
# The advantages and limitations of Lean Six Sigma in process (re)design:

## *Combining continuous improvement methods to align the product characteristics with the customer's requirements.*

**Bachelor's Thesis Organization & Strategy – Lean Management**

**Academic year 2009/2010**

**Name:** T.J.F. Reijns

**Program:** Premaster Logistics and Operations Management

**Date:** June 2010

TILBURG UNIVERSITY

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# Preface

This report is the written result of my Bachelor's Thesis at the department of Organization & Strategy from the Tilburg University. For this thesis I selected Lean Management as the field of research because continuous improvement programs are interesting to me. More specifically I chose to study the characteristics of Lean Six Sigma, a combination of two popular process improvement methodologies.

During the process of writing this thesis I have learned to remain objective towards scientific literature and form discussions regarding a wide variety of interesting topics in the field of quality management, while discovering what the academic world has to offer concerning these topics.

I would like to take the opportunity to thank my supervisor at the Tilburg University, Drs. Mark Overboom, for his support and feedback regarding my research during the meetings we had. His knowledge regarding Lean as well as other theories has been valuable for me to stay on the right track and keep improving my thesis by finding new area's to explore within the existing scientific literature.

Tom Reijns,
Tilburg, June 2010

# Management summary

Lean Manufacturing and Six Sigma are both popular and important process improvement methodologies in the field of quality and performance management. Contemporary scientific literature has thoroughly discussed the advantages and limitations of both. The two methodologies can be combined into one overlapping and more comprehensive methodology called Lean Six Sigma, which has been discussed far less within the available scientific literature.

This thesis has revealed the main differences between Lean and Six Sigma as separate methodologies, and has discussed how they can complement each other when combined into Lean Six Sigma. This new methodology incorporates Lean's speed and waste reduction characteristics, while it also integrates Six Sigma's statistical decision making and quality standard for process performance and improvement. More specifically, Lean Six Sigma's main characteristics are:

- Satisfy customer demand by delivering speed and quality;
- Improve processes by increasing flow while reducing variation and defects;
- Take decisions based on data and facts;
- Use human resources to increase cross functional teamwork.

Firms that wish to apply the Lean Six Sigma methodology within their organization will have to carefully develop a structured implementation plan. The implementation of Lean Six Sigma is a key factor influencing the success of the methodology. A top-down approach is recommended for the implementation process, this way the firm can reallocate required (human) resources within the firm and distribute the methodology structurally throughout the company. Firms must be aware of the impact of Lean Six Sigma on the organizational culture.

Once the Lean Six Sigma program and the accompanying improvement specialist structure are in place within the organization, the firm can start selecting improvement initiatives. Project selection can be done using a top-down or bottom-up approach. Whichever approach is chosen, management must be aware that all employees should be fully committed to the Lean Six Sigma program in order for it to be successful. This means that all employees should receive a basic awareness training, while the improvement specialists receive advanced training in Lean Six Sigma's methods and tools.

Recommendations for further research regarding the Lean Six Sigma theory development, the implementation process and the proposed conceptual model have been made in the final chapter.

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# 1. Introduction

Lean Manufacturing has been an important business philosophy and approach to production and operations management for the last decades. The methodology has, since its introduction to the U.S. in 1984, been subject to transformation on both an academic and managerial level (Shah & Ward, 2007). Six Sigma has, just like Lean, become increasingly popular in the field of performance management (Schroeder, Linderman, Liedtke & Choo, 2008).

Lean Six Sigma has been developed by combining the Lean Manufacturing and Six Sigma methodologies. As George (2002) suggests, the mixture of these two can lead to the best of both worlds: the waste-eliminating and speed improving characteristics of Lean Manufacturing, and the statistically-based and structured way of process improvement and (re)design taken from Six Sigma.

## 1.1 Problem indication and statement

Limited research is done concerning Six Sigma, unlike the availability of literature regarding Lean Manufacturing, even though the industry is experiencing significant results when applying the Six Sigma methodology in practice (Linderman, Schroeder, Zaheer & Choo, 2003; Zu, Fredendall & Douglas, 2008; Kumar, Antony, Montgomery & Park, 2008). Zu et al. (2008) imply that it is interesting to examine the combination of Six Sigma with other improvement methods like Lean Manufacturing. Pepper and Spedding (2010) suggest that little has been written about the integration of Lean Manufacturing and Six Sigma and the development of Lean Six Sigma as a methodology by itself. They stress the importance of a systematic approach for the implementation of Lean Six Sigma and advise further research to be focused on the development of a framework for the methodology.

