

Standardization and Certification in Lean Manufacturing

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Lean manufacturing is a term that we have been hearing very often in many sectors and areas. Lean started as a manufacturing system and philosophy that was first developed by Toyota using key production principles that were introduced by Henry Ford. After successful implementations and great results in quality, cost and service levels, lean is now considered as a business system or as a culture. Lean principles and tools are widely used in every step of an entire process, from customer service to supply chain management. Although there are a lot of success stories about lean implementations, many companies are also struggling to adapt their culture towards the implementation of lean principles. In this thesis, standardization of lean manufacturing is studied and an analysis is provided to discuss if standardization would help eliminate the major obstacles that hinder successful lean implementation. Potential benefits and disadvantages of having standards for lean enterprises are analyzed. As a part of the research a survey was conducted to get feedback from lean professionals about standardization. The survey results suggest that there is an overall support for lean standardization. However, there are both positive and negative views about the potential benefits and disadvantages of using lean standards as an implementation guide. A case study is also provided to measure the benefits of lean and to understand how lean standards may help companies implement lean principles. Based on a simulation model that was develop to verify the benefits, a 15 % reduction in inventory carrying cost and a 5% reduction in total queue time was predicted.

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Chapter 1

Introduction

1.1 Introduction

Due to global competition and market dynamics, companies all over the world are under tremendous pressure to reduce their costs and increase their service level. There are many tools and strategies that organizations implement to achieve these goals. Toyota Production System (TPS) or lean manufacturing is one of the strategies that was implemented by many companies in different areas. The success of the companies that adopted lean principles has increased the interest towards lean manufacturing. Based on a survey by Industry Week that was released in November 2007, nearly 70% of manufacturers in the United States have adopted lean manufacturing as an improvement strategy (Pay, 2008). The companies and organizations that are in other areas such as the service industry and the healthcare sector are also applying the lean principles to reduce their cost and improve their systems.

Although many companies are interested in lean and trying to implement lean tools, the percentage of companies that have a successful lean initiative is not very high (Katz, 2008; Aberdeen, 2006). In this thesis, the standardization and certification in lean manufacturing will be studied and a review will be provided to analyze if lean standards can help companies eliminate the problems encountered during their lean implementation. Before explaining the details of our research objectives, background information about lean manufacturing will be presented in the next section.

1.2 Background Information about Lean

Lean manufacturing can be defined as a business system and a generic process management philosophy with a systematic approach to eliminating waste through continuous improvement (Womack and Jones, 1996; LEI, 2008; Surya, 2004). Lean manufacturing and its key principles were developed by Toyota and today the Toyota Production System (TPS) is more generally known as lean manufacturing.

The historical background of lean goes back to Frederick Taylor who introduced the basic management tools of mass production (Figure 1.1). In the 1920s, Henry Ford implemented many revolutionary manufacturing tools such as moving assembly lines and interchangeable parts. After World War II, Taiichi Ohno and other engineers in Toyota studied the system that was developed by Henry Ford and developed the Toyota Production System (TPS). TPS is defined by Ohno as the absolute elimination of waste and as an effort to make product in a continuous flow with minimum interruption (Ohno, 1988). In the 1980s, the first investigations about TPS were introduced in North America. In 1984, NUMMI, a joint venture between Toyota and GM was opened in California. International Motor Vehicle Program (IMVP), a five year study at MIT, was conducted to analyze the performance gap between Japanese and Western auto industries. With these two important events, the interest in TPS increased in North America. In 1988, John Krafcik, a researcher at MIT, coined the term “lean” to describe the TPS (Krafcik, 1988; Shah and Ward, 2003). The breakthrough book by Womack, Jones and Roos, “The Machine that Changed the World” was published in 1990. It was the result of the IMVP research and one of the most important sources which explains the details of the system in Toyota plants (Womack et al., 1990). In recent years, lean manufacturing has been widely adopted by manufacturing firms and extended to other sectors and industries. Especially, the success of Toyota to become the number one automaker in the world made lean manufacturing one of the most popular topics in business and manufacturing literature.

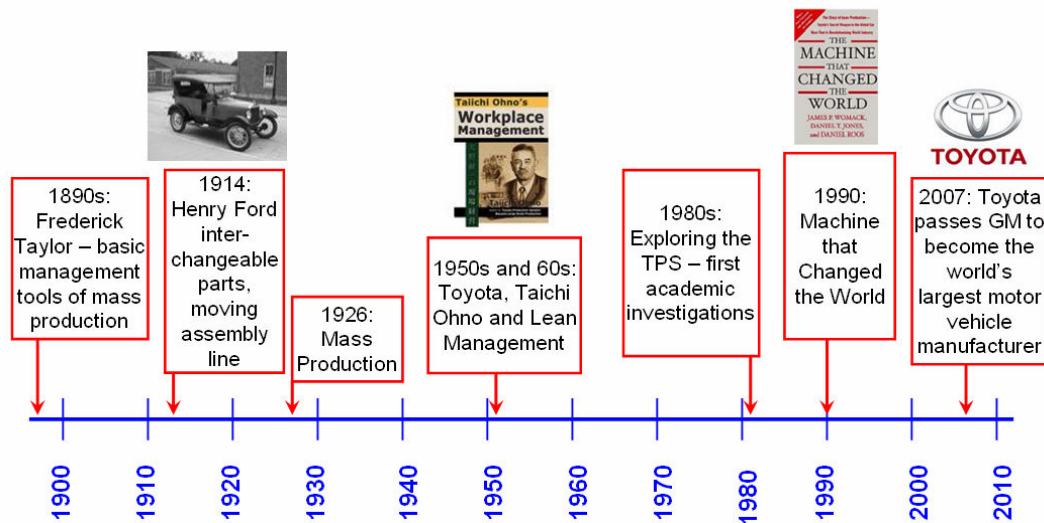


Figure 1.1 – Historical background of lean manufacturing

According to Womack and Jones, there are five key principles of lean thinking (Womack and Jones, 1996):

- *Define value from the customer perspective:* Value needs to be specified from the standpoint of the end customer. If the customer does not pay for an activity, it is considered as non-value-added and it should be eliminated.
- *Identify the value stream:* The value stream is the set of all the specific actions required to produce a specific product or service. All of the steps in the value stream should be identified for each product family and every action and every practice that does not create value must be eliminated.
- *Make the process flow:* The materials should flow through the system with minimum interruption and waiting.
- *Pull from the customer:* The customer should pull the product from the source as needed rather than the source process pushing products onto the customer. In other words, no upstream function or department should produce a good or service until the customer downstream asks for it.

- *Head toward perfection*: After implementing these steps, the managers and teams of employees should eliminate further waste and pursue perfection through continuous improvement.

There are also lean tools and technical requirements to implement these lean principles. It was suggested in the literature that, the companies should apply these tools as a total approach rather than just selecting and implementing a couple of them. Some of the lean tools can be summarized as (Bhasin and Burcher, 2006; Abdullah et al., 2006; LEI, 2008; Womack and Jones, 1996):

- *Total Productive Maintenance (TPM)*: A tool to improve the reliability, consistency and capacity of machines through preventive maintenance methods.
- *5S*: This tool is used to reduce the clutter and inefficiency in the production or office environment through workplace organization. It has originated from five Japanese words. These words in English are Sort, Set in order, Shine, Standardize and Sustain.
- *SMED set up reduction*: SMED (Single minute exchange of dies) is a method to eliminate delays in changeover times on the machines in order to reduce the lead time and improve the flow.
- *Cellular manufacturing*: It can be described as a manufacturing system where a family of parts is produced in one cell or on one line. The machines that are required to make a product are grouped together.
- *Supplier relationships*: The suppliers are seen as partners and a long term relationship with the suppliers is necessary in lean manufacturing.
- *Visual control*: This tool is used to create a work environment where quick visual inspection of products and processes is possible without detailed audits and checks.
- *Continuous improvement (kaizen)*: The endless pursuit of improvements in the system is another important tool in lean implementations.

Following the above background information about the definition, history and principles of lean manufacturing, the research objective of this thesis will be explained in the next section.

1.3 Problem Statement and Research Objectives

Lean principles and tools are widely used in every step of an entire process in a wide range of manufacturing industries. Nonprofit organizations, government agencies, healthcare institutions and some other non-manufacturing organizations also adopt lean principles to improve their systems. There are many stories in literature about companies that have successfully implemented lean and achieved significant improvements such as shorter lead times, lower inventories, better quality, and higher profitability.

However, there are also a lot of companies that are struggling to change the culture in their facilities and are having problems in adapting and sustaining the lean principles. The following list presents some statistics about the success rate in lean implementations:

- Based on a survey by Aberdeen Group, only 20% of the participating companies that started their lean journey is succeeding with their lean implementations and getting the benefits (Aberdeen, 2006).
- Based on a survey with 433 US manufacturers, 74% of companies admit that they are not making good progress with lean implementations (Pay, 2008).
- Only 5% of senior executives rate their lean programs as extremely effective (Katz, 2008).
- Only less than 10% of UK organizations have accomplished successful lean implementation (Bhasin and Burcher, 2006).

These statistics suggest that there are a lot of companies that consider lean as a tool to help them improve their processes. These companies try to implement lean principles, but unfortunately the success rate is not very high. Many companies are having problems in implementing and sustaining lean. Based on these issues, the research goals in this thesis were determined as:

- To study lean standardization and certification in detail and analyze the benefits and disadvantages of lean standards;
- To investigate if standardization would help companies eliminate problems in implementing and sustaining lean initiatives;
- To review the lean certifications for lean practitioners and analyze the benefits;

- To provide information about current available lean standards and lean certification programs for individuals.

The review of the related literature and the interviews with lean professionals are some of the tools that were used to obtain information for the research. Also, a survey was conducted to support the study and to acquire feedback from the lean practitioners about the lean standardization.

Another goal of this thesis is to provide a case study from a real manufacturing plant which demonstrates the benefits of lean tools by using continuous improvement (kazien) strategy and simulation studies.

1.4 Thesis Organization

In Chapter 2, some of the previous articles that are related to lean manufacturing and standardization will be provided. Chapter 3 will contain a review of some examples of the current management standards and certification programs. There will also be a lean manufacturing perspective of standardization in Chapter 3, with a discussion of the benefits and disadvantages of lean standards. Details of the survey that was conducted to get feedback from lean practitioners will be presented in Chapter 4. In Chapter 5, the case study from a manufacturing plant will be presented and the simulation models that were developed to verify the benefits of lean will be explained. In Chapter 6, the conclusions for this research will be presented and future study directions will be discussed.

Chapter 2 Literature Review

With the significant increase in the level of interest on lean manufacturing, there have been many research articles and books which have been published in this field. Among the subjects that were most frequently studied by researchers are: lean tools and principles, basics of Toyota Production system (TPS), benefits of lean, human resources implications and implementation examples.

In this chapter, previous work related to lean manufacturing and standardization will be classified into three sections (Figure 2.1). In the first section, a review will be presented for the studies that give information about the definition and history of lean and explain lean tools and principles. The second section will contain some examples of previous works which study the benefits and implementations of lean. In the last section, the articles that discuss standardization and certification will be reviewed.

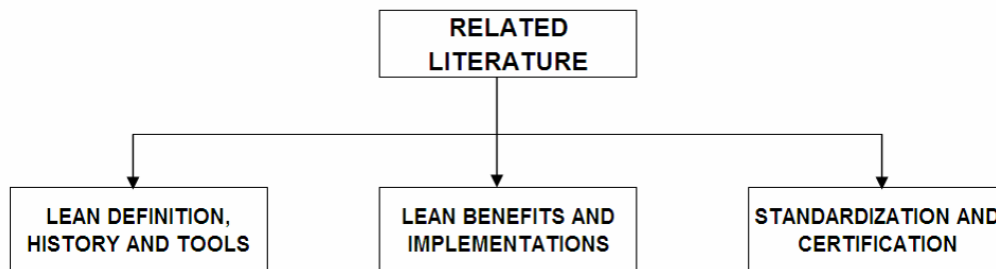


Figure 2.1 – Literature review classification

2.1 Lean Definition, History and Tools

As discussed in Chapter 1, many of the lean principles developed by Toyota have originated from Henry Ford’s ideas. One of the important resources about Henry Ford and his ideas is his own book “Today and Tomorrow” (Ford, 1926). In this book Henry Ford explains some basic business principles that he implemented in Ford plants. Some of these principles can be

summarized as: showing respect to workers and paying them good wages, insisting upon absolute cleanliness, putting all machinery in the best possible positions, making changes when it is demonstrated that the new way is better than the old way and lastly conserving material and labour in every possible way. When we review these principles, it can be observed that they are inline with the basic lean principles. Levinson (2002) also indicates this in his book where he studies Ford's principles and ideas on eliminating waste, adding value, customer and supplier relationships and labour relations.

After the development of the lean management system at Toyota in the 1950s and 1960s, Taichi Ohno published the book "Toyota Production System" (TPS) in 1978 in Japanese. This book was published in English in 1988 (Ohno, 1988). In his book, Ohno indicates that he used basic principles of Ford plants and the systems at American supermarkets when he developed the "Just in Time" system. According to Ohno, the primary goal of TPS is to eliminate waste and produce only the items needed at the required time and in the required quantities. Another book that studies Toyota's system is "Toyota Production System" by Monden (Monden, 1983).

The most well-known resources about lean definition and tools were introduced by James Womack and Daniel Jones. Womack and Jones together with Roos introduced "The Machine that Changed the World" (Womack et al., 1990) in 1990. In their book, the authors present great accomplishments of Toyota and significant quality and productivity differences between Japanese and North American automotive companies. The book describes Toyota's production system and includes its underlying components. "Lean Thinking" (Womack and Jones, 1996) is another book that was published by Womack and Jones. This was a follow-up to their book "The Machine that Changed the World" in which they extended the philosophy and guiding principles. "Lean Thinking" describes the main concepts of lean and gives examples from manufacturing firms. The same authors also published "Lean Solution" (Womack and Jones, 2006), where they established the principles of lean consumption and showed how to eliminate inefficiency during consumption.

One of the recent studies on Toyota and lean is "The Toyota Way" (Liker, 2004). Liker, a professor at the University of Michigan, explains the management principles and the business philosophy behind Toyota's success. After visiting many Toyota plants, supplier plants and sales offices and interviewing many Toyota managers and executives from

different areas, he identified 14 principles of the Toyota system. Having a long-term strategy, using continuous process flow and pull systems, standardizing the tasks, becoming a learning organization through continuous improvement, respecting the suppliers and improving them and creating a strong culture are some of these principles. According to Liker, these key principles drive the techniques and tools of the Toyota Production System and the management of Toyota. He also discusses how companies can apply the Toyota Production System to become a lean organization.

2.2 Lean Benefits and Implementations

An important portion of the lean literature belongs to the articles that study the benefits of lean implementations. Inventory reduction, shorter lead times, improved productivity and increased quality level are the benefits that are most often reported by researchers.

To measure the benefits of lean initiatives, Fullerton and McWatters (2001) use the data obtained through the survey with executives from manufacturing companies that implemented lean. Participants were asked the improvement level with lean implementation in areas such as quality, inventory reduction, employee utilization and firm profitability. Based on the results, 28% of participants reported significant improvements and 61% of the results were positive. 75% of participants achieved significant inventory reductions.

Nystuen (2002) uses the case study information from three different manufacturing firms and reports the benefits after lean implementations. Some of the benefits that were achieved by these companies were: 35% increase in labour efficiency, 82 % inventory reduction and 40% improvement in space utilization.

Lynch (2005) specifically focuses on 5S workplace organization tool and investigates the benefits based on observations from a manufacturing plant. According to the author, 5S may have positive effects on productivity and cycle time and companies can reduce cost by implementing 5S principles.

There is also vast amount of published research regarding the implementation of lean. First of all, many researchers suggest that lean should be implemented as a whole system and as a total approach rather than applying only some of lean tools and principles (Liker, 2004; Meier, 2001; Sanchez and Perez, 2001). They indicate that lean should be adopted in its

entirety in order to be effective. This total approach will strengthen the system and problems will be identified quickly. The lean tools need to be utilized simultaneously during implementation. In order to have a long term and sustainable system, the majority of the lean system elements should be addressed (Sheridan, 2000; Bergmiller, 2006). The ultimate goal of lean implementations should be to extend lean principles to other areas like accounting, product development, logistics and purchasing. Many companies are struggling to implement lean as a whole system. Developing and applying lean management standards, which forms the backbone of this study, could be a solution to problems in applying lean tools in total. Since management standards cover all areas, it can be suggested that using lean standards may help companies deploy lean principles throughout the entire organization.

Another important aspect of lean implementations is to see lean as a long term strategy and a journey instead of a destination. This critical point is discussed and emphasized in many articles (Karlsson and Ahlstrom, 1996; Brown et al., 2006). Lean should be seen as a direction rather than as a state to be reached after a certain time and the pursuit is almost more important than reaching the goal. Liker also emphasizes the importance of this essential part of lean by making it the number one principle in his book where he presented 14 principles of Toyota system (Liker, 2004). He suggests that companies should base their management decisions on a long-term philosophy, even at the expense of short-term financial goals.

Some companies consider lean as a process control system or a set of tools to improve production systems. However, the success of lean implementations highly depends on seeing lean as a philosophy and a culture. This is another important point that was suggested by literature that affects a company's lean implementation. According to Flinchbaugh, it is not the quality of lean tools that makes a real difference. What is really behind the successful lean implementations is the level of thinking driven by lean rules and principles (Flinchbaugh, 2003).

Among many scholars who indicate this point, Bhasin and Burcher present a very detailed analysis about this subject (Bhasin and Burcher, 2006). In this study, the authors indicate that a company will succeed with its lean implementations only if it views lean as a philosophy rather than another strategy. According to the authors, an organization needs to live, breathe, and mentor lean in all of its aspects and lean should be the way of doing

business or a mind-set that governs how companies look at the processes. Since getting this cultural change in a short time is very difficult, this point also suggests that seeing lean as a long term journey is very important. Lean standards and certification may help companies to sustain lean level in the long term through audits and recertification programs. Therefore this study aims to fill the gap in the literature regarding standardization of lean and to guide the professionals who are working on lean implementation.

Human resources implication or “human side” of lean implementation is another subject that was studied in the literature. Dahlgaard and Dahlgaard-Park (2006) indicate that lean manufacturing is not a traditional quality assurance or process management system, it is first of all a human-based system and the foundation for the system is leadership and empowerment through education and training. The authors state that trust is a prerequisite for communication and building a company culture. Martin (2006) also indicates this point and suggests that along with the trust in the management, the trust in the new processes should also be built. The employees should believe in the system and this trust will help implement the lean tools.

The literature suggests that the management support and communication are two critical factors for a successful lean implementation and the executive management must provide employees with more information on the lean manufacturing initiative and why it is needed. The management team must also offer resources such as time and materials to the workforce to allow the employees to successfully participate in the lean manufacturing effort (Worley and Doolen, 2006). It was also studied that worker well-being in lean initiatives depends heavily on management choices in designing and operating lean systems (Conti et al., 2006).

After providing some high level and basic points about lean implementations, now the articles that study specific lean implementations in details will be reviewed.

Shah and Ward (2003) investigate the effect of plant size, plant age and unionization status on implementing key principles of lean manufacturing. Based on their analysis, plant size has an important effect on lean implementations, while effect of unionization and plant age is less than anticipated. The authors also suggest that implementing lean practices such as just in time and total productive maintenance together creates a synergy and makes a significant contribution to operational performance. In another similar study, Cua et al.

(2001) also investigate joint implementation of total quality management, just in time and total productive maintenance and their effect on company performance. Their findings suggest that implementing these practices together could improve manufacturing performance.

Abdullah et al. (2006) explain that lean manufacturing is widely implemented in discrete manufacturing industries, but there is also considerable interest from process industries such as textile, paper, steel and glass sectors. According to the authors, many lean techniques can be applied in varying degrees to the process industry.

Another research area about lean implementation is to study lean initiatives from different sectors other than manufacturing. Tracy and Knight (2008) indicate that although most of the lean implementation examples have originated from the manufacturing sector, number of service industry companies that are applying lean is increasing very rapidly. Bowen and Youngdahl (1998) study the lean approach for the service sector. They suggest that lean experience and best practices from the manufacturing industry can be transferred to the service sector. The authors defend a production-line approach and give some examples of successful lean implementations from the service industry. Abdi et al. (2006) also study lean implementation for the service industry. They provide a service sector view for each of the five main principles of lean and explain the differences and similarities with the manufacturing industry.

Some researchers study implementation of lean tools in an office environment (May, 2005; Tischler, 2006). They suggest that there are many office employees in the corporate world and by implementing lean principles, productivity of office work could be increased. May indicates that a more human centered approach should be implemented for knowledge work, and information flow is the primary basis of this implementation. He summarizes some of the benefits of lean implementation to the office as better business process design, higher level of focus on strategies and more effective employee development. Tischler gives an example of lean initiative from an admission office of a university, and shows the benefits achieved after lean implementations, such as reducing the process time for handling the phone call inquires for a university from two weeks to less than a day.

