case study sites visited as part of the larger NSF research project. For the other case study sites the order of the data collection was reversed, with observations and unstructured interviews occurring in the employee's natural environment first and structured interviews occurring second. It is believed that this allowed rapport to build more easily and naturally between the researcher and the interviewees, creating a greater level of trust. The amount of information collected during the structured interviews at the other case study sites was substantially greater and may be in part attributed to the rapport that was allowed to grow in a less threatening setting. Fortunately, the amount of data collected from the unstructured interviews and observations at the case study site for this research was substantial and helped to negate the lack of response that occurred in some of the structured interviews.

3.4.3. Phase Two – Unstructured Interviews/Observations

The second phase of data collection involved observing operations on the manufacturing floor and in some of the support areas. During observations, unstructured interviews also took place. While formal interviews provide information regarding specific questions, unstructured interviews and observations of the participants in their natural environment can provide invaluable information about the topics of interest. Unstructured

interviews in particular offer the researcher the opportunity to collect data that could not be collected in other ways (Cunningham, 1993).

An unstructured interview employs a nonstandard format. It relies on the spontaneity of the situation and it allows the interviewer to generate questions as part of an observational situation (Patton, 1990). Sometimes the information may be generated when an interviewer makes a statement or a comment and then waits for a response from the interviewee (Lofland & Lofland, 1995). Such an approach often puts the subject more at ease. During an unstructured interview, the tone of the interview may be more conversational and the interviewee may not even realize that he or she is being interviewed (Patton). It is important for the interviewer to remain flexible and be willing to follow multiple lines of inquiry (Patton). The data that is gathered from an unstructured interview will vary from subject to subject as no formal framework is in place (Patton).

At times it may be difficult to secure the cooperation of potential subjects for an unstructured interview. Often, subjects do not wish to be interviewed unless the interviewer can provide some justification or compelling reason for cooperating (Guba & Lincoln, 1981). Compounding this difficulty is the often personal or sensitive nature of the questions asked (Guba & Lincoln). A technique for securing the cooperation of a subject may involve allowing the interviewee to act as teacher to the interviewer's student (Guba & Lincoln). Many people are interested in filling the role of teacher and enjoy having the opportunity to discuss their work and their opinions with another person not connected with the organization.

Unstructured interviews offer the advantage of allowing the interviewer to remain responsive to differences in the subjects and the environment (Patton, 1990). Some of the disadvantages of an informal interview include the amount of time required to collect the data and the reliance on the interviewer's interpersonal skills (Patton). As with structured interviews, the building of rapport is vital. The interviewer must be able to interact smoothly with a variety of people in different environments (Patton). The results of the unstructured interviews may also be more difficult to analyze. Some time must be invested in filtering data

for relevant patterns and supporting or contradicting evidence for the research propositions (Patton).

During the course of observations at CompX, unstructured interviews took place multiple times. In all cases, the unstructured interview took place as a conversation, with the interviewer asking follow-up questions in response to statements made freely by the interviewee. At times, the unstructured interviews led to irrelevant information, but at other times the data collected proved pertinent to the research questions and offered supporting or contradictory data. The length of the unstructured interview varied greatly and as the unstructured interview almost always took place within the larger context of an observation, a detailed record of the amount of time devoted to this activity was not kept.

Observations typically involve recording behaviors or conditions particular to the environment that pertain to the research propositions (Yin, 1994). Observations are collected to describe a setting, the activities that took place in the setting, and the people participating in the activity (Patton, 1990). Activities observed may include meetings, manufacturing work, or classrooms (Yin, 1994). Observations may be made of people, but could also include the condition of an environment such as the location of machinery or the furnishings contained in a lunchroom. To increase the reliability of the data obtained through observations, more than one researcher should perform observations (Yin).

Understanding the complexity of an environment may be best achieved by observation. Observations may allow the researcher to collect data that interviewees were unwilling to discuss during an interview (Patton, 1990). Interviews possess the inherent weakness of collecting data based on the possibly flawed understanding of others (Patton). Observations permit the researcher to reach his or her own understanding and affirm or reject the understanding and perceptions of the interviewees (Patton). Sometimes errors in interview data may occur because of memory lapses or emotional involvement with the topic. Observing the situation allows the researcher to draw his or her own conclusion, protecting against potential bias on the part of the interviewee (Guba & Lincoln, 1981). Observations

also allow the researcher to collect data on activities that may have become so routine to the members of an organization that they are never discussed in either structured or unstructured interviews (Patton). As an example, during the course of this research, employees of the case study organization often remarked that they didn't know why they performed a task a certain way as they had never really thought about it.

Two types of observations are commonly employed by researchers. Participant observation involves becoming a part of the study as an active participant (Patton, 1990). Observations are made from within the activity or environment as a member of the organization. This type of observation may introduce bias into the study, but at times the environment requires the researcher to become a participant in order to gather data (Patton). The other type of observation is defined as overt or covert observations. An overt observation occurs when the researcher observes a situation or activity with the people participating in the observation fully aware of the researcher's role (Patton). A covert observation occurs when the participants in the study do not know they are being observed (Guba & Lincoln, 1981; Patton).

As it is impossible to observe everything, it is important the researcher maintain a focus during the observations (Patton, 1990). Sometimes a researcher will employ a framework that specifically details what kinds of events, activities, or behaviors are important (Patton). Another method for achieving focus is to organize observations by data sources and purposely observe different work areas, subjects, or types of data (Patton).

Observational data has a limitation related to data collection in that only data deemed important enough is recorded or collected. This decision is based on the researcher's judgment. Researchers must be trained in observation (Patton, 1990). With practice, a researcher should be able to accurately record the important details while weeding out the trivial data. It is also equally important that a researcher be ready to observe. Observation involves using all senses and being able to concentrate (Patton). Formal training in

observation was not pursued prior to this research, but respected sources on qualitative research (Patton; Miles & Huberman, 1994; Yin, 1994) were studied.

Another problem that may occur during observations is the tendency of the people being observed to be too concerned about the researcher's opinion. It is important the researcher guard against being drawn into making inappropriate comments when solicited for an opinion (Patton, 1990). For example, an employee may ask the researcher what he or she thinks of another employee. To maintain credibility at the case study site it is vital the researcher respond with an appropriately neutral comment. Another drawback of observations is the amount of data collected. As with data collected from unstructured interviews, the data collected during observations typically is considerable, creating a potential problem during analysis.

A critical issue often associated with observations is the unintended effects the researcher may have on the person(s) observed. If the employees know they are being observed, they may act differently or perform duties the way they should be performed, not how the employees actually perform them. While some researchers advocate covert observations, Patton (1990) recommends full disclosure to employees. In many cases, employees usually suspect the truth of the research. Trying to purposefully deceive employees not only causes undue stress on the researcher, but can skew results as well if employees turn suspicion into uncooperativeness (Patton, 1990). During observations for this research, employees were told the purpose of the larger NSF study and its effort to find a link between specific lean practices and success. The variables studied for this particular research, however, were not disclosed to participants.

For this research, the manufacture of products from the point of order to the point of shipment was observed. This is typically referred to as value stream mapping, though a formal value stream map was not completed. A value stream map typically involves following the flow of a product or a family of products through the factory, usually from the point of shipping backward to the point of product order. Following each product on its entire path was

not possible in the time allowed for this research. Instead, the work currently in the area was followed as it went through the various processes within the area. The value stream mapping activity gave a focused purpose for the observations and allowed the opportunity for unstructured interviews to take place. While most of the data collected from observations occurred during the value stream mapping activity, one observation also occurred during an evaluation of the Five S activity.

The decision regarding which area to observe on each visit to the case study site was completed jointly with the operations manager the morning of the observation. The decision was based on the amount of work in the area, job priorities, and the number of employee hours available. An effort was made to follow the product in a logical order, but this wasn't always possible. The departments visited and the number of sources in each department are detailed in Table 3.7.

Table 3.7. Summary of Departments Observed

Department	Number of Employees	Percentage of Employees Interviewed in Department
Materials	5	83.3%
Surface Mount Assembly (SMT)	1	20.0%
Hand Assembly & Quality Assurance	3	25.0%
Cables	2	66.7%
Mechanical Assembly 1 & Wave Solder	2	66.7%
Mechanical Assembly 2	2	33.3%
Test	2	66.7%
Order Entry	2	100%
Production Planning	1	100%
Purchasing	3	100%

Observational notes and unstructured interviews were recorded with paper and pencil during the observations. It was determined that the use of electronic devices such as a laptop for note taking or video or audio equipment would detract from the observational opportunities and impede the building of rapport with the employees. Most of the

manufacturing process was observed. The time spent in each area varied depending on the complexity of the processes in the area. The reluctance to share information noted in the unstructured interviews was greatly reduced during the observations and unstructured interviews.

Data collected during the observations included understanding the manufacturing process in each area and how the process fit into the overall system, the technical tools needed, the placement of machines and support equipment, and the flow of data and paperwork through the department. Observations were unstructured and did not follow a formal process. A wide range of employees provided information during the observations. Data was collected from area leads as well as line personnel. Many of the line personnel spoke English as a second language. This was not an obstacle to data collection except in one area. In this area the lead was the only source during the observations. The lead in this department was interviewed using both a structured and unstructured format, but this limitation did not seem to have a substantial impact on the research.

3.4.4. Phase Three – Document/Organizational Data Collection

Documents provide a rich source of information that the researcher can use to more fully understand the organization (Patton, 1990). Documents may consist of a variety of items including letters, memos, meeting minutes, proposals, newspaper clippings, or production data (Yin, 1994). Documents may be useful in providing specific details that support data collected through other methods such as observations or structured interviews (Yin). Documents offer the advantage of being a stable data source that can be reviewed repeatedly without worry that the data will change (Yin). Documents may also provide a history of events that may span great lengths of time (Yin). It is critical to remember, however, that documents were not created for the case study, but instead offer information created for a specific purpose that may have little to do with the purpose of the case study (Yin). As a result,

information supporting the research will need to emerge from the documents instead of collecting data through a framework constructed for the purpose of the research (Guba & Lincoln, 1981). The disadvantage of utilizing documents in a case study involves the potential bias to which a researcher may unwittingly fall prey. The organization may limit the documents the researcher has access to or may censor some documents, introducing potential bias on the part of the document collection (Yin). If documents provide contradictory evidence or if they open new lines of inquiry, they should prompt the researcher to investigate further (Yin).

For this research, an organizational survey instrument was developed prior to the initiation of data collection. The organizational survey was completed during an initial interview with the president and the operations manger. The organizational survey was divided into six categories: physical (attributes), production style, financial, customer/marketing, manufacturing personnel and internal operations. Table 3.8 provides a sample of the items from each category on the survey. Appendix D contains the entire survey instrument.

Table 3.8. Sampling of Questions from the Organizational Survey

Physical	**Production Style**	**Financial**
– Average age of machinery – Square footage of buildings – Number of managerial positions	– Production system – Product variety – Production volumes – Skill level of production personnel	– Average per unit cost – Revenue per full time employee – Gross profit margin
Customer/Marketing	**Manufacturing personnel**	**Internal Operations**
– Average order completion time – Average percentage of orders delivered on time – Average amount invested per year in marketing/sales	– Turnover rate – Average amount of initial training – Compensation policies	– Number of suppliers – Amount of inventory typically held – Typical amount of work in progress

The data collected from the organizational survey did not directly support or contradict any of the research propositions, but did provide background on the organization. For example, the physical and manufacturing personnel categories provided information on the organizational structure. The background information collected also provided details about the organization for researchers wishing to replicate this research in a similar organization.

Additional documents collected consisted of the memo regarding the Five S activity and the activity sheets each manufacturing area submitted for the Five S activity. While the documentation was not used extensively in the analysis phase, it did provide important details about the lean implementation.

Raw production data was also collected and analyzed for the organization. The raw production data consisted of the number of products on the floor with shortages on a day in March 2003, a database listing all of the adjustments to inventory made from May 2002 to March 2003, a listing of all of the finished product held in inventory that did not have a pending order on a day in March 2003, and a database of all of the filled shortages from May 2002 to March 2003. The results of the analysis, based on the production data and the observations, were formally reported to the organization's management team with the aggregated results of the structured interviews. The raw production data was not used in this research, but did provide context for some of the struggles facing the organization.

3.4.5. Phase Four – Transcription

After initial data collection began, all field notes were transcribed using a word processing program. Field notes will not usually reflect all of the content of the structured/unstructured interview or observation and the transcribing process allowed for some content to be added back to the notes as memory of events was stimulated (Miles &

Huberman, 1994). The transcription process also sometimes raised further questions which allowed the researcher to go back to the case study site and fill in gaps in the data.

Sometimes it is recommended that interviews be transcribed word for word to be ensure all data is present (Patton,1990). This is particularly true if a tape recording was made of the interview and the transcription is completed by a typist. For this research, the researcher transcribed all observations and unstructured interviews. An attempt was made to utilize an outside typist for the transcription of the structured interviews, but the abbreviations used by the researcher caused some gaps in the data. Subsequently, the researcher transcribed the structured interviews, also. During the interviews, the researcher attempted to faithfully record everything word for word, but during transcription, unfinished sentences or thoughts were not transcribed if they provided no relevant information.

Transcription of the data collected during observations required more editing of content. At times, in order to allow a data source to finish a tangential thought, questions pertaining to one topic were suppressed until a break in the conversation. Such a tactic allowed the conversation to flow more easily, and put the interviewee more at ease, but it added another level of complexity to the reading of the field notes. As the field notes were also utilized as part of the larger NSF research project, the transcribed field notes needed to be understandable by other researchers. As a result, it was necessary to organize the data in a logical fashion to maximize readability. The content of the field notes remained the same, but the order of the data was moved and grouped by topic as appropriate.

3.4.6. Phase Five – Data Base Development

The amount of data collected in this research to be analyzed was considerable and could not be expediently or accurately processed without the aid of a computer. A database was designed to permit the data to be easily manipulated, allowing for more valid analysis (Miles & Huberman, 1994). While entering data into a database increases the amount of

work associated with the research, it does provide the advantage of allowing other researchers the opportunity to inspect the data leading to the conclusions presented by the researcher (Yin, 1994).

The details of the database design along with relevant background information on database models are described in this section. A database may utilize a relational data model, a network model, a hierarchical model, a record-based data model or an object data model (Elmasri & Navathe, 2000). The designing of the database is also commonly referred to as modeling. The modeling tools commonly employed include the Entity-Relationship (ER) model, the Universal Modeling Language (UML) and the Object Modeling Technique (OMT) (Elmasri & Navathe, 2000). Though the word "model" is frequently used when discussing database design, it's important to maintain the distinction in the definitions. For this research, the database model was based on a relational data model. The database was designed using an Entity-Relationship model.

The relational database model is a type of data model utilized in many database management systems (Elmasri & Navathe, 2000). The relational model was first introduced in 1970 and has its basis in mathematics (Elmasri & Navathe, 2000). It quickly became popular due to its simplicity (Elmasri & Navathe, 2000). In a relational model, the database is created based on a collection of relations. A relation is typically described as resembling a table of values, with each row in the table representing a collection of related data (Elmasri & Navathe, 2000). For example, a row in a table in an employee database would have all of the pertinent data for one employee. A relational database will then have a series of tables, with each table related to at least one other table. As an example, in an employee database, the employee table might be related to another table called department.

The design of the database for this research was accomplished by employing an Entity-Relation (ER) model. The ER model is a high-level tool for database design employed by many database designers (Elmasri & Navathe, 2000). The ER model has some variations, but the model typically utilized has four steps associated with it. The first step involves

understanding the functions of the database and what will be required of it. The second step requires creating a conceptual model based on the requirements of the database. The conceptual model is independent of both the database model and the software application employed to create the physical database. The third step involves translating the conceptual model into a logical model. The logical model is dependent on the database model, which for this research was the relational model. The logical model is independent of the software application utilized to create the physical database. A subsequent step of the logical model involves analyzing the model for efficiency. The last step of ER modeling involves creating the database in a software application based on the logical model.

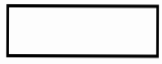
3.4.6.1. Database Requirements

The first step of database design involves examining the data to be stored in the database and the needs of the people who will be utilizing the database. At times it may mean collecting specific forms or pieces of data to promote further understanding of the requirements for the database. This database was designed not only for this research, but also for the larger NSF research project, requiring input from multiple database users as to requirements and expectations. The data to be collected in the database included the organizational survey, the structured interview data, the unstructured interview data, the observations, the case study report presented to the organization, and the list of all of the documents collected from the case study site. The basic data stored in the database did not change during the design of the database, though requirements pertaining to how the data was reported did change. Most of the data utilization changes affected the physical design of the database in the software application program.

3.4.6.2. Conceptual Model

The second step of the database design involves the creation of the conceptual model. The conceptual model is built using ER model specific terminology. Those terms necessary for explaining the conceptual model are defined in Table 3.9 as provided by Elmasri and Navathe (2000).

Table 3.9. Database Terminology

Term	Definition	Example	Graphical Representation
Entity (also known as a table)	The basic object represented by the ER model. An entity represents an object that exists independently.	An employee, an organization, a college course.	. 
Attribute	The characteristics associated with the entity.	Age, address, model, color, course time	
Value	The specific value an attribute has for each entity in the database.	Age: 39; Address: 222 Elm St.; Model: Toyota; Color: blue;	Not represented graphically.
Key	An attribute that will have a unique value for each set of attributes in the entity.	Social Security Number, Employee number,	Designated as PK for primary key. The attribute will also be underlined.
Composite Key	A key consisting of more than one attribute.	Vendor number and product number.	Both attributes will be underlined.
Foreign Key	A key that is "migrated" or copied to link entities.	Employee number might link the employee entity to the project entity.	Designated as FK for foreign key. It will only be underlined if it is a primary key or part of a composite primary key.
Relationship	Refers to how the entity relates to other entities.	Employee works for a department.	
Cardinality Ratios	Determines the number of relationships an entity can have with another entity.	An employee can work for one department, but a department may have multiple employees working for it.	A "1" represents those entities that have only 1 relationship. An "M" represents those entities that may have many relationships. If both entities have multiple relationships, an "N" is used on one side of the relationship.
Participation Constraint	Defines if an entity must have a relationship with another entity.	Every employee is assigned a car, but not every car has an employee assigned to it.	A single line between relationships indicates a relationship may occur. A double line indicates a relationship is required.

The initial conceptual design is illustrated in Figure 3.6. Attributes are typically represented with ovals, but to conserve space and present the design as concisely as possible, they were graphically represented in this conceptual design without the ovals. The dash across the participation constraints for the observations, the interviews, and the specific questions entities indicates that these entity types are a special type of entity called aggregates.