Additional research regarding this topic is both relevant and interesting because of the positive outcomes Lean Six Sigma has when successfully implemented within the industry (George, 2002). A literature review and discussion of both the Lean Manufacturing and the Six Sigma methodology is necessary in order to reveal the advantages and limitations of Lean Six Sigma. The following central problem statement has been formulated for this thesis as a result of the problem indication:

*"How can firms successfully apply Lean Six Sigma to achieve an environment of continuous improvement in process (re)design?"*

The following research questions are developed as guidance during the literature review and to be able to research all relevant aspects of the problem statement:

1. What motivates firms to apply methodologies for continuous improvement?
2. Which aspects of Lean Manufacturing and Six Sigma can be identified as important factors for a successful implementation of the methodologies?
3. What is key criticism regarding Lean Manufacturing and Six Sigma?
4. In which way can Lean Manufacturing and Six Sigma complement to each other?
5. Which (managerial) aspects of Lean Six Sigma are important to improve success rates of process improvement or (re)design projects?

## 1.2 Relevance

Academic and managerial relevance is important for a research topic to be interesting enough. The reason why the selected topic is relevant is clarified below.

**Academic relevance**

Authors of scientific papers regarding quality management and, more particular, Six Sigma suggest that further theory-development is required (Linderman et al., 2003; Schroeder et al., 2008; Zu et al., 2008; Kumar et al., 2008). While Lean Manufacturing literature is broadly represented in various quality journals, the Six Sigma literature requires further research to be able to support the methodology fully in practice. Moreover, the combination of Lean and Six Sigma is an emerging research trend (Kumar et al., 2008). The thesis will emphasize the relatively recent conversion of the two methodologies into Lean Six Sigma.

**Managerial relevance**

Even though the industry seems to have already accepted Lean Six Sigma as a successful methodology for continuous improvement and process design (Arnheiter & Maleyeff, 2005), it is necessary to further research Lean Six Sigma's potential (Zu et al., 2008). Further attempts to optimize the methodology can be of great value for firms in a wide variety of branches. Lean Six Sigma projects can prove to be difficult because of the long-term efforts a firm has to put into them (Spector & West, 2006). The thesis will underline the essence of a successful Lean Six Sigma application in process (re)design which will aid firms in aligning their product or service better to their customer's requirements.

## 1.3 Research design and data collection

The nature of the thesis will be primarily exploratory and descriptive. The main element of the thesis' research will be formed by a thorough literature review. The function of this review is to document relevant, essential and valuable results found in the current scientific literature. The most important findings will be presented in the form of a discussion which shows different views and approaches within the existing knowledge (Sekaran, 2003, p. 67). These are key for clarifying the problem statement and to answer the research questions.

Because the research will be done in the form of a literature review, the data (knowledge) collection will take place while studying existing papers from scientific journals. These academic papers will be sourced from various databases (e.g., ABI/Inform, ProQuest, JSTOR, ScienceDirect). Keywords used in the search process will mainly contain 'Six Sigma', 'Lean' and 'Process design' or a combination of those. Interesting references within the papers can also lead to other material. The emphasis will be on recently published papers, however, older publications can be interesting to indicate a shift in scientific knowledge throughout the years. Besides the quality journals found in the databases indicated above, it might become interesting to explore other disciplines during the research for a different perspective regarding a topic.

## 1.4 Structure

The structure of this thesis will mainly correspond to the research questions as stated in paragraph 1.1. Chapter 2 contains a literature review on both Lean Manufacturing and Six Sigma, which also includes the development and criticism on the methodologies. The next chapter (3) discusses the development of Lean Six Sigma as a new methodology and explains its most important characteristics. Chapter 4 contains key managerial aspects of managing Lean Six Sigma within an organization or supply chain. Finally, the conclusions and recommendations are presented in chapter 5 of the report.

With the structure of the report made clear, it is also useful to visualize the conceptual model which will be researched in the thesis. The conceptual model (Figure 1.1) shows that there are a number of independent variables, 'Factors' (to be examined throughout the thesis), which influence the dependent variable 'Process (re)design' through a mediating variable 'Lean Six Sigma implementation'.