The information technologies sector is another area that was investigated by researchers for lean implementations (Middleton, 2001; Dickerson and Turner, 1999). These

papers study the lean approach for information and software development sector and show how to transfer lean principles from the manufacturing sector to this area in order to achieve similar benefits. The results suggest that lean tools can be successfully implemented in non-manufacturing areas, but, the significant change is required in the traditional management principles.

Rising costs and personnel problems in the healthcare sector directed the healthcare industry to look for some possible improvement opportunities. The interest from the healthcare sector on lean has increased significantly in recent years and there are many lean implementations in hospitals and other healthcare organizations (Jones, 2006). According to Dan Jones, healthcare is the next important industry for lean and successful lean implementations is possible for hospitals. In his book “Lean Hospitals”, Mark Graban suggests that lean is proven to work for the healthcare sector and provides some examples of benefits gained by hospitals such as a 60% reduction in turnaround time for lab results and a 29% less waiting times for patients (Graban, 2008). Some of the other papers that study lean approach in the healthcare sector are Ben-Tovim et al. (2007), Ezzeddine (2006) and Alvarez (2007).

Examples of some other areas in literature that were investigated for lean implementations are construction (Kim, 2002; Nahmens, 2007), local government (Furterer, 2004), and non-profit organizations (Sampson, 2004).

Based on these studies, it can be suggested that lean can be successfully implemented in organizations that are from different sectors and areas. The researchers indicate that many of the lean failures are due to the lack of a strategically focused implementation plan (Nash and Poling, 2007), and strategy and management commitment is one of the most critical points in lean implementations (O'Rourke, 2005; Achanga et al., 2006). In light of these results, it can be suggested that having an implementation guideline and a well developed plan may help companies eliminate most of the problems with lean implementations. This is another indicator that suggests the potential advantage of developing and using lean management standards and certification system. These standards may also increase the management commitment since the managers will have certain responsibilities for their companies to meet the standards and stay as certified.

2.3 Standardization and Certification

In the previous section, we reviewed the articles that study how companies can successfully implement lean strategies in order to receive the benefits of lean manufacturing. A well developed guideline and implementation plan, long term strategy, sustainability, management commitment, employee cooperation and company culture can be defined as the most critical factors for lean implementations. These critical factors are also addressed in many management standards. Therefore, it can be suggested that a lean management standards system that was developed based on these factors may help companies become more successful in implementing and sustaining lean. In this section, a literature review will be provided for the studies that investigate standardization and certification, and different views from researchers about standards will be presented.

There is an ongoing debate about standardization in literature due to different views of the researchers. Positive views suggest that standards help companies improve their system and it is a very good start for a successful a new system implementation. The articles that have negative views stress that standards drive companies away from modern management theories and limit innovation and improvement.

There is vast amount of research on management standards and its benefits. Most of these papers use ISO 9000 Certification as a base, since ISO 9000 is one of the most well-known quality management standards that has been adopted by a large number of companies all over the world.

Dawes (2005) indicates that guidelines and requirements that were defined by ISO 9000 match the goals of executive management of companies. He suggests that ISO 9000 would help companies improve their profitability. He presents some examples of companies that achieved benefits with ISO 9000 certification and suggests that ISO 9000 is a powerful tool to fight with economical challenges. Gotzamani and Tsiotras (2002) also support this idea. Their research shows that companies that implemented ISO 9000 with a true motive can have significant operational and other benefits. The authors indicate that to achieve these benefits, standards should be implemented with continuous improvement spirit and with company-wide employee participation. Rao et al. (1997) suggest that ISO 9000 registered

companies have a higher level of quality results and better supplier relationships and employee development based on an international empirical study. In another research that was performed with companies in Spain, Nicolau and Sellers (2002) analyze the effect of granting an ISO 9000 certificate on stock market value of the company that received the certificate. Based on their study, it was indicated that the market shows a positive reaction to the awarding of certification.

On the other hand, Dick (2000) suggests that there is no proven link between quality certification and improvement of business performance. Ralphs (1998) challenges the effectiveness of ISO 9000 and states that obtaining ISO certification does not guarantee that a company has improved its processes. He also indicates that motive behind the certification is mostly external requirements, not improvement of the system. Casadesus and Karapetrovic (2005) investigate the changes in the perceived benefits of ISO implementations. Based on two surveys conducted in 1998 and 2002, although most companies still think that ISO is beneficial, there is a significant decrease in understanding of the benefits of ISO standards.

Although there are many publications about other aspects of lean manufacturing, standardization and certification of lean is not studied by researchers in detail. To the best of the author's knowledge, there are only a few papers that mention the idea of lean standards and certification.

Levinson (2005) suggests that a lean management standard should be developed and this should have the same force as ISO 9000. According to the author, standardization and best practice deployment were the key parts of the Henry Ford's system and it is now time to standardize the lean management system. He also explains that lean covers much of ISO 9000 and it is even more compatible with ISO 14000 environmental standards. The potential features that lean standards should include were also suggested in the paper.

Another article that is on the standardization of lean is by Vasilash (2000). He indicates that there is a need for lean standards and explains the potential benefits. The author also reviews the SAE J4000 Lean Standards and provides some details on how the standardization and certification would work. There are other studies that provide a brief review of lean standards based on J4000 Lean Standards (Bergmiller, 2006; Green, 2002).

Based on the conducted literature review, it was determined that standardization and certification of lean was not studied or investigated in detail by the scientific community.

There is no detailed analysis or empirical data about the potential benefits or disadvantages of standardization. The support from lean practitioners for lean standards has also not been determined. One of the research goals of this thesis is to help fill this gap in literature and contribute to the future studies.

Chapter 3

Standardization and Certification of Lean

3.1 Introduction

Although there are many research articles on lean manufacturing and management standards, development of the lean standards and analyzing the benefits of lean standardization was not studied in detail. The interest in lean manufacturing has significantly increased in the last decade and there are many companies that are using lean as an improvement strategy. The lean standards and a certification system may help companies improve the success level in their lean implementations. In order to achieve this goal, lean professionals need to have detailed information about the lean standards and understand the true motive behind the standardization.

In this chapter, standardization and certification in lean manufacturing will be studied. Details of the standards and the current certification programs will be provided from a lean manufacturing perspective. The benefits and disadvantages of standardization will also be analyzed.

3.2 Examples of Management Standards and Certification Programs

In a very small organization, processes and activities can be managed without a documented system. All information is in the head of the employees or managers and everybody has their own way of doing things. However, when a company becomes larger and more people are involved, it is very difficult to keep the business in order without written procedures and instructions. Management standards may help for this issue. With written policies, forms and records, it can be suggested that a company will have a system in place and this system will be there even when people change.

Based on this idea, different management standards are available in industry. International Organization for Standardization (ISO) is the world's largest developer and publisher of international standards for business, government and society. In these standards, ISO 9000 is the most popular and widely implemented standard. Up to the end of December 2006, at least 897,866 ISO 9000 certificates had been issued in 170 countries (ISO, 2006).

The first version of ISO 9000 was published in 1987 by ISO as an international quality system standard. ISO 9000:1987 had five different sections: 9000, 9001, 9002, 9003 and 9004. ISO 9000:1987 and 9004:1987 were support material for the companies that intended to get certified in one of the ISO 9001, 9002 and 9003. In 2000, ISO standards were updated. After this change, there was only one standard ISO 9001:2000 by which companies could get certificated. Arbuckle (2004) indicates that with this change, ISO also took more of a Total Quality Management (TQM) approach. Today ISO 9000 is a very important tool for many companies to improve their quality systems. It is also considered as an important aspect for marketing.

The 2000 version of ISO 9000 standards has 21 elements in five categories which specify activities that need to be considered when a company implements the ISO system. These categories are:

- Overall requirements for the quality management system and documentation
- Management responsibility, focus, policy, planning and objectives
- Resource management and allocation
- Product realization and process management, and
- Measurement, monitoring, analysis and improvement (ISO, 2000).

Organizations that are seeking ISO 9000 certification are required to develop documentation to prove that their system works based on quality standards. This documentation has four levels: quality manual, system procedures, job instructions and documentation of proof that the quality system is in place.

There are also management standards developed for a specific industry. QS 9000 Standard is one of them. The main objective of the QS 9000 quality system was to create a uniform set of requirements related to existing or planned quality systems of suppliers to the US automotive industry. An important part of that effort was the standardization of quality system documentation to be developed and maintained by each supplier. The QS 9000 quality system was developed and published in the USA in 1994 by a team consisting of representatives of the USA's big three automotive manufacturers (General Motors, Ford and Chrysler) and the US truck manufacturers (Bramorski et al., 2000).

QS 9000 standards have three main sections. In the first section, there are common requirements and this has the same text as ISO 9001 with the addition of automotive and heavy trucking requirements. The second section covers the production part approval process, continuous improvement, and manufacturing capabilities. The third section includes customer-specific requirements that are unique to General Motors, Ford and Chrysler (Kantha, 2004).

In December 2006, all QS9000 certifications were terminated and QS9000 was considered superseded by ISO/TS 16949. ISO/TS 16949 are the standards that were developed by ISO for all automotive industry worldwide. With QS9000 no longer valid, businesses had a choice between either ISO9001 or ISO/TS16949 (Reid, 2007).

Another example for industry specific standards is Woodmark. The Woodmark Quality Certification Program is the first quality management program specifically designed for the wood products manufacturing industry in Canada. It was developed by the Wood Products Quality Council of Canada in cooperation with researchers at the University of British Columbia in 1999. The Woodmark Quality System (WQS) has been designed specifically to be less document-oriented, with more focus placed on continuous improvement and process measurement to achieve immediate benefits (WPQC, 2008). The Woodmark Quality System has 30 elements that are organized in the following seven standards: (Maness and Kozak, 2002)

- Management commitment
- Quality plan
- Inspection of incoming material
- Measurement and control of in-process work
- Traceability
- Training
- Continuous improvement



Figure 3.1 – Woodmark Quality Management System (Source: wpqc.org)

The other aspect of standardization and certification is the certification programs for individual professionals. Individual certifications can be defined as a formal recognition that an individual has proficiency of a specified body of knowledge related to an area.

There are many certification types for almost every profession. Certified in Production and Inventory Management (CPIM) is an example for certification. CPIM is offered by APICS (The Association for Operations Management) for professionals who work in production and inventory management, operations, supply chain management and procurement (APICS, 2008). To earn CPIM designation candidates must pass all exams for the following modules:

- Basics of Supply Chain Management
- Master Planning of Resources
- Detailed Scheduling and Planning

- Execution and Control of Operations
- Strategic Management of Resources

APICS offers computer-based exams throughout the year. After passing all exams and getting the designations, CPIM certified professionals must maintain their certification every five years through a certification maintenance program.

Project Management Professional (PMP) certification is another example of certifications for individuals. PMP certification is offered by the Project Management Institute (PMI). Individuals who hold PMI's PMP credential demonstrate a proficient level of project management and leadership skills (PMI, 2008). To be eligible for the PMP credential, an individual must meet certain educational and professional experience requirements and must pass a 4-hour exam that has 200 questions. Similar to CPIM, once PMP certification has been attained, a PMP certified person must participate in the Continuing Certification Requirements (CCR) program to maintain an active certification status. The PMP certification cycle lasts three calendar years.

After having provided some background information and examples of management standards and certification programs, details about the certification process are presented in the following section.

3.3 How Standards Development and Certification System Works

In many standardization systems, there is usually an international organization that develops and updates the standards. For example, in the case of ISO 9000, it is the International Organization for Standardization (ISO) that develops, maintains and publishes the standards. Industry specific management standards could be developed for national or international use. For these types of standards, the organization that was established by the representatives of that industry is responsible for developing and updating the standards. In the case of Woodmark, it is the Wood Product Quality Council of Canada that has developed the standards.

The organization that is responsible for developing the standards usually works with representatives from large corporations, consultants, government agencies and academic

personnel to have different opinions and to develop efficient standards. Standards should be global solutions to satisfy industries and customers (ISO, 2008).

Development of a management standard process starts with the determination of the need for the standard. This could be expressed by professionals, industry representatives or corporations. Once the need is recognized and agreed upon, the organization that will be responsible for developing the standard forms a team to work on the project. This team determines the scope of the project and develops the draft standards. This draft version is published as an interim document to obtain feedback. After the required changes, the final standard is formed and published. For most standards, periodic revision is necessary due to technical developments, new methods or requirements.

The companies that implemented the management standards do not necessarily have to get certified. A company is free to choose to implement the standards in order to obtain the benefits and not seek certification. But due to motivation or marketing purposes, many companies that implement management standards prefer to also get certified.

In most cases, the organization that develops and updates the management standards is not responsible for the certification process and it does not perform audits and assessments of companies. Auditing and certification activities of management standards are carried out by independent certification companies. They are responsible for auditing the companies that implemented the standards to verify that they are implemented in conformity with the requirements of the standards. These certification companies could be accredited by an international accreditation organization or the organization that developed the standards.

The audit process is done by the auditors of the certification body. They review the documentation that was developed by the companies based on the requirements that were on the standards. Their role is to make sure that the company performs activities based on the documentation and the standards are implemented. They may conduct paperwork reviews for procedures and instructions, conduct interviews with employees and observe the production floor or office. After the audit is complete, if the auditor is satisfied with the system, the certification body issues the management standard certification for the audited company. If there are some points that need to be revised by the company, a time line is determined for these revisions and after verification of the required changes, certification is issued. The certified company operates based on the documentation that was developed. There is usually

a re-certification program for management standards. The companies that obtain the certification are periodically audited and their certifications are renewed. The companies are required to renew their certifications usually every 2-5 years. **Figure 3.2** summarizes the certification process.

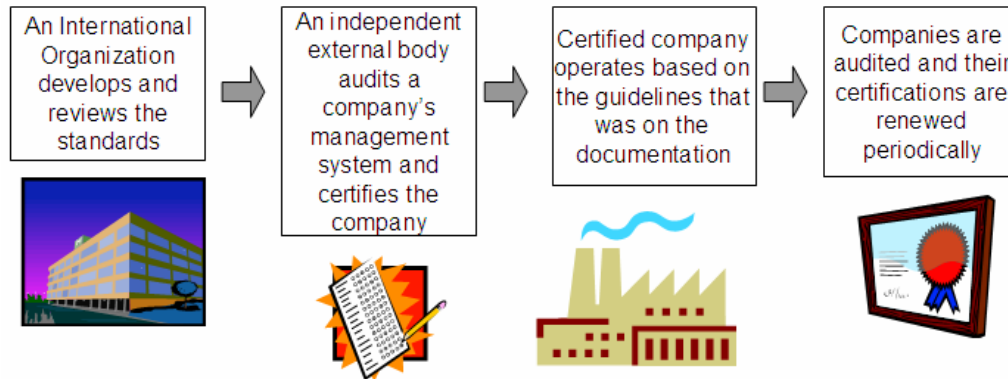


Figure 3.2 – Management standards certification process

In the case of certifications for individuals, as mentioned in the previous section, the professional associations that the certifications belong to are responsible for designing the certification program and determining the requirements (exam, educational or experience requirement etc.). They also offer studying material and courses for the people that are planning to get certification. These organizations create and update exam questions and organize the exams. In some cases, a third party body might carry out the exam procedures. Similar to the management standards, individual certification programs are also revised or new programs are introduced due to new systems or developments.

Following background information on management standards and certification programs, the most recent activities toward the standardization of lean manufacturing will be presented in the following section.

3.4 Lean Management Standards and SAE J4000

Although the interest in lean manufacturing increased significantly, especially with the success of Toyota and companies/organizations that have adopted such principles,

standardization and certification in lean manufacturing has not received a great deal of attention in academic studies. As discussed in the Section 2.3, there are only a few articles that can be found on this subject. Also, standardization of lean has not been discussed in detail to date by lean practitioners.

The only lean management standard development attempt in literature was J4000 by the Society of Automotive Engineers (SAE). SAE was founded in 1905 as Society of Automobile Engineers and Henry Ford was the first vice-president. In 1916, the organization changed its name to the Society of Automotive Engineers and became a new society representing engineers in all types of mobility-related professions (SAE, 2008). Today SAE is an international organization with many offices all over the world. SAE develops standards for automotive and aerospace industries, publishes globally-recognized magazines and organizes training and professional development programs.

SAE develops and publishes standards which can be defined as documentation of broadly accepted engineering practices or specifications for a material, product, process, procedure, and test methods. In early 1999, SAE started a research to determine the best lean practices for the automotive industry. This research was conducted in cooperation with executives of large automotive companies and some other companies that are not in the automotive sector, industry personnel, and academicians. The representatives visited the companies to observe the activities in order to determine the best practices (Vasilash, 2000). After the research and studies, the following three documents were published in August 1999:

- J4000: Identification and Measurement of Best Practice in Implementation of Lean Operation
- J4001: Implementation of Lean Operation User Manual
- RR-003: Automotive Lean Enterprise Conversion-Best Practice Examples

J4000 and J4001 are standards and RR-003 is a book which was published by SAE. J4000 can be defined as a tool that is used to identify and measure best practices in the implementation of lean operation in a manufacturing organization. SAE J4001 provides instruction for evaluating levels of compliance to SAE J4000. A procedure for evaluating and scoring of each component in J4000 is included in the J4001. RR-003 contains the examples

that represent best practices in the implementation of lean operation at representative companies, which are in the advanced stages of evolution in the process (SAE, 2008).

Similar to ISO 9000, there is a third party organization, the Performance Review Institute, which provides certification and auditor training for SAE J4000 standards.

The SAE J4000 document covers six lean implementation areas: (SAE, 1999)

- Management/Trust
- People
- Information
- Supplier/Organization/Customer chain
- Product
- Process/Flow

In these six areas, J4000 lists 52 components that provide measurable points of reference for successful lean implementation. The lean implementation in an organization can be measured by evaluating all of the components. The level of compliance can be used as a reference by an organization to compare itself to the current best practices in establishing a lean system. (See Appendix A for complete list of SAE J4000 components)

These six areas are weighted by percentage. SAE J4000 relates the following approximate topic percentages to the implementation process as a whole: (SAE, 2008)

- Element 4 Management/Trust: 25%
- Element 5 People: 25%
- Element 6 Information, Element 7 Supplier/Organization/Customer and Element 8 Product (combined): 25%
- Element 9 Process/Flow 25% (Figure 3.3)

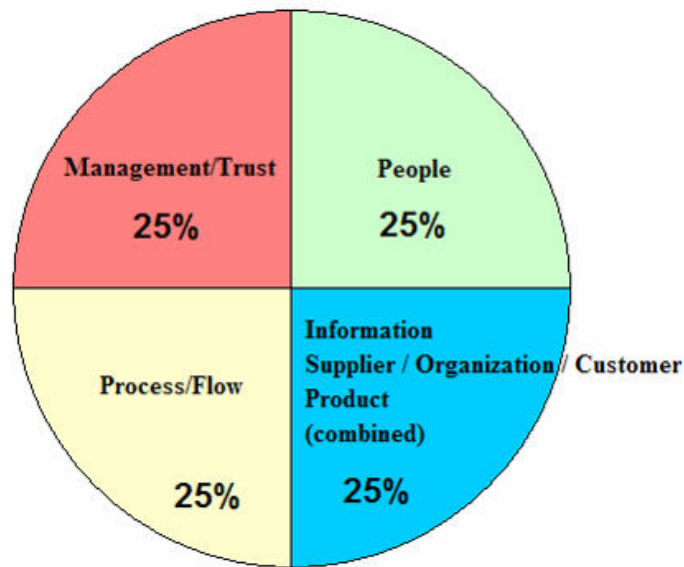


Figure 3.3 – J4000 Implementation areas and their percentages

Vasilash (2000) suggests that the order of the six implementation areas is not random and it represents the sequence that companies should follow when they implement lean manufacturing strategies. It should start with executive management commitment and continue with the support of employees from all levels. Availability of accurate and adequate information is the next important tool for a successful lean implementation. Relationship with suppliers and their performance has a big impact on lean. The next important aspects are product and process flow. According to Vasilash, this implementation sequence also indicates the implementation timeline. Starting with management and people suggests that lean is not a quick fix and short term plan. It should be seen as long term strategy and companies should not be discouraged with slow progress at the beginning.

For each of the 52 components, there are four states that define where a company is in implementing that particular component (SAE, 1999). These implementation levels can be described as:

- Level 0: The component is not in place at all or there are major inconsistencies in implementation.
- Level 1: The component is in place but there are minor inconsistencies in implementation.
- Level 2: The component is fully in place and effectively implemented.
- Level 3: The component is fully in place, effectively implemented and exhibits improvement in execution over the past 12 months.

If we analyze the description of these states, Level 0 describes the minimum level with no implementations or with major problems. Level 1 is the next stage with a better progress. Level 2 is the stage where that particular component is fully implemented. And Level 3 is the stage that the component is implemented and there is a progress in last 12 months.