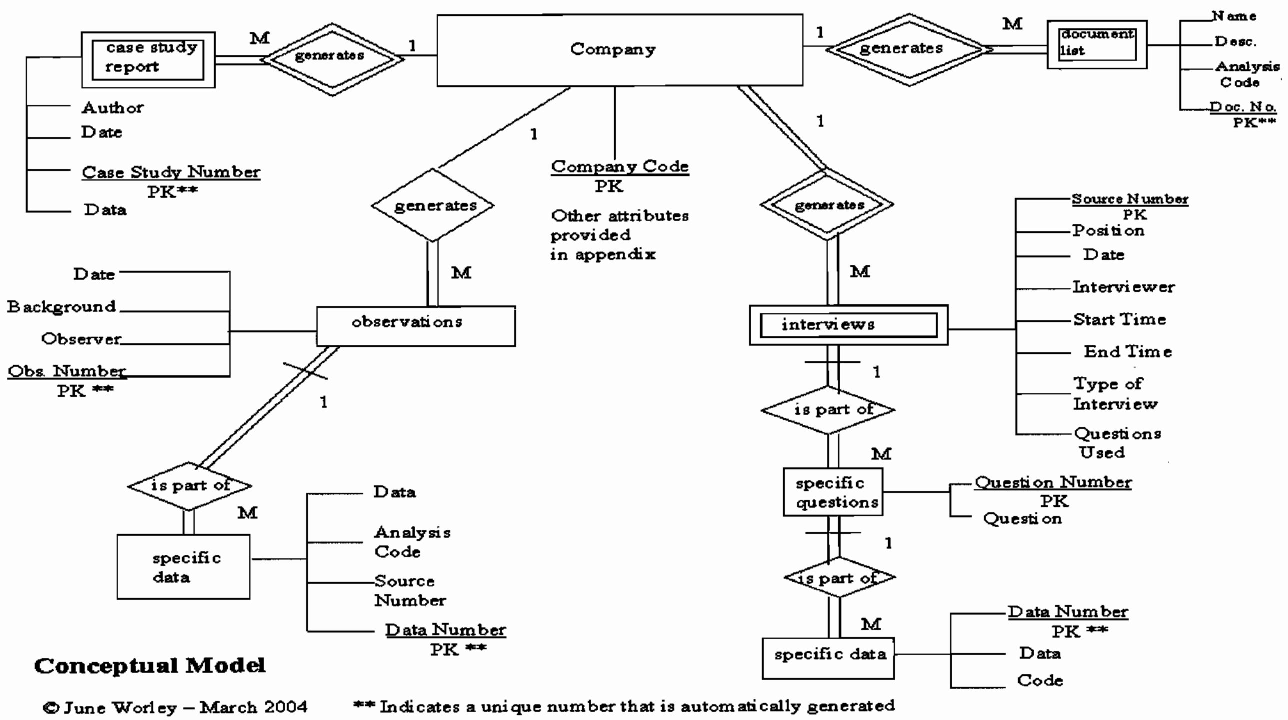


Figure 3.6. Conceptual Model

As data collection progressed, it was determined that more attributes were needed in the conceptual design. In was also determined that storing the interviews separately from the observations would only add unnecessary complexity to the database and possibly slow down entry of the data into the database. The revised conceptual design is shown in Figure 3.7.

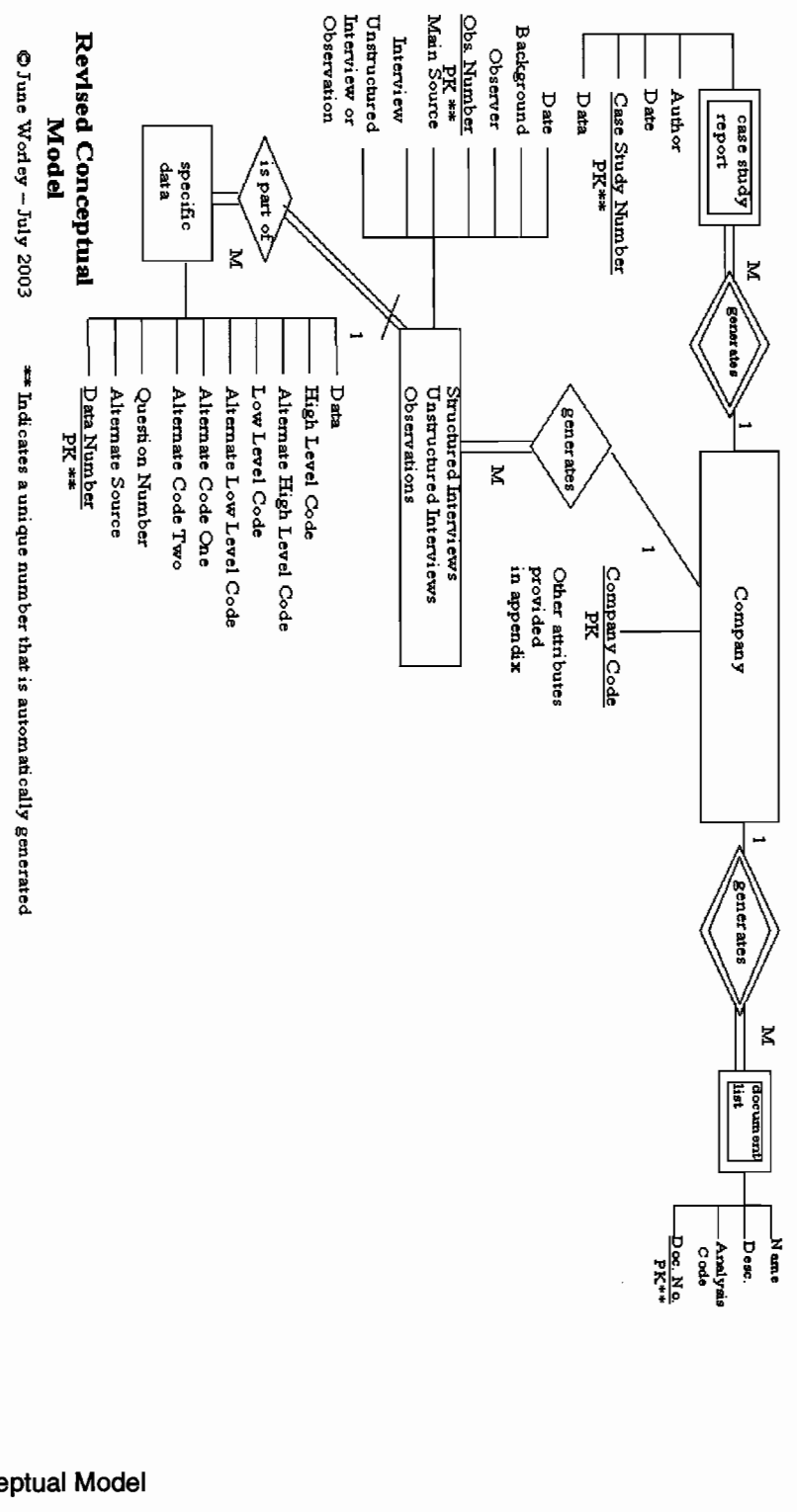


Figure 3.7. Revised Conceptual Model

The revised conceptual design deleted the interviews entity type and all of the associated entities (specific questions and specific data). It was determined that storing the actual questions was unnecessary. After conducting structured interviews, it was found that interviewees often would not answer the question posed. It was also determined that the question itself was often irrelevant and the raw data was the focus of interest. The observations and interviews were combined into one entity type. For those times when the question was of interest, a question number attribute was added to the specific data entity.

An interview attribute and an informal/observation attribute were added to the observations entity type. Upon later scrutiny, after data had already been entered into the database, it was determined that employing one attribute that specified the type of data would have been a more efficient method, but as data had already been entered into the database and extensive data entry would have been required to fix it, the attributes were left as initially created.

During the course of observations, sometimes more than one person would contribute to the conversation. To help maintain the separateness of the data sources for triangulation purposes, a main source attribute was added to the observations entity and an alternate source attribute was added to the specific data entity. Source number was deleted from the specific data entity.

Initial coding of the data also resulted in some additional requirements for the database. Coding data involves assigning specific codes to the data according to a framework developed by the researcher. For the NSF research, a framework was developed that utilized four higher level codes and 21 lower level codes. Initial coding also revealed the need to sometimes utilize multiple codes for the same piece of data. To facilitate analysis, a high level code attribute, a lower level code attribute, an alternate high level code attribute and an alternate low level code attribute were added. It was envisioned that the database would be utilized for future research. To add even more flexibility, two additional attributes were also added: alternate code one and alternate code two.

After the database had been translated into application software, it was discovered that creating reports utilizing alternate codes for the same piece of data was difficult. The problem may have been solved with some extensive programming, but it was determined at the time that a simpler solution would involve simply copying the data to another record and adding the appropriate high level and low level codes in the new record. Though this caused duplication of the raw data in the database, storage space was not a constraint and it was determined that this redundancy provided the best solution to this issue. As a result, the alternate high level code attribute, the alternate low level code attribute, the alternate code one attribute and the alternate code two attribute were not utilized in the database. They were left in the database, however, as they may be useful in future research projects.

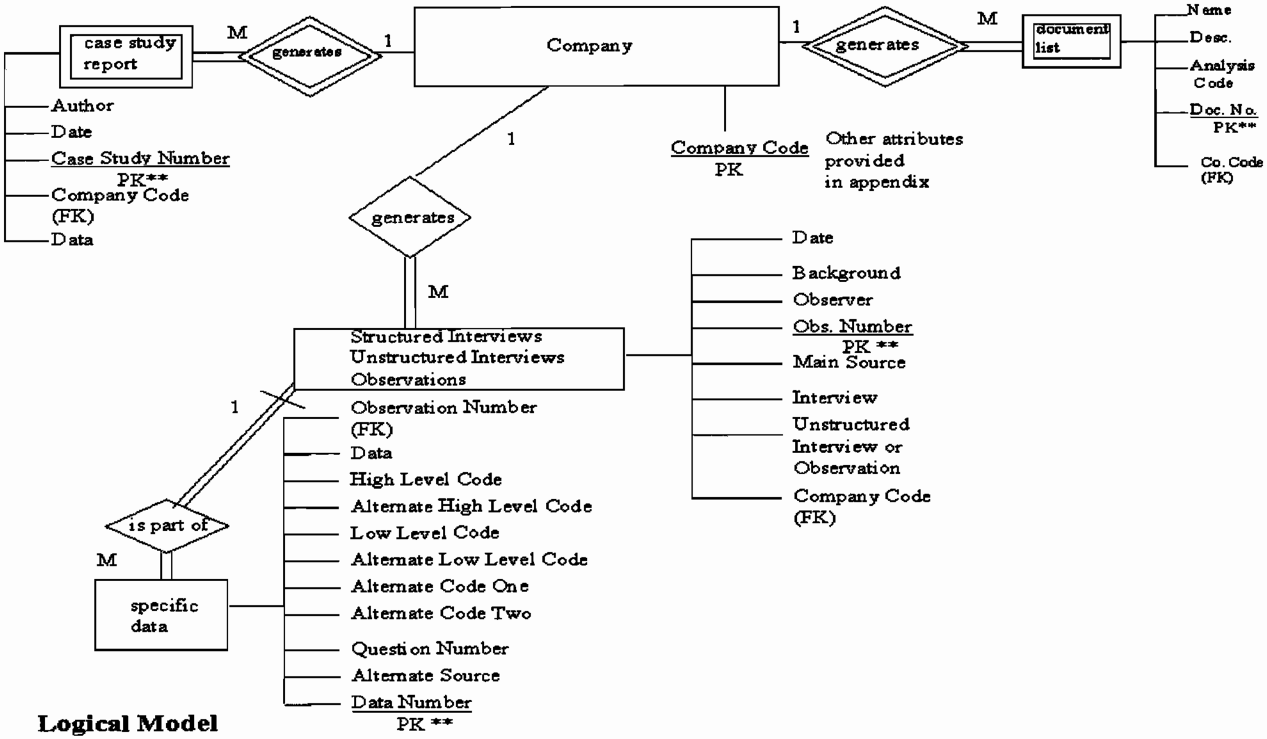
3.4.6.3. Logical Model

The logical model of the database involves relating the conceptual design, to the database model (Elmasri and Navathe, 2000). For this research, the conceptual design was related to a relational data model. For more complex database models, this step of database design can be extensive. For this database, it only involved migrating the primary keys based on the rules of cardinality and participation.

Migrating the primary keys is defined as moving a copy of an attribute to a related entity. It creates a link between the entities, and in turn, related records in a database. For example, if the entity "employee" is assigned to the entity "car," each entity has a unique primary key. Each employee record in the database is uniquely identified by the employee's social security number. Each record in the car database is uniquely identified by the vehicle identification number. To link the specific employee to the car he or she is assigned, key migration must occur. Assuming each employee is assigned a car, but some cars may not be assigned to an

employee, according to the rules of migration, the vehicle identification number would migrate to the employee entity.

For this research, the company code attribute was used as the link between the company entity and the case study report entity, the document list entity, and the structured interviews/unstructured interviews/observations entity. The observation number was the key used as a link between the structured interviews/ unstructured interviews/observations entity and the specific data entity. The logical model for this research is in shown in Figure 3.8. The logical model serves as the foundation to analyze the database design for efficiency, also known as normalization. The logical model also acts as the architectural plan when implementing the database in application software.



Logical Model

** Indicates a unique number that is automatically generated

Figure 3.8. Logical Model

3.4.6.4. Normalization

Normalization involves determining if the entities in the database use space as efficiently as possible (Viescas, 1999). Normalization ensures that the database has minimized redundancy and minimized the possibility of anomalies occurring when updating, deleting, or inserting data (Elmasri and Navathe, 2000). Some normalization may involve scrutinizing the entities for fields that are redundantly represented. The migrating keys will be unavoidably redundant data, but duplication of other information should be avoided (Viescas, 1999). Normalization also involves analyzing the attributes in each entity for functional dependency. Functional dependency occurs when the value of an attribute depends on the value of another attribute (Elmasri and Navathe, 2000). For example, if the value of the social security number attribute equals 555-55-5555, then the value of the name attribute in the employee entity will always equal John Doe.

The process of normalization occurs by analyzing the entities through five subsequent steps called first normal form, second normal form, etc. (Elmasri and Navathe, 2000). The entities in this research were normalized through the fourth normal form. It was determined that the fourth normal form was adequate due to the lack of complexity associated with this database. If an entity fails a normal form, the entity is decomposed into a series of smaller relationships until the criteria of the specific normal form are met (Elmasri and Navathe, 2000).

During the first normal form, the possible values of the attributes in the entity are evaluated. The attributes must contain only single values. Multiple solutions exist for transforming a model into first normal form, but the most common solution involves placing the attributes that violate first normal form in a separate entity, with the attributes forming a composite primary key for the entity. For example, if a department number attribute has multiple possible locations associated with it, the department number attribute and the location

attribute would be moved to another entity where the primary key would consist of both the department number and the location. Each record in the new entity would have only one location entered for each department number. Figure 3.9 provides an illustration of this concept.

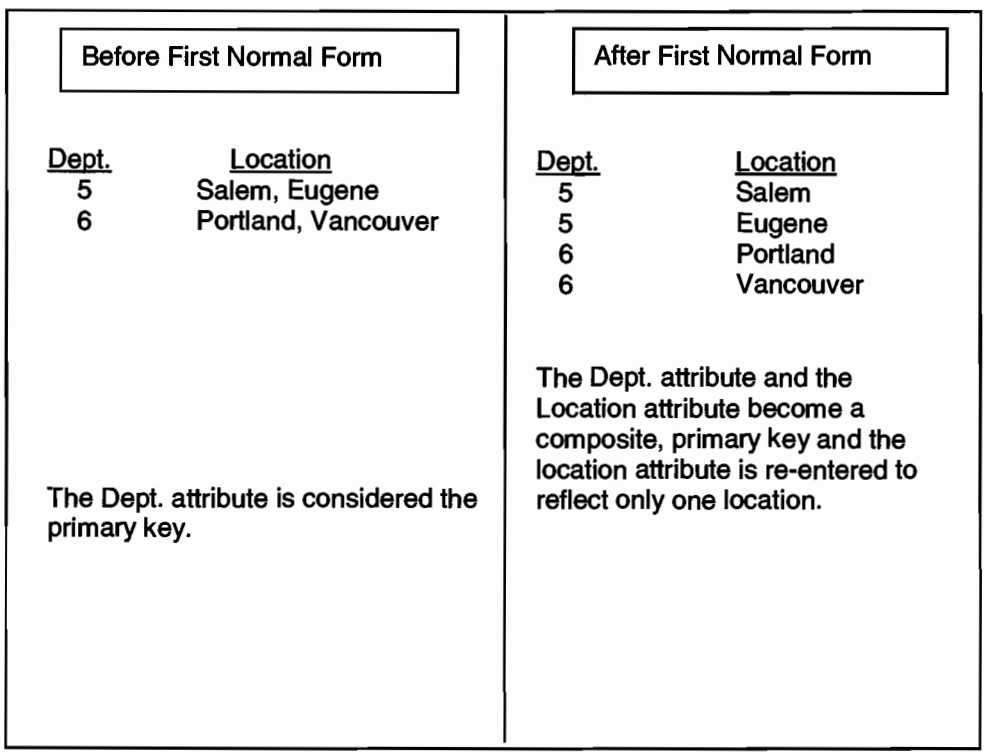


Figure 3.9. Example of First Normal Form Transformation

For this research, none of the attributes were determined to have violated first normal form.

The second normal form involves scrutinizing the attributes for functional dependencies (Elmasri and Navathe, 2000). This step is only necessary for those entities containing a composite key (a primary key consisting of more than one attribute) (Billo, 2002). Every attribute that is not designated as a key must be fully dependent on the primary key. If a violation is found, the attributes must be placed in their own entity. For example, a supplier entity may include the supplier number, the part number, the location of the supplier, and the

quantity. The composite key is the supplier number and the part number. The location attribute, however, is solely dependent on the supplier number. This concept is illustrated in Figure 3.10 with a dependency diagram. A dependency diagram is a graphical illustration of attribute dependencies. An arrow indicates that the attribute's value is dependent on value of the other attribute.

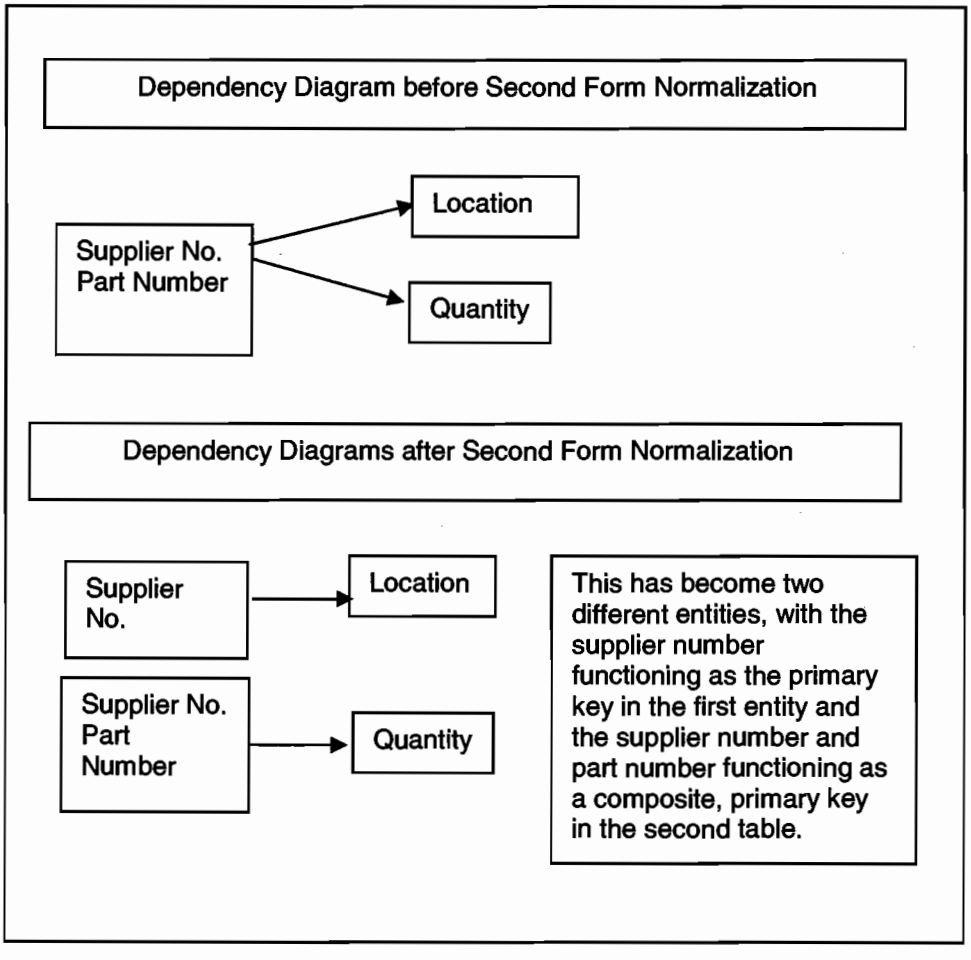


Figure 3.10. Example of Second Normal Form Transformation

This database design contained no composite keys so no further analysis was necessary. The logical design was judged to be in accordance with second normal form.