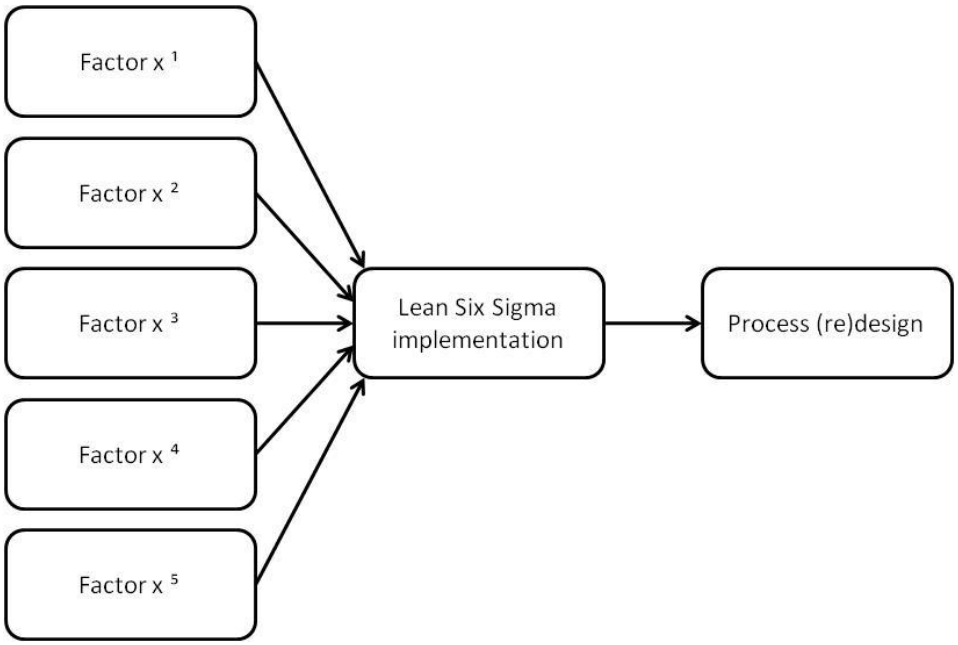


**Figure 1.1: The conceptual model for the research**

The independent X-variables result from the initial literature reviews, these are examined in chapters 2 and 3. The mediator 'Lean Six Sigma implementation' is studied in the chapters 3 and 4. Finally, the dependent variable is explained within the conclusions and recommendations section of the report.

# 2. Literature Review

This section contains a literature review regarding Lean Manufacturing (2.2) and Six Sigma (2.3) as separate methodologies. The most important advantages, limitations, managerial aspects and criticism will be discussed and the methodologies' key strengths and weaknesses will be presented. An overview of how the two methodologies complement each other is presented at the end of the chapter (2.4). But first, the opening discussion will shed light on the types of organizational motivation factors for firms to use these kinds of improvement methodologies.

## 2.1 Organizational motivation

A key objective for commercially oriented firms is to continuously put large efforts in increasing customer satisfaction through high quality products and services, and maximizing profit against the lowest possible costs (Naveh & Erez, 2004). Firms are forced to increase their flexibility while (both internal and external) customer requirements are increasingly becoming more demanding, unique and volatile (Stratton & Warburton, 2003).

A learning curve can be recognized for a firm's quality improvement initiatives. Product or service (quality) improvements have the largest impact in earlier stages of the product lifecycle. Further, an organization's culture heavily influences the success of the effort put into improvement initiatives and requires managers to implement organizational innovations (quality improvements and reengineering) carefully within the firm (Detert, Schroeder & Mariel, 2000; Naveh & Erez, 2004).

Successful implementation of quality improvement programs can create an organizational environment of continuous improvements, and a workforce which strives to increase the quality and efficiency of processes and products. (Conti, Angelis, Cooper, Faragher & Gill, 2006) The objective for firms is to create such an environment by implementing quality improvement methodologies like Lean Manufacturing or Six Sigma, which are discussed in the coming paragraphs.

## 2.2 Lean Manufacturing theory

The Lean Manufacturing method originates from Taiichi Ohno's Toyota Production System (TPS) which is closely related to the Just-In-Time (JIT) principles (Shah & Ward, 2007). Lean is essentially aimed at the reduction of waste and inefficiencies within processes across the entire supply chain, and is focused on those activities that increase the quality and value of the product for the customer. The method stimulates continuous improvement cycles within all layers of the firm and its entire

supply chain to reach increased process performance rates (De Treville & Antonakis, 2006). In the Lean process of continuously identifying and eliminating waste (Chen, Li & Shady, 2010), redesign programs are initiated to maximize the customer perceived value of a product or service (Gautam & Singh, 2008). In this process it is essential to know what aspects of the product or service the customer values to prioritize improvement initiatives throughout the supply chain.