The description of the Level 3 state is one of the most important points of J4000. Management standards usually determine a level and if a company reaches to that level it is considered that it has met the standard. The next step is to stay in that level. The difference of J4000 is that it does not accept being at a certain level and requires an improvement in last 12 months (Vasilash, 2000). This was indicated in the description of Level 3 which is the highest level in the implementation of a component. Based on this, a company can be in a stage where a full implementation of a component is in place, but if there is not any improvement in last 12 months, it will not be considered to meet the highest level of the J4000 standard. This suggests that J4000 is not a static system and supports continuous improvement and the idea of “lean is a journey, not a destination.”

Based on this review of J4000, it can be said that J4000 was developed after extensive research by representatives from different areas and it covers the most important aspects of lean. When J4000 was developed, it was expected to receive significant attention from industry, with the intention of becoming a common standard for lean implementation. Tom Epply of Continental Design & Engineering Inc. indicated in his Lean Manufacturing Handbook: “SAE J4000 is on its way to becoming to Lean Manufacturing what QS 9000 and ISO 9000 has become to quality.” However, if we review the interest level and number of companies that have used J4000 as a guideline for their lean implementations, it can be observed that J4000 was not known by lean practitioners and it was not implemented in many companies. Results of the survey that was conducted in this thesis show that 85% of

the participants have not heard or read about J4000 at all. Detailed information about the survey is provided in Chapter 4. Another indicator of the level of interest is the number of companies that contacted to the Performance Review Institute, the organization that provides certification and auditor training for SAE J4000 standards. According to information that was obtained from the Performance Review Institute, there were only a few workshops organized about J4000 and there is not any recent activity or training regarding J4000.

To investigate the reasons of the low awareness of J4000, the author has contacted SAE and had a phone interview with Jack Pokrzywa, Director of SAE Automotive Headquarters Operations. He was on the team that developed J4000 and he believes that the following can be determined as some of the reasons why J4000 was not successful in reaching to companies and lean professionals:

- “Lack of advertising and promotion: After J4000 was published; there was not enough promotion for it. This can be understood from the number of publications that mention J4000. There are only a few articles that reviews J4000 and gives information about it. One of the reasons of this lack of promotion is that Roy Trent, the head of the team that developed J4000 and the director of SAE's Best Manufacturing Practices Automotive Manufacturing Initiative, passed away shortly after J4000 published.” Jack Pokrzywa also states that “This hugely affected the promotion and advertising activities of J4000 since the person who was behind the whole study was not there to promote the standard.”
- “SAE is a sector oriented organization: Although J4000 was not developed only for automotive companies; SAE is seen as an organization that only deals with issues within the automotive industry. This is one of the reasons that the companies that are in different sectors have not shown a big interest in the standard that was developed by SAE.”
- “Companies adopted Lean principles from other resources: Many companies use different resources for their lean implementations. Considering the high number of these resources, J4000 was not accepted by companies that already started in their lean journey.”

Although J4000 was developed after extensive research and covers very important aspects of lean, it was not successfully deployed in industry. This may be perceived as a negative factor in relation to re-introducing the lean standards. However, if a new lean standards system is developed and introduced by an international organization with an effective promotion program and support from well known lean experts, it can be suggested that the awareness for lean standardization can be improved.

3.5 Lean Certification Programs for Individuals

Another aspect of standardization and certification of lean is the lean certification programs for professionals. This part of standardization also has a big impact on lean initiatives since the qualification of the lean professionals is one of the critical factors for a successful lean implementation. In this section, current lean certification programs for individuals and will be reviewed.

The Society of Manufacturing Engineers conducted a survey in 2005 with 1,100 participants. Based on the results of this survey, 77% of participants said that they would pursue a lean certification, 83% of participants indicated that lean certification for professionals is critical and important, and 60% of participants think that the key lean leaders at their suppliers should have a lean certification (Hutchins, 2005). After these results showed that there is interest and need for certification, the Society of Manufacturing Engineers (SME), Association for Manufacturing Excellence (AME), and Shingo Prize for Excellence in Manufacturing decided to collaborate to develop a lean certification program for lean professionals in cooperation with industry and academia (Hogan, 2005). It was introduced in 2005 and intended for manufacturing professionals who wanted transportable credentials that prove their knowledge about lean principles and tools.

Lean certification has three levels: Bronze, Silver and Gold. All certification candidates must complete the requirements of each level before they can progress to the next (SME, 2008). The progression model shows how higher levels build upon the development acquired during previous levels (Figure 3.4).

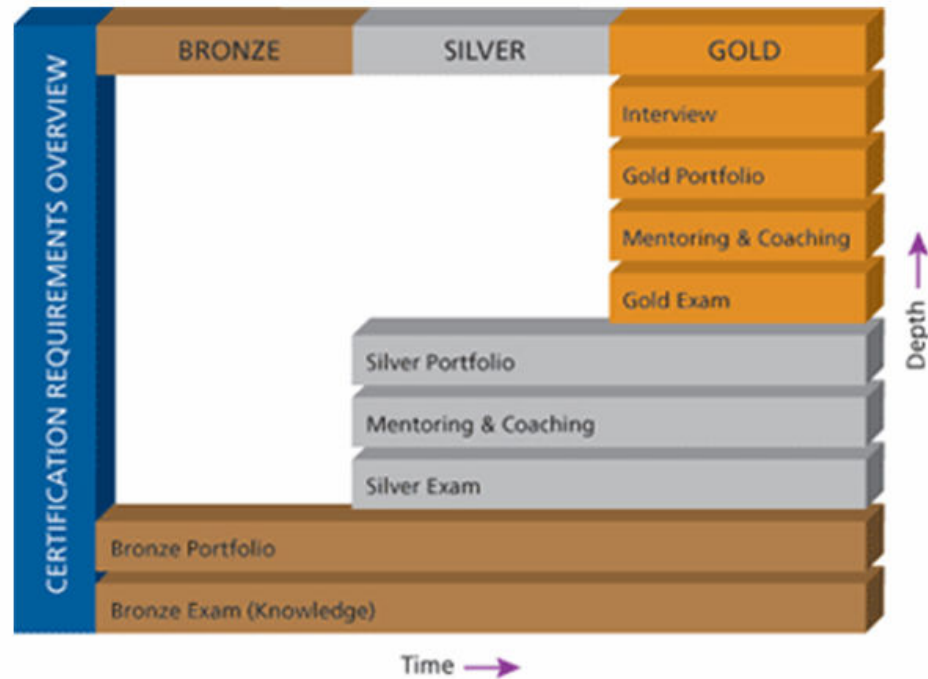


Figure 3.4 – SME Lean Certification levels and requirements (Source: SME)

The body of knowledge for the lean certification has been defined by the alliance partners and a panel of experts. See Appendix B for a complete body of knowledge. To achieve the lean certification, candidates must understand lean thinking as applied to:

- Leadership, empowerment, respect for people,
- Business strategy, product design, customer focus,
- Supplier relationships,
- Tools for finding and eliminating waste,
- Tools for continuous improvement,
- Improving quality, cost, delivery, business and service processes, and business results (SME, 2008).

The following is a summary of knowledge requirements for each level:

- Bronze: Understand tactical implementation of lean, be able to teach lean tools and have knowledge about lean project management

- Silver: Candidate should have a broad understanding of lean principles and tools and know how to implement them at value stream level. He/she should understand lean enterprise integration and have the ability to teach it.
- Gold: Candidate should understand strategic enterprise transformation and know how to implement lean principles to achieve significant results. They should also have the ability to teach lean strategy leadership (SME, 2008).

There are also experience and education requirements. Candidates must build and submit an experience portfolio for review. Each level of lean certification requires continuing education, either academic coursework or structured classroom training. There is a 150-question, 3-hour, open-book examination for each level. Exam questions are based on recommended readings selected by a team of experienced lean practitioners and educators. Candidates may request a mentor to guide them through the certification process (SME, 2008).

There are also some consulting firms that developed their own lean certification programs. Lean certification by TBM Consulting Group is one of these. TBM Lean certification is a validation process that delivers training in lean principles in both classroom and real-time situations. These latter experiences occur under the guidance of a mentor who possesses real-world successes in lean environments. With TBM certification, students learn how to apply their training directly in their own companies. As part of the curriculum, participants are required to define their companies' value streams and identify strategic projects for their own sites and are then held accountable for project sustainability and performance metrics. In addition to strategic planning, successful implementation, and the on-time delivery of projects, the curriculum for certification addresses budget objectives that lead to significant return on investment. For this reason, the TBM Consulting Group stresses that all improvement projects identified during the course of training must realize an annualized savings of 3–5 times the cost of the training. If this criterion is not met, the candidate cannot be certified. Following the completion of each training session, participants are tested before being allowed to proceed to the next level of training and must complete an extensive “lean transformation exercise” based on actual scenarios before they are certified (TBM, 2008).

3.6 Benefits and Disadvantages of Standardization

As mentioned in Section 2.3, there is an ongoing debate among researchers and practitioners about management standards and their benefits and disadvantages. Some scholars think that standards are great tools for a company's improvement, while others think they do not bring any significant advantage (Levinson, 2005; Raplths, 1998). The ideas about lean standards are not much different. In this section, benefits and disadvantages of management standards and certification will be reviewed and some different views from lean professionals will be presented. A summary of benefits and disadvantages of lean standards can be seen in Figure 3.5. This list is discussed in detail in this section

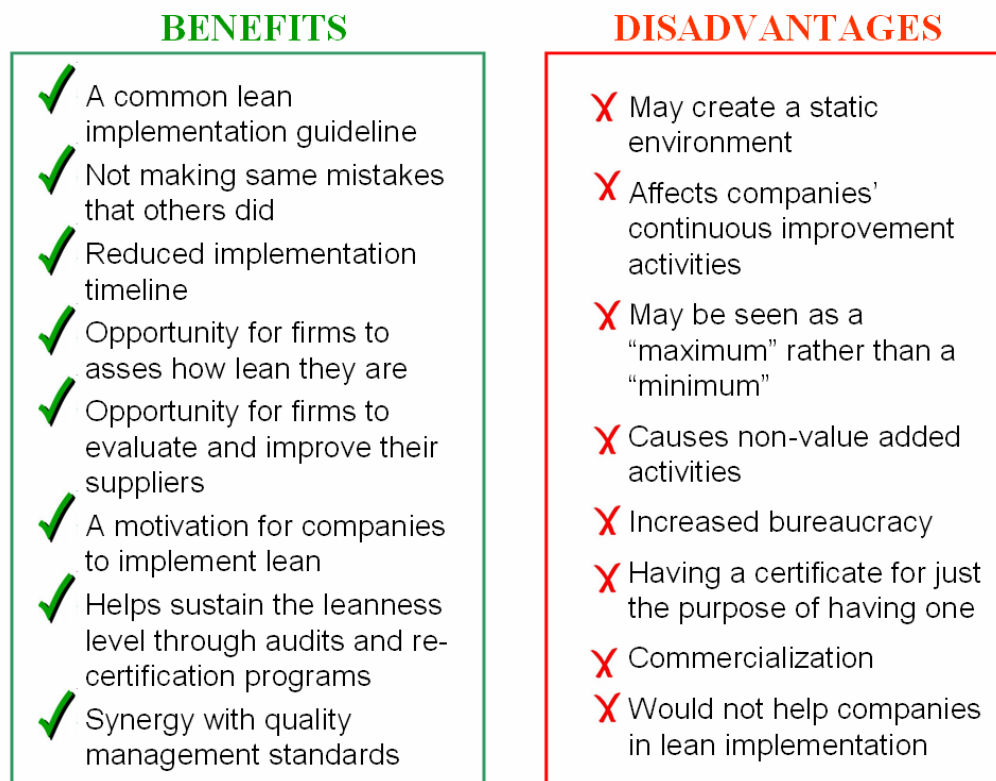


Figure 3.5 - Summary of benefits and disadvantages of lean standards

The people who support standardization indicate that the term "lean" is defined in so many different ways and sometimes refers to dozens of different systems although most share the same fundamentals (Green, 2002). Each company, consulting firm or lean

professional, have their own definition of lean and their own approach for lean implementations. On the other hand, industry and academia need a common definition of lean and a guide for implementation which will present the best practices. So, with lean management standards, a common definition and implementation guideline can be developed. According to a report that was issued by Aberdeen Group, standardization of lean processes across the entire enterprise is the differentiator for best-in-class performance. The report indicates that this standardization plays a crucial role as a building block for success of lean implementations (Aberdeen, 2008).

Two major benefits of lean standards can be defined as better and faster implementation and having a chance to evaluate a company's leanness level. One of the biggest problems with lean implementations is a lack of implementation know-how (LEI, 2007). According to the LEI survey, many companies are having difficulties in their lean implementations since they do not have a guideline which was developed after detailed research and feedback from different industry personnel and academia. It can be suggested that by developing and using lean management standards, this obstacle can be eliminated. Levinson (2005) also indicates this point and explains that standardization and best practices deployment were a central part of Henry Ford's system and it is now time to standardize the management system by developing lean standards. QS 9000 is an example of this application. It was developed to create a common guideline and a quality management system for automotive suppliers. Another benefit of standardization is to have a shorter implementation timeline. It can be suggested that by having a best practices example and a game plan, companies will not make the common mistakes that were made by others in the past, and this may help them to implement lean tools in a shorter time period. According to Roy Trent of SAE, on average, it takes approximately five years to fully implement lean in a company and he suggests that this can be reduced to two years by using lean management standards (Vasilash, 2000).

Another benefit of lean standardization is that companies will have a chance to evaluate their status in their lean journey. By using lean standards, companies will have a tool to measure their leanness level and they will also have a methodology to compare their operations with the most successful companies in lean implementations. (Green, 2002) One of the problems with lean operations is that after implementing some lean principles and

having some improvements, companies think that they have come a long way and slow down. By using the lean standards, it can be suggested that they will objectively know where they are and how they are doing in comparison with other companies.

Companies can also use standardization as a tool to evaluate and improve their suppliers. Since suppliers' success and reliability is a key factor for a company's performance, many companies use some tools to audit and evaluate their suppliers. Especially for just in time implementation, supplier's lean principle implementation level is very important. According to Joseph Day, CEO of Freudenberg-NOK, while companies are making important progress in implementing lean principles within their own organizations, they are missing millions of dollars in waste caused by suppliers (Anonymous, 2001). He also indicates that there are no major initiatives to sponsor small suppliers in lean training or to mandate to use of the SAE J4000 lean standards. He proposes that the waste caused by suppliers can be eliminated by helping them appreciate and apply lean, and J4000 can be used as a tool for this purpose. So, as suggested by Joseph Day, having common standards may provide companies a big advantage to evaluate and improve their suppliers' status in their lean journey.

Sustainability is one of the big challenges that companies face during their lean journey. Backsliding to the old system was identified as a major problem in lean implementations (LEI, 2007). Starting the lean process can be easy, but sustaining it over long term period is not easy and requires planning, discipline and commitment (Alukal, 2006). Having lean standards may help companies sustain their lean level. Since there will be audits and a re-certification process, companies would have to keep their lean level in order to stay certified. Companies will constantly have to monitor their lean implementations and continuous improvement level by using lean standards. It can be suggested that an efficient and well planned audit and re-certification system may increase the discipline and commitment about lean, and companies may have a better chance to keep lean alive.

Another benefit of lean standardization is its support for other management certification programs. According to Green (2002), lean standards may be useful to companies in meeting some requirements of QS 9000 or ISO/TS 16949. Levinson (2002) also indicates this point and suggests that lean enterprise encompasses much of ISO 9000 and if a company has lean management standards, it will probably do well with ISO 9000 quality

management standards. Levinson thinks that lean audits can be combined with ISO 9000 audits and it may create a strong synergy between lean and quality management systems.

There are also opinions about disadvantages of lean standardization. Especially, motivation behind management standards has been discussed in many articles. Gotzamani and Tsiotras (2002) indicate that many companies seek certification mainly for advertising purposes or are forced to by their customers. But the authors also state that these types of companies will fail in their implementations since they focus only on short term advantages without understanding the real idea behind standardization. So, it can be suggested that if companies consider lean standards as a tool that will help in their lean journey, they may get the benefits. But if they see certification as a maximum level and try to use it as a marketing tool, they will not see any improvement in their lean initiatives.

One of the disadvantages that are expressed in literature is the effectiveness of standardization. The people who are against standardization suggest that having a certificate does not guarantee that a company is lean. For example, Robert Simonis states in his post at Lean Enterprise Institute's discussion forum: "The audit of "leanness" creates a set of standards that people achieve without learning the "why" and so it will be unsustainable. Audits produce companies that are good at passing audits, not necessarily what the audit is supposed to measure."

Some other lean practitioners focus on the cultural aspect of lean and they think that standardization would not help improving this side of lean. For example, Bob Benett, President of Lean Consulting Associates, LLC and retired VP of Toyota Motor Sales, U.S.A indicates this point in a phone interview, which was conducted for this thesis, and says that "Lean is a culture and you can not certify the culture or mental values. Certification is a tool that helps eliminate some problems in implementing lean principles on the factory floor. This is a very small portion of the problem for implementing lean."

Another concern about lean standards and certification is paperwork and non-value activities that it will create. By implementation of lean standards, there will be procedures, instructions and audits. These will cause an increase in paperwork and bureaucracy and it will be an extra burden for companies. Also some people think that some activities related to lean standardization are non-value added, therefore certification should not be implemented.

As discussed in the previous section, another aspect of lean standardization is lean certification programs for individuals. There is a common idea in industry about the benefits of lean certification for individuals. Some of the benefits that were suggested in literature can be summarized as the following: (Ulmer, 2008; SME, 2008)

- “Provides a widely recognized and transportable lean certification credential”
- “Documents certified person’s knowledge and skill to show that he or she qualifies for new roles and responsibilities”
- “Sustained knowledge level through recertification process”
- “Provides a consensus-based tool for measuring proficiency of lean practitioners”
- “Identifies true lean experts, removing uncertainty when engaging a consultant or hiring an employee”
- “Helps align lean practices within the company, through supply chains and across industries”
- “Provides customers with confidence that the organization’s continuous improvement efforts will be effective”

3.7 Chapter Summary

In this chapter, the examples of the current management standards and certification programs were presented. A review was provided about how standardization and certification systems work. Standardization and certification from a lean manufacturing perspective is studied with examples of lean standardization efforts.

Based on our review of the benefits and disadvantages of lean standards, it can be suggested that standardization of lean manufacturing has important advantages for companies, but also there are some concerns regarding the effectiveness of the standards. Success of standardization highly depends on how it is approached by companies. If it is seen as a tool to help them implement and improve their lean initiatives, and if it is understood and accepted by all employees, lean standards can be a great tool for companies to adopt and sustain lean principles. But if it is considered as a marketing tool or a level where further lean efforts will be terminated, it carries the potential to cause companies to fail in their lean journey.

Chapter 4

Survey about Lean Standards

4.1 Objective

As discussed in the previous chapters, there are different opinions about lean standards and certifications. Some people think that it is a great tool and will help companies with their lean journey. On the other hand some lean professionals think that standardization would not work for lean.

Based on the conducted literature review, there isn't any opinion survey conducted about the lean standards and certification. To fill this gap in literature and to have a better idea of what lean practitioners think about the subject, we decided to conduct a survey. By conducting this survey, we have had a chance to quantify the different objectives of industry personnel and lean professionals. The objectives of this survey can be summarized as:

- To understand the level of interest from lean practitioners about lean standards and certification
- To get different opinions from people to make our research stronger
- To measure the support from industry and lean professionals about standardization to understand if introduction of lean standards is possible
- To contribute to the ongoing debate about management standards

Table 4.1 shows the step-by-step procedure of design and distribution of the survey as a flow chart.