The third normal form focuses on nonkey attributes that may be dependent on other nonkey attributes (Elmasri and Navathe, 2000). If a violation of third normal form is found, the attribute that has other attributes depending on it is evaluated. If it is an attribute that is a candidate to be a primary key (as it has a unique value for each record), then the entity is considered to be in Boyce-Codd normal form and it is left as originally constructed (Elmasri and Navathe, 2000). An example of this occurs in an employee entity that contains an employee number attribute and a social security number attribute. All other attributes of the entity are dependent on both attributes. Figure 3.11 illustrates this concept.

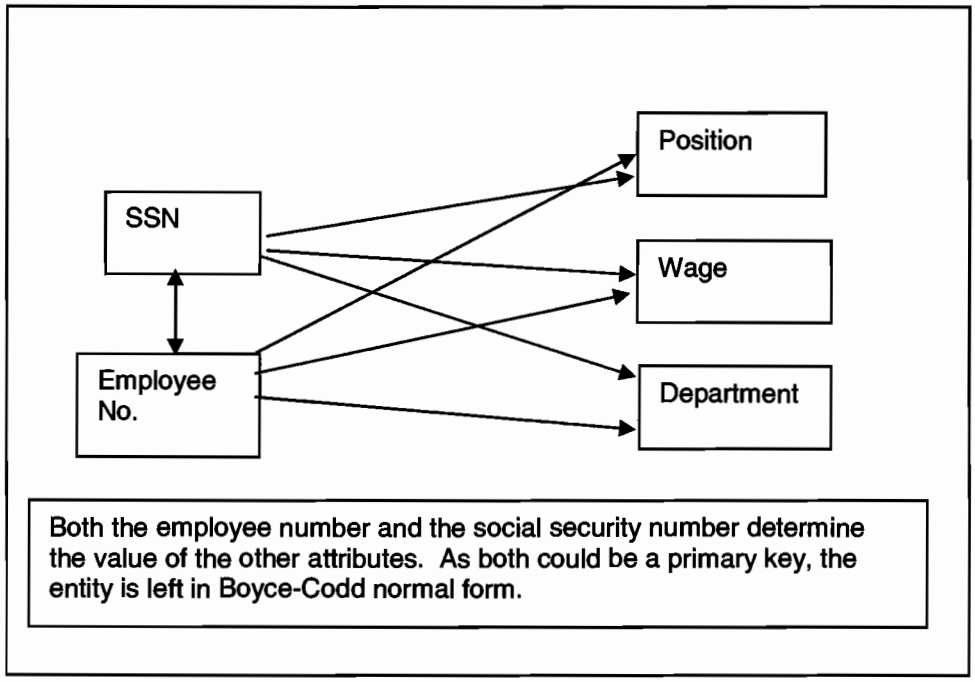


Figure 3.11. Example of Boyce-Codd Normal Form

If the attribute is not a candidate to be a primary key, the attributes would be deconstructed into their own entity (Elmasri and Navathe, 2000). For example, an employee table includes various attributes relating to the employee including a street address, a city, a

state, and a zip code. The city and state attributes are dependent on the zip code. This relationship would be broken out into its own entity as illustrated in Figure 3.12.

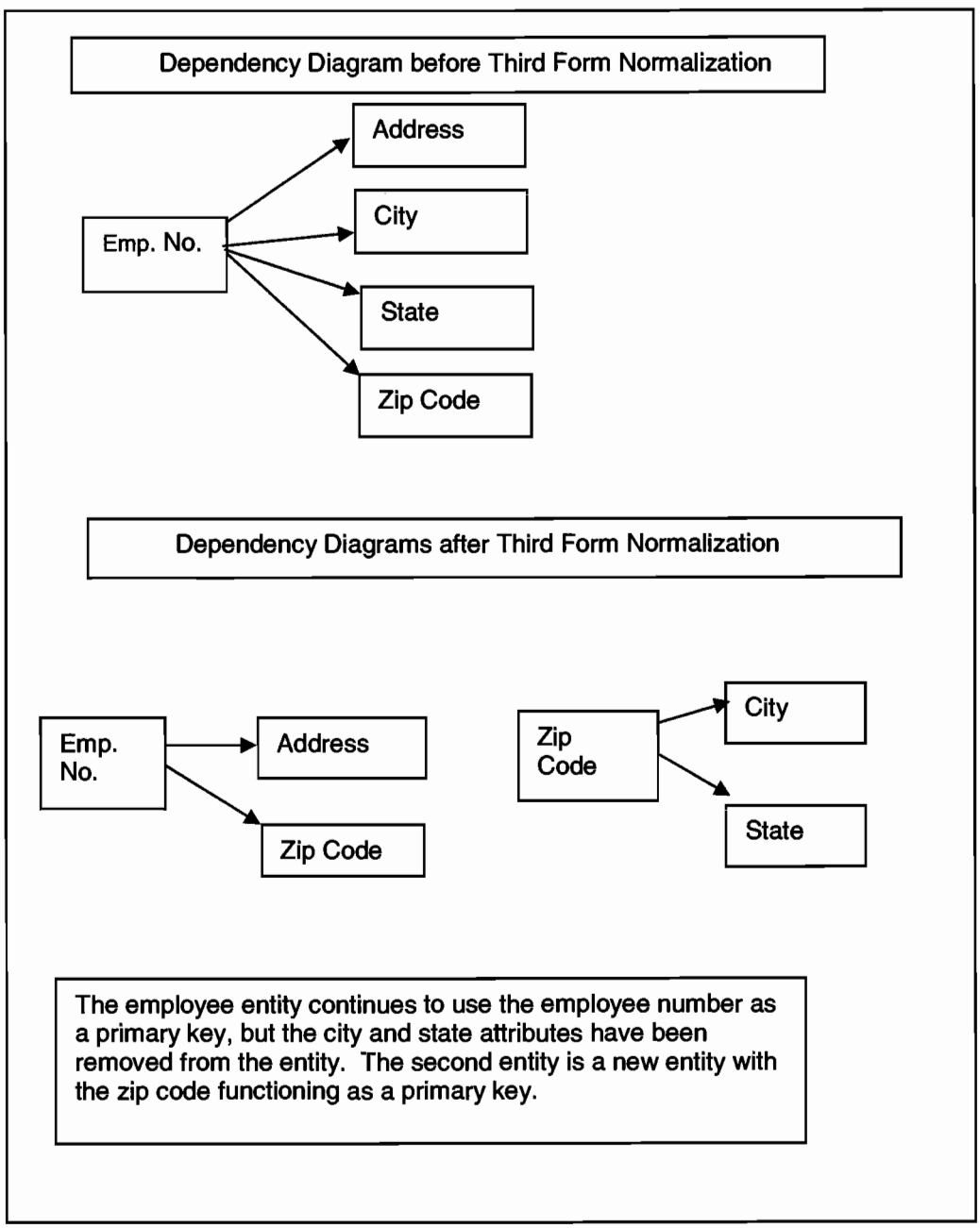


Figure 3.12. Example of Third Normal Form Transformation

The logical model was analyzed for third normal form violations. Some possibilities immediately surfaced and were investigated. In the case study report entity, the author, date,

and company code could all be dependent on the data attribute. The data attribute is unique, however, and a candidate to be a primary key. Designating it as a primary key would be impractical, as a primary key should be short and preferably numeric to increase efficiency in application software. As the data attribute is a candidate for a primary key, the entity was considered to be in Boyce-Codd normal form and it was left as originally constructed. The dependency diagram for the case study report entity is illustrated in Figure 3.13.

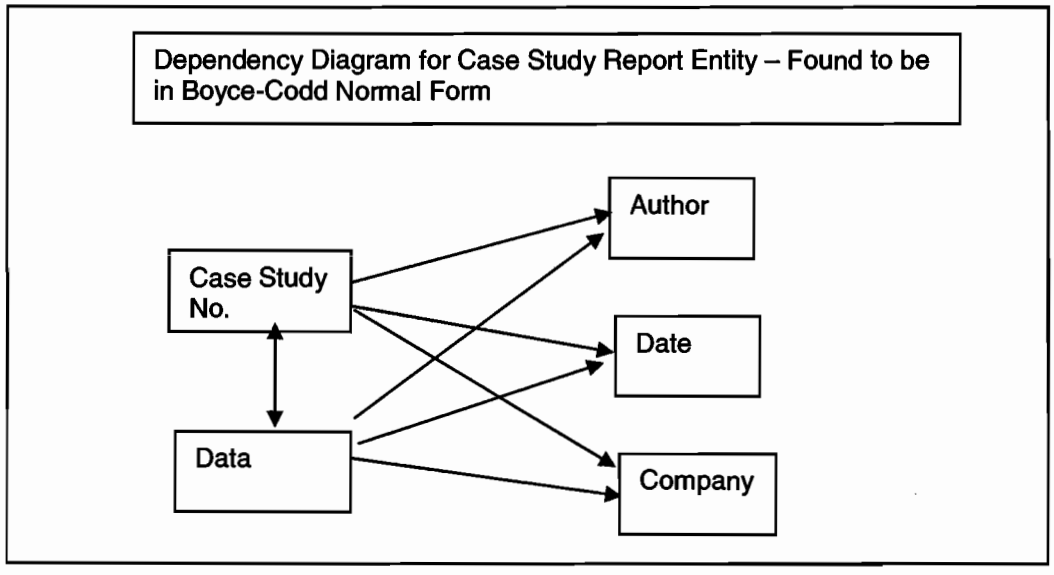


Figure 3.13. Dependency Diagram for Case Study Report Entity

The document list entity was examined next. The description attribute could be an attribute that would be unique enough to provide potential dependencies , but it was determined that at times this attribute may not be filled in, as the name of the document would be description enough. As the description attribute could contain null values, it would not pose a violation of the third normal form.

The company entity was examined and found to also be in Boyce-Codd normal form as the company code attribute as well as the company name attribute could both function as primary keys. As the company entity was in Boyce-Codd normal form, its structure was left as

originally designed. The dependency diagram for the company entity is illustrated in Figure 3.14.

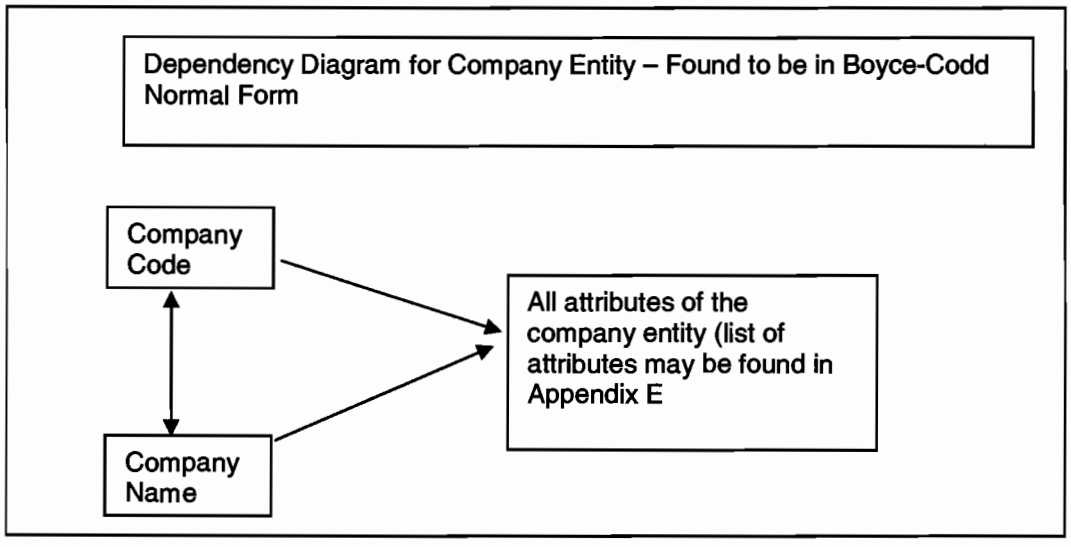


Figure 3.14. Dependency Diagram for Company Entity

The structured interviews/unstructured interviews/observations entity was found to be similar to the document list entity. The background attribute could potentially have other attributes dependent on it, but the background attribute was often left unused, resulting in many null values. Due to the null values, the structured interviews/unstructured interviews/observations entity was not considered to be in violation of the third normal form.

The last entity examined, the specific data entity, contained the data attribute that also had the potential of violating the third normal form if it had not been decided that data would sometimes be duplicated within the database when more than one code applied to it. If the data had not been duplicated, it would have been a potential primary key and the entity would have been considered in Boyce-Codd normal form. As the data attribute was the only attribute potentially in violation of the third normal form, the specific data entity was deemed to be in third normal form in its present structure.

The last normalization performed for this research is called fourth normal form. It involves examining the database for attributes which have multivalued dependencies. This is a complex topic and is best served by illustration. Figure 3.15 provides an example of an entity that is in violation of fourth normal form (adapted from Elmasri & Navathe, 2000).

Employee Entity in Violation of Fourth Normal Form

Employee	Project Assigned	Employee Dependents
Doe, John	72	Jim
Doe, John	73	Jim
Doe, John	75	Jim
Doe, John	72	Molly
Doe, John	73	Molly
Doe, John	75	Molly
Doe, John	72	Xavier
Doe, John	73	Xavier
Doe, John	75	Xavier
Wilson, George	72	Dennis
Wilson, George	74	Dennis

Figure 3.15. Example of Fourth Normal Form Violation

In this example of a fourth normal form violation, the employee entity requires all three attributes to form a unique composite primary key. Problems occur in such a design when new records are added. For example, to add employee John Doe to project 74, three records would need to be added to the database: one that lists his son Jim, one that lists his daughter Molly, and one that lists his son Xavier. This causes inefficiencies not only when new records are added to the database, but also in terms of storage (Elmasri & Navathe, 2000). Problems during the deletion or modification of records could also occur in databases with fourth normal

form violations (Elmasri & Navathe, 2000). To fix this example, the employee entity is deconstructed into an employee projects entity and an employee dependents entity. Figure 3.16 provides an illustration of how the records would appear once the entity is deconstructed to meet fourth normal form requirements. In the project entity, the composite primary key is the employee name and the project name. In the employee dependents entity the composite primary key is the employee name and the dependent name.

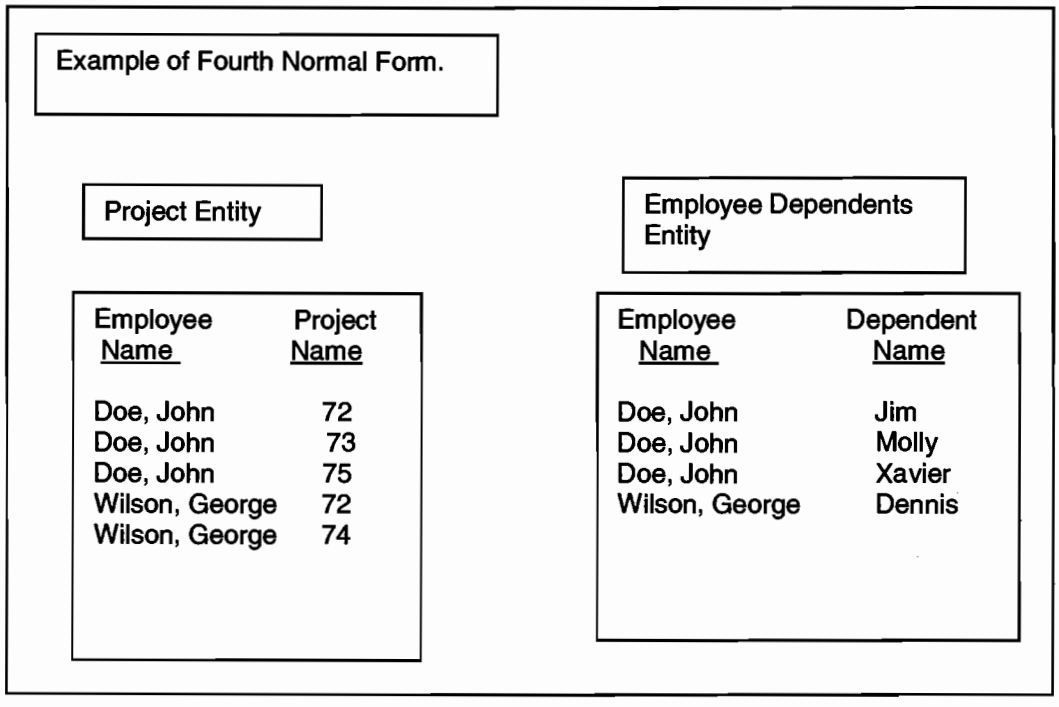


Figure 3.16. Example of Fourth Normal Form Transformation

Re-constructing the employee entity to meet fourth normal form requirements reduced the number of records stored. Finding violations of fourth normal form is difficult, but a violation usually involves those entities requiring three or more attributes to form a composite primary key (Billo, 2002). The database constructed for this research contained no composite keys. The database was determined to be in accordance with fourth normal form.

Normalizing a database can be a complex task involving multiple steps. Often, once an entity is deconstructed into smaller, related entities, the smaller entities must be scrutinized to ensure normalization is maintained. Once the logical model is in place and the database has been thoroughly examined for efficiency and redundancy it can be physically implemented in an application software.

3.4.6.5. Application Software

During the last step of ER modeling, the logical model is translated into an application software program. For this research, Microsoft Access 2000 was used. A table was constructed for each entity, utilizing the attributes detailed on the logical model. The tables were related in Access through the migrating (also known as foreign) keys. The screens for interacting with the data, also known as "forms" in Access, were then constructed. A main menu screen, also known as a "switchboard" was constructed to allow the user to enter data or print reports. A copy of the switchboard is shown in Figure 3.17.