**Definition**

The adaption of Lean Manufacturing by U.S. managers and the explanation and analysis of the method by academics has proven to be a challenge, because of this the literature contains somewhat contradicting definitions (Shah & Ward, 2007), which can cause hazardous situations for firms wanting to implement the methodology (Pettersen, 2009). A study regarding these contradicting definitions of Lean by Shah and Ward has provided the following explanation: *"Lean production is an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability."* (Shah & Ward, 2007: 791). This definition indicates the wide coverage of Lean within a firm or even its supply chain. The emphasis is on the reduction of waste within processes which leads to standardization, reduced cycle times, and an efficient process flow (De Treville & Antonakis, 2006), simply put, Lean is about doing more with less (Christopher, 2000). Lean is a way to continuously improve quality and performance of products and processes, as well as reducing costs and streamline the development of innovations (Gautam & Singh, 2008). On a supply chain level, long-term relationships with suppliers and customers regarding integration of information and physical flows are also incorporated into the Lean philosophy (Cagliano, Caniato & Spina, 2004).

**Human resources**

Teamwork and total employee involvement are key necessities for successful Lean applications (Shah & Ward, 2007; Fullerton & Wempe, 2009). The waste-reducing and standardization characteristics of Lean has been suggested to lead to unwanted working conditions for workers (Conti et al., 2006 ). This has been contradicted by De Treville and Antonakis (2006), they imply that Lean makes work more motivating and tolerable because of increased training, cross-functional placement and a greater contribution to the overall process. They also suggest that business leaders have to individually motivate workers to contribute to the Lean way of operations. Conti et al. (2006) mention that the waste-eliminating characteristic of Lean does in fact improve the performance of processes, but it subsequently increases the intensity of work. The acquired availability of time is converted into higher worker capacity. The same authors have concluded that Lean practices have no direct effect on the stress-levels of workers. From a managerial point of view, managers should be

aware of the fact that Lean improvement projects can take a long time before significant results can be measured which results in the manager to lose sight on which projects are most important to remove the firm's key constraints (Spector & West, 2006). Regarding this matter, Shah and Ward (2007) mention that employee involvement forms an important factor within the Lean philosophy. Managers should allow the bottom-up approach of Lean to be effective within the organization.

### Criticism

Critics of Lean have argued the originality and effectiveness of the Lean philosophy. Näslund (2008) suggests that Lean is only a mere replacement for earlier quality improvement methods like the JIT principles. Further, the author implies that comparable process management methods follow a similar product life cycle. A literature study by Cox and Chicksand (2005) indicates that critics suggest that the method is only successfully applicable in high volume production situations and that it can be difficult to achieve a win-win situation in case of buyer dominance within the supply chain. Because Lean requires involvement and commitment from almost everyone within a firm, it can be a costly choice for firms to implement the Lean philosophy (Fullerton & Wempe, 2009). However, a case study by Chen et al. (2010), indicates that smaller firms are equally able to successfully implement a Lean environment into their operations and gain considerable performance results. This somewhat contradicts the findings of Cox and Chicksand's literature study (2005) mentioned earlier.

### Deviations of Lean

Lean is continuously evolving regarding both definition and purpose (Pettersen, 2009), one of these deviations of the Lean concept is called Agile Manufacturing. Agility enables firms to be more flexible towards their customer's unique demand but this simultaneously puts pressure on the firm's cost and delivered quality (Jiang & Chen, 2007), which is contradictory to the Lean philosophy. The key differences between Lean and Agile are that Lean is mostly suited in a situation where the market is stable and the product is standard, whereas Agile is more appropriate in the case of an innovative product with high variety and an unstable, highly volatile demand (Stratton & Warburton, 2003; Cox & Chicksand, 2005). Agile can be more flexible than Lean by its focus on achieving a high responsiveness towards the market demand by managing a dynamic supplier network, and through operational management lacking large investments which enables rapid rearrangement of physical flows (Cagliano et al., 2004).