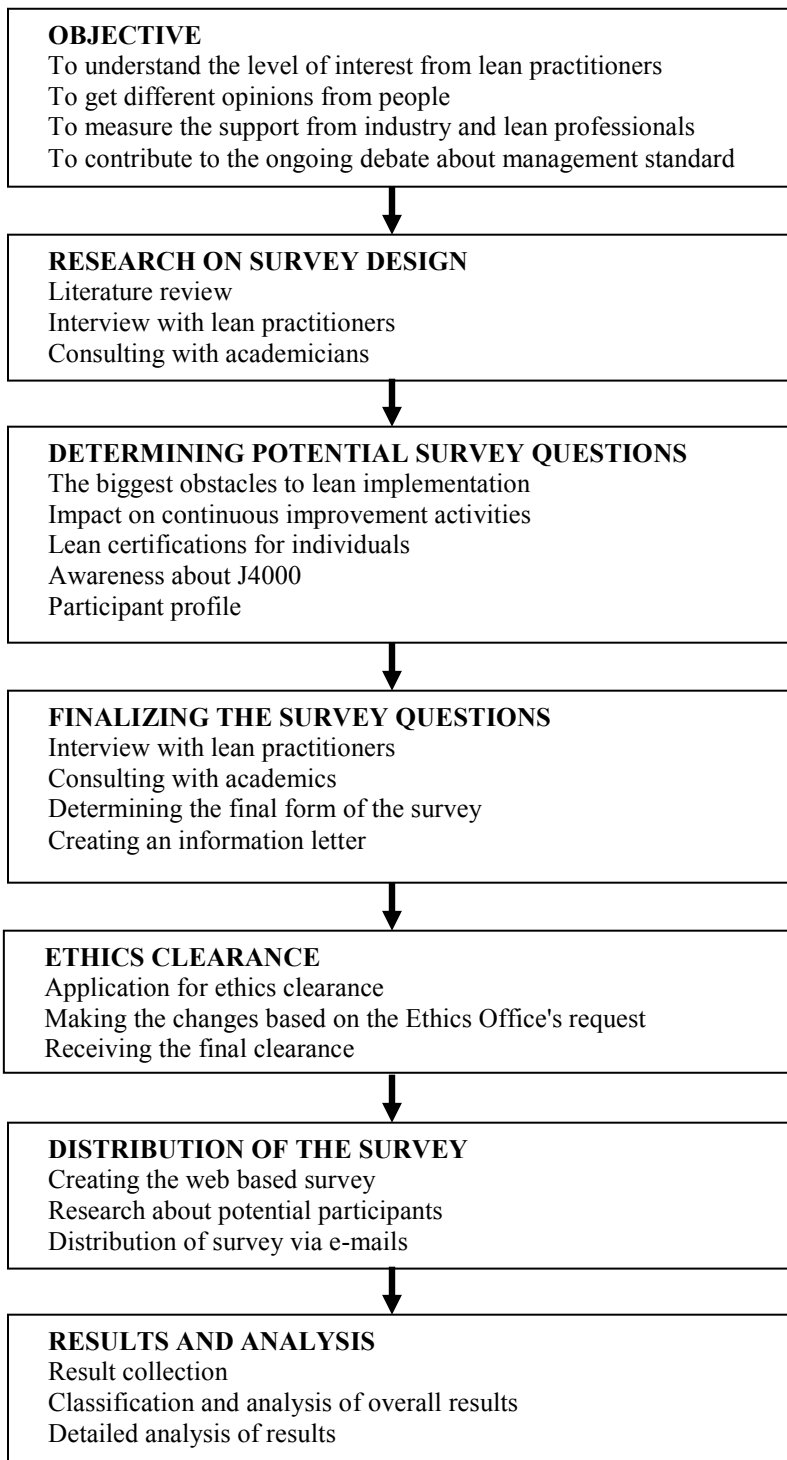


Table 4.1 - Design and distribution procedure of the survey

4.2 Survey Design

The research goal of this thesis is to study the perceived or potential benefits and disadvantages of lean standards and certification, and analyze if the standardization would be helpful in implementing and sustaining lean principles. So, when we designed the survey questions, we first wanted to get the opinion of lean practitioners about how standardization would help eliminate major problems in implementing the lean tools and principles. The first step towards reaching this goal was to determine the major obstacles in the way of a successful lean implementation.

The Lean Enterprise Institute (LEI) is a nonprofit education, publishing, conferencing and management research center. It was founded in 1997 by James Womack, co-author of the book “The Machine that Changed the World”, to promote and advance the principles of lean thinking in every aspect of business and across a wide range of industries (LEI, 2008). Since 2003, LEI has surveyed managers and executives annually to get their opinion on lean implementations and other trends related to lean. One of the questions that were asked in these surveys was on the key obstacles that lean professionals face in transforming their companies from mass production to lean. Based on 2,444 responses in the 2007 survey, the following three obstacles were determined as the biggest problems in lean implementations (LEI, 2007):

- Lack of implementation know-how
- Middle management resistance
- Employee resistance

These three obstacles, together with the sustainability issue, were on the top three of the obstacle list with an average of 30% of participant vote in each of the last three year’s surveys. Based on this information, we have decided to ask participants if they think standardization and certification of lean manufacturing would help in eliminating these three obstacles. For these questions, participants had the following five options to choose:

- 1) Strongly agree
- 2) Agree
- 3) Neither agree nor disagree
- 4) Disagree
- 5) Strongly disagree

As discussed in the previous chapters, one of the suggested concerns with lean standards is that it may create a static environment and slow down the companies' continuous improvement activities after reaching the certification. Especially due to some bad examples of ISO 9000 implementations, this possible disadvantage was mentioned by many industry personnel. To determine what lean professionals think about the impact of standardization on companies' continuous improvement activities, we decided to ask the following question: "What kind of impact will standardization and certification make on companies' continuous improvement activities and their pursuit of lean?" The options for this question were:

- 1) It will make continuous improvement activities much more effective
- 2) It will make continuous improvement activities more effective
- 3) It will have no impact
- 4) It will make continuous improvement activities less effective
- 5) It will make continuous improvement activities much less effective

The benefit of lean certification for individuals was another point that we wanted get feedback from the participants. So, in another question, we asked participants if they think lean certification for individuals would be beneficial to companies and their lean implementations. For this question, too, participants had the following five options to choose:

- 1) Strongly agree
- 2) Agree
- 3) Neither agree nor disagree
- 4) Disagree
- 5) Strongly disagree

In the previous chapter we provided information about SAE J4000 and discussed the possible reasons why it was not successful in terms of interest level from lean practitioners. To measure the awareness about J4000 among industry professionals, we asked if the participants have ever heard or read about SAE J4000 standards. The options for this question were "Yes" and "No".

The rest of the survey questions were about participant profile. To have an idea about the general status of participants, we asked questions related to the participant's position and some information about the company where the participant is employed. These questions are also important to measure the impact of the participant profile on the answers.

The profile questions were about the participant's position in the company, the company's location, annual revenue and the number of employees. We also asked about how long the participant's company had been implementing lean principles. Another question was the sector in which the participant's company operates. For the sector question, we used the North American Industry Classification System (NAICS) for the options that the participant would choose.

With the participant profile questions, there were a total of 13 questions in our survey. The following is the list of the questions:

- Do you think standardizing Lean Manufacturing (similar to ISO 9000) would help in eliminating the lack of implementation know-how obstacle?
- Do you think standardizing Lean Manufacturing would help in eliminating the middle management resistance obstacle?
- Do you think standardizing Lean Manufacturing would help in eliminating the employee resistance obstacle?
- What kind of impact will standardization and certification make on companies' continuous improvement activities and their pursuit of lean?
- Do you think certifications for Lean Professionals (similar to CPIM, CMA etc) would be beneficial to companies and their Lean implementations?
- Have you ever heard or read about SAE J4000 Standards? (SAE J4000: Identification and Measurement of Best Practice in Implementation of Lean Operation, Lean Standards developed by Society of Automotive Engineers, SAE International)
- How long has your company been implementing Lean Manufacturing Strategies?
- What is your position within the organization?
- In which industry does your company operate?
- If your company operates in manufacturing industry, please select the sector.
- What was your company's annual revenue for 2007?
- What is the approximate headcount of employees in your company?

- In what geographic region is your company headquarters located?

Please see Appendix C for the list of survey questions with the complete answer options.

The next step before we send the survey to the participants was to get the ethics clearance. The University of Waterloo requires all research involving human participants conducted by its students, staff and faculty, on or off-campus to undergo prior ethics review and clearance through the Office of Research Ethics. The ethics review and clearance process is intended to ensure that projects comply with the Office's Guidelines for Research with Human Participants and guidelines of various professional organizations. The goal is that the safety, rights and welfare of participants are adequately protected. Based on these guidelines, our survey questions reviewed by the Office of Research Ethics and we received the ethics clearance.

4.3 Survey Distribution

For this study, web based survey method is selected. After finalizing the survey questions and obtaining the ethics clearance, we created the web-based survey. Web base surveys are usually sent to the participants via e-mail with a link to the website where the survey will be conducted. The participants select the link and connect to the survey page which is specifically designed for the survey. After they choose the options for each question, the participants submit the survey and the answers are stored in the web site's database. Web-based survey method offers great control and an effective data collection opportunity for the researcher. The results can only be seen by the researcher and no individual can be identified from the summarized results. For our survey, we used surveymonkey.com web page to conduct the survey and collect the data.

The next step was to design an information letter for the survey. This is a cover letter that was sent to the participants in the body of the e-mail. This letter explains the objective of the survey and gives brief information about the research. It also explains the survey method, confidentiality, ethics clearance info and provides the contact information of the researchers. The link to the survey web page is also in this letter. Please see Appendix D for the information letter.

One of the biggest challenges in conducting surveys via e-mail is the unavailability of reliable source of e-mail addresses for conducting this type of research. The professional organizations such as SAE or SME have e-mail databases for their members and these members are surveyed for empirical research via e-mail questionnaires. However, these e-mail databases are not usually available for academic research and these organizations do not share these lists due to confidentiality of the personal information. To solve this issue and to reach as many participants as possible, we created a list of potential participants for our survey.

The main sources for the potential survey participants can be classified in four groups (Table 4.2). The first group is the lean organizations that were usually established as non-profit organization to provide lean training, to organize conferences, to publish books and to help companies for their lean initiatives. This group also contains the consortiums that were established by companies in a region to share lean experiences and improve their performance. Alliance for Enterprise Excellence in Kitchener, Ontario and Lean Institute in Turkey are two example organizations in this group. We contacted these organizations and they accepted to distribute our survey e-mail to their members and contacts.

LEAN ORGANIZATIONS	Lean institutions and associations Lean consortiums and alliances Lean consulting firms Other professional organizations
CORPORATIONS	The researcher's employer corporations and its divisions Suppliers of the researcher's employer Some other companies
ONLINE SOURCES	Lean forums Discussion groups Online magazines Lean networks
OTHER SOURCES	Industry magazines Authors Academics Personal contacts

Table 4.2 – Sources for survey distribution

The second group is the companies and corporations and their lean practitioners. The main source in this group is the employer of the author of this thesis. It is a large international corporation with many divisions in different sectors and facilities all over the world. For the distribution of our survey e-mail, we contacted Corporate Executive VP of Manufacturing and he agreed to send the e-mail to the lean professionals within the corporation. We also contacted the VP of Purchasing for distribution of the survey to the company's suppliers. This was also accepted by the purchasing group and our e-mail was forwarded to the main suppliers in North America and Asia. We also contacted some other companies that were known for their successful lean implementations.

The internet and online sources is another important group of potential participants. Due to the widespread availability of internet access, and efficiency of online communication, there are many discussion groups available on the internet to communicate and share information about lean practices. We sent our information letter to the moderators of these websites and three important groups allowed us to post our survey in their discussion groups. These groups are highly sensitive not to overwhelm their members with too many surveys. However, since the main purpose of our survey was academic, and they found the subject interesting, they accepted to send this survey to their members.

The last group of sources is personal contacts, lean professionals at companies and the academics who work on the similar subjects. The authors of the books that are related to lean and the editors of some industry magazines are other examples of the potential participants.

By using this list of potential participants, we started sending out our survey in April 2008. During distribution of our survey, we received feedback and different opinions from the participants. We also conducted interviews with some of the participants who contacted us for more information. This provided the opportunity to evaluate the interest level on the research subject.

We finalized the data collection at the end of May 2008 and we received a total of 244 responses. When we review the literature, except for the surveys conducted by large lean institutions or professional organizations, the number of participants in similar surveys is around 150-300 (Shah, 2002; Aberdeen, 2008; Cua et al., 2001). The participant profile also

showed that we have opinions of lean professionals from different sectors and positions with different lean experiences.

4.4 Survey Results and Discussion

In this section, the survey results for each question will be presented and the outcome will be discussed. First, the participant profile questions will be reviewed to provide some background information.

Geographic Location:

70% of the participants are from North America which includes USA, Canada and Mexico. 22% are from Europe and 8% are from Asia/Pacific (Figure 4.1). As we can see, the majority of the participants are located in North America. This shows that results will mostly indicate opinions of lean professionals from this part of the world. This is important since most of the lean implementation issue statistics and case studies in literature originate usually from North American companies.

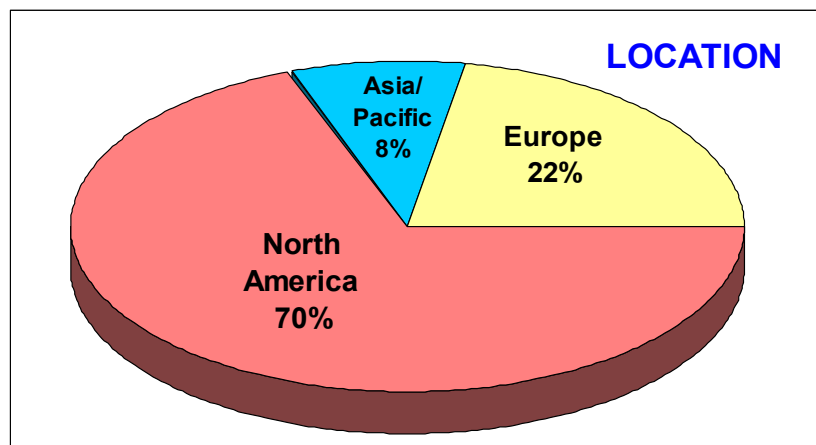


Figure 4.1 – Geographic location of the survey participants

Position:

The biggest group in the participants is managers making up 50% of the respondents (Figure 4.2). 24% of the participants are staff (engineers, analysts, coordinators etc.). The percentage of senior management is 11%, and the directors are 8%. So, in total 19% of the participants are in executive positions such as Director, VP or Senior VP. This group of participants is important, since the executives will have a major impact on lean standards and

certification. 3% of the participants are consultants and the remaining 4 % belong to other positions.

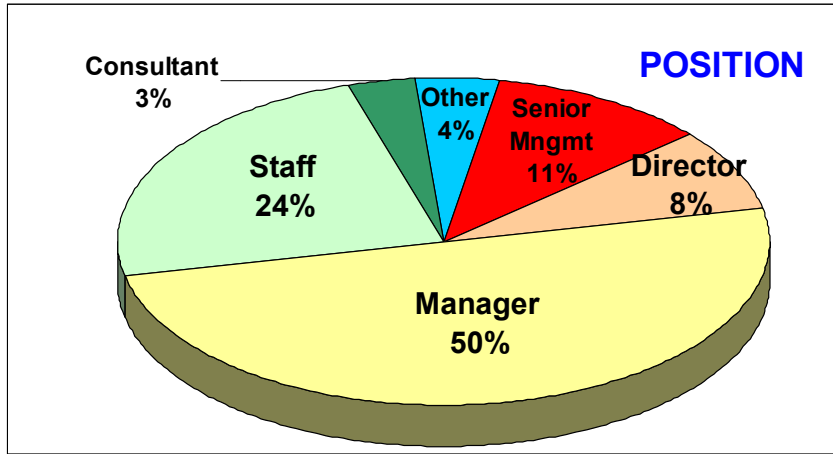


Figure 4.2 – Position of the participants

Sector:

Most of the lean manufacturing implementations are in the manufacturing sector. Although there are other sectors, such as healthcare and information technology, where lean is becoming very popular, the manufacturing sector is very advanced in lean implementations. This is also reflected in our survey. 90% of the participants are from the manufacturing sector (Figure 4.3). The other 10% of the participants are from construction, mining, transportation, and technical sectors.

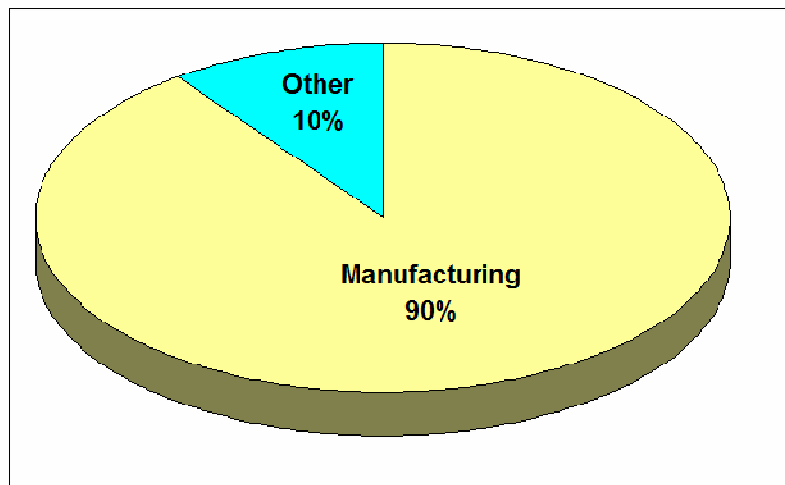


Figure 4.3 – The sector of the participant's employer

We also asked the participants in which industry their companies operate. There are many different industries that the participants' companies belong to (Figure 4.4). The largest two groups are the metal and wood industries. Electrical equipment and appliances, computer and electronic, paper and machinery industries are other groups with close percentages. The total percentage of all other industries such as chemical and textile is 13%. This distribution suggests that the results represent the ideas of the participants who are from variety of different industries.

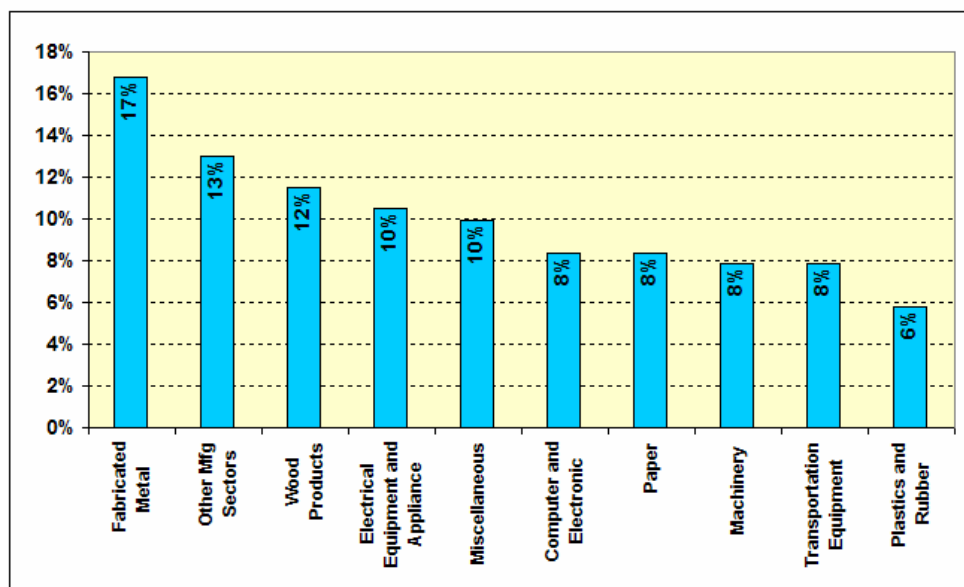


Figure 4.4 – Industries in which the participants' companies operates

Number of Employees:

One of the questions was about the number of employees who work at the participant's company. These results also represent different size of companies (Figure 4.5). The two big groups are the companies with 250-500 employees and the ones with more than 2500 employees.

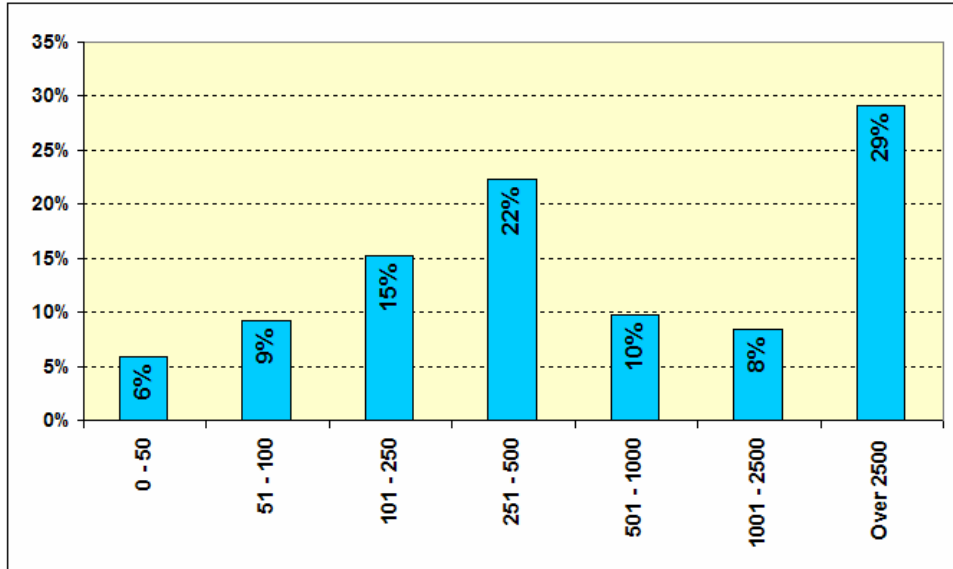


Figure 4.5 – Number of employees

Annual Revenue:

Annual revenue of the companies was another question about the participant profile. There is a similar situation for this question as with the previous two questions, where the companies have different annual revenue figures (Figure 4.6). The largest group is the companies with more than 1 billion U.S. dollars of annual revenue. The second biggest group is \$100 - \$250 million. The rest of the groups have very close percentages.