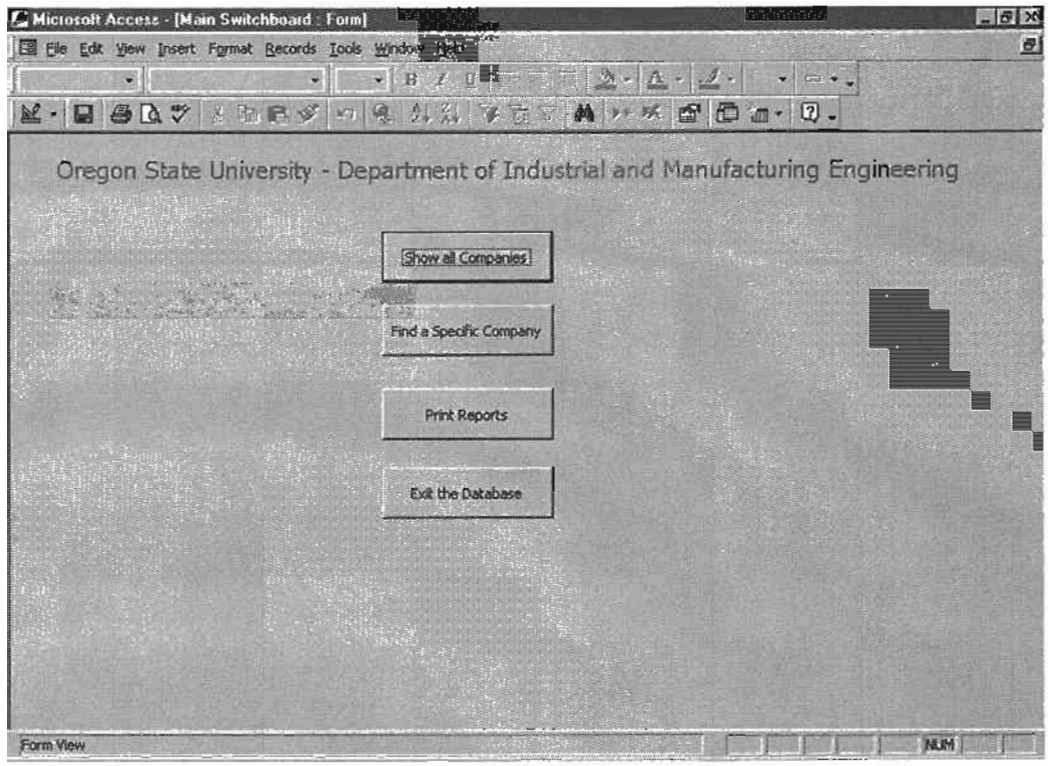


Figure 3.17. View of Switchboard Screen

If a user chooses to enter data or look at the data in the data base, the user can choose a specific organization ("Find a specific company") or all of the organizations ("Show all companies"). Choosing either option will open another form that will allow the user to choose which type of data entry to perform. The form is illustrated in Figure 3.18.

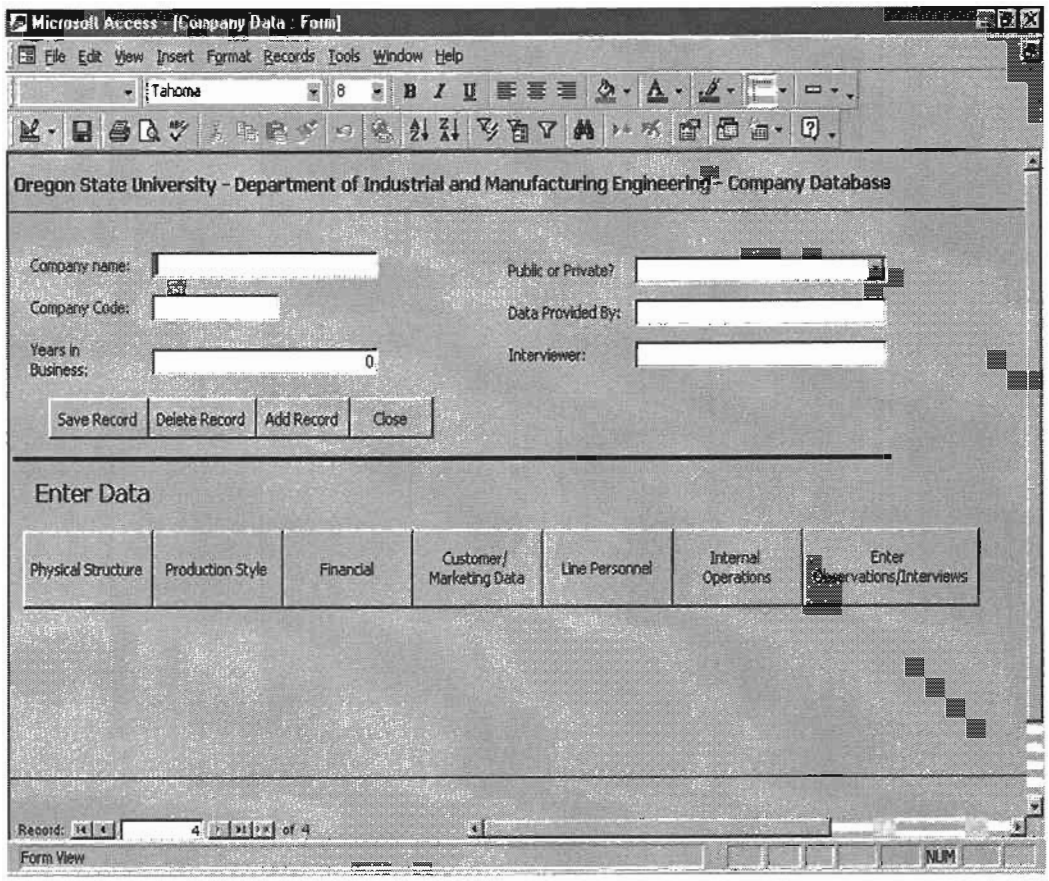


Figure 3.18. View of Data Entry Screen – Organization

From this screen, the researcher is able to enter or access data from the organizational survey, as well enter or access data from the observations, unstructured interviews, or structured interviews. The screen for entering observations, unstructured interviews, or structured interviews is illustrated in Figure 3.19.

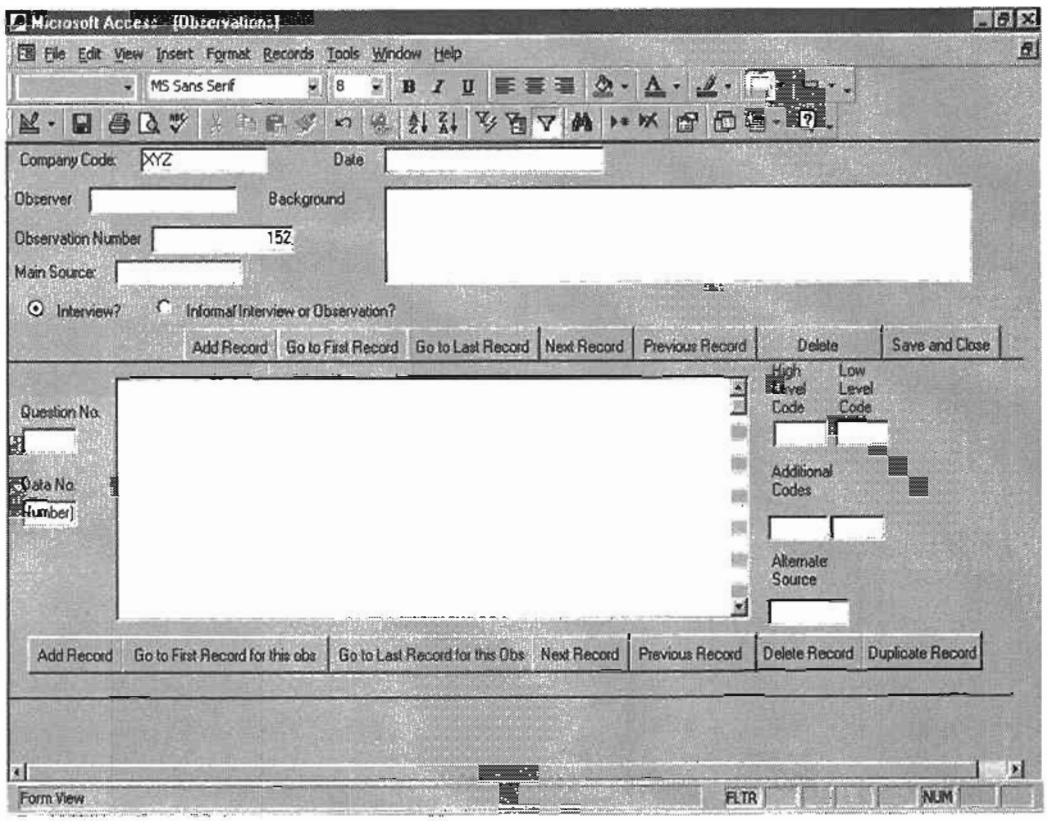


Figure 3.19. View of Data Entry Screen – Specific Data

The logical model lists a case study report entity and a document list entity. Tables for both entities were constructed in Access, but forms were not implemented. It is anticipated that this aspect of the database will be implemented during the next year.

The last aspect of transforming the logical model into the physical application software involved creating the reports. The reports were critical in providing a concise and efficient summary of the data. Several reports were created specifically for the NSF research. The report created for this research sorted the data by code, providing a useful tool for further analysis. An example of the report created for this research is illustrated in Figure 3.20.

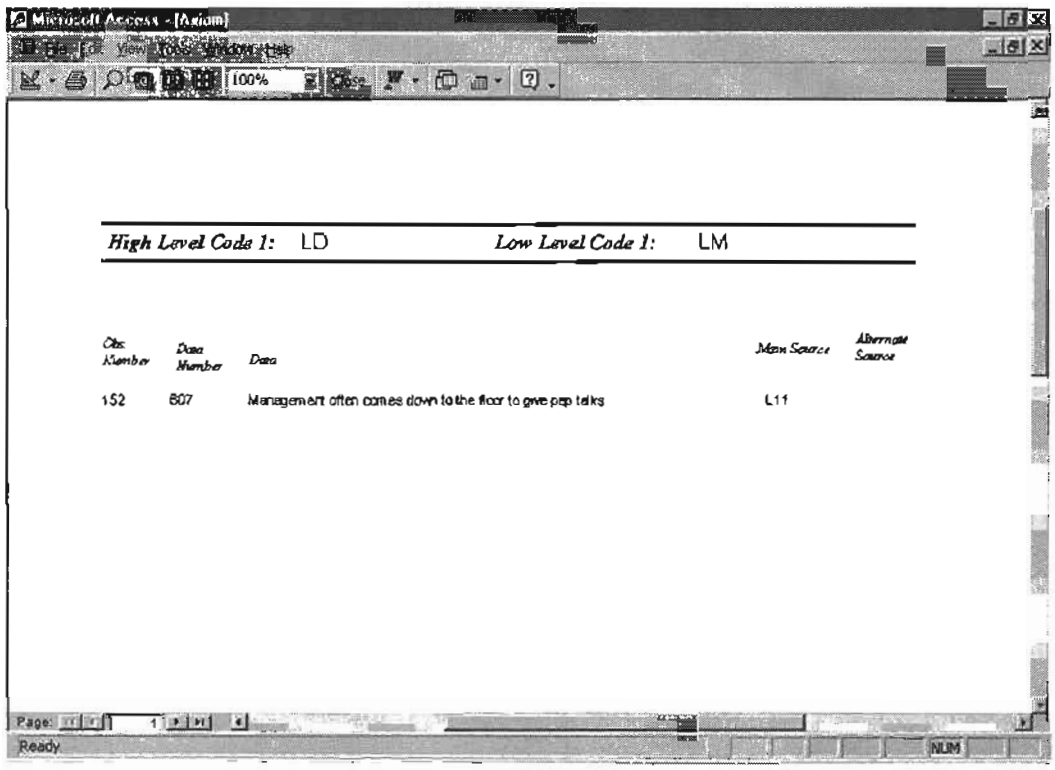


Figure 3.20. Example of Matrix Report

This report is very simple, sorting the data by high level code (listed in the example as LD) and low level code (listed in the example as LM) and then sorting by observation number and data number. The interviews and observations were entered chronologically from the transcribed field notes so sorting by observation number and data number provides some order. The report also lists the source(s) the data is attributed to so responses may be evaluated to ensure they provide unique evidence, and not just a continuation of evidence provided by the same source.

Completion of the database, data collection, transcription of the field notes and some coding of the field notes occurred concurrently. This allowed the design of the database to be adjusted to assure that the database could provide flexibility for both the NSF research and

this research. With the completion of the database, the coding of the remainder of the field notes was concluded.

3.4.7. Phase Six – Data Coding and Analysis

Upon development of the research questions, a conceptual framework was developed to group the data into appropriate categories (Miles & Huberman, 1994). A conceptual framework graphically illustrates the variables of interest in the research and the relationships between them (Miles & Huberman). The initial framework developed for this research is illustrated in Figure 3.21.

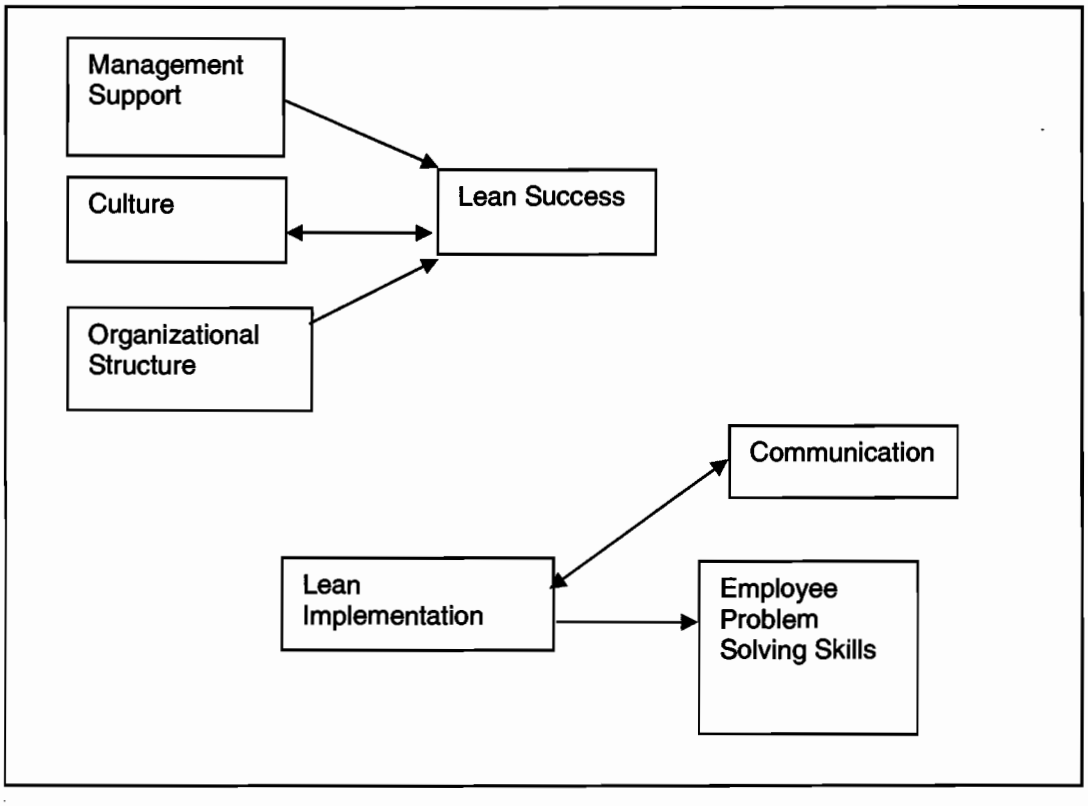


Figure 3.21. Initial Conceptual Framework

At conception of the research propositions, an attempt was made to relate the independent variables management support, culture, and organizational structure to lean success. Further investigation revealed the complexity of measuring a qualitative entity such as lean success and the research propositions were modified to study the impact of the independent variables on the lean implementation through the balanced scorecard. During initial formulation of the conceptual framework, the culture variable was viewed as both an independent and a dependent variable, but in the interest of maintaining a tighter focus, it was determined that investigating its role as an independent variable would be more appropriate. Communication was also initially designated as an independent and dependent variable, but it was determined that focusing on its role as a dependent variable would be more consistent with the overall research objectives. The revised conceptual framework is illustrated in Figure 3.22.

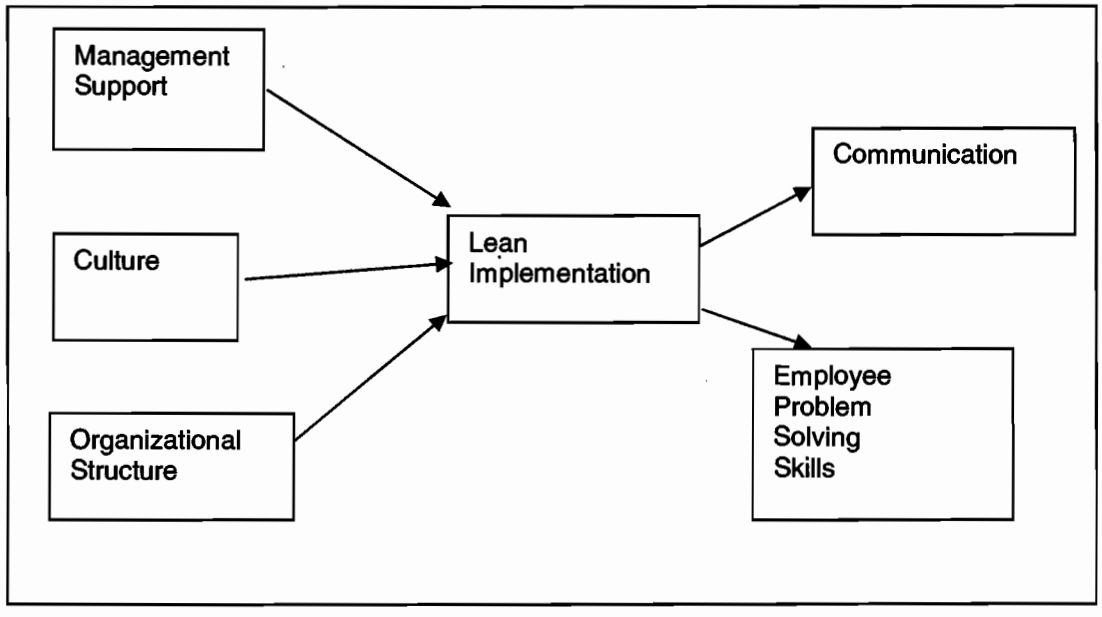


Figure 3.22. Revised Conceptual Framework

The amount of data collected in a qualitative study is often voluminous. Coding is a method for coping with this large data set. A code is defined as a label or tag that assigns meaning to a piece of data (Miles & Huberman, 1994). Coding can also be considered part of analysis as it involves scrutinizing transcribed field notes and assigning codes, while maintaining meaningful relationships between the pieces of data (Miles & Huberman). The codes allow the researcher to organize the data and also motivate the researcher to clarify those aspects of the research that remain unclear as the data is labeled and grouped.