## 2.3 Six Sigma theory

Besides Lean, there are other ways for firms to continuously improve process efficiency to ultimately increase customer satisfaction and profits. Another popular methodology is called Six Sigma. Six Sigma can be seen as an organized and structured methodology for continuous process improvements and quality management which uses improvement specialists and statistics to increase customer satisfaction, reduce process variation and achieve strategic objectives (Schroeder et al., 2008). McAdam and Lafferty (2004) question the true implications for organizations when implementing or applying Six Sigma programs. The authors suggest that Six Sigma is often used to actually reduce process variation and statistical decision making, but the method as a strategic tool is often understated.

### Definition

A process operates at a Six Sigma performance level when the number of defects (faulty products) per million opportunities (DPMO) is at 3.4 (Linderman et al., 2003). The strict focus on the customer requirement is one of the main characteristics for the methodology. This methodology was originally introduced by Motorola in the 1980's and further specified and popularized by, among others, General Electric under the leadership of Jack Welch. Nowadays the methodology is still gaining acceptance because of increasing amounts of reports of highly successful Six Sigma projects at leading firms (Arnheiter & Maleyeff, 2005; Chakravorty, 2009). Even though Six Sigma was initially put to practice in a manufacturing environment, the methodology is nowadays being applied throughout a wide variety of industries (Kumar et al., 2008). Six Sigma can be divided into two structured methods: DMAIC and DFSS (Linderman et al., 2003), which will shortly be discussed below.

### Methods and tools

The abbreviation DMAIC stands for Define-Measure-Analyze-Improve-Control which are the five structured steps all Six Sigma projects are to complete in order to successfully improve process performance and, more importantly, retain its improved performance. Each phase provides a variety of tools and techniques to guide the improvement team to the root cause of the process variation (Kumar et al., 2008). The method can only be applied to existing processes because the method is aimed at improvement. DFSS stands for Design For Six Sigma and is utilized to create new processes from scratch, but can also be applied to create new products or services (Schroeder et al., 2008). A strict customer focus is a characteristic for the design process, which is similar to the DMAIC method.

The Six Sigma methodology applies statistics and standardized project-processes to eventually comply with customer requirements regarding process defect rates (Schroeder et al., 2008). Its

statistical foundation resulted in the methodology using various performance-, finance- and customer-related metrics to improve processes. Various tools like the cause-and-effect analysis, pareto and run charts, value stream mapping and regression analysis add to Six Sigma's standardized nature of identifying the root causes of process variation (Linderman et al., 2003).

**Six Sigma strategy**

The strategic importance of certain processes highly determines the desired performance level. Reaching a Six Sigma (6σ) performance level for a process can be costly because the *"… the effort and difficulty increase exponentially as the process sigma increases"* (Linderman et al., 2003: 195). More sophisticated statistical tools and knowledge is required to get the process to the 6σ performance level. The benefits and expected return on investment must therefore be apparent before such a project is initiated (Linderman et al., 2003). A wide variety in application and implementation of Six Sigma programs exists. Besides the large multinationals which are reporting high savings, also small and medium enterprises are able to apply the Six Sigma methodology successfully within their business. However, it is recommended for smaller firms to be cautious with initial investments regarding the training of improvement specialists and carefully develop knowledge (Kumar et al., 2008). A study by Chakravorty (2009) indicates that many Six Sigma programs fail because of the unavailability of a sequence for implementing the various elements of Six Sigma into an organization. The implementation itself seems to withhold firms from reaching the full capabilities of Six Sigma and utilize its potential for successful process improvements.

**Human resources**

Zu et al. (2008) state that a firm's management needs to establish a structure of Six Sigma specialists into the existing human infrastructure. This structured hierarchy of specialists is a distinctive characteristic of the Six Sigma methodology. The specialists purpose is to manage and support the improvement projects (Schroeder et al., 2008). This hierarchy consists of Champions, Master Black Belts, Black Belts and Green Belts which are categorized by their knowledge and skills regarding Six Sigma's statistical tools, project management, training or leadership (Zu et al., 2008). In the Six Sigma specialist structure the Champion is often the project sponsor and initiator and is the direct report of the project leader. Master Black Belts are skilled professionals able to train and support Black Belts in their process of managing Six Sigma projects. The Black Belts are responsible for the project progress and support Green Belts who have the task to prepare and analyze statistical data and solve problems within the various Six Sigma phases (DMAIC/DMADV) (Schroeder et al., 2008; Kumar et al., 2008).