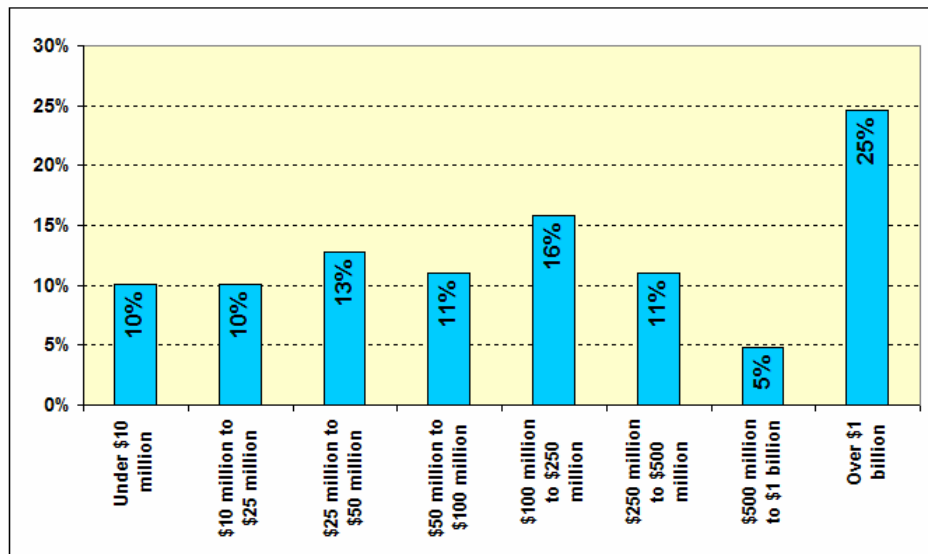


Figure 4.6 – Annual revenue

Lean Journey:

The last question about the participant profile is the number of years in their lean journey. We asked participants how long their company has been implementing lean strategies. The results show that 33% of the companies have been in their lean journey for 2-5 years (Figure 4.7). The second largest group is 5-10 years with 22%. In total, 56% of the companies have a lean journey that is less than 5 years, 31% is more than 5 years, and 13% has no lean implementation. The experience in lean implementations has an important impact on the participants' opinion about standardization. This impact will be discussed when we present the detailed analysis of the results.

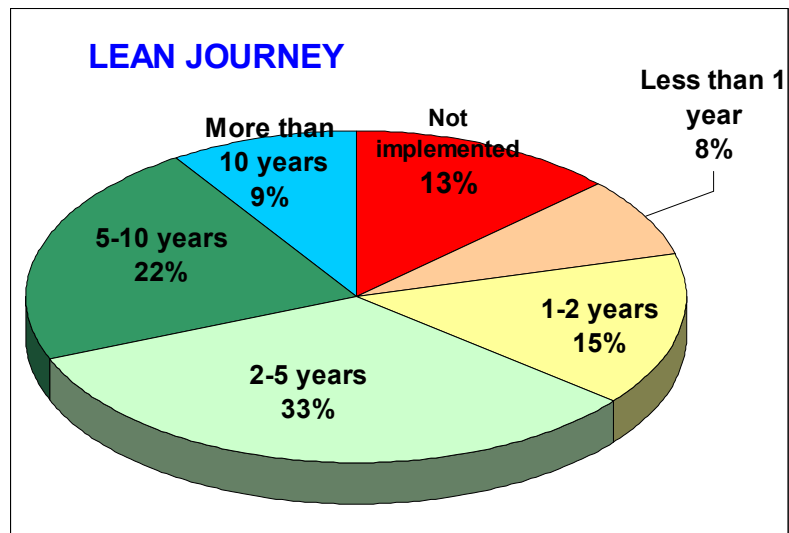


Figure 4.7 – The number of years in lean journey

After providing the results of the participant profile questions, the results of the other survey questions will now be presented. We will review each question and discuss the results.

Lack of implementation know-how obstacle:

We have asked participants if standardization and certification of lean manufacturing would help in eliminating the lack of implementation know-how obstacle. 46% of participants agree and 15% of participants strongly agree that lean standards would help in eliminating the know-how problem (Figure 4.8). This gives us a total of 61% support from the participants for this question. In total, 25% of the participants either disagree or strongly disagree with this idea. 15% of participants are neutral. These results suggest that a majority of the participants support standardization for eliminating the lack of implementation know-how obstacle.

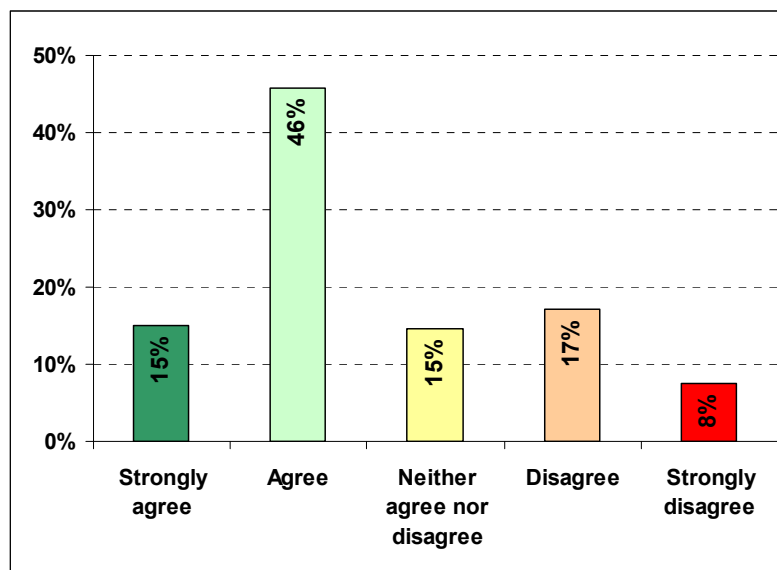


Figure 4.8 – The results for the lack of implementation know-how question

Middle management resistance obstacle:

Middle management term defines the people that are between the supervisors and directors. They usually have a team of supervisors and production workers who work under them. In our survey, we asked participants if they think that standardization would help in eliminating the resistance from the middle management in lean implementations. Similar to the previous question, 46% of the participants agree and 13 % of the participants strongly agree that lean standards would help in eliminating this issue (Figure 4.9). Total support for this question is 59%. On the other hand, 21% disagree and 6% strongly disagree that lean standards would help in eliminating the middle management resistance problem. To have a

better idea about this question, we have made a detailed analysis on the positions of the participants who agree or strongly agree. If we look at the results, 56% of the participants who agree or strongly agree are middle managers (Figure 4.10). This suggests that even the managers themselves think that lean standardization would help eliminate the resistance of middle managers.

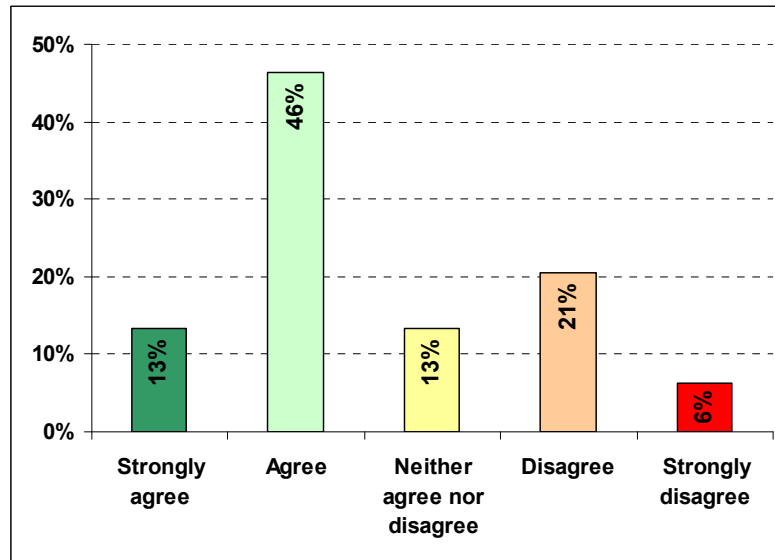


Figure 4.9 – The results for the middle management resistance question

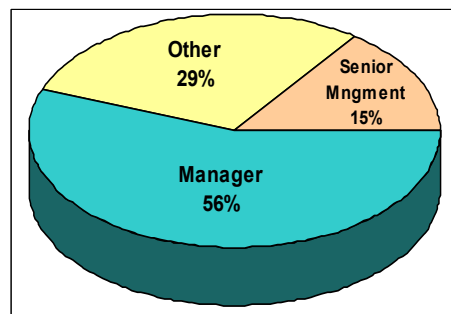


Figure 4.10 – Position of the participants who agree

Employee resistance obstacle:

It was suggested in literature that the “human side” of the lean is very important and without acceptance from all workers, a successful lean implementation is impossible. We asked the participants if lean standards would help eliminate the resistance from employees.

Although the percentage of the participants who agreed is more than that of who disagreed, the support level is significantly lower than the previous two questions (Figure 4.11). In total, 49% of the participants support this idea and 33% of the participants do not agree that standardization would help eliminate employee resistance issue. 18% of the participants are not taking any side. This percentage is higher than the implementation know-how and middle management resistance questions. The results suggest that the lean professionals are less supportive for standardization about the employee resistance issue. This could be an important challenge for introducing lean standards since eliminating the employee resistance is very critical to a successful lean implementation.

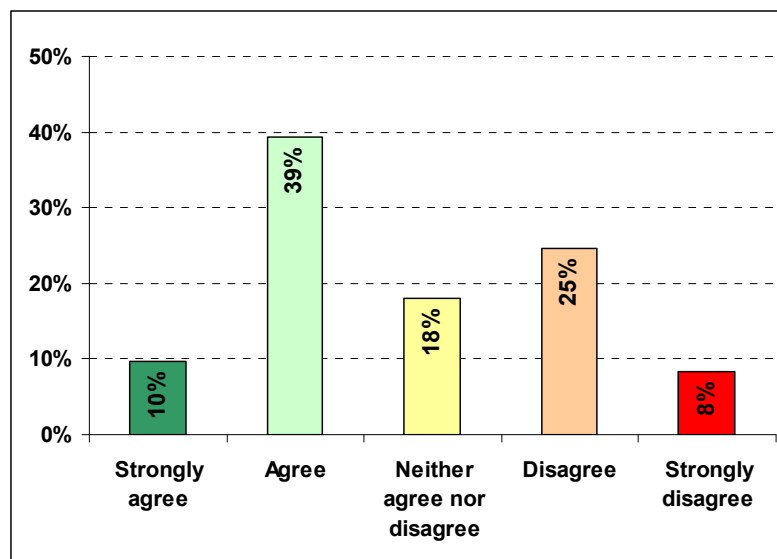


Figure 4.11 – The results for the employee resistance question

Impact on continuous improvement activities:

The impact of standardization on a company’s continuous improvement activities was another point that was asked to the participants. If we review the results, in total 72% of participants think that standardization will make companies’ continuous improvement activities more effective or much more effective (Figure 4. 12). Only 11% of the participants think that it will negatively affect the improvement. According to these results, the majority of participants did not see standardization as an issue that prevents or halts continuous improvement activities. 72% support from the participants suggests that lean professionals think that standardization would help the companies in their lean pursuit, and not negatively

affect the improvement. It is also a possibility that this critical point might have been overlooked by the participants of the survey.

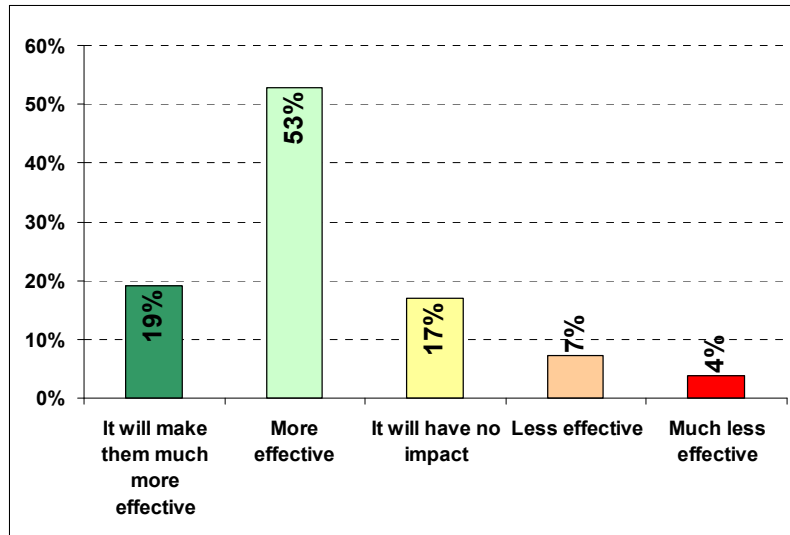


Figure 4.12 – The results for the impact on continuous improvement activities question

Lean certification for individuals:

As mentioned in Section 3.5, there are many benefits of lean certification for individuals. The previous surveys show that a very high percentage of the lean professionals support lean certification programs (Hutchins, 2005). Our survey showed similar results where 75% of the participants in total agree that lean certification for individuals would be beneficial to companies and their lean implementations (Figure 4.13).

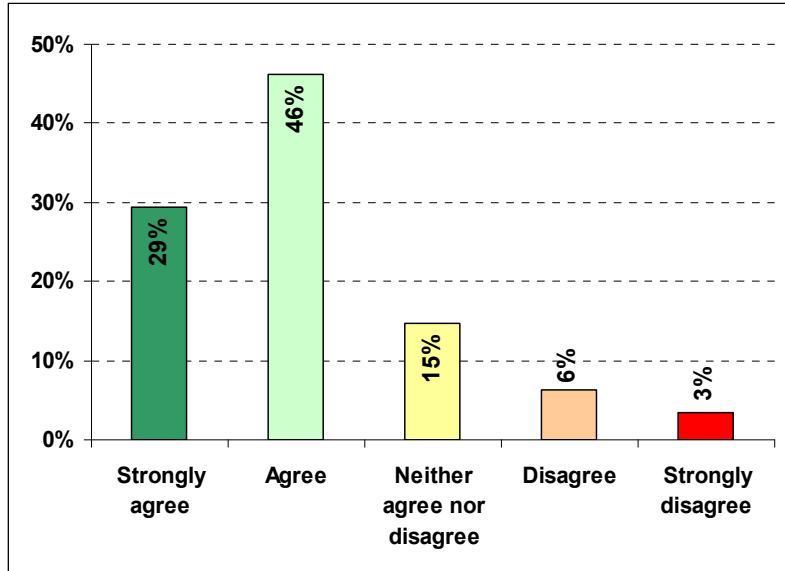


Figure 4.13 – The results for the benefits of lean certification for individuals question

Awareness of J4000 Lean Standards:

In section 3.4, it was stated that the awareness of J4000 Lean Standards is very low among lean professionals. One of the questions in our survey was to measure this awareness level. We asked the participants if they have ever heard or read about J4000. Only 15% of the participants were aware of J4000, while 85% of the participants had not heard about J4000. This result is another indicator of the lack of promotion and advertising about J4000 lean standards.

4.5 Detailed Analysis of the Survey Results

In the previous section, the overall results of the survey were reviewed. In this section, analysis will be focused on some of the details about the survey. It was expected that the participants’ support level for standardization would change based on their positions in their companies. The same can be said about the number of years that their company has been implementing lean principles. To measure the impact of the participant’s position and their companies’ lean journey, further analyses was performed for the survey results.

First, we reviewed the results based on the participant’s position. The results are classified into two sections: executives and others. For these two groups, the support level for the implementation know-how, middle management resistance and employee resistance

questions are measured (Figure 4.14). The results show that executives are less supportive than the other group for standardization. This may be a challenge for introducing lean standards, since the executives are expected to have big impact on this initiative.

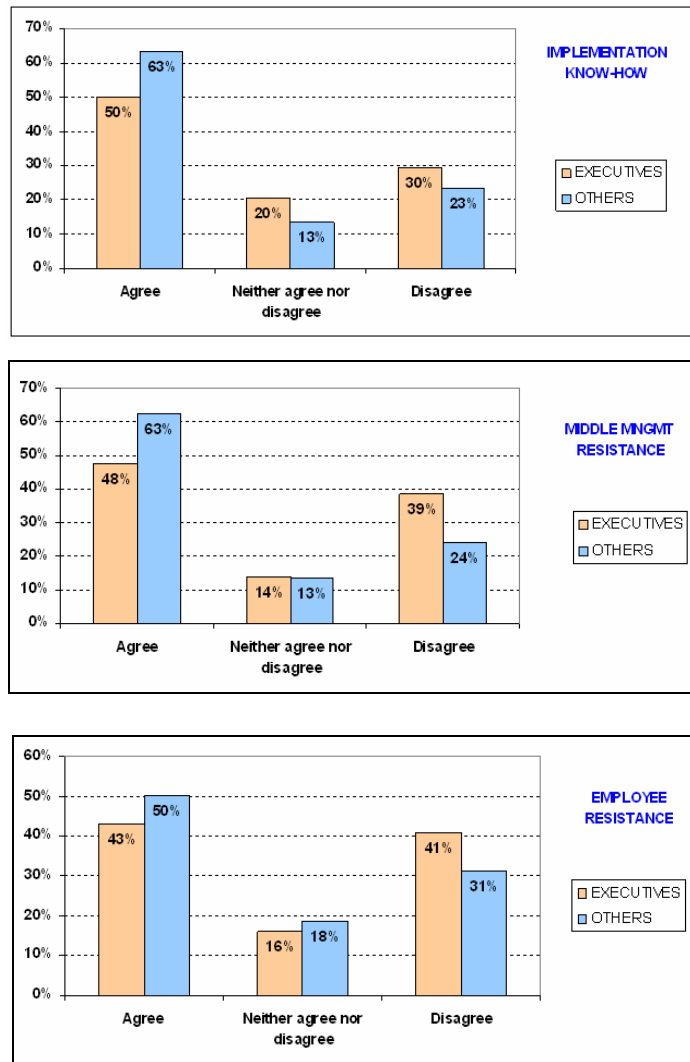


Figure 4.14 – Detailed analysis of results based on the participants’ positions

The other detailed analysis was performed based on the companies’ lean journey. The two groups were determined based on the lean implementation timeline: more than five years and less than five years. To measure the impact of this factor on the support level for

standardization, the answers were classified based on these two groups. The results suggest that the support level for lean standards is significantly higher in the companies in which the age of the lean journey is five years or less (Figure 4.15). Based on these results, it can be suggested that the companies with more lean experience show less support for lean standardization.

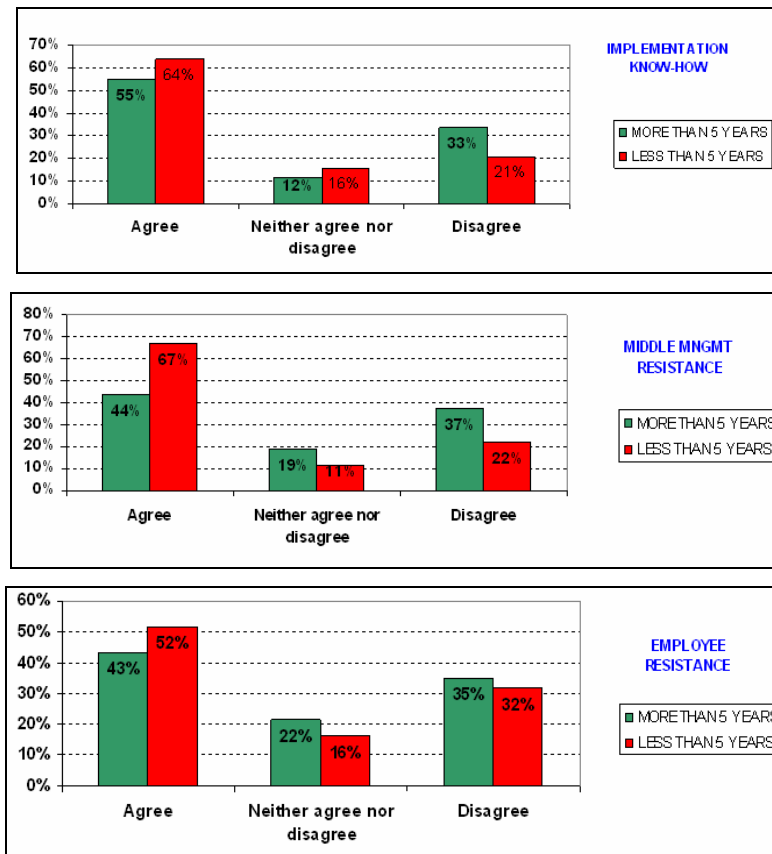


Figure 4.15 – Detailed analysis of results based on the length of the lean journey

4.6 Chapter Summary

In this chapter, information is provided on conducting the survey about lean standards. The design and distribution of the survey is reviewed and the results from 244 participants are presented. A detailed analysis is also performed in order to measure the impact of different factors on the support level about standardization.