Codes are commonly created from the conceptual framework, the hypotheses, or the research questions (Miles & Huberman, 1994). It is important that the codes have some sort of structure detailing the relationship between the codes. Three types of codes are commonly used. A descriptive code assigns a "class of phenomena" to a piece of data (Miles & Huberman, 1994: 57). An interpretive code involves more judgment on the part of the researcher as to the underlying meaning of the data (Miles & Huberman). A pattern code is employed when a pattern or theme has been detected. It is used to explain or infer meaning to the data (Miles & Huberman). Pattern codes are usually employed as a grouping mechanism for pre-coded sets of data. Pattern coding reduces a data set into more manageable units for analysis. Pattern coding also allows the researcher to begin preliminary analysis to focus subsequent data collection at the case study site (Miles & Huberman).

At times, the codes initially defined before data collection will need to be revised (Miles & Huberman, 1994). Many times codes will be created during data collection as new ideas emerge. Remaining open to these new ideas will strengthen the research. Additionally, some of the codes initially used will be inadequate and will subsequently be abandoned. On other occasions, the researcher may find much of the data is assigned the same code because the initial list of codes was too generally defined. In this case it is necessary to refine the codes into sub-codes to provide smaller sets of more meaningful data.

When coding the actual data, the researcher may assign more than one code to a piece of data, but care should be taken to manage this thoughtfully (Miles & Huberman, 1994).

Assigning multiple codes to the same piece of data may make analysis more difficult later. It is also important to realize that not every sentence or paragraph from the field notes will be coded. Often, the field notes contain a great deal of extraneous information and providing every word with a code is unnecessary. It is also a good practice to code field notes before the next visit to the case study site to facilitate ongoing analysis.

Based on the conceptual framework established for this study, the field notes were initially coded using the labels communication, management support, culture, organizational structure, problem resolution, success, and failure. During the coding process, some of the field notes provided no pertinent information for the research propositions and as a result were not labeled with a code. Some pieces of data were assigned more than one codes.

After initial coding, the field notes were entered into the database. The database was opened and sized to fit approximately one half of the computer screen and the word processing program was opened and sized to fit the other half of the computer screen. Employing such a process allowed the data to be easily copied and pasted into the database. The appropriate background data was entered into the database as well as the preliminary data codes.

Once data is coded and entered into a database, it may be displayed employing a variety of frameworks. A context chart displays a mapping between the roles and the groups to provide context for the data (Miles & Huberman, 1994). A checklist matrix displays a table of the data for a single variable (Miles & Huberman). Checklist matrices offer a methodology for exploring a new research question (Miles & Huberman). An event listing displays the data in a matrix arranged chronologically, with the data sorted by category (Miles & Huberman). Event listings help researchers understand processes and can be transformed into event state networks to provide a more graphical representation (Miles & Huberman). Role ordered matrices display data grouped by the roles of the sources and help the researcher explore how interactions occur between entities (Miles & Huberman). Conceptually clustered matrices group items of interest, such as a grouping of the data by research question and by

interviewee. A conceptually clustered matrix allows the researcher to discover relationships between variables and make contrasts or comparisons (Miles & Huberman). An effects matrix displays data related to outcomes and is particularly useful when working with dependent variables (Miles & Huberman).

Upon completion of data entry, a checklist matrix was generated which sorted the pieces of data by the data code. After examining the matrix, it was found that some of the data labeled with one of the independent variables (management support, culture, or organizational structure) were incorrectly coded and were re-coded as a failure or a success. The pieces of data that were re-coded were cross-referenced against the existing data coded as a success or failure. If the data was duplicated, the re-coded piece of data was deleted. Most of the remaining field notes coded as culture, management support, or organizational structure typically provided background information regarding the variable and its relationship to the lean implementation or general information unrelated to the lean implementation.

After initial examination of the data, a subsequent coding scheme was developed to further classify the data to reflect the research propositions. As the data coded with the independent variables provided background information rather than examples of how the variable impacted the lean implementation, the data coded as success or failure had to be further refined to not only assess the impact of the independent variables, but to also categorize the success in terms of the balanced scorecard. The dependent variables (communication and employee problem solving skills) were also given another set of codes to assess how the lean implementation impacted them. Table 3.10 provides the new coding scheme.

Table 3.10. Coding Scheme

Initial Code	Second Code	Third Code
Independent Variables: – Culture – Organizational Structure – Management Support	NA	NA
Success, Failure	– Customer needs – Customer satisfaction – Employee attitude – Employee skills – Processes streamlined, waste eliminated – Lean concepts adopted	– Culture, Management Support, or Organizational Structure played a direct role in the success or failure – None of the independent variables played a role in the success or failure
Dependent Variables: – Communication – Employee Problem Solving Skills	– Positive evidence, attributable to the implementation – Positive evidence, but not attributable to the implementation – Difficulties noted despite the implementation – Variable deteriorated due to the implementation – Variable deteriorated, but not attributable to the implementation	NA

The second code for the pieces of data labeled as success or failure classified the success or failure in terms of the balanced scorecard developed for this research. The third code for the notes coded as success or failure was used to assess the impact of the independent variables on the success or failure. After the second level of coding was completed, a new matrix was generated. A partial sample of the matrix is shown in Figure 3.23.

High Level Code 1 *S* ***Low Level Code 1:*** EA **ALT:** NV

102 170	Comments: L2 felt was much better working in own cell – it's nice to have own space and not feel like intruding on others and they aren't intruding on L2. Doing the exercise	E3
102 176	Comments from the team: They have more room – it's much neater and got rid of lots of extra stuff. It looks nicer when customers come through.	E3

Figure 3.23. Sample of Matrix Report

Once data is organized, interpretation of the data, also commonly referred to as analysis, can begin (Patton,1990). Interpretation is defined as "attaching significance to what was found, offering explanations, drawing conclusions, extrapolating lessons, making inferences, building linkages, attaching meanings, imposing order, and dealing with rival explanations, disconfirming cases, and data irregularities as part of testing the viability of an interpretation (Patton, 1990: 423). Interpretation of the data is an important step in research, but the researcher must be clear as to what is interpretation and what is description. The researcher should confirm what is supported by the data, highlight misconceptions of the data, and provide evidence of important data that may not have been obvious. It is also important that other interpretations of the data be presented (Yin, 1994).

Interpreting or analyzing the data in qualitative research provides unique challenges. The data set is large and absolute sets of rules for analysis of qualitative data do not exist (Yin, 1994). Analysis often depends on the researcher's skill level. The primary goal of qualitative data analysis is to present the data fairly while communicating the results of the data (Patton, 1990; Yin). Methodologies for analysis vary considerably, with no formulas to follow. The methodologies that are documented offer different perspectives. Some of the

methodologies focus more on the organization and presentation of the data, while other methodologies offer specific advice as to the analysis process itself (Miles & Huberman, 1994; Yin).

Miles and Huberman (1994) write of several tactics for organizing the data. Many of the tactics either reduce the data set even further or attempt to find patterns in the data. Some of the tactics include finding patterns, clustering the data, comparing and contrasting the data, counting the data, and factoring the data.

Pattern finding involves looking for patterns in the data (Miles & Huberman, 1994). Finding patterns in the data is a natural human behavior, but it is important to evaluate the patterns to ensure they are logical and can be tested against new data. Clustering the data is a tactic to group entities with similar patterns or characteristics and may involve grouping actions, data sites, data sources, or processes. Comparing and contrasting data offers another methodology for evaluating the differences between cases and trying to understand why the differences may exist. Factoring involves studying those pieces of data that are clustered together and exploring the factor that the data has in common. Counting data involves tallying the number of pieces of evidence supporting a proposition or contradicting it. Counting allows the researcher to see how much evidence was actually accumulated. It may also help to confirm or discredit a hypothesis. Most importantly, counting may help justify the researcher's claims (Miles & Huberman). Researchers often tend to give more credence to facts they believe in and may forget facts that contradict their propositions. Counting the supporting evidence and the contradicting evidence helps confirm the researcher's analysis and findings.

Pattern matching is a dominant analytical method (Yin, 1994). A pattern or theory is used to predict outcomes. If the overall pattern of the data matches the predicted pattern, it adds strength to the research propositions. If the data does not match the predicted pattern, the research propositions must be re-evaluated (Yin). Explanation building is another analytical method that employs some pattern matching (Yin). Explanation building is often

employed for exploratory case studies and involves investigating links between a phenomenon and the variables affecting it. Explanation building often involves comparing the findings of an initial data set against initial propositions, revising the propositions, and comparing the findings of a data set from another case study against the new propositions (Yin). This process continues as needed.

Some analysis of the data in this research occurred during the coding process, especially when patterns were noted after the initial coding. After the matrix report was generated, an explanation building methodology was employed. Causal links between the data and the research propositions were evaluated for supporting and contradictory evidence. Some patterns were found in the data that did not support the propositions and the factoring technique was employed to investigate common factors in the contradictory evidence. Counting of the supporting and contradictory evidence was also employed to further characterize the findings.

The methodology for analyzing qualitative data is varied. Analyzing and interpreting qualitative data begins during data collection, when the researcher is making observations or writing down responses to questions. The data is analyzed and filtered again during the transcription process. When the data is coded it is again interpreted. The final analysis is just another step in the overall analysis process. Triangulation will help address the issue of bias. During the last stage of analysis the researcher must take care when presenting the data and the conclusions. All evidence must be presented, and different explanations should be evaluated and presented to allow other researchers to draw their own conclusions when examining the data.

3.5. CONCLUSION

Most research conducted in the engineering disciplines concerns numbers and quantitative measures. As qualitative research is not widely used in many engineering

disciplines, considerable time was devoted to outlining and summarizing the details of the methodology utilized in this research. Even in disciplines more accustomed to qualitative research, qualitative methodologies are highly variable and not always well documented.

This research employed multiple data collection techniques to gather different types of data from different sources. Case study site information was collected and has been summarized to provide the necessary context for the remainder of the analysis. The development of a database to facilitate analysis of the data was vital to completing this research. The database allowed the coded data to be sorted and presented in a logical matrix format which facilitated final analysis. The analysis resulted in many interesting findings that both supported and contradicted the research propositions. The research findings and the detailed results from the analysis are presented in the next chapter.

4. RESEARCH FINDINGS

The analysis of the coded field notes revealed interesting patterns. Some of the analysis provided encouraging evidence to support further research. Other results were not as expected. Some of the field notes for specific research propositions required further categorization beyond the initial coding model. The additional categorization of data allowed simple explanation building to occur. The categorization process was unique for each research proposition.

The field notes contained multiple pieces of evidence that could be linked to each of the research propositions. Sample evidence from the field notes was provided when discussing each research proposition. To protect the confidentiality of the sources, "operator X" is used in the sample evidence to identify the comments made by a person employed in a non-management position and "executive Y" is used to identify the comments made by someone from the executive management team.

Each of the research propositions and findings are presented and discussed in detail in this chapter. After discussing the findings, the topics of reliability and validity are addressed.

4.1. SUCCESSES OR FAILURES NOT ATTRIBUTED TO AN INDEPENDENT VARIABLE

Some of the field notes coded as a success or a failure could not be directly linked to any of the independent variables included in this study. It could be argued that most of the evidence could be indirectly linked to management support, as executive management led the implementation of many of the lean activities. For this analysis, only those pieces of evidence with a **direct** link to management support were used to measure the impact of management support on the lean implementation. This section is focused on those findings that were not

directly linked with the research propositions, but were relevant to the organization's lean transformation.

4.1.1. Failures Not Attributed to an Independent Variable

The pieces of evidence coded as failures that could not be directly linked to one of the independent variables of this study are summarized in Table 4.1.

Table 4.1. Evidence of Failures Not Attributed to an Independent Variable

Balanced Scorecard Category	Number of Pieces of Evidence/Sources	Sample Evidence
Customer Needs	0	NA
Customer Satisfaction	0	NA
Employee Attitude	5/3	– It [lean manufacturing] adds more work to things. There are more tasks cutting into the time employees need to do their job. – In operator X's opinion lean hasn't been much of a success.
Employee Skills	0	NA
Processes streamlined	3/2	– All parts are looked up in an auxiliary database created to track shortages when they are received into inventory.
Lean concepts adopted	3/2	– The bad side is CompX has to carry more inventory to meet customer demands, but the good side is CompX is able to keep the customer happy.

Note. Information in brackets provided by the researcher for clarification.

Of the field notes coded as employee attitude, three of the pieces of data came from one source that expressed negative comments about the entire lean implementation. This source felt the work area had already been employing lean concepts but management was unaware and unappreciative of this work. This source also felt the lean implementation would

be a detriment to employee skills and employee value rather than an enhancement. This is a fear documented in other research on lean implementations (Parks, 2002). The field notes coded as employee attitude highlighted a need for management to provide more information to the employees about lean itself and the positive impact it can make on the organization and the employees' work areas.

The evidence for a lack of streamlining and waste within the organization was related to the procedures for handling raw materials or the flow of raw materials through the factory. The organization has struggled to find a process for coordinating the management of parts needed to build product. The lack of coordination created situations where not all of the raw materials required to complete a product were on the floor. Processes were put into place to work around the issue, but at the end of data collection, these new processes still continued to consume large amounts of employee time.

Of the three pieces of evidence related to the lack of adoption of lean methodologies, one was related to the lack of coordination within one work area to completely clean and label the area despite the Five S activity. The other two pieces of evidence were paradoxical in nature. In an attempt to meet customer demands, the organization carried excessive inventory or created extra internal paperwork to allow the customer to qualify for a quantity discount with staggered shipping dates. Both circumstances met customer demand, but at the price of lean concepts. These failures are indicative of the need for the organization to continue its work, and they also highlight some of the challenges of a lean transformation.

4.1.2. Successes Not Attributed to an Independent Variable

The pieces of evidence coded as success that were not attributable to an independent variable were more numerous. The successes are summarized in Table 4.2.

Table 4.2. Evidence of Successes Not Attributed to an Independent Variable

Balanced Scorecard Category	Number of Pieces of Evidence/Sources	Sample Evidence
Customer Needs	0	NA
Customer Satisfaction	3/2	– The area looks organized. The customers like that. – There have been a lot of changes in the company and operator X thinks it's a good idea. The customers see that the company looks more professional.
Employee Attitude	14/8	– Operator X felt it was much better working in [operator X's] own cell – it's nice to have [operator X's] own space and not feel like operator X is intruding on others and they aren't intruding on operator X. – Operator X thinks things are way better, but there is always more to do. What they have done so far is great. – People are pretty hyped on it [lean manufacturing]
Employee Skills	0	NA
Processes Streamlined	9/6	– The people in the department see value in the system. By organizing, they reduced time previously wasted trying to find things. – The department has done well with the Five S stuff...it's easier to get to stuff and there is less time spent walking around looking for stuff.
Lean Concepts Adopted	10/8	– Some of the parts are on the Kanban system. – They have a clean place now. A lot of junk was taken away, and it freed up space. [From the Five S activity]

Note. Information in brackets provided by the researcher for clarification.

Of those successes coded as employee attitude, six were related to the changes in the work area made during the Five S activity. Seven of the successes addressed employee feelings about the lean implementation in general or how employees felt the lean implementation would impact the profitability of the organization in the future. Of those

successes categorized as streamlining of processing, eight originated from the Five S activity and were related to re-organizing the work area to facilitate work flow. The remaining success was a practice recently implemented to facilitate the collection of raw materials for the floor. Though this new practice was not specifically linked to the lean implementation, it was included as it fits the definition of lean as a practice put in place to eliminate wasted motion. Of the ten successes attributed to the adoption of lean concepts, nine were outcomes of the Five S activity and focused on the positive impact the activity made on the organization of materials in the work area or the resulting increased work space. The other success was related to the use of a Kanban system.

4.1.3. Impact of Failures and Successes Not Attributed to an Independent Variable

Table 4.3 provides a summary, by balanced scorecard perspective, of the general successes and failures found in the case study. While some evidence was found to indicate the lean implementation had not been a complete success, it was interesting to note the positive comments about lean and the positive attitudes of employees towards the lean implementation. This evidence indicated a favorable environment for deploying other lean practices.

Table 4.3. Summary of Successes and Failures Not Attributed to an Independent Variable

Balanced Scorecard Perspective	Number of Pieces of Evidence of Failure	Number of Pieces of Evidence of Success	% of Failures	% of Successes
Customer Perspective	0	3	0%	100%
Employee Perspective	5	14	26.3%	73.7%
Internal Perspective	6	19	24.0%	76.0%

While the successes and failures in this section were not attributable to one of the independent variables studied, they did offer some contextual background that was helpful in the interpretation of the research findings related to the propositions. The number of successes and failures illustrated the overall impact the lean implementation made on the organization as well as the need for continued work on various aspects of the management of the lean transformation and the utilization of lean practices.

4.2. ORGANIZATIONAL CULTURE

Organizational culture was defined, for this study, as any shared basic assumptions that in turn determined how organizational personnel perceived and solved problems. The field notes coded solely as culture were examined first. These notes were separated into two categories for summarization purposes: implementation issues with respect to organizational culture and observations of general culture. Table 4.4 provides a summary of the field notes coded as culture.

Table 4.4. Summary of Field Notes Coded as Culture

Category	Number of Pieces of Evidence/Sources	% of Category	Sample Evidence
Implementation Issues with Respect to Culture	7/5	87.5%	– The format for rolling out a lean manufacturing practice: there really isn't anything that's typical. The work centers all do their own thing. – When a practice is deployed, the group implementing the practice needs to be involved.
General Culture Observations	1/1	12.5%	– Fridays are busy days – too many people are out sick.

While the field notes coded as culture offered little insight into the research propositions, they did provide some interesting contextual background. The lean implementation was conceived of and organized by executive management, but an effort was made to make it accessible to all employees. The field notes reflected this methodology as most of the notes involved details of the lean implementation deployment. A weakness of the deployment was apparent as most of the sources were from the executive level of management, implying that many of the employees on the factory floor did not have enough information to visualize the overall goal of the implementation.

4.2.1. Failures Attributed to Culture

The failures attributed to culture were analyzed next. Despite the efforts of the lean implementation, some of the old cultural norms for perceiving and solving problems remained in place. Table 4.5 summarizes the failures that could be attributed to culture employing the framework of the balanced scorecard.

Table 4.5. Failures Attributed to Culture

Balanced Scorecard Category	Number of Pieces of Evidence/Sources	Sample Evidence
Customer Needs	0	NA
Customer Satisfaction	0	NA
Employee Attitude	1/1	– For some builds there were concerns [whether or not] lean would work because of set-up times. Operator X is hesitant. It's hard to understand how lean will make production more efficient.
Employee Skills	0	NA
Processes Streamlined, Waste Removed	11/8	– At set-up the kits are re-checked for shortages. If the kit is short, operator X checks multiple things trying to find the part. – Many times the shortages occur because the kits are pulled before there are even orders for them. The planners/kitting are a few days ahead of the buyers. – They are expected to respond to returned items within 90 days. Usually it's too hard to get to these items during the week so they often work on Saturday to clean them up.
Lean Concepts Adopted	10/6	– Things work great if they [the people in the department] could get people to put things back in the right area. It works within the department but people from outside the department are not respecting the organizing [organizing that was completed during the Five S activity.] – Some of the kits have samples; operator X just knows which kits do have samples. – Some of the parts in the kit don't need to be prepped. Operator X usually knows which. If operator X has any questions operator X asks the lead in the next work area.

Note. Information in brackets was provided by the researcher for clarification.