**Criticism**

Organizations find Six Sigma to put too little emphasis on employee involvement and managers are mostly using the methodology to address technical process performance issues (McAdam & Lafferty, 2004). However, Zu et al. (2008) suggest that top management commitment is crucial for employees to recognize the importance and relevance of quality improvement within the organization, awareness needs to be created throughout the firm. Näslund (2008) implies that Six Sigma is the same as an earlier quality improvement methodology, called Total Quality Management (TQM). However, the author's statement that *"… Six Sigma essentially shares the same fundamental approach to change with TQM"* (Näslund, 2008: 281) is contradicted by Kumar et al. (2008). They state that Six Sigma differs from TQM on three aspects: (1) Six Sigma is result-oriented and focuses firmly on savings, (2) the tools used throughout improvement initiatives are to be used in a structured sequential manner and (3) the methodology employs a hierarchical organization of improvement specialists.

## 2.4 Conclusions: complementary and contrasting aspects

The prior literature review of Lean Manufacturing and Six Sigma has revealed the main advantages and limitations of the two methodologies within the contemporary academic literature. In conclusion, the complementary and contrasting aspects of the two methodologies need to be identified before the review can continue to study Lean Six Sigma as a stand-alone methodology. Table 2.1 below presents the main differences between Lean and Six Sigma which have been found throughout the literature review.

| | **Lean Manufacturing** | **Six Sigma** |
|---|---|---|
| **Product** | Standardized product, preferably with low variety | Manufacturing-, service-, health-care-, government-related product |
| **Market situation** | Stable, high forecast accuracy | No special requirement |
| **Demand** | Preferably but not limited to high volume | No special requirement |
| **Organization** | Total commitment, long-term buyer/ supplier relationships | Specialist hierarchy, project-based, metric-performance-driven |
| **Human resources** | Intrinsic, shop-floor level project initiation, bottom-up approach | Extrinsic, top-down selection of improvement initiatives |
| **Focus** | Efficiency, flow, JIT, standardization, cost and waste reduction | Customer, stakeholder value, process variation, statistical decision making |
| **Limitations** | Expensive implementation, questionable flexibility | Structured implementation, expensive projects |

**Table 2.1: The main differences between Lean and Six Sigma regarding various characteristics**

Lean and Six Sigma can complement each other is various ways. The type of product is important for the Lean production philosophy because the product needs to be standardized with a low product variety. The flexibility of Lean is the most important reason for this, for Six Sigma, this is not necessarily a constraint. A stable market situation is preferable for Lean while Six Sigma can be useful within any market. The same applies for the demand where Lean prefers to deal with high volume situations, Six Sigma can deal with all possible demand situations.

Regarding the organizational design of a firm, both methodologies stress the commitment from management to the shop floor. Six Sigma utilizes a structure of specialists which manage improvement projects, which lacks within the Lean methodology. The responsibility of Six Sigma's specialists is to provide guidance and structure to improvement initiatives, such a structured hierarchy can also be appropriate for Lean. Both methodologies emphasize the importance of the customer within a process. A different focus can be identified regarding Lean and Six Sigma, in which they can complement each other.

Lean and Six Sigma have different approaches regarding the use of an organization's human resources and the accompanying culture. Within the Lean methodology, all employees are seen as process experts which are encouraged to be critical towards their own work. This leads to improvement projects to be initiated in a bottom-up manner from the employees themselves (intrinsic). Six Sigma uses the specialist structure for completion of improvement initiatives which are selected on among others quality improvement, increase in shareholder value or efficiency improvement. This is more of a top-down approach to utilize the organization's human resources and can be seen as extrinsic because most employees (except for the specialists) are not directly involved in the decision to initiate an improvement project and the actual process improvement itself.

Where Lean focuses mainly on the reduction of waste and increase of process flow and standardization, Six Sigma has a firm focus on controlling process variation and statistical decision making. Limitations for both methodologies come in the form of the actual implementation and the associated expenses.

The literature study regarding both Lean and Six Sigma has revealed that both methodologies emphasize a structured approach to problem solving and process improvement. Further, both methodologies will eventually lead to a standardized process but they reach this in a different matter. Lean can be seen as a bottom-up approach (from the shop-floor), whereas Six Sigma is more of a top-down method.

# 3. The Origin of Lean Six Sigma

The two methodologies, Lean and Six Sigma, have been discussed in detail in the previous chapter, the next phase is to examine how they can be combined to complement each other in the development of Lean Six Sigma as a new methodology. This chapter will illustrate the establishment of Lean Six Sigma throughout the business, as well as within the academic environment. Further, the key characteristics and success criteria will be discussed.