Based on these results, the following main conclusions can be suggested:

- The overall results show that the percentage of the participants supporting standardization of lean is higher than those who do not.
- There is less support from participants about eliminating the employee resistance problem.
- The executives are less supportive about standardization than the other level participants. This could make introducing lean standards more difficult, since executives are typically in a more influential position to initiate the implementation of lean standards in their organization.
- The participants from companies with less lean experience show higher support for standardization, since they think that this would help them in their lean implementation.
- More experienced companies are less supportive about standardization. This could be due to resistance to implementation of a new system which is different than the company's current practice.
- There is consensus on the benefits of lean certification for individuals.

This survey is important in terms of measuring the level of interest from professionals regarding the standardization of lean. The results of the survey suggest a base line for future studies and may help companies in their decisions about applying lean standards in their systems.

Chapter 5 Case Study

5.1 Introduction

In the previous chapters, lean standards and certification were reviewed and the benefits and disadvantages were studied. Different opinions about the subject were presented and the survey results were analyzed to see the support level from professionals for lean standardization.

In this chapter, a case study from a manufacturing plant will be presented to analyze the benefits of lean tools such as using a pull system (kanban) and applying continuous improvement principles (kaizen). This real life example will provide an opportunity to study the implementation of lean manufacturing and measure the benefits. It is also important in order to understand how lean standards and best practice guidelines would help companies in implementing lean tools.

In this case study, the company's general processes will be reviewed and information about the current system will be provided. Based on a continuous improvement (kaizen) event, a future system will be developed and a simulation method will be used to measure the benefits of the purposed system. There are similar studies in literature in which the authors use simulation techniques to verify the benefits of lean implementations (Surya, 2005; Khadem, 2004; Shah, H., 2006). In these studies, simulation models are developed either to analyze the benefits of lean tools or to make decisions about the new system.

5.2 Information about the Company and Current System

The case study will be presented from the company that is in the wood working industry as a manufacturer of ready to assemble closet organizers. The company is a division of a large international corporation and has a 500,000 square feet facility in Cambridge, Ontario,

Canada. There are over 400 employees working in the company and the lean principles have been implemented for over 5 years.

The main raw material of the company is called raw board. Raw board is a type of particleboard that has no laminate applied to its surface. The manufacturing process of the company starts with lamination where a paper based laminate is applied to the surface of the raw board (Figure 5.1). The laminated boards are stored in a storage area where they wait to be moved to the next stage. The next step of the process is cutting the laminated board into sizes. This is done in the saw department where the laminated boards are transferred to as lifts in stacks of 50 or 60 sheets. After the saw department, the cut pieces of laminated boards are called “blanks” since they have no edge band or holes. There is also a storage area for blanks after the saw department. The blanks are then moved to the band and bore department, where an edge band is applied and holes are drilled. The pieces after the band and bore process are called “finished parts” and they are now ready to be packed. The finished parts and some other raw materials such as hardware or backers are packed in boxes in the pack department. The boxes are placed on a conveyor and required parts are put in the box as they move on the conveyor. At the end of the pack line, the machine closes the box by applying a type of glue. The boxes are then placed on pallets and these pallets are moved to the warehouse where they are shipped based on customer orders.

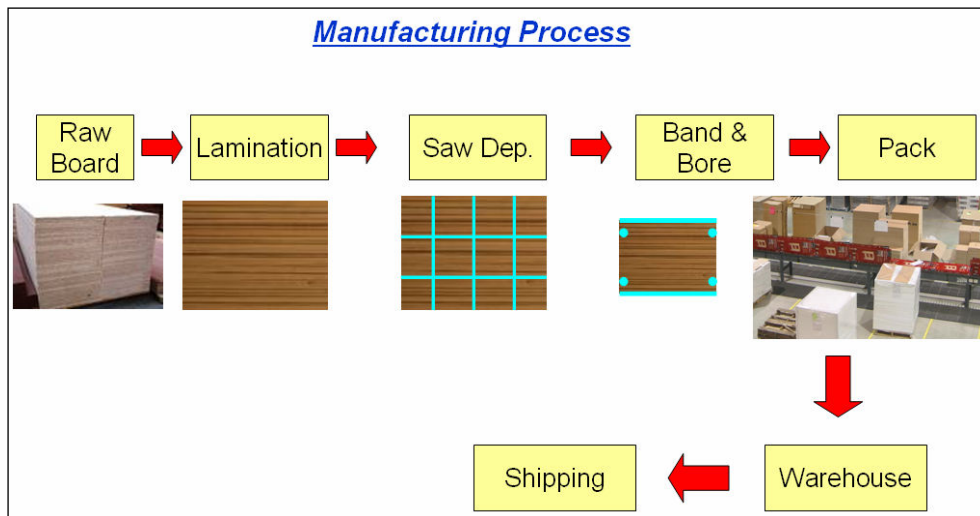


Figure 5.1 – Manufacturing process of the company

In this case study, the material flow between pack, band & bore and saw departments will be analyzed. First, the current material flow system will be presented and then the proposed system that was developed after a kaizen event, will be reviewed. Details of the kaizen event will also be discussed.

In the current system, the company uses a kanban (pull) system that was implemented about four years ago. In this system, finished part pallets are stored between pack and band & bore departments and each pallet has a kanban card attached (Figure 5.2). The kanban cards contain part information such as part number, material, size and pallet quantity. When one finished part pallet is moved to pack department to be used for packaging of an end item (movement number 1 in Figure 5.2), the kanban card of that pallet is moved to the kanban card holder which is located between the lamination and saw departments (movement number 2 in Figure 5.2). This cycle continues for each pallet that is moved to the pack department. When the number of the kanban cards on the card holder reaches a certain level, that is called run level, the laminated board lifts are moved to the saw department for cutting (movement number 3 in Figure 5.2). So, the saw department uses the run level on the card holder as a signal to pull the material from the laminated board inventory. After laminated board lifts are moved to the saw department, they are processed in this department and then moved to the band & bore department for edge band application and drilling. After this process is completed, the finished part pallets are moved to the storage area between the band & bore and pack departments.

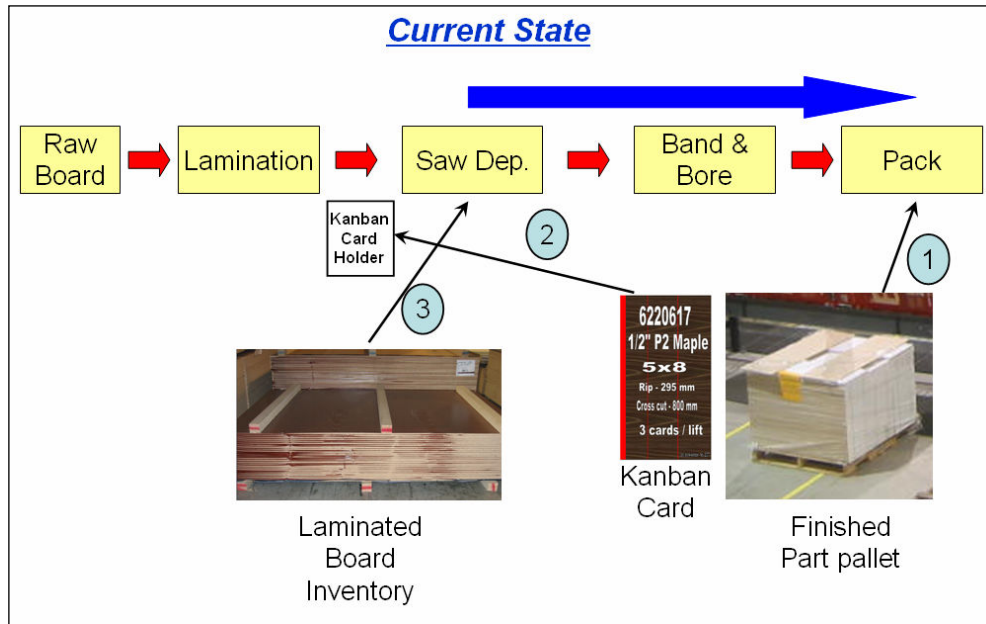


Figure 5.2 – Current material flow system

This system was designed and implemented about four years ago and there have been some machinery and other system changes in the plant. Due to some material flow issues, and with the aim of seeking further improvement over the current system, the management of the company has decided to organize a kaizen (continuous improvement) event.

5.3 Problem Statement and Kaizen Event

In this section, details of the kaizen event will be presented and the problems with the current system will be analyzed. Based on the outcome of the kaizen event, the new system and the potential benefits will be explained.

Kaizen events are part of the company's continuous improvement activities. Based on the company's processes and the problems that were identified, a kaizen event is organized to solve the issues and improve the system. The kaizen event in this case study was organized as a two-day meeting. There was an external consultant to moderate the event and help the participants develop potential solutions. There were a total of 15 participants in the event

who were from Production, Logistics, Maintenance, Quality Control, Engineering and Planning departments. Some machine operators and maintenance staff from manufacturing floor also attended the event. The author of this thesis was part of the kaizen event team as well. Having representatives from different departments is a very critical part of the kaizen event. This gives an opportunity to see the different points of view and ultimately develop better solutions.

The agenda of the event was to identify the current system and problems in day one, and to develop solutions in day two. In day one, the general kaizen event rules and basic lean principles were reviewed in order to refresh everyone's memories. We made a plant tour to observe the system and tried to identify potential wastes. The next step was to develop the current system map in detail. For this purpose, we used value stream mapping techniques and created a map which shows the current material flow. Figure 5.2 is a simplified version of the current state map and the full map can be seen in Appendix E.

Based on the analysis of the current system, we identified the problems and determined the following objectives for the second day:

- Improve the material flow
- Eliminate prioritizing problems and know what to run when
- Reduce inventory carrying cost
- Reduce paperwork

Our guideline to evaluate the potential solution was to make sure that the solutions are visible, simple and flexible. They also should be controllable and easy to implement. Based on analysis of the current system, we identified the following problems (Figure 5.3 shows the summary of the problems and solutions):

- First of all, based on the review, it was identified that the current kanban system is not a true kanban system. In kanban systems, each department is the customer of the previous department and pulls the material from the previous department. However, in the current system, after pulling a pallet, the pack department sends the signal to the saw department and the saw department processes the material and pushes it through the system. This creates prioritizing issues in the band & bore department, since it does not receive the signal from its actual customer, the pack department.

- Since all materials are pushed through the system, inventory is kept as finished part pallets between pack and band & bore departments. The finished parts have higher cost than the blanks and this creates a higher inventory carrying cost and an inflexible system.
- Based on our review for potential wastes, it was identified that there was too much paperwork and some of it was either duplicates or not used by anybody. This creates extra paper cost and labour cost since operators spend their times filling out this unnecessary forms.
- We also identified some discipline and sustainability problems such as lost kanban cards and 5S implementation issues.

PROBLEMS	SOLUTIONS
<ul style="list-style-type: none"> <input type="checkbox"/> Current kanban system is not a true kanban <input type="checkbox"/> Prioritization problem in band & bore department – production flow issue <input type="checkbox"/> Inventory is kept as finished part – higher cost <input type="checkbox"/> Too much paperwork <input type="checkbox"/> Kanban cards are lost <input type="checkbox"/> 5S implementation issues 	<ul style="list-style-type: none"> <input checked="" type="checkbox"/> Implement a kanban between Saw and band & bore for blanks <input checked="" type="checkbox"/> Review each paperwork and eliminate the unnecessary ones <input checked="" type="checkbox"/> Develop and implement standard operating procedures for the new system

Figure 5.3 – Problems in the current system and the proposed solutions

The purposed solution to these problems can be summarized as:

- Design and implement a new kanban system. In the new system, the pack department pulls the finished part pallet from the inventory and sends the kanban card to a new card holder between saw and band & bore (Figure 5.4). Band & bore pulls the blank part pallets based on this signal and sends the kanban cards to the kanban card holder that is located between the lamination and saw departments. So, there will be two kanban systems and this will create better control and improved material flow.

Another advantage of this system is the reduced inventory carrying cost. The inventory will be kept as blanks between the saw and band & bore departments and due to the lower cost of the blanks; inventory carrying cost will be reduced.

- Another solution was to review all paperwork and analyze where they are used. Based on this review, we eliminated the unnecessary paperwork and simplified or combined the forms where possible.
- We developed a standard operating procedure and a review system to make sure that the new system is understood and applied correctly. Based on the review system, it was decided that the proposed system and run levels will be revised quarterly.

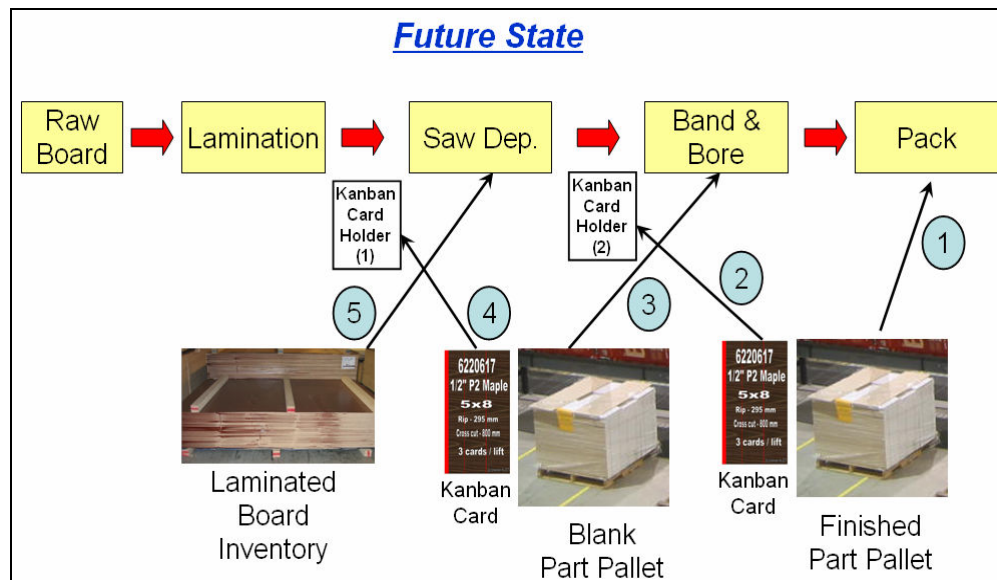


Figure 5.4 – Purposed future state

By implementing these solutions, the kaizen team reached the objectives that were determined at the beginning, which were: better material flow, improved prioritization by the new kanban system, less paperwork and reduced inventory carrying cost.

5.4 Simulation Model

One of the challenges that the kaizen team faced was to quantify the inventory carrying cost benefit that would be achieved with the implementation of the new system. The cost saving from the paperwork reduction was obvious and easy to calculate. However, how much the company would save in inventory carrying was not easy to quantify. In order to address this issue, it was decided to use simulation method.

Two simulation models were developed using SIMUL8 simulation program. The first model was developed to simulate the current system and the second model was for the proposed system. By comparing the predictions obtained with both models, the company would have the opportunity to quantify the inventory carrying cost reduction and verify that the new system would work successfully.

For the two models, the same parameters are used to keep the conditions the same, in order to measure the incremental benefit provided by the new scheme. The summary of these parameters are shown in Table 5.1.

Parameter	Value
Run level at saw department	60 pallets
Warp up period	20 weeks
Result collection period	5 years
Inventory carrying cost rate	21% of average unhand inventory value
Average customer demand at pack department (inter-arrival times for demand per pallet)	5 minutes
Standard deviation of the demand	2 minutes
Machine time at saw department	4.65 minutes per pallet
Machine time at band & bore department	4.86 minutes per pallet
Average finished part cost	\$570 per pallet
Average blank part cost	\$425 per pallet
Inventory carrying cost of finished parts per year	\$ 119.70 per pallet
Inventory carrying cost of blank parts per year	\$ 89.25 per pallet

Table 5.1 – Simulation parameters for the two models

The flow charts for the current and future states are shown in Figure 5.5 and Figure 5.6. As can be seen in these diagrams, in the current system there is one kanban card system and it is between the pack and saw departments. In the future state, there are two kanban systems, implemented to allow better control and improved material flow.

Based on these flow charts, and by using the parameters in Table 5.1, two simulation models were developed. The screen shots for the two simulation models can be seen in Figure 5.7. These models were run for the result collection period of five years and the results were compared to measure the cost savings in inventory carrying cost.