The failure in the employee attitude category provided evidence of the need for executive management to make more information available about the lean implementation to help the employees see the benefits and possibilities of the new system. It will be difficult for some of the employees to adopt the new methodologies without an understanding of how or why these methodologies will lead to improvement (Alavi, 2003; Bamber & Dale, 2000; Hancock & Zayko, 1998).

All of the field notes coded as a lack of streamlining highlighted continued evidence of waste within the organization despite the lean implementation. Seven of the pieces of evidence were related to the intricate processes put into place to compensate for the poor management of raw materials. One piece of evidence highlighted the lack of time management skills within a department, leaving the department unable to adequately meet all demands. The two remaining pieces of evidence involved unnecessary paperwork that was being generated and filed, but not referred to again.

The majority of the field notes coded as lack of adoption of lean concepts provided evidence of processes dependent on the employee "just knowing" what to do. In a lean factory, the process for every circumstance must be clearly defined. Many of the sources repeatedly used the phrase "I just play it by ear" and "I just know what to do." While it is desirable to know what to do for each new task that may arise during the day, it is worrisome that this knowledge usually resided with only one individual within the department (often the lead), and many of the other employees required direction when performing simple tasks. All employees performing a task should have a highly specified methodology to follow. The other piece of evidence categorized as a failure to adopt lean concepts involved employees from outside a department failing to respect the process changes in the department.

All of the notes coded as a lack of streamlining or failure to adopt lean principles provided evidence of how an ingrained culture continues to function using old rules despite efforts to approach problems differently. This is consistent with previous research (Ahls, 2001; Filson & Lewis, 2000; Parks, 2002; Womack & Jones, 1994). In particular, it is interesting to

note the number of incidents of waste related to the management of inventory. Some of this waste may have occurred because the purchasing department and the scheduling coordinator did not participate in the lean implementation. An effort should be made to involve all departments that directly affect the value stream in the lean implementation so all employees may share in the new assumptions created by the lean implementation and incorporate these assumptions in problem solving (Boyer & Sovilla, 2003; Holden, 2003, Maskell, 2000; Schein, 1996). When some of the employees directing materials into the value stream continue to operate under the old assumptions, those employees on the floor exposed to the lean implementation are also forced to work from the old assumptions to maintain operations. This practice only fosters waste and adds unnecessary complexity as illustrated by the excessive number of practices put into place to manage the raw materials.

4.2.2. Successes Attributed to Culture

Those field notes coded as success attributable to culture yielded some interesting results as well. Table 4.6 provides a summary of those successes attributable to culture.

Table 4.6. Successes Attributed to Culture

Balanced Scorecard Category	Number of Pieces of Evidence/Sources	Sample Evidence
Customer Needs	0	NA
Customer Satisfaction	0	NA
Employee Attitude	3/3	– At first everyone was skeptical. The changes seemed unnecessary. But once everyone buckled down and got into it they started noticing the impact. Once they [the personnel within the department] figured out the benefits, more people got on board.
Employee Skills	0	NA
Processes Streamlined, Waste Removed	2/1	– They don't want to spend a lot of money. They take time and look things over. They got a cabinet to put stencil files in. Now they can find the stencil in seconds.
Lean Concepts Adopted	4/3	– All employees are fully cross trained – usually there is no down time. When the people in quality control have time, they help out in the area. – The receiving and shortages areas help out in the shipping area quite a bit.

Note. Information in brackets was provided by the researcher for clarification.

The evidence from the employee attitude category reflected a culture that was open to change and willing to try new ideas. During the interviews, some employees commented they felt some doubt about the implementation, but they were willing to participate in the Five S activity, signaling a willingness to try out new ideas. A culture open to change will be more successful when implementing lean (Alavi, 2003).

The pieces of evidence from the streamlined processes/reduction of waste category illustrated how the culture influenced some of the decisions made during the Five S activity and subsequent streamlining. It was an accepted assumption within the culture that time and money were both valued and should be used frugally. This aligned well with the concepts of

lean and was helpful when deciding what processes to streamline and how to accomplish the streamlining.

The field notes coded as adoption of lean concepts involved evidence of teamwork within the organization. These notes were labeled as a success because teamwork is a key component of lean (Womack, Jones, & Roos, 1990). Not all of the work areas were new to the concept of teamwork, but the interviews revealed that some employees felt that the Five S activity increased teamwork. For those areas not previously employing team concepts, the idea of working as a team during the Five S activity appeared to succeed with little trouble. Though the executive management team had not focused on teamwork during any aspect of the lean implementation, the easy adoption of the teamwork concept reveals it is an idea that is aligned with previously held cultural norms (Lathin & Mitchell, 2001).

The link of teamwork to a successful lean implementation is indisputable (James-Moore & Gibbons, 1997; Womack, Jones & Roos, 1990). Employees must work together within their departments, and they must also work with employees from other departments, often in cross functional teams, to solve problems impacting multiple work areas. Previous research indicates that cross functional teams play an important role in lean success (Bamber & Dale, 2000). The evidence of teamwork from the Five S activity would suggest that forming effective cross functional teams will not be difficult for the organization.

4.2.3. The Impact of the Lean Implementation on the Culture

The specific focus of this research was to investigate the impact culture made on the lean implementation, but evidence in the field notes also pointed to a positive impact on the culture by the lean implementation. No evidence of the lean implementation making a negative impact on the culture was found. Table 4.7 provides a summary of the impact the lean implementation made on the organizational culture.

Table 4.7. Summary of the Impact of the Lean Implementation on the Organizational Culture

Balanced Scorecard Category	Number of Pieces of Evidence/Sources	Sample Evidence
Customer Needs	0	NA
Customer Satisfaction	0	NA
Employee Attitude	3/2	– Overall it's better. Not sure if it's lean itself or if they are just getting more people who want to make things better. – The employees seem to be into it.
Employee Skills	2/2	– They are working as a team and operator X has seen a difference on the floor. – There is more getting together and doing things.
Processes Streamlined, Waste Removed	0	NA
Lean Concepts Adopted	0	NA

Note. Information in brackets was provided by the researcher for clarification.

Some of the employees perceived that the implementation had led to more positive attitudes about the work place as well as improved team based problem solving. While the culture was already accepting of teamwork, it was interesting to note how many sources talked about an increase in teamwork attributable to the Five S activity. One comment by an executive manager offered particular insight into how the effort to become lean was also making an impact on the culture. The manager commented that "change is difficult – some embrace it, some run from it, some hide from it and hope it goes away, but it's inevitable. It is becoming part of the culture. If they have change and it's constant, they might as well make it good. Management has embraced it, and now they [the executive management team] are seeing the floor embrace it."

4.2.4. Impact of Organizational Culture

Based on the evidence collected, the culture of the organization impacted the lean implementation, both negatively and positively. Table 4.8 provides a summary, by balanced scorecard perspective, of the impact organizational culture made on the lean implementation.

Table 4.8. Summary of Successes and Failures Attributed to Organizational Culture

Balanced Scorecard Perspective	Number of Pieces of Evidence Coded as Failure	Number of Pieces of Evidence Coded as Success	% of Failures	% of Successes
Customer Perspective	0	0	0%	0%
Employee Attitude	1	3	25%	75%
Internal Perspective	21	6	77.8%	22.2%

No successes or failures attributable to culture from the customer perspective were found. This may be due to a lack of awareness of customer needs by factory floor employees. The employees involved directly in manufacturing activities were not as aware of customer needs and demands as the executive management team or the support personnel who had direct contact with the customer. As the lean implementation progresses, this may be an area the executive management team can address to align cultural assumptions about priorities. When implementing lean, many researchers recommend defining value from the customer's perspective (Allen, 2000; Barker, 1994; Knuf, 2000; Womack & Jones, 1996). It has been argued that a common focus is required to unite a lean enterprise into a "single, functioning whole" (Jenner, 1996: 403). Previous research has also found that an external customer focus is a positive factor in successfully implementing change within an organization (Yauch & Steudel, 2002).

The number of successes and failures from the employee perspective was small, but the culture was such that employees were comfortable trying out new concepts. This

perspective will be helpful to the organization as it continues to implement new lean concepts (Lathin & Mitchell, 2001). It was also noted that though some of the work areas were already comfortable working as a team, the Five S activity appeared to have increased that comfort level. Those areas working as a team for the first time were successful in accomplishing the goals of the Five S activity.

The volume of evidence categorized as waste or failure to adopt lean concepts confirmed that ingrained cultural assumptions were affecting the adoption of lean practices. These failures may stem in part from the deployment process. Personnel from the support functions did not participate in the lean implementation, and within the work areas on the factory floor, a small number of employees also opted not to participate in the lean activities. To obtain alignment and shared organizational goals, it is important that the organization address the nonparticipation. A lean organization incorporates the concepts of lean into every aspect of the organization (Boyer & Sovilla, 2003; Hancock & Zayko, 1998; Jordan & Michel, 1999; Spear & Bowen, 1999; Stamm, 2004; Womack, Jones & Roos, 1990).

4.3. ORGANIZATIONAL STRUCTURE

Organizational structure was defined for this research as the number of management levels between manufacturing personnel and the executive management of the organization. Examining the field notes coded as organizational structure revealed information about who was involved in the deployment of the lean implementation, how the work areas managed supervisory duties, and the involvement of executive management in everyday duties. Table 4.9 provides a summary of those notes coded as organizational structure.

Table 4.9. Summary of Field Notes Coded as Organizational Structure

Category	Number of Pieces of Evidence/Sources	% of Category	Sample Evidence
Deployment Details	4/4	40%	– Composition of teams involved in implementation of lean manufacturing practices: the lead, employees in the work area, and occasionally executive management staff – It can go from the operations manager down to the lead operator or the production scheduler down to the line operator. It's top to bottom [speaking about how lean practices are deployed]
Handling of Supervisory Duties	2/2	20%	– The leads are being given more supervisory duties such as performance reviews, vacation scheduling and prioritizing within their department. The leads will be in charge of the people below them. The production manager will be in charge of the leads.
Executive Management Involvement	4/2	40%	– If a part doesn't have a price, operator X will get a quote from the company president. – The company president, the operations manager and the production manager determine the re-order point in MRP.

Note. Information in brackets was provided by the researcher for clarification.

This data revealed how structurally flat the case study site was. It also illustrated the level of involvement of executive management in the operational aspects of the organization. Management was beginning to shift some supervisory duties to the manufacturing leads at the time of data collection. This delegation of power would result in another level of formal

management, but it would also free the operations manager and the production manager from the daily details of personnel management.

No field notes coded as success could be attributed to organizational structure. There were a small number of field notes coded as failure that could be attributed to organizational structure. Table 4.10 provides a summary of the impact of organizational structure on the lean implementation.

Table 4.10. Failures Attributed to Organizational Structure

Balanced Scorecard Category	Number of Pieces of Evidence/Sources	Sample Evidence
Customer Needs	0	NA
Customer Satisfaction	0	NA
Employee Attitude	0	NA
Employee Skills	1/1	– They need more training for the line people. The line people weren't included in the training so they didn't feel involved.
Processes Streamlined, Waste Removed	0	NA
Lean Concepts Adopted	6/5	– The biggest issue: because their operation is low volume, high mix, it is hard to find the right opportunity for implementation. – When they are busy, lean gets pushed aside. – Lean manufacturing is difficult in this environment. It takes a lot of overhead to monitor the kanbans.

All of the organizational structure evidence involved the inability of the organization to focus on the lean effort due to lack of personnel and time restrictions. The evidence would seem to suggest that for this case study site, the lack of support staff and the minimal management structure acted as a detriment to the lean implementation. Without dedicated personnel to lead and manage the lean implementation, the organization was not able to maintain or develop appropriate performance measures to gauge the effectiveness of the

implementation. Executive management worked on lean as work loads permitted. The number of staff participating in the training was limited because the flat structure of the organization did not permit the factory to remain functional without employees remaining in the work area. The lack of flexibility caused by the flat organizational structure appeared to inhibit the organization's ability to maintain focus on the lean implementation effort and prevented continuous progress from being made.

The flat organizational structure did not seem to provide any benefit when implementing lean at this case study site. This finding does not support the proposition developed for this research. It is possible, however, that in an organization with more flexibility and a dedicated department to manage the lean effort, the lack of management levels could work to the organization's advantage. Anecdotal evidence suggests that an organization that is not already structurally flat will transform into a flatter organization as it adopts a lean mindset (Alavi, 2003; Jenner, 1996). Given these results, it is clear that additional research is needed to more fully explore the relationship between organizational structure and lean implementation.

4.4. MANAGEMENT SUPPORT

Management support was defined as the participation of the executive management team in leading or supporting the lean implementation. Those portions of the field notes coded as management support were analyzed first. Most of the management support notes involved evidence of executive management's role in the deployment of the lean implementation. The remaining field notes provided information about executive management's efforts to educate themselves about lean or their commitment to the effort. Table 4.11 provides a summary of the field notes coded as management support.

Table 4.11. Summary of Field Notes Coded Solely as Management Support

Category	Number of Pieces of Evidence/Sources	% of Category	Sample Evidence
Deployment Details	18/6	90%	– At this time, the operations manager leads the lean effort. – Executive Y sees opportunity to eliminate waste already – executive Y is trying to target easy stuff to get people fired up. – In some instances, if the practice didn't perform, it was a combination of lack of buy-in, lack of planning, or lack of leadership [comment by member of executive management team]. – For the kick-off (of the Five S activity), management brought it up and said that the floor needs to do it [comment made by line operator]. – They are trying to make the employees aware that management is serious [comment by member of executive management team].
Dedication to Lean Effort	2/2	10%	– They [the executive management team] have some literature they read on lean. The operations manager has gone through some training.

Note. Information in brackets was provided by the researcher for clarification.

Most of the data provided evidence of the dedication of the executive management team to the lean effort. Fifteen pieces of evidence substantiated the role of the executive management team in the lean deployment. Three separate sources from the factory floor

provided data on executive management's role in the deployment, indicating that management's role in the lean implementation was visible to manufacturing personnel. The high association between management and the lean deployment is significant and reinforces the importance of the lean implementation to employees. Previous research has supported the need for leadership to be actively involved in the implementation (Alavi, 2003; Bamber & Dale, 2000; Boyer & Sovilla, 2003; Emiliani, 2001; Parks, 2002).

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4.4.1. Failures Attributed to Management Support

The number of incidents of failure attributable to management support was small, but provided some interesting insight into the lean implementation effort. Table 4.12 provides a summary of the failures attributable to management support.

Table 4.12. Failures Attributed to Management Support

Balanced Scorecard Category	Number of Pieces of Evidence/Sources	Sample Evidence
Customer Needs	0	NA
Customer Satisfaction	0	NA
Employee Attitude	4/3	– Operator X doesn't agree with the direction leadership is taking the lean effort. – In operator X's personal opinion, it hasn't been much of a success. There is no time to ever finish the process.
Employee Skills	1/1	– The cycle count was targeted when they had training by an outside facilitator. If they had more time as a group with the teacher from the class they could have done more.
Processes Streamlined, Waste Removed	2/2	– Management previously wasn't receptive to giving them time to clean up their area. Time is a resource they [the department] just recently acquired.
Lean Concepts Adopted	2/2	– They [the personnel within the department] are trying to make it a go, but things aren't put into place as they planned it. They have a good understanding of what they need.

Note. Information in brackets was provided by the researcher for clarification.

Evidence from the employee attitude category provided examples of the frustration experienced by some of the employees about the changes within the work areas and a lack of understanding about why the changes were needed. More information from executive management might help employees cope with the changes resulting from the lean implementation. The piece of evidence from the employee skills category and one of the pieces of evidence from the lack of streamlining category both dealt with the amount of time that people were allotted to complete lean activities. The employees believed being given an inadequate amount of time hampered their ability to develop the skills necessary to keep up

the momentum of the lean implementation. The other piece of evidence coded as a lack of streamlining involved an efficiency concern with the Kanban system, a project led by the operations manager.

The evidence related to the adoption of lean methods included an example of an employee within a work area choosing not to participate in lean activities. The executive management team decided not to force employee participation. This led some employees to feel as if a rift had been created within the team. The other pieces of evidence highlighted a lack of help for employees implementing changes within the work area. These findings are significant. Executive management must provide the resources necessary for employees to implement changes within their areas. Based on previous research, if employees make plans for changes but see no follow through, disillusionment can occur, and future lean activities may not be supported within the work areas (Abrahamson, 2004; Alavi, 2003; Boyer & Sovilla, 2003; Kotter, 1995; Parks, 2002). For CompX, the executive management team must address the failures highlighted in this research to assure the future success of the lean transformation.

4.4.2. Successes Attributed to Management Support

The field notes coded as successes attributable to management support provided evidence for all three perspectives on the balanced scorecard. Results of the analyses relating lean successes to management support are included in Table 4.13.

Table 4.13. Successes Attributed to Management Support

Balanced Scorecard Category	Number of Pieces of Evidence/Sources	Sample Evidence
Customer Needs	4/3	– A large part of the lean effort is customer driven. – With the kanban used for some parts, CompX realized it's less efficient but it's o.k. – CompX is able to deliver to the customer [kanban was instituted at the request of a customer who was also implementing lean within their operation].
Customer Satisfaction	2/2	– On time delivery has significantly improved in one case.
Employee Attitude	8/5	– It's nice to get the employees on the floor involved [comment made by line operator]. – Employee morale seems better – people seem excited about what they are doing. Executive Y was actually thanked by an employee for kicking off the Five S activity and implementing it. – Management is very willing to listen. Everything is available as far as operator X can see. – There is more interaction with management [comment made by line operator].
Employee Skills	0	NA
Processes Streamlined, Waste Removed	1/1	– The Kanban system is working well. They never come up short on the parts that are kanbanned. [The Kanban effort was led by the operations manager. The comment was made by an employee regarding materials handling].
Lean Concepts Adopted	5/5	– CompX has done some kanbans, some Five S, and some other lean practices [implemented and led by the operations manager]. – Some of the parts are on the Kanban system. – Management gave them more shelf space, and the other areas cleaned out the stuff they had stored in their area so they have more room now [during the Five S activity].

Note. Information in brackets was provided by the researcher for clarification.

Executive management was aware of the benefits the lean implementation provided for the customer. Some of the lean practices, such as the Kanban, were implemented at the request of a customer. The organization also implemented lean in an effort to improve quality and comply with customer requests for just-in-time deliveries. As a result of these activities, some gains in product delivery time were realized.

While lean was initially implemented to increase customer satisfaction and meet customer requirements, a number of pieces of evidence related to employee satisfaction were found. Some employees on the manufacturing floor felt that the lean activities led to more interaction with management and an increase in positive feelings toward management. Some employees also attributed an increase in morale to the Five S activity. The majority of employees expressed satisfaction with the lean implementation which may aid the organization in the introduction of additional lean concepts (Alavi, 2003; Boyer & Sovilla, 2003; Parks, 2002).

The Kanban system was working well from the point of view of the materials handling and purchasing departments as the parts on the Kanban system required little management. The other pieces of evidence coded as the adoption of lean concepts involved specific lean practices. The implementation of tools such as Five S, Kanban, color coding, and visual recognition provided evidence that the organization was able to implement a variety of lean practices in a relatively short time span. These findings support the importance of the role of management support in an organization's lean transformation.