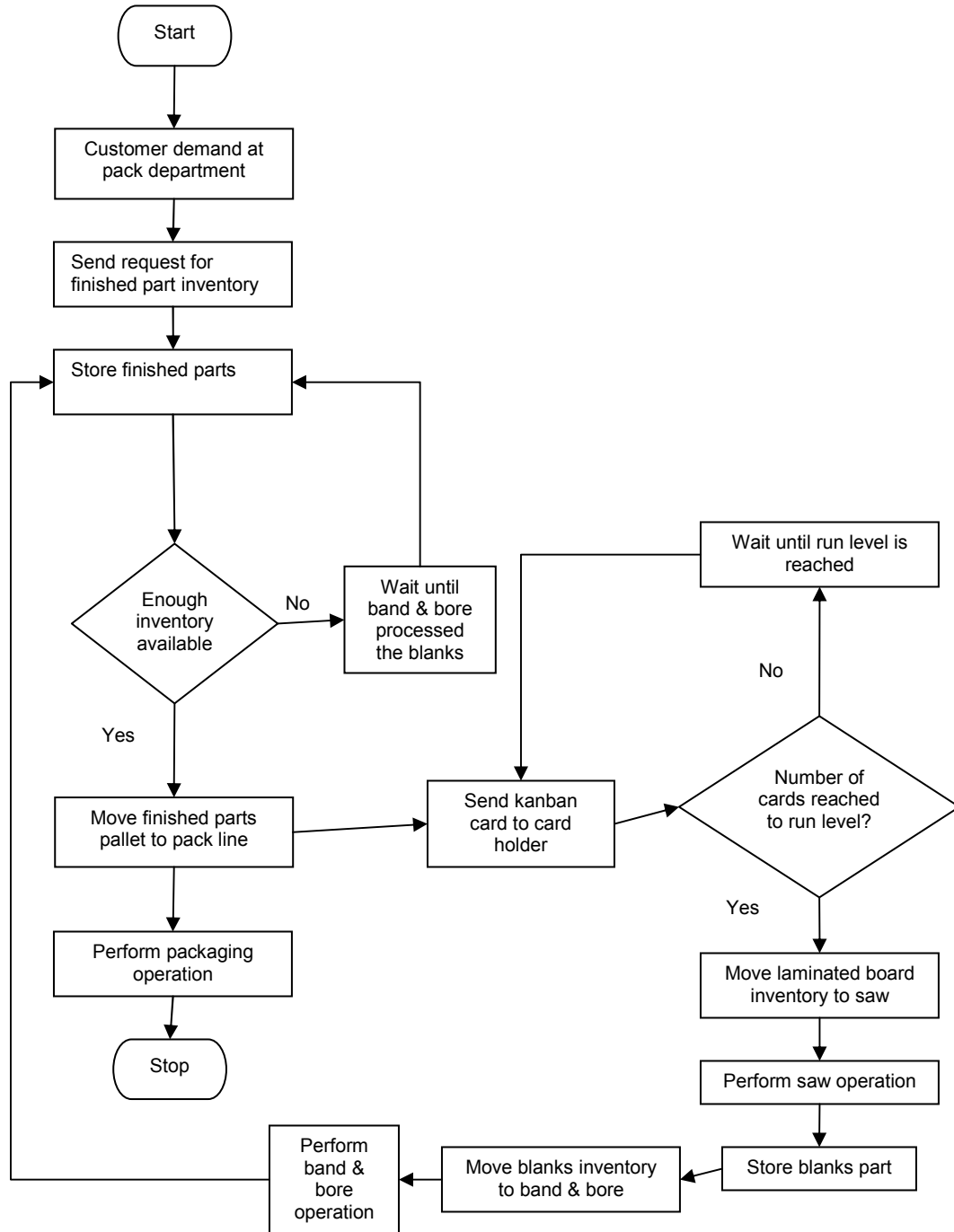


Figure 5.5 – Flow chart for the current system

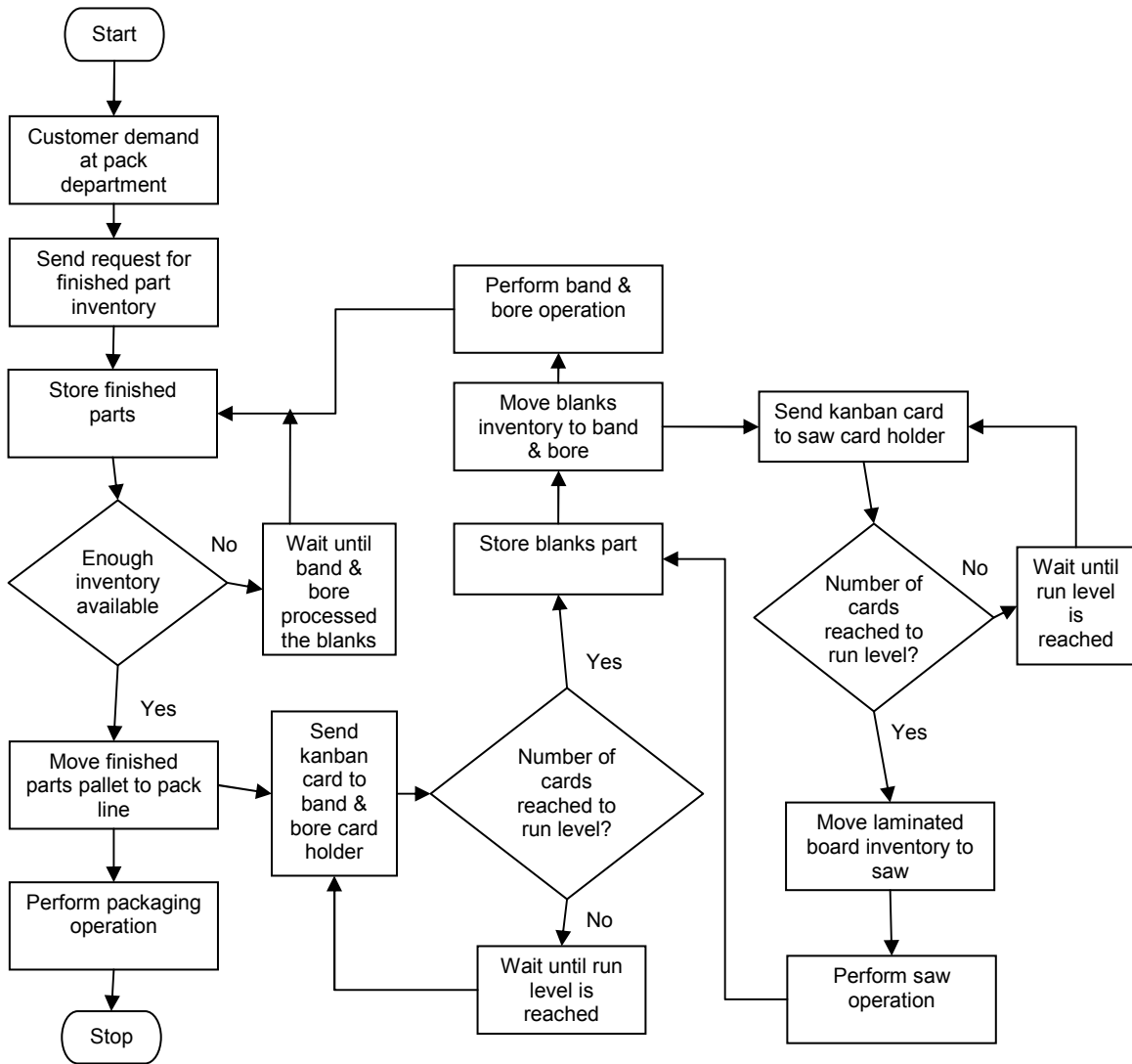
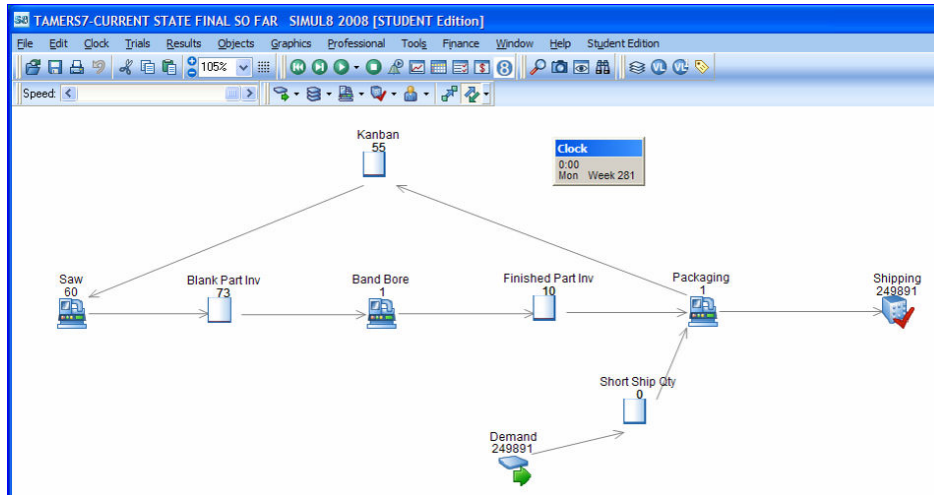


Figure 5.6 – Flow chart for the proposed system

CURRENT SYSTEM



FUTURE SYSTEM

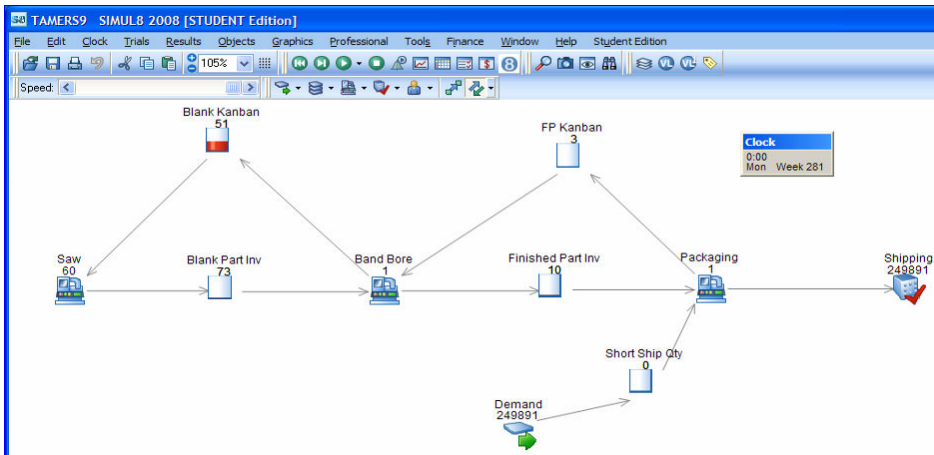


Figure 5.7 – Screen shots for the two simulation models

5.5 Results and Discussion

The two performance indicators that were used in this simulation were inventory carrying cost and total average queue time. After multiple runs of the two simulation models for the current and future system, the results were compared. Based on the simulation results, the inventory carrying cost for the current system was on average \$50,487 and for the future system it was \$42,814 per year. As a result, 15% of reduction in inventory carrying cost was achieved. This reduction in inventory carrying cost is due to the new kanban system, where the inventory is kept as blank and processed at the band & bore department based on the signal that comes from the pack department. Since the blank parts have a lower cost, the total inventory carrying cost was reduced by 15%.

The results for the other performance indicator, queue time, were 243 minutes for the current system and 231 minutes for the future system. For this parameter, there was 5% reduction. Due to this reduction in total queue time, parts will wait less in the queue and this will reduce the required space for storage.

The other outcome of the kaizen event was the reduction in paperwork. Based on the review of the current system, unnecessary paperwork was eliminated and some of the paperwork was either simplified or combined. As a result of this, there was total \$26,097 cost savings. \$23,200 of this saving was due to paper cost and \$2,897 of it was due to labour cost. The summary of the results can be seen in Figure 5.8.

<u><i>Inventory Carrying Cost</i></u> Before : \$50,487 After : \$42,814 15% reduction	<u><i>Total Avg. Queue Time</i></u> Before : 243 minutes After : 231 minutes 5% reduction	<u><i>Paperwork Reduction</i></u> Paper : \$23,200 Labour : \$2,897 \$26,097 reduction
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Figure 5.8 – Summary of kaizen event results

In this case study, lean principles such as continuous improvement, pull system and value stream mapping were used in order to achieve the objectives that were set at the beginning. To analyze the case study from a lean standardization perspective, a review will be provided based on some of the J4000 Lean Standards components.

As discussed in Section 3.4, SAE J4000 Lean Standards have 52 components. The following list contains some of these components that are particularly related to this case study. In this list, there is a component from each area of J4000 which can be used as a best practice guideline. We will list the component and explain the relationship to the case study.

- *4.1 Continuous progress in implementing lean operating methods is the organization's primary tool in pursuing its strategic objectives:* This component explains one of the most critical aspects of lean implementation. It is also the key part in our case study, since the improvement of the current kanban system was the goal of the company. To reach this goal, a kaizen event was organized and reduction in inventory carrying cost and total queue time was achieved.
- *5.8 Employee development through continuous improvement teams is encouraged and supported at all levels:* The Company always encourages its employees to be part of the kaizen teams and to participate in continuous improvement activities. In this case study, there were a total of five employees who represent the manufacturing floor. This is very important in order to have a successful continuous improvement program.
- *6.1 Adequate and accurate operating data and information is available to members of the organization as needed:* This component is related to developing the simulation models and other analyses that were performed for cost calculations. Accurate information is a key factor for effective control and successful continuous improvement activities. Without accurate or adequate operating information, it is impossible to calculate and measure the cost savings. The company makes sure that the required data is available to the employees to measure the progress.
- *8.1 Product and process design is conducted by fully integrated teams with team representations from all stakeholders:* Based on this component, the new process design should be conducted by a team with representatives from different departments. This is also applied to this case study. There were representatives in the kaizen team from Production, Logistics, Engineering, Quality and Planning departments. This creates a synergy and a better environment for improvement.

- *9.13 The value stream undergoes examination for continuous improvement on a regularly scheduled basis:* One of the action items of the kaizen event was to create standard operating procedures for the new system. In this procedure, it was stated that the new system will be reviewed at least every quarter to make sure that the system works based on the rules and the run levels are updated. This is a reflection of this J4000 component where the importance of scheduled reviews is indicated.

5.6 Chapter Summary

In this chapter, a case study from a real manufacturing plant is provided. The current system was reviewed and possible improvements were simulated and implemented as a result of the kaizen event. Based on the kaizen team's observations, it was determined that the current kanban system is not a true kanban and needs to be revised. After some analysis and discussion, a new system was designed in which there are two kanban systems to better reflect the customer signals and eliminate prioritizing issues. Another benefit of the new system was the reduction of inventory carrying cost. To measure the cost savings in inventory carrying cost, two simulation models were developed. By comparing the results, 15% reduction in inventory carrying cost and 5% reduction in total queue time were predicted.

A review of some of the J4000 components that relate to this case study was also presented. This case study is important in terms of providing insight into a real-life lean implementation, and how lean standards can be used for implementing and improving lean strategies.

Chapter 6

Conclusions and Future Work

6.1 Conclusions

Lean manufacturing is one of the most popular topics that have emerged in manufacturing and business literature in recent years. There is a tremendous interest from the industry in lean and many companies are trying to implement lean principles. However, as discussed in Section 1.3, the number of companies that have a successful lean initiative is very low.

In this thesis, the standardization and certification of lean manufacturing is studied and an analysis is provided on the possible contributions of lean standards towards a successful lean implementation. Management standards are widely discussed in literature. Especially, many ISO 9000 based articles can be found, since it is the most well-known management standards system. There are also a vast amount of articles that are on the benefits and implementations of lean, and their number has increased significantly in recent years. However, developing and using lean standards has not been studied in detail by researchers. This thesis aims to fill this gap in the literature and to contribute to the lean implementations.

This thesis has reviewed the current management standards and has provided a lean manufacturing perspective. J4000 standards were developed by SAE and it is the only lean standard system in the literature. J4000 was published in 1999 and has not received a high interest from the industry. In this research, the details of the J4000 Lean Standards were presented and the possible reasons of the low awareness for J4000 were investigated. Lean certification for individuals is another aspect of standardization that was studied in this research. Current lean certification programs for the professionals who work in this field are reviewed and details of the certification process are presented.

Based on this background information, perceived and potential benefits and disadvantages of standardization of lean manufacturing were discussed. Some of the potential benefits of standardization could be summarized as: to have a common lean implementation

guideline, reduced implementation time, to provide opportunity to assess leanness level and a motivation for lean implementations. On the other hand, potential negative impact on continuous improvement activities, possible risk of creating a static environment, and adding non-value added activities could be considered as some of the disadvantages of lean standardization.

There are different opinions about lean standards and certifications. Some people think that it is a great tool and will help companies with their lean journey, while others think that standardization would not work for lean. Based on the literature review, there isn't any opinion survey conducted about the lean standards and certification. To fill this gap in literature and to have a better idea of what lean practitioners think about the subject, a survey was conducted. It was a web-based survey and was distributed to the corporations, lean consortiums, academics and lean forums. There were a total of 244 responses from different industries and geographic locations. The results of the survey provided an opportunity to get feedback from industry professionals.

The last part of the research was to develop a case study from a manufacturing plant to measure the benefits of lean, and to explain how lean standards and best practices would help companies implement lean principles.

Based on the conducted research and the survey results the following conclusions could be reached:

- Researchers and lean professionals have different views about lean standardization which is similar to the debate in literature about the other management standards. Some people think it is a great tool to improve companies' systems while others consider it as a waste and a tool that would not help in effective implementation of lean. The researchers who support lean standardization indicate that with standardization companies will have a common definition of lean and there will be a standard implementation guideline across industries. This would give companies a chance to evaluate their system and play a role to improve the motivation for lean. They also suggest that lean standards could also be used as a tool to improve suppliers' performances. Lean practitioners and researchers who do not support standardization indicate that lean is a culture which is based on continuous change and standardization might affect this system since standards are developed to create a

system with certain rules and way of doing things. Another concern that was about lean standards was the risk of seeing lean certification as a maximum rather than a base or a minimum. Based on these opinions, it can be suggested that, the benefits of standardization can be achieved only if a company has a true motivation for lean standards and certification.

- The results of the survey suggest that there is an overall support for the lean standards. The percentage of the participants who think standardization is beneficial is more than that of who do not agree with the idea. On average 56% of the participants support the standardization and think that lean standards would help companies to eliminate problems such as lack of implementation know how, middle management resistance and employee resistance. The percentage of the participants who think the opposite is 28% on average.
- Detailed analyses of the survey results show that the support level from executives is lower than the participants who are from other positions. Executives showed less support for standardization and its potential benefits about eliminating implementation issues. Lower support level from executives might be due to their concerns about the required cost and effort in order to obtain and keep the lean certification. This could cause a challenge in introducing lean standards, since executives would play a key role in their lean implementation.
- Another result of the survey was the impact of the number of lean implementation years on the support level. Companies that are on their lean journey for less than five years show higher support for lean standards since they think it would help them to learn and implement lean more efficiently. These companies are relatively new with their lean implementation and they might be open to a new tool that would help them implement lean principles. On the other hand, the companies that are in lean implementation process for a long time already have a system in place and they may not want to implement a new tool such as lean standards for their system. This could be suggested as one of the reasons behind the lower support level from more experienced companies.
- Based on the case study that was provided, with the implementation of lean principles a 15% reduction in inventory carrying cost and a 5% reduction in total queue time

were predicted. Another cost saving was \$26K with the elimination of unnecessary paperwork. Simulation techniques were used to calculate the benefits of lean implementation. The results of this case study suggest that lean implementations and further development in a company's current system could provide significant savings. The case study also suggest that J4000 lean standards and best practices guideline could be used as a tool for lean implementations and continuous improvement activities.

6.2 Future Study

Possible studies to expand and further the results that were obtained in this thesis can be summarized as follows:

- The simulation models can be improved by adding more criteria and applying different scenarios. The current parameters can be changed and their impact can be measured. For example, impact of batch sizes and machine efficiencies on the results can be measured.
- The requirements for an effective lean management standards system can be studied. As a part of this possible research, J4000 can be revisited to evaluate its strengths and determine possible improvement areas, after nearly 10 years that this standard was published.
- A feasibility analysis can be done to investigate if a new international lean management standard can be introduced by ISO and if it would be beneficial for lean implementations. For this purpose, more detailed research can be done and another survey can be conducted possibly by ISO or another large international organization. Included in this future research, QS9000 and its conversion to an ISO standard could be investigated in detail and potential outcomes could be discussed if a similar approach was implemented for J4000 standards.

Appendices

Appendix A

SAE J4000 Identification and Measurement of Best Practice in Implementation of Lean Operation

Aug 1999

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4. Management/Trust

- 4.1. Continuous progress in implementing lean operating methods is the organization's primary tool pursuing its strategic objectives.
- 4.2. Structured policy deployment techniques are used to plan the organization's lean deployment.
- 4.3. Lean progress targets are defined and have been effectively communicated
- 4.4. Knowledge of the philosophy and mechanics of lean operation has been obtained and effectively communicated
- 4.5. The organization's senior managers are actively leading the deployment of lean practices
- 4.6. Lean progress is reviewed by senior management against planned targets on a regular basis.
- 4.7. Meaningful incentives that reward organizational lean progress are in place
- 4.8. Individual managers' performance is evaluated and rewarded relative to lean progress
- 4.9. A non-blaming, performance oriented, process-driven organizational atmosphere exists
- 4.10. There is regular, direct personal involvement by senior management with operating workforce concerning lean practices
- 4.11. Consistent policy for disposition of individuals made surplus by lean progress in place and followed
- 4.12. No employee has reason to perceive their livelihood to be jeopardized by contributing to organizational lean progress
- 4.13. Management has chosen to adhere to lean principles in the face of short term operating objectives inconsistent with lean progress

5. People

- 5.1.** Adequate training resources are provided and paid employees training time is made available.
- 5.2.** The training syllabus includes training in the lean-specific tools and measurable suitable to the organization's needs, at all level within the organization.
- 5.3.** Training is conducted as scheduled, records are not kept or are inadequate or no measure of training effectiveness exists.
- 5.4.** Organization is structured to correspond to the structure and sequence of the value chain through the enterprise.
- 5.5.** Each employee participates in the structure as corresponds to his work role
- 5.6.** Labor and employment policies and agreements are in place which allow lean progress within the organization
- 5.7.** Team authority level and accountability level is clearly defined.
- 5.8.** Employee development through quality circles/Continuous Improvement (CI) teams is encouraged and supported at all levels.
- 5.9.** Team is accountable for CI in its segment of the value chain
- 5.10.** Team decision-making authority and authority to act corresponds to the level of team accountability
- 5.11.** Management does not supersede team decisions and actions when within the team's authority
- 5.12.** Management supports team decisions and actions with required resources, consistent with good business practices.

6. Information

- 6.1.** Adequate and accurate operating information is available to members of the organization as needed.
- 6.2.** Knowledge is shared across the organization
- 6.3.** Data collection and its use are the responsibility of the individuals most closely associated with that part of the process
- 6.4.** The operating financial system is structured to present correctly the results of lean progress

7. Supplier/Organization/Customer Chain

- 7.1. Both suppliers and customers participate at the earliest possible stage in the organization's undertaking of a product/process project
- 7.2. Both suppliers and customers are appropriately represented on the organization's product/process/project teams.
- 7.3. Both suppliers and customers participate in regular reviews of product/process/project progress.
- 7.4. Effective incentives for supplier, organization and customer are in place that reward shared performance improvements or cost reduction

8. Product

- 8.1. Product and process design is conducted by fully integrated teams with team representation by all stakeholders.
- 8.2. Cost, performance and attribute specifications for product and process are unambiguous, measurable and agreed to by all stakeholders
- 8.3. Product and process design is conducted from a life-cycle systems approach, fully adhering to DFM/DFA principles and consistent with lean principles
- 8.4. Product design and process capability parameters are set to be as robust as possible, consistent with good business practice.
- 8.5. Provision is made for continuity of team knowledge for duration of product/process launch.
- 8.6. Lead times for product and process design are measured and being continually

9. Process/Flow

- 9.1. The work environment is clean, well organized and audited regularly against standardized 5S practices.
- 9.2. An effective planned preventative maintenance system is in place with the appropriate maintenance conducted at the prescribed frequencies for all equipment
- 9.3. Bills of material are accurately catalogued and standard operations are accurately routed, timed and have been value engineered.
- 9.4. Value stream is fully mapped and products are physically segregated into like-process streams.

- 9.5.** Production sequence is Load-smoothed to customer Pull, and Demand is leveled over the manufactured planning period.
- 9.6.** Process flow is controlled by visual means, internal to the process.
- 9.7.** Process is in statistical control with capability requirements being met and process variability continually reduced.
- 9.8.** Preventative action, using disciplined problem-solving method, is taken and documented in each instance of product or process nonconformance.
- 9.9.** Production flow commences only upon receipt of shipment order. Process flows at takt time rate, in single unit quantities, to point of customer receipt.
- 9.10.** Procedures are in place and being followed that result in continually shorter changeover times and smaller lot sizes.
- 9.11.** Factory layout requires continuously synchronous flow of material and in-factory product travel distance is continually reduced as flow path is improved.
- 9.12.** Documented standard work methods are in us that distribute and balance worker loads to eliminate waste, throughout the range of expected takt times
- 9.13.** The value stream undergoes examination for continuous improvement on a regularly scheduled basis

Appendix B

Lean Certification Body of Knowledge

(Version 2.0, March 2006)

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	WEIGHTINGS PER EXAM		
	Lean Bronze (tactical)	Lean Silver (integrative)	Lean Gold (strategic)
MODULE 1			
1. ENABLERS FOR LEAN	15%	25%	35%
1.1. Leadership	5%	10%	15%
1.1.1. Business vision, mission, values, strategies and goals, including resource allocation.			
1.1.1.1. Business Vision			
1.1.1.2. Business Mission			
1.1.1.3. Business Purpose			
1.1.1.4. Business Values, Philosophy, Ethics			
1.1.1.5. Strategic Business Assessment (external evaluation)			
1.1.1.6. Strategy Development			
1.1.1.7. Business Goals and Objectives			
1.1.1.8. Core Competencies			
1.1.1.9. Critical Success Factors			
1.1.1.10. Resource Allocation			
1.1.2. Respect for Humanity and Social Responsibility			
1.1.2.1. Schools and Communities			
1.1.2.2. Unions			
1.1.2.3. Other Stakeholders			
1.1.3. Long and Short-term Planning			
1.1.3.1. Hoshin Planning and Policy Deployment			
1.1.3.2. Execution and Metrics			
1.1.3.3. Project Management			
1.1.4. Principles of Lean leadership			
1.1.4.1. Go and See (Genchi Genbutsu)			
1.1.4.2. Defining Value Versus Non-value			
1.1.4.3. Identifying Waste			
1.1.4.4. Achieving Flow			
1.1.4.5. Recognizing Normal Versus Abnormal			
1.1.4.6. Respect for Humanity			
1.1.5. Lean corporate culture			

1.1.5.1. Value Stream Mapping			
1.1.5.2. Kaizen Blitz Events			
1.1.5.3. Continuous Improvement and Change			
1.1.5.4. Communication of Business Values, Philosophy, Ethics			
1.1.5.5. Change and knowledge management systems			
1.1.5.6. Resource Standards and Measures for Business Results			
1.2. Empowerment and Human Development	10%	15%	20%
1.2.1. Principles of empowerment			
1.2.1.1. Communication			
1.2.1.2. Delegation			
1.2.1.3. Recognition			
1.2.1.4. Rewards			
1.2.1.5. Employee Satisfaction and Morale			
1.2.1.6. Employee and Labor Relations			
1.2.2. Employee Training and Development			
1.2.2.1. Instructional Goals			
1.2.2.2. Skills Assessment			
1.2.2.3. Continuous Learning Strategy			
1.2.2.4. Cross-Training			
1.2.2.5. Classroom and On-the-Job Training			
1.2.2.6. Coaching and Mentoring			
1.2.3. Teamwork			
1.2.3.1. Cross-Functional Team Selection and Leadership			
1.2.3.2. Multi-Level Participation			
1.2.3.3. Roles and Responsibilities			
1.2.3.4. Decision-Making (types of decision making, e.g. consensus)			
1.2.3.5. Team Dynamics (storming, norming, forming, team relations, etc.)			
1.2.4. Suggestion/Feedback/Appraisal System			
1.2.4.1. Information Sharing (Yokoten)			
1.2.5. Employee turnover, absenteeism and compensation			
1.2.6. Ergonomic, clean and safe work environment and results			
1.2.6.1. Environment			
1.2.6.2. Ergonomics			
1.2.6.3. Safety			
MODULE 2			
2. LEAN CORE OPERATIONS	45%	35%	15%
2.1. Operational Vision and Strategy	2%	5%	7%
2.1.1. Operational Vision and Strategy			
2.1.1.1. Operational Processes Vision, Mission, Strategy, and Goals			
2.1.1.2. Lean Principles in Strategy			
2.1.1.3. Empowerment in Strategy			

2.1.1.4. Operational Alignment with Organizational Vision, Mission, Strategy, and Goals			
2.2. Innovations in Product Design and Market Service	8%	12%	5%
2.2.1. Product Design and Development (product/service)			
2.2.1.1. Quality Function Deployment (QFD)			
2.2.1.2. Concurrent or Simultaneous Engineering			
2.2.1.3. Variety Reduction			
2.2.1.4. Engineering Changes			
2.2.1.5. Design for Manufacture and Assembly			
2.2.1.6. Design for Product Life Cycle (DFx) (cradle to cradle)			
2.2.1.7. Failure Mode and Effects Analysis			
2.2.1.8. Life Cycle Engineering			
2.2.1.9. Production Process Preparation (3P)			
2.2.1.10. Knowledge Transfer Methods & Practices			
2.2.2. Product Market Service			
2.2.2.1. Customer Feedback and Market Needs Analysis			
2.2.2.2. Customer Specs and Requirements			
2.2.2.3. New market development and current market exploitation			
2.2.2.4. E-commerce systems			
2.2.2.5. Benchmarking			
2.3. Suppliers and Customers (relationship development)	3%	10%	3%
2.3.1. Suppliers			
2.3.1.1. Supplier Development Processes			
2.3.1.2. Supplier Certification			
2.3.1.3. Supplier Benchmarking			
2.3.1.4. Supplier Satisfaction Measures			
2.3.1.5. Corrective Action System			
2.3.2. Customers			
2.3.2.1. Customer Training and Development Processes			
2.3.2.2. Customer Selection and Focus			
2.3.2.3. Demand Load Leveling			
2.3.2.4. Corrective Action System			
2.3.3. Distribution and Transport Alliances			
2.3.3.1. Warehousing			
2.3.3.2. Distribution Centers			
2.3.3.3. Cross-Docks			
2.3.3.4. Reverse Logistics (returns, dunnage, etc.)			
2.3.3.5. Remanufacturing / Maintenance, Repair and Overhaul (MRO)			

2.3.3.6. Just-in-Time Alliances			
2.3.3.7. Supplier Managed Inventory Systems			
2.4. Core Operations & Processes	32%	8%	0%
2.4.1. Systematic identification and elimination of waste			
2.4.1.1. Waste Identification and Elimination (7+ wastes)			
2.4.1.2. Value Stream Mapping			
2.4.1.3. Value Analysis			
2.4.1.4. 5S Standards and Discipline			
2.4.1.5. Visual Workplace			
2.4.1.6. Kaizen Blitz Events			
2.4.1.7. Mistake / Error Proofing (Poka-Yoke)			
2.4.1.8. Quality at the Source / Source Inspection			
2.4.1.9. Continuous Improvement (Kaizen)			
2.4.1.10. 5-Why's Problem Solving			
2.4.2. Just-in-Time Operations			
2.4.2.1. Takt Time			
2.4.2.2. Material Signals (Kanban)			
2.4.2.3. Pull System			
2.4.2.4. Continuous Flow			
2.4.2.5. Just-in-Time (JIT)			
2.4.2.6. Quick Changeover/Setup reduction (SMED)			
2.4.2.7. Total Productive/Preventative/Predictive Maintenance (TPM)			
2.4.2.8. Load-Leveling (Heijunka)			
2.4.3. Cellular and Continuous Flow			
2.4.3.1. Cellular Manufacturing			
2.4.3.2. One Piece Flow			
2.4.3.3. Standard Work (operator instructions, etc.)			
2.4.3.4. Multi-Process Handling (multiple machines operating simultaneously)			
2.4.3.5. Autonomation (Jidoka)			
2.4.3.6. Production Schedule			
2.4.3.7. Bills of Material			
2.4.3.8. Routings			
2.4.3.9. Flow Analysis Charts (spaghetti diagrams, man-machine, etc.)			
2.4.4. Lean Tools for Continuous Improvement			
2.4.4.1. Plan-Do-Check-Act (PDCA) (DMAIC)			
2.4.4.2. Reliability and maintainability			
2.4.4.3. Root Cause and corrective action			
2.4.4.4. Flowcharting			
2.4.4.5. Pareto			

2.4.4.6. Cause and effect diagrams (Fishbone)			
2.4.4.7. Check Sheets			
2.4.4.8. Histograms			
2.4.4.9. Scatter and Concentration Diagrams			
2.4.4.10. Control Charts (includes SPC)			
2.4.4.11. Problem Solving Storyboards			
MODULE 3			
3. BUSINESS CORE OPERATIONS - SUPPORT FUNCTIONS	20%	15%	10%
3.1. Administrative Vision and Strategy in Finance and Accounting, Human Resources, Materials Management, Information Technology, Sales and Marketing, Quality Assurance, Process & Manufacturing Engineering and Legal & Regulatory	20%	15%	10%
3.1.1. The BOK in this section is analogous to Module 2, it applies to business and service processes			
3.1.1.1. Application of lean principles and techniques			
3.1.1.2. Focus on value adds and waste identification and elimination			
3.1.1.3. Commitment to Continuous Improvement			
3.1.1.4. Business operations improvement metrics			
3.1.2. Alignment and Systematic Business and Service Process Design			
3.1.2.1. Finance and Accounting: measurement and control systems, etc.			
3.1.2.2. Human Resources: alignment of selection, development, teamwork, performance feedback and discipline, compensation and rewards, regulations, etc.			
3.1.2.3. Materials Management: inventory control, planning and scheduling, procurement, logistics, material handling, etc.			
3.1.2.4. Information Technology: appropriate alignment with process changes, accessibility, flexibility to change, etc.			
3.1.2.5. Sales and Marketing: alignment of sales and operations planning and execution, product rationalization, customer interaction, etc.			
3.1.2.6. Quality Assurance: regulation and certification, inspection rationale, feedback, quality improvement system, etc.			
3.1.2.7. Process & Manufacturing Engineering: system for engineering changes, feedback for new product development, concurrent process, etc.			
3.1.2.8. Legal and Regulatory: alignment with core lean			

MODULE 4			
4. QUALITY, COST & DELIVERY MEASURES	15%	10%	10%
4.1. Quality & Quality Improvement	5%	3%	0%
4.1.1. Quality Results			
4.1.1.1. Rework			
4.1.1.2. Customer PPM Rejects			
4.1.1.3. First Pass Yield			
4.1.1.4. Scrap (Internal PPM Rejects)			
4.1.1.5. Process Variation			
4.1.1.6. Cost of Quality			
4.1.1.7. Warranty Costs			
4.2. Cost and Productivity Improvement	5%	4%	4%
4.2.1. Cost and Productivity Results			
4.2.1.1. Inventory Turns			
4.2.1.2. Record Accuracy (inventory, bill of material, operator instructions, etc.)			
4.2.1.3. Cycle Time, Takt Time and Throughput Time			
4.2.1.4. Operational Equipment Effectiveness (OEE)			
4.2.1.5. Labor Value-Add			
4.2.1.6. Product Cost Reduction			
4.2.1.7. Changeover			
4.2.1.8. Resource Utilization			
4.2.1.9. Energy Efficiency			
4.2.1.10. Performance to Load Leveling (linearity in production)			
4.3. Delivery and Customer Service Improvement	5%	3%	6%
4.3.1. Delivery and Customer Service Measurement			
4.3.1.1. Line-Items Delivered On-Time to Customer Requirements			
4.3.1.2. Complete Orders Delivered On-Time to Customer Requirements			
4.3.1.3. Customer Lead Time			
4.3.1.4. Premium Freight			
4.3.1.5. Mistakes in Shipments			
4.3.1.6. Warranty Response, Service, etc.			
MODULE 5			
5. BUSINESS RESULTS	5%	15%	30%
5.1. Customer Satisfaction	3%	8%	15%
5.1.1. Customer Satisfaction Results			
5.1.1.1. Market Share			
5.1.1.2. Reorder Rate			
5.1.1.3. Customer Survey Results			
5.1.1.4. Customer Audit Results			
5.1.1.5. Other Customer Feedback			
5.1.1.6. Value / Improvement Analysis			
5.1.1.7. Customer Retention			

5.1.1.8. Customer Awards			
5.2. Business Results	2%	7%	15%
5.2.1. Profitability Measurement			
5.2.1.1. Operating Income on Sales and Assets			
5.2.1.2. Operating Income on Space			
5.2.1.3. Fixed and Variable Costs			
5.2.1.4. Cash Flow			
5.2.1.5. Value Stream Profitability			

Appendix C

The complete list of survey questions and answer options

Q1: How long has your company been implementing Lean Manufacturing Strategies?

Currently no implementation

Less than 1 year

1-2 years

2-5 years

5-10 years

More than 10 years

Q2: Do you think standardizing Lean Manufacturing (similar to ISO 9000) would help in eliminating the lack of implementation know-how obstacle?

Strongly agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

Q3: Do you think standardizing Lean Manufacturing would help in eliminating the middle management resistance obstacle?

Strongly agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

Q4: Do you think standardizing Lean Manufacturing would help in eliminating the employee resistance obstacle?

Strongly agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

Q5: What kind of impact will standardization and certification make on companies' continuous improvement activities and their pursuit of lean?

It will make continuous improvement activities much more effective

It will make continuous improvement activities more effective

It will have no impact

It will make continuous improvement activities less effective

It will make continuous improvement activities much less effective

Q6: Have you ever heard or read about SAE J4000 Standards? (SAE J4000: Identification and Measurement of Best Practice in Implementation of Lean Operation, Lean Standards developed by Society of Automotive Engineers, SAE International)

Yes

No

Q7: Do you think certifications for Lean Professionals (similar to CPIM, CMA etc) would be beneficial to companies and their Lean implementations?

Strongly agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

Q8: What is your position within the organization?

Senior Management (CEO, COO, President, VP and other Executives)

Director

Manager

Staff

Consultant

Other

Q9: In which industry does your company operate?

Agriculture, Forestry, Fishing and Hunting

Mining and Oil and Gas Extraction

Utilities

Construction

Manufacturing

Wholesale Trade
Retail Trade
Transportation and Warehousing
Information and Cultural Industries
Finance and Insurance
Real Estate and Rental and Leasing
Professional, Scientific and Technical Services
Management of Companies and Enterprises
Administrative and Support
Waste Management and Remediation Services
Educational Services
Health Care and Social Assistance
Arts, Entertainment and Recreation
Accommodation and Food Services
Other Services (except Public Administration)
Public Administration

Q10: If your company operates in manufacturing industry, please select the sector.

Food Manufacturing
Beverage and Tobacco Product Manufacturing
Textile Mills and Textile Product Mills
Clothing Manufacturing
Leather and Allied Product Manufacturing
Wood Product Manufacturing
Paper Manufacturing
Printing and Related Support Activities
Petroleum and Coal Product Manufacturing
Chemical Manufacturing
Plastics and Rubber Products Manufacturing
Non-Metallic Mineral Product Manufacturing
Fabricated Metal Product Manufacturing
Machinery Manufacturing
Computer and Electronic Product Manufacturing
Electrical Equipment, Appliance and Component Manufacturing
Transportation Equipment Manufacturing
Furniture and Related Product Manufacturing
Miscellaneous Manufacturing

Q11: What was your company's annual revenue for 2007?

Under \$10 million
\$10 million to \$25 million
\$25 million to \$50 million

\$50 million to \$100 million
\$100 million to \$250 million
\$250 million to \$500 million
\$500 million to \$1 billion
Over \$1 billion

Q12: What is the approximate headcount of employees in your company?

0 - 50
51 - 100
101 - 250
251 - 500
501 - 1000
1001 - 2500
Over 2500

Q13: In what geographic region is your company headquarters located?

North America (Includes USA, Canada, Mexico)
South/Central America
Asia/Pacific
Europe
Middle East
Africa

Appendix D

Information / Cover Letter for the Survey

This study is being conducted by Tamer Degirmenci as part of my Master of Applied Science thesis project under the supervision of Dr. Mustafa Yavuz of the University of Waterloo, Canada. We are conducting a research study about how standardization would help in implementation and sustainability of Lean Manufacturing strategies.

To find out what professionals think about this topic and support our research, we are asking for your participation in the study.

If you decide to volunteer, you will be asked to complete a 13 question survey. The questionnaire will ask general questions about your opinion about standardization of Lean Manufacturing. Your participation in the study should take no longer than five to ten minutes. Participation in this study is voluntary. You may decline to answer any questions that you do not wish to answer and you can withdraw your participation at any time by not submitting your responses. There are no known or anticipated risks from participating in this study.

It is important for you to know that any information that you provide will be confidential. All of the data will be summarized and no individual could be identified from these summarized results. Furthermore, the web site is programmed to collect responses on the questionnaire alone. That is, the site will not collect any information that could potentially identify you (such as machine identifiers).

If you wish to participate, please visit the following link and follow the instructions provided.

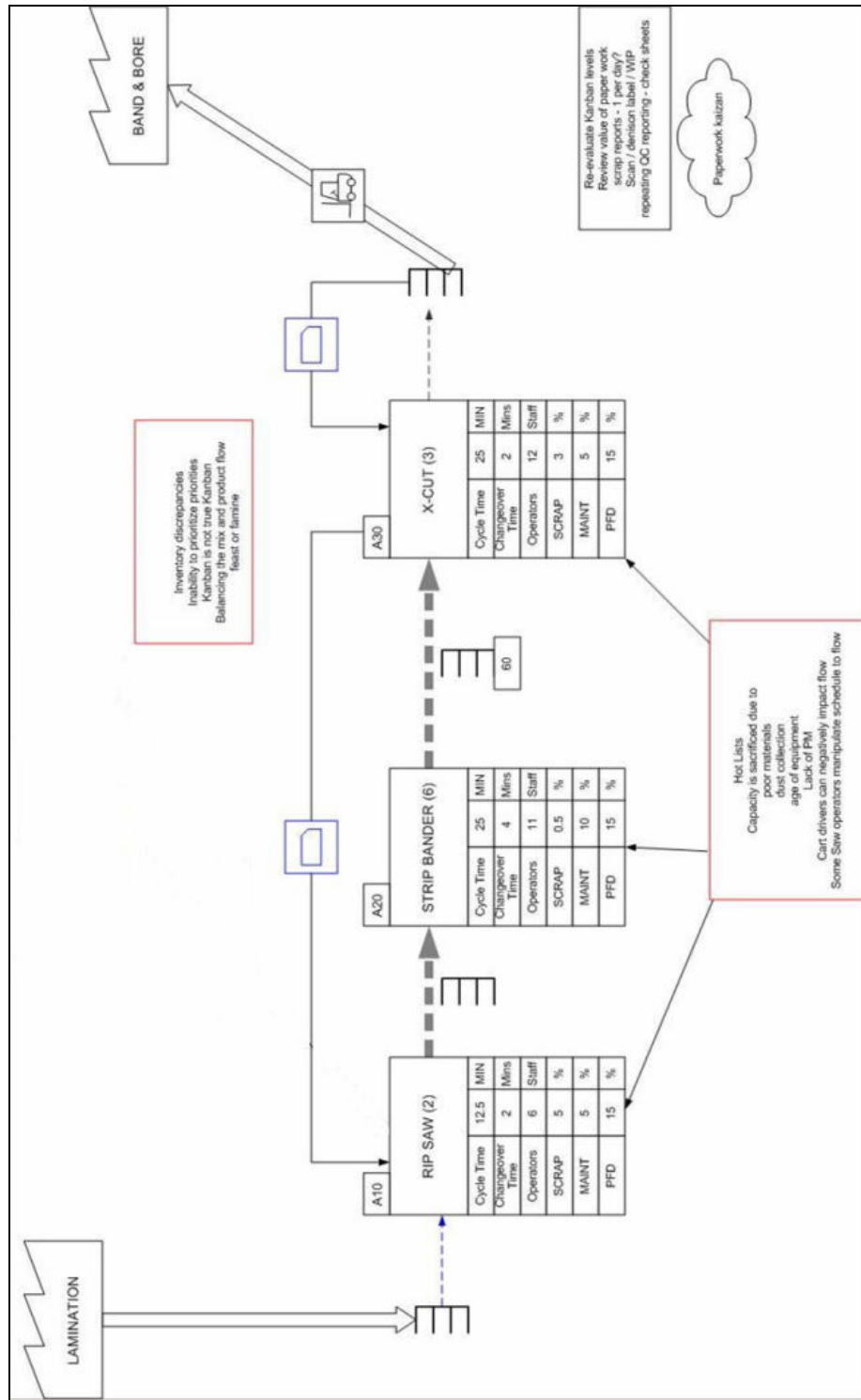
[link to the survey](#)

Should you have any questions about the study, please contact either Tamer Degirmenci at tdegirme@uwaterloo.ca 519-500-7295 or Mustafa Yavuz at myavuz@uwaterloo.ca 519-888-4567 x 32093.

I would like to assure you that this study has been reviewed and received ethics clearance through the Office of Research Ethics at the University of Waterloo. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please feel free to contact Dr. Susan Sykes, Director, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or by email at ssykes@uwaterloo.ca .

Thank you for considering participating in this study.

Appendix E Current State Map



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