4.4.3. Impact of Management Support

Strong evidence existed that management support had a significant impact, both negatively and positively, on the lean implementation. Table 4.14 provides a summary, by balanced scorecard perspective, of the impact management support had on the lean implementation at CompX.

Table 4.14. Summary of Successes and Failures Attributed to Management Support

Balanced Scorecard Perspective	Number of Pieces of Evidence Coded as Failure	Number of Pieces of Evidence Coded as Success	% of Failures	% of Successes
Customer Perspective	0	6	0%	100%
Employee Perspective	5	8	38.5%	61.5%
Internal Perspective	4	6	40.0%	60.0%

Based on the analysis completed, management must increase employee understanding of the need for the lean implementation. This was particularly true for employees on the manufacturing floor. A positive aspect of the implementation was the increased visibility of management due to leadership's direct role in the implementation. The executive management team also communicated their commitment to the effort with their role in the implementation. The obvious support of the executive management team for the lean implementation helped to negate the potential reaction among some employees that the new program was just a fad.

As predicted by the literature, management support is an important factor in a lean implementation (Alavi, 2003; Bamber & Dale, 2000; Boyer & Sovilla, 2003; Emiliani, 2001; Moore, 2001a; Parks, 2002; Stamm 2004). Management can have both a positive and a negative impact on the implementation. For this research, it was interesting to note that top-level management negatively impacted the lean implementation in the categories of employee perspective and internal perspective almost as much as top-level management made a positive impact. Such evidence suggests that top-level management must not only provide commitment to the lean effort and visibly support it, but top-level management must also provide the necessary material support. Education, time, and resources must be supplied to employees to allow them to participate fully in the lean effort. Carefully crafting the

implementation plan to include all employees in the lean effort is also important to ensure all areas of the organization fully participate.

4.5. COMMUNICATION

Communication was defined as a method, usually verbal or written, by which employees in the organization transfer work related information to other employees. The field notes contained numerous examples of communication, but few successful examples could be attributed directly to the lean implementation. Table 4.15 provides a summary of the impact the lean implementation made on communication within the organization.

Table 4.15. Impact of Lean Implementation on Communication within Organization

Type of Effect	Number of Pieces of Evidence /Sources	% Type of Effect	Sample Evidence
Positive Evidence Attributable to Implementation	5/4	9.1%	– Communication has also improved. – Operator X can talk to anyone about anything that's going to improve things.
Positive Evidence Not Attributable to Implementation	1/1	1.8%	– Everyone in operator X's group knows it's an open forum.
Communication Difficulties Despite Implementation	48/16	87.3%	– There are no performance measures readily available to the people at operator X's level. No cost savings information is fed back to the line employees. – Operator X will view it as a success [lean] when CompX is able to implement the type of organization and feedback loops that are meaningful to the employees. – If CompX wants to drive lean manufacturing they should have meetings devoted to it and talk about plans and timelines. Management may have these, but they aren't communicated to the manufacturing floor level.
Deterioration Due to Implementation	1/1	1.8%	– If the area had an order for something before lean, the other departments would send operator X an e-mail. Now they [the other departments] have to go through the paperwork and wait to pull it. Now, instead of a few minutes, it takes a few days. They [the other departments] can't rush it.

Note. Information in brackets was provided by the researcher for clarification.

Four pieces of evidence linked a positive impact on communication within the organization to lean. Two production employees felt the communication lines with management had been opened as a result of the lean implementation. One member of the

management team also felt that communication, in general, had improved within the organization.

Many examples, however, were found of poor communication within CompX. In addition, one source felt that communication had deteriorated between departments since the lean implementation, but this example was not corroborated by other sources. Many of the examples of poor communication shared common features that allowed the field notes to be further analyzed and categorized. Previous research supported the development of the six categories used in Table 4.16 to summarize the examples of poor communication (Ahls, 2001; Alavi, 2003; Emiliani, 2000; Hancock & Zayko, 1998, Jenner, 1998; Spear & Bowen, 1999; Storch & Lim, 1999).

Table 4.16. Summary of Evidence of Poor Communication Despite Implementation

Category	Number of Pieces of Evidence/Sources	% of Category
Lack of Communication of Performance Measures	2/2	4.2%
Lack of Feedback Loops	2/2	4.2%
Lack of Information about Lean Implementation	9/7	18.8%
Lack of Communication within the Department	4/3	8.3%
Lack of Communication with other Departments	9/4	18.8%
Lack of Clear Communication for Facilitating Material Flow	22/11	45.8%

While the data would seem to suggest that the lean implementation had not made a positive impact on communication, it must be noted that the lean implementation at the case study site was still in an early stage at the time of data collection. A majority of the evidence for poor communication referred to communications between departments or communication paths for facilitating materials through the factory. The lean implementation at the time of data collection had focused almost entirely on improving processes within individual departments. The communication between departments and the failed communications related to material

movement through the factory did not appear to be impacted by the lean implementation to date. As the lean implementation progresses and the organization begins to focus on improving the connections between departments, it is possible that many of the negative issues associated with communication between the departments will disappear (Jenner, 1996; Spear & Bowen, 1999).

Another identified challenge for the case study organization is the dissemination of information to all employees about the lean implementation. Both management and the area leads appeared to have a good grasp of lean, but the employees did not receive sufficient information about the lean implementation. In addition, employees seemed to have difficulty understanding the information that they had received. It was also clear that communications with management were not perceived by all employees as a two-way process. In particular, three of the employees participating in the study did not feel as though management provided them with opportunities to give any feedback about the implementation.

The communication field notes provided evidence that some initial inroads had been made in improving communications, especially between the employees on the manufacturing floor and the executive management team, but a great deal of improvement is still possible. As the evidence of poor communication illustrates, the organization should focus on building stronger communication paths between departments, especially as it pertains to the movement of materials through the factory. Communication is a vital part of lean (Jenner, 1996; Spear & Bowen, 1999; Womack, Jones, & Roos, 1990). As the organization continues its lean journey, it is critical that improved communication become an organizational goal in order to maintain progress.

4.6. EMPLOYEE PROBLEM RESOLUTION SKILLS

Problem resolution was defined as the ability of personnel to define a problem and seek root cause solutions to resolve problems. Many pieces of evidence related to problem solving

were found, suggesting that the organization had made some progress in this area, but numerous examples still existed of the inability of employees to seek root causes to problems. Table 4.17 provides a summary of the evidence associated with employee problem resolution skills.

Table 4.17. Impact of the Lean Implementation on Employee Problem Resolution Skills

Type of Effect	Number of Pieces of Evidence /Sources	% Type of Effect	Sample Evidence
Positive Evidence Attributable to Implementation	14/8	27.5%	– Employees enjoyed doing it [the Five S activity]. The area was time constrained but they still worked it in. – They [personnel within the department] sat down and figured out what they needed to do [in regards to the Five S activity] and then did it when they had time. – Some ideas [for the Five S activity] were initiated in the group [the department].
Positive Evidence Not Attributable to Implementation	14/7	27.5%	– As there are items that look exactly the same after potting, personnel in the area will put colored dots on some to differentiate between the different items. – Operator X is looking at the possibility of combining multiple kits into one so the kits don't need to be pulled multiple times. – Kitting will either try to find internal parts to substitute with engineering approval or they will notify the customer [in regards to consigned parts].
Employee Problem Solving Difficulties Despite Implementation	22/11	43.1%	– They didn't throw the materials away as they didn't have the authority [comment made by line operator]. – If they had more room they could do more. Not enough time during work hours [comment made by line operator]. – If a lot of pieces are missing from a kit, operator X will either let Kitting know, or if the person in Kitting is having a bad day, operator X will just get the pieces. – Operator X looks at the kits that have shortages and checks the computer system for short parts. If the inventory system says the part is on hand operator X looks at the work in progress database to see where the part is used.
Deterioration Due to Implementation	1/1	1.9%	– Before lean they had more involvement [in the work processes]. The employees feel more replaceable and less counted on. It's like they are just a machine and anyone can do the job.

Note. Information in brackets was provided by the researcher for clarification.

Most of the successes coded as employee problem solving involved aspects of the Five S activity. One piece of evidence, however, involved shifting of personnel in the area. One of the leads noted that it was difficult for the area to adjust to her absence while she attended training for lean manufacturing, but the area learned to cope with it, and because of it, "the area has learned ways to work so if someone is gone it's not a big deal." What is especially interesting about this comment is the source used this as an example of a negative aspect of the lean implementation, indicating the source may not see this as a positive outcome. In terms of lean, however, it provides evidence of problem solving skills on the part of the employees in the area. A multi-skilled workforce is a key component of the flexibility commonly associated with a successful lean enterprise (Alavi, 2003; Krafcik, 1988; Womack, Jones, & Roos, 1990). Based on the evidence found, CompX employees are beginning to develop the capabilities necessary for a multi-skilled workforce.

Most of the evidence that had no direct link to lean involved general problem solving skills. All of the evidence involved problem solving within the work areas, indicating employees were capable of seeking the source of problems affecting their immediate work area. Some of the evidence coded as a lack of problem solving provided examples of innovative ideas for working around a problem. While innovation might be looked upon favorably, in this case the root cause of the problem was not confronted and waste was generated as a result. Thirteen of the pieces of evidence involved employees' elaborate solutions to problems initiated by other departments or outside processes. As the lean implementation progresses, the processes put into place to work around problems should disappear. Processes that work around problems would be considered waste and are a target for elimination in a lean enterprise (Alavi, 2003; Allen, 2000; Spear & Bowen, 1999, Womack & Jones, 1996).

Some of the evidence highlighted a general lack of initiative on the part of the employees to solve problems, a lack of a wider understanding of the problem to enable effective solutions, and a lack of understanding of the boundaries associated with a problem.

Most of the pieces of evidence attributed to a lack of understanding of the boundaries stemmed from the Five S activity. Employees were confused as to what they were allowed to throw away in their area. This lack of empowerment could also be attributed to a lack of communication or a lack of leadership, but, for the purposes of this research, it was categorized as a lack of problem solving skills. Executive management must set decision making boundaries to empower the employees and give them the opportunity to practice their problem solving skills (Allen, 2000; Holden, 2003; Jenner, 1996).

The one piece of evidence coded as a deterioration of problem solving skills stemmed from the same employee who generated three of the pieces of evidence under the employee attitude category in the general failure section (section 4.1.1). This employee was no longer employed with the organization when the work area was observed, so no further data could be gathered from this source.

Many pieces of evidence related to employee problem solving skills, especially within an employee's department, were found. It is apparent the employees already have some problem solving abilities. Management must facilitate additional skill building in root cause analysis, especially for problems initiated from outside of an employee's department. Often, in a lean implementation, cross functional teams will be formed to obtain resolutions to problems (Alavi, 2003; Bamber & Dale, 2000; Womack & Jones, 1994). Cross functional teams might be an effective mechanism for helping CompX employees continue to improve their problem solving skills.

4.7. VALIDITY OF THE RESEARCH

The quality of a qualitative research project is dependent on many factors. Four tests (construct validity, internal validity, external validity, and reliability) are commonly used to validate empirical research (Yin, 1994). These four tests allow the reader to judge the quality of the research design (Yin, 1994). It is important to discuss each test and how it applies to

this research to allow the reader to make his or her own judgment on the quality of the research.

4.7.1. Construct Validity

Construct validity involves developing measurements for the variables being studied (Yin, 1994). It is sometimes referred to as external reliability or objectivity/confirmability (Miles & Huberman, 1994). Construct validity requires the researcher to discuss the specific types of changes that are being studied and demonstrate that the chosen measurements will reflect the changes (Yin, 1994). Construct validity may be increased by using multiple sources of evidence, creating a chain of evidence, and asking key sources to review a draft of the case study results for accuracy (Yin, 1994).

For this research, multiple pieces of evidence were used when analyzing each proposition. The number of sources was reported with the number of pieces of evidence to allow the reader to judge the uniqueness of the data. If a source dominated a category of the balanced scorecard, it was noted in the results. A chain of evidence allows a reader to trace a conclusion back to a research question or to trace a research question to the conclusion. The methodology used in this research was thoroughly documented in chapter 3. The field notes are linked in the database with background information, such as the date of the data collection, any pertinent background information, and designation as to the type of data collected (interview or unstructured interview/observation). Each variable was operationalized, and a specific link between the variables and possible outcomes was detailed in the coding framework.

An initial case study report was generated and presented to the company in the spring of 2003. It was presented as an assessment of the lean implementation to date, as well as some suggestions for improvement. It did not contain specific reference to the research

variables, but provided an overall assessment of the research findings. The executive management team did not voice any disagreement about the contents of the report.

4.7.2. Internal Validity

Internal validity is usually associated with explanatory or causal case studies, where the researcher is attempting to validate that a specific condition will lead to another condition (Yin, 1994). Strategies for increasing internal validity include coding of the data and then performing pattern matching, creating a time-series analysis of events, or performing explanation building (a special form of pattern matching) on the data (Yin, 1994). This research was exploratory in nature, though some preliminary causal links were explored during the presentation of the results. All causal links were the result of coding and pattern matching.

4.7.3. Reliability

Reliability involves ensuring that another researcher employing the same methodology and conducting the research at a similar case study site would reach the same conclusions as the first researcher (Yin, 1994). Reliability can be improved through the use of a case study protocol and a case study data base.

A case study protocol documents the methodology used in the collection and analysis of data. A case study protocol was not developed specifically for this research, but a case study protocol was written for the larger NSF research project under which this data collection took place. This protocol was utilized during data collection. The sections of the NSF research protocol that did not apply to this research included the proposition development, the coding

model, and the analysis methodology. The database was also developed for the NSF research, but a copy of the database was employed for this research as well.

4.7.4. External Validity

External validity is perhaps one of the most important aspects of evaluating research results. External validity defines the generalizability of the research (Yin, 1994). It's important to determine if the findings of a research study can be generalized to apply to other case study sites. For example, the results of this research suggest that a flat organizational structure does not positively impact a lean implementation. This finding should not be generalized to say, however, that a flat organizational structure will not positively impact a lean implementation in other organizations.

Increasing external validity requires replicating the results at multiple case study sites (Yin, 1994). Replication is sometimes confused as being similar in concept to increasing a sample size (Yin, 1994). Instead, replication is analogous to conducting another experiment, with the intent of replicating the results of the experiment. If multiple case studies are conducted and similar results are found, researchers can begin to state with more certainty that a hypothesis or proposition is generalizable to a larger population than that represented by a single case study site.

This research was exploratory in nature. The findings were consistent with previous research, however, indicating some degree of generalizability at a macro level. To increase generalizability, comparable findings at other case study sites similar to CompX would need to be found.

This research has made a significant contribution through its investigation of the impact that management support, organizational culture, and organizational structure made on a lean implementation, as well as the impact the lean implementation made on organizational

communications and problem resolution. The findings provide a strong basis for future research to further investigate the link between a lean implementation and these variables.

5. CONCLUSION

This research employed a qualitative research methodology at one case study site to explore the impact of organizational culture, organizational structure, and management support on a lean implementation. This research also examined how the lean implementation impacted organizational communications and employee problem resolution skills at the case study site. The qualitative methodology employed in this research afforded a deeper examination of the links between the variables and the lean implementation while allowing some preliminary explanation building to occur.

Though this was an exploratory case study, strong evidence was found that management support, organizational culture, and organizational structure can impact a lean implementation, both positively and negatively. Strong evidence was also found of the impact a lean implementation can make on organizational communications and employee problem resolution skills.

5.1. SUMMARY OF RESEARCH FINDINGS

Culture is a key component when implementing any kind of organizational change. A culture that does not value innovation and flexibility may find it difficult to adopt the principles of lean (Alavi, 2003). This research found that the organizational culture both positively and negatively impacted the lean implementation. The negative impact of culture was demonstrated when employees used the old cultural norms to solve problems related to inventory management and the routing of materials. Instead of adopting lean practices and solving the root cause of the problem, elaborate procedures were put into place to manage the problem.

The positive impact that culture made on the lean implementation was evident in the readiness of most of the employees to participate in lean activities. This evidence provided proof of a culture that was open to trying new ideas. The largest positive impact of culture was found in the willingness of the employees to embrace the concept of teamwork. Teamwork is a vital part of lean and evidence was found that the culture was able to integrate this concept without formal direction or coaching from the executive management team.

Though organizational culture was definitely linked to the lean implementation, evidence of organizational structure impacting the lean implementation was sparse. The evidence that did exist exemplified the negative impact a structurally flat organization can make on a lean implementation. An organization with a small management team and minimal support staff may find it difficult to manage the lean implementation and provide support to line employees. This research found that the minimal organizational structure made a negative impact on the deployment of lean and the organization's ability to maintain focus on the implementation.

Management support was found to have made both a negative and positive impact on the lean implementation. Most of the evidence related to the negative impact of management support involved the deployment process. Leaders did not require participation in the lean effort. Most of the employees on the manufacturing floor participated in the lean effort, but in the work area where an employee chose not to participate, a rift was created in the team. Other problems occurred because only the manufacturing floor participated in the lean effort. None of the support functions within the organization chose to participate, creating a misalignment of culture between the manufacturing floor and the support functions. The misalignment of the culture made it difficult for the groups to solve problems effectively. Leaders also failed to provide a method for educating all employees about lean and its impact on the organization.

Some of the strong evidence of the positive impact of management support on the lean implementation involved top-level management's commitment to the lean effort. The

dedication of the executive management team to the lean effort was visible to employees on the manufacturing floor, reinforcing the importance of the lean effort and creating more positive feelings towards management. Evidence was also found for executive management's role in implementing new lean practices such as the Kanban and the Five S activity.

Strong evidence was found for the impact the independent variables (organizational culture, organizational structure and management support) made on the lean implementation. Results for the dependent variables (organizational communications and employee problem resolution skills) were more mixed. The evidence related to organizational communications indicates that initial progress in opening the communication lines within the organization was being made as a result of the implementation. A greater percentage of the evidence provided examples of poor communication that continued despite the implementation. The majority of evidence related to poor communications involved lack of information about the lean implementation itself, lack of communications with other departments, and lack of communication when facilitating material flow on the manufacturing floor.

The evidence of poor communications is not unexpected as the lean implementation was still very new to the organization, and little focus had been placed on working as an organizational unit with a common goal rather than a series of work areas. Some of the evidence of poor communications could also be attributed to failings in culture and management support, illustrating the interconnectedness of the research propositions.

Some positive evidence existed linking improvement in employee problem resolution skills to the lean implementation. The majority of the evidence classified as problem solving difficulties involved special processes that were put into place to work around a problem instead of seeking the root cause of the issue and solving it. Working around a problem is not a lean approach, hence it was classified as a problem solving difficulty. The evidence demonstrated, however, that the employees had basic problem solving skills. To align these skills with lean concepts would only require re-directing those skills towards finding and solving the root cause of problems instead of patching solutions together.

5.2. IMPLICATIONS

This research has shown empirically that lean implementations do have an impact on many sociocultural aspects of an organization. While financial or operational measures of lean success (such as lowered inventory or higher productivity) are important, leaders should be aware of both the positive and negative sociocultural impacts of a lean implementation. Many strong implications exist when designing, deploying, and implementing lean. This is of great importance to non-manufacturing organizations or manufacturing organizations that have low volumes and may not see the traditional benefits associated with lean. At CompX, the low volume, high mix manufacturing paradigm made it difficult for the executive management team to see the benefit of a lean implementation. From the research findings, it is apparent the lean implementation did make many positive impacts on sociocultural aspects of the organization.

Though this research explored five very different propositions related to lean manufacturing, the implications from the propositions often shared similarities. From the investigation of the impact that culture and management support made on the lean implementation as well as the evidence provided by the impact of the lean implementation on organizational communications and problem resolution, it is evident that it is important to involve the entire organization in the lean implementation. Implementing lean just on the manufacturing floor will misalign the organizational culture, creating difficulties when issues need to be resolved. It will be difficult for communications to flow effectively and efficiently when the personnel within the organization are not communicating from the same perceptional level or even using the same terminology. It will also be difficult for employees to effectively seek out and solve the root cause of problems if only part of the personnel within the organization are operating under the principles of lean.

The organizational structure evidence indicated that in order for a lean implementation to progress at a steady pace, a dedicated person or a dedicated staff must be assigned to facilitate the lean process. Assigning the lean transformation to an employee with an existing work load makes it difficult for the implementation to progress and may leave the employees implementing lean feeling unsupported.

The evidence of the impact of management support on the lean implementation supports the change management literature in emphasizing the importance of management support in embracing the lean implementation. It is also important that leadership thoroughly educate all employees on lean and its associated benefits. Expecting the information to trickle down to employees not directly involved in training is not an effective way to manage the lean effort.

While this research was only conducted at one case study site, it is important to acknowledge the implications from this research. In particular, it is apparent that attempting to implement lean in specific areas of the organization, without a structure in place to support the implementation, creates difficulties which may lead senior management to conclude that lean is not beneficial to the organization. This research underscored the need to involve the entire organization in the implementation, educate the employees thoroughly, and create a work group that can effectively manage the lean effort.

5.3. FUTURE WORK

Sufficient evidence was found to justify further exploration of the relationships between lean implementations and organizational structure, organizational culture, management support, organizational communications, and employee resolution skills. Each research proposition had some evidence linking the variable to the lean implementation.

A follow-on study should involve multiple case study sites with the collection of data occurring before the lean implementation and again after the implementation was underway.

Employing such a methodology will strengthen the links between the lean implementation and the variables. A study that also incorporates some quantitative tools, such as surveys, would provide another data source to corroborate the findings through triangulation (Miles & Huberman, 1994). A study employing both qualitative and quantitative methods would also create a richer data set, enabling more analysis (Miles & Huberman).

To increase external validity, an initial follow-on study should focus on selecting case study sites within the electronics manufacturing field. To increase the ability to generalize the findings, further research should focus on applying the research methodology to a variety of organizations in both manufacturing and service oriented industries and performing a cross case study analysis of the results. Such research could have far reaching implications for a variety of industries wishing to implement lean.

5.4. CONCLUSION

Lean manufacturing is not a set of tools an organization can implement in isolation and expect significant results. Lean is also not an impossible goal that only certain organizations are destined to achieve. Lean manufacturing is possible for any organization to implement successfully if the executive management team is dedicated to the concept and willing to make the changes necessary for lean to be a success. Lean requires a change in culture and organizational structure, with an emphasis on flexibility.

Lean will also impact aspects of the organization that many organizational leaders may not realize. As illustrated by this study, communications and employee problem solving skills are just two characteristics that will likely be impacted in some way by the implementation. Examples of other characteristics that may be impacted could include organizational culture, organizational structure, employee conflict resolution skills, and social hierarchies within the organization. It is also likely that external relationships with customers, vendors, and shareholders will be impacted by the lean implementation.

The transformation of an organization to a lean enterprise is a dynamic process that is unique for each organization. It is important that executive management be aware of the many variables affecting the lean implementation, as well as the variables impacted by the implementation when committing to the concept of lean manufacturing. While the process of becoming lean will not be easy, it will create an organization that is more flexible and capable of meeting the unique challenges of business.

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APPENDICES

Appendix A. Unsigned Informed Consent Document

The informed consent document for interviews

Over the next few months, members of your organization will be asked to participate in a research project being led by researchers at Oregon State University. This research project looks at the use of certain manufacturing practices by electronic manufacturers in the Pacific Northwest. As a member of the faculty at Oregon State University, I am asking your help in this effort. I am engaged in an academic research project entitled "The Impact of Lean manufacturing Practices and Principles on Electronics manufactures." While many manufacturers have incorporated lean manufacturing practices to become more competitive, there is little data focused on the role of lean manufacturing in the electronics industry.

Your participation in this study is voluntary and you may refuse to answer any question. Only a small sample of organizational members will be interviewed, so your participation is vital to the study. Interviews will take between 60 and 75 minutes.

The confidentiality of your responses will be protected to the extent permitted by law. Your name will not be used in any summarization of the information or on any notes documenting the interview.

I understand that my participation in this study is completely voluntary and that I may either refuse to participate or refuse to answer any question at any time without any impact on my employment. I understand that any questions I have about the research study or specific procedures should be directed to Toni Doolen, Covell Hall 118, Oregon State University, Corvallis, OR 97330, (541) 737-5641.

If I have questions about my rights as a research subject, I should contact the OSU Institutional Review Board (IRB) Human Protections Administrator at IRB@oregonstate.edu or (541) 737-3437.

My signature below indicates that I have read and that I understand the process described above and give my informed and voluntary consent to participate in this study. I understand that I will receive a signed copy of this consent form.

Signature of subject _____

Name of Subject _____

Date Signed _____

Appendix B. Interview Instrument for Non-Supervisory Personnel

INTERVIEW GUIDE FOR WORK TEAM PERSONNEL

Position:
Company:
Interviewer:
Date:
Start time:
End time:
Source:

Introductory Comments

- Thank you for making the time for this interview.
- The **purpose** of the interview is to **obtain your views on a number of questions related to lean manufacturing practices in your organization.**
- Anything you say is confidential – nothing will be tied back to any individual names.
- Provide participant with an estimate of the time to complete the interview.

1. When was lean manufacturing first implemented in your work area?

2. What kind of training in lean manufacturing practices have you received?

3. What is your understanding as to why lean manufacturing practices were needed? (customer-driven? Competition-driven? Etc.)

4. Has there been a particular focus for lean manufacturing efforts in your area? (such as set-up reduction? Waste reduction?)

5. What types of performance measures are typically targeted in the implementation of lean manufacturing practices?

6. What are the resources available for implementing lean manufacturing practices? (Budget? Facilitation? Training?)

7. When implementing a new lean manufacturing idea or practice, does your area follow a formal schedule, and if so, how does it usually look? (e.g., kick-off? Training? Formal training, Training by other team members, Analysis? Designing future state?) How long do you spend on each portion of the schedule?

8. How many team members are actively involved in lean manufacturing practices in your area?

9. What is the composition of your team in the implementation of lean manufacturing practices?

10. Which lean manufacturing practices have you implemented or attempted to implement in your area?

Appendix B. (Continued)

11. Have certain lean manufacturing practices been more successful than others? Do you have a feel as to why some performed better than others?

12. Have certain practices not performed as expected? If yes, do you know why the practice didn't succeed in your area?

13. Have you discontinued any lean practices not mentioned above? If yes, why were the practices discontinued?

14. What objective/measurable results did you actually **achieve** with the implementation of each practice?

15. What types of non-measurable benefits have you realized?

16. To what extent are lean manufacturing practices viewed as a success in your area?

17. To what extent are lean manufacturing practices viewed as a success in your company?

18. What are some of the positive or negative issues not previously mentioned that you have experienced in the implementation of lean manufacturing practices?

19. Do you have any practices scheduled for implementation? If yes, what does the team hope to achieve with these new practices?

Appendix C. Interview Instrument for Executive Personnel

INTERVIEW GUIDE FOR EXECUTIVE PERSONNEL

Position:
Company:
Interviewer:
Date:
Start time:
End time:
Source:

Introductory Comments

- Thank you for making the time for this interview.
- The **purpose** of the interview is to **obtain your views on a number of questions related to lean manufacturing practices in your organization**.
- Anything you say is confidential – nothing will be tied back to any individual names.
- Provide participant with an estimate of the time to complete the interview.

1. When was lean manufacturing first implemented in your company/work area? Can you give a schedule of lean implementation by area or department?

2. What percent of your organization has participated in lean manufacturing efforts? (by production line/cell?)

3. What percent of your workforce has participated in lean manufacturing efforts?

4. Who leads the lean manufacturing efforts in your company? (a lean department, HR, a member of management, etc.?)

5. If a lean department has been created to lead lean manufacturing efforts, what is the make-up of the team? (HR personnel, people from all areas of the company, IEs, MEs, etc.?)

6. How do the personnel leading the lean efforts learn about lean practices? (formal training, reading, etc.?)

7. How has lean manufacturing been introduced to the company? (mandatory participation, voluntary, incentives, etc.?)

8. What are the resources available for implementing lean manufacturing practices? (Budget? Facilitation? Training?)

9. What have typically been the catalysts for change determining the need for lean manufacturing practices? (customer-driven? Competition-driven? Etc.)

10. Has there been a particular focus for your lean manufacturing practices (such as set-up reduction? Waste reduction?)

Appendix C. (Continued)

11. What types of performance measures are typically targeted in the implementation of lean manufacturing practices?

12. What is the typical format for rolling out lean manufacturing practices and how long is spent in each portion of the roll out? (e.g., kick-off? Training? Analysis? Designing future state?)

13. How many people are typically involved in your lean manufacturing implementation efforts? (How big are the teams during Kaizen events, etc.?)

14. What is the composition of various teams involved in the implementation of lean manufacturing practices? (everyone, managers, line, clerical, etc.?)

15. What particular lean practices have been implemented so far in your company?

16. Have certain lean practices been more successful than others? Do you have a feel as to why some practices performed better than others? Examples?

17. Have certain practices not performed as expected? If yes, do you know why the practice didn't succeed in your area?

18. Have you discontinued any lean practices not mentioned above? If yes, why were the practices discontinued?

19. What types of objective/measurable benefits/results have you achieved with the practices implemented to date?

20. What types of non-measurable benefits have you realized as a result of implementing lean manufacturing?

21. To what extent are lean manufacturing practices viewed as a success in your organization?

22. What are some of the positive or negative issues, previously not mentioned, that you have experienced in the implementation of lean manufacturing practices?

23. Do you have any practices scheduled for implementation? If yes, what do you hope to achieve with these practices?

Appendix D. Organizational Survey

COMPANY DATA SHEET

Name:_____
Years in Business:_____
Public/Private:_____
Data Provided by:_____
Interviewer:_____

A. Physical

1. Physical Structure: (Satellites?, number of people at each site, function of each site?):

2. Age of buildings(s):

3. Average age of machinery:

4. Square footage of building(s):

5. Approximate dates used for "Prior to Lean" and "After Lean" data:

	Prior to Lean	After Lean
6. Number of days shut down per year:		
7. Number of managerial positions:		
8. Number of executive positions:		
9. Number of HR positions:		
10. Number of technical/engineering positions:		
11. Number of operators/line personnel:		
12. Number of administrative/support personnel:		

Appendix D. (Continued)

B. Production Style

Production System:

Product Variety:

Production Volumes:

Material Flow:

Layout:

Equipment:

Fixed Costs:

Variable Costs:

Skill Level:

Organizational Structure:

Organizational Style:

Note: Adapted from Miltenburg, J., (1995). Manufacturing Strategy: How to Formulate and Implement a Winning Plan. Portland, Oregon: Productivity Press.

Appendix D. (Continued)

C. Financial

	Prior to Lean	After Lean
1. Average per unit cost:		
2. Company debt ratio:		
3. IRR:		
4. Amount per year spent on capital investment:		
5. Return on investment:		
6. Revenue per FTE (full time employee):		
7. Gross profit margin:		
8. Change in earnings:	XXXXXXXXXXXXXX	

D. Customer/Marketing Data

	Prior to Lean	After Lean
1. Number of customers:		
2. Sales disbursement among customers (one large customer, many small?, etc):		
3. Average order completion time (average lead time from order placement):		
4. Average percentage of orders delivered on time each month:		
5. Average percentage (or average number of customer orders) expedited through the manufacturing line each month:		
6. Common reasons for expediting customer orders through the manufacturing line:		
7. Customer satisfaction (if measured, how is it measured; if qualitative response, how did the respondent arrive at his or her answer):		
8. Percentage of customers retained:		
9. Percentage of market share:		
10. Average amount invested per year in R & D:		
11. Average length of time invested in developing a new product:		
12. Average amount invested per year in Marketing/Sales:		

Appendix D. (Continued)

E. Data on Line Personnel

	Prior to Lean	After Lean
1. Turnover rate:		
2. Absentee rate:		
3. Employee morale (if measured, how is it measured; if qualitative, how did the respondent arrive at his or her answer):		
4. Average amount of initial training of line employees:		
5. Average amount of subsequent training for line employees:		
6. Average amount invested per year in training for employees:		
7. Starting wage for line personnel:		
8. Top wage for line personnel:		
9. Profit sharing (quarterly, yearly; how long does a person need to work at the company before qualifying for this?):		
10. Average amount of overtime worked per month (in hours per employee):		

11. Union shop?

12. If yes, how much influence does the union have on company policy regarding efficiency?

13. Employees organized into teams?

14. If team structure is used, how much power is given to the team (totally autonomous, closely supervised by team leader or department manager, all human resource issues handled by the team, etc.):

15. Sick leave policy:

16. Structure of performance reviews (quantitatively based, qualitative or a combination of the two; who provides the data for the review; how often are reviews given):

Appendix D. (Continued)

F. Internal Operations

	Prior to Lean	After Lean
1. Number of suppliers:		
2. Percentage of supplier orders arriving on time:		
3. Average number of orders from suppliers that must be expedited or shipped express per month:		
4. Amount of inventory typically held (measured in terms of units or dollar amount or storage space):		
5. Kanban system in place (if yes, how was the re-order point decided upon, what was catalyst for implementing system):		
6. Average volume processed per month (jobs or pieces):		
7. Typical amount of WIP:		
8. Typical amount held in finished goods (no order placed yet):		
9. Number or percentage of defects found per month internally:		
10. Average monthly cost associated with fixing defects (if fixable):		
11. Percentage of items scrapped per month:		
12. Average monthly cost for scrapped parts or units:		
13. Number of pieces coming back for re-work per month:		
14. Number of pieces or percentage of pieces coming back for re-work per month still under warranty:		
15. Average monthly disposal costs associated with defects/scrap/reworks (if any special handling required during disposal):		
16. Average number of environmental incidents per month:		
17. Efficiency (if it is measured, how is it measured and is it shared with employees):		
18. Production statistics shared with employees (if so, what is shared and how):		

19. Do you track the financial status/stability of suppliers? If yes, how much time is dedicated to this activity?

Appendix E. Data Attributes for Company Entity

Name:
Company Code: - Primary Key (referred to as Co. Code when migrated)Years in Business:
Public/Private:
Data Provided by:
Interviewer:
A1. Physical structure
A2. Age of building
A3: Average age of machinery
A4: Square footage of building(s)
A5: Approximate dates used for prior to lean and after lean
A6p: Number of Days shut down per year
A6a: Number of Days shut down per year
A7p: Number of managerial positions
A7a: Number of managerial positions
A8p: Number of executive positions
A8a: Number of executive positions
A9p: Number of HR positions
A9a: Number of HR positions
A10p: Number of technical/engineering positions
A10a: Number of technical/engineering positions
A11p: Number of operators/line personnel
A11a: Number of operators/line personnel
A12p: Number of administrative/support personnel
A12a: Number of administrative/support personnel
B1: Production system
B2: Product variety
B3: Production volumes
B4: Material Flow
B5: Layout
B6: Equipment
B7: Fixed Costs
B8: Variable Costs
B9: Skill Level – Line Emp.
B10: Organizational Structure
B11: Organizational Style
C1p: Average per unit cost
C1a: Average per unit cost
C2p: Company debt ratio
C2a: Company debt ratio
C3p: IRR
C3a: IRR
C4p: Amount per year spent on capital investment
C4a: Amount per year spent on capital investment
C5a: Return on investment

Appendix E. (Continued)

C5a: Return on investment
C6p: Revenue per FTE
C6a: Revenue per FTE
C7p: Gross profit margin
C7a: Gross profit margin
C8a: Change in earnings
D1p: Number of customers
D1a: Number of customers
D2p: Sales disbursement among customers
D2a: Sales disbursement among customers
D3p: Average order completion time
D3a: Average order completion time
D4p: Average % of orders delivered on time (month)
D4a: Average % of orders delivered on time (month)
D5p: Average % expedited each month
D5a: Average % expedited each month
D6p: Common reasons for expediting
D6a: Common reasons for expediting
D7p: Customer satisfaction
D7a: Customer satisfaction
D8p: % of customers retained
D8a: % of customers retained
D9p: % of market share
D9a: % of market share
D10p: Average amount invested in R & D (year)
D10a: Average amount invested in R & D (year)
D11p: Average length of time to develop new product
D11a: Average length of time to develop new product
D12p: Average amount invested per year in Marketing/Sales
D12a: Average amount invested per year in Marketing/Sales
E1p: Turnover rate
E1a: Turnover rate
E2p: Absentee rate
E2a: Absentee rate
E3p: Employee morale
E3a: Employee morale
E4p: Average amount initial training line emp.
E4a: Average amount initial training line emp.
E5p: Average amount subsequent training
E5a: Average amount subsequent training
E6p: Average $ amount invested in training (year)
E6a: Average $ amount invested in training (year)
E7p: Starting wage for line personnel
E7a: Starting wage for line personnel
E8p: Top wage for line personnel

Appendix E. (Continued)

E8a: Top wage for line personnel
E9p: Profit sharing
E9a: Profit sharing
E10p: Average amount overtime (week)
E10a: Average amount overtime (week)
E11: Union shop
E12: How much influence does union have regarding efficiency improvements
E13: Employees organized into teams
E14: How much power given to team structure
E15: Sick leave policy
E16: Structure of performance reviews
F1p: Number of suppliers
F1a: Number of suppliers
F2p: % supplier orders arriving on time
F2a: % supplier orders arriving on time
F3p: Average number orders expedited (month)
F3a: Average number orders expedited (month)
F4p: Amount inventory typically held
F4a: Amount inventory typically held
F5p: Kanban system
F5a: Kanban system
F6p: Average volume per month
F6a: Average volume per month
F7p: Typical WIP
F7a: Typical WIP
F8p: Typical amount in finished goods
F8a: Typical amount in finished goods
F9p: % defects found internally per month
F9a: % defects found internally per month
F10p: Average monthly cost to fix defects
F10a: Average monthly cost to fix defects
F11p: % items scrapped per month
F11a: % items scrapped per month
F12p: Average monthly cost for scrapped items
F12a: Average monthly cost for scrapped items
F13p: Number pieces coming back for re-work
F13a: Number pieces coming back for re-work
F14p: Number pieces re-worked, under warranty
F14a: Number pieces re-worked, under warranty
F15p: Average monthly disposal costs associated with special handling for scrap
F15a: Average monthly disposal costs associated with special handling for scrap
F16p: Average number environmental incidents per month

Appendix E. (Continued)

F16a: Average number environmental incidents per month
F17p: Efficiency
F17a: Efficiency
F18p: Are production statistics shared with emp.
F18a: Are production statistics shared with emp.
F19: Does company track suppliers