## 3.1 Development of the methodology

The foundation of Lean and Six Sigma as separate methodologies can be found within different backgrounds, thus, they both give different priorities to organizational performance. Arnheiter and Maleyeff (2005) state that lean has its roots in the TPS and JIT philosophy, whereas Six Sigma can be traced back to TQM and the development by the Motorola Corporation.

Regarding the origin of each methodology, they further explain the underlying assumptions for Lean:

- A pull system with batch size equal to 1, derived from the TPS;
- Strive to reach a Make-to-Order environment without non-value-adding activities, derived from the TPS.

And for Six Sigma:

- Everyone in the organization is responsible for quality, derived from TQM;
- Training of human resources, derived from TQM. All employees get a basic awareness training, whereas some employees get a more advanced training as specialist or mentor in support of improvement initiatives;
- Focus on customer satisfaction, derived from TQM;
- The 6σ metric (3.4 DPMO), derived from the Motorola Corporation as customers demanded higher quality and products became more complex.

The use of either Lean or Six Sigma can cause firms to put incorrect priority on certain improvement initiatives, while Lean Six Sigma can solve such a problem because: *"The activities that cause the customer's critical-to-quality issues and create the longest time delays in any process offer the greatest opportunity for improvement in cost, quality, capital, and lead time."* (George, 2002: 4). Hence, a synergy should be obtained which results in better overall performances rather than individual approaches to process improvement (Brett & Queen, 2005).

The Lean and Six Sigma methodologies have been united by "*… the application of Lean techniques to increase speed and reduce waste and process complexity, while employing processes to improve quality and focus on the voice of the customer.*" (Brett & Queen, 2005: 60). This essentially means that Lean Six Sigma strives to reduce waste and complexity internally, while externally deliver the product to the customer at the appropriate quality level and speed which are specified by the market demands. Firms using Lean Six Sigma will capitalize on the strengths of both Lean and Six Sigma (Arnheiter & Maleyeff, 2005). George provides a definition which covers the overall meaning of Lean Six Sigma as "*… a methodology that maximizes shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital.*" (George, 2002: xii).

Näslund (2008) suggests that Lean Six Sigma is the likely to be the next popular methodology (or 'management fad' as he states) for continuous improvement (after JIT, TQM, Lean and Six Sigma) and stresses the importance of placing ways of organizational change and improvement methods under one overlapping methodology.

## 3.2 Key characteristics and success criteria

George, Rowlands and Kastle (2004) define four key factors which form the basis for Lean Six Sigma: (1) Satisfy customer demand by delivering speed and quality, (2) Improve processes by increasing flow while reducing variation and defects, (3) Take decisions based on data and facts, and (4) Use human resources to increase cross functional teamwork. These four factors will be shortly discussed below:

**Satisfy customer demand**

The customer, either internal or external, is always the most important focal point for a Lean Six Sigma project. The customer focus comes partially from Lean and partially from Six Sigma. Lean incorporates customers in the supply chain and allows them to pull the product through the supply chain which increases process speed (Cagliano et al., 2004). Six Sigma focuses on the customer as a source to define what aspects of a certain process are 'critical to quality' (Schroeder et al., 2008). The Lean speed and Six Sigma quality are brought together in Lean Six Sigma to be able to fulfill the delivery and process control requirements according to the Voice of the Customer (Brett & Queen, 2005). The Voice of the Customer represents the aspects which the customers expect or demand from a product and how this can be translated to more specific relevant aspects of the process, this helps firms prioritize goals consistent to the specific customer requirements (George, Rowlands, Price & Maxey, 2005).

**Process improvement**

This part of Lean Six Sigma essentially shows how the two methodologies, Lean and Six Sigma, are brought together and complement each other. The Lean philosophy is applied to create a steady flow where the customer pulls the product through the supply chain, and the speed and performance of the process is increased (De Treville & Antonakis, 2006). Six Sigma is then applied to reduce variations within all processes and eliminate the number of defects while the process is operational (Linderman et al., 2003). Six Sigma's statistical tools and metrics are utilized to keep the process under control within its targeted lower and upper specification limits.

**Factual decision-making**

George et al. (2004) emphasize the importance of data and facts while making decisions within the organization. This is where the many statistical tools of Six Sigma play a main role. As stated by Zu et al. (2008), data provides information about the process output quality and is used to initiate improvements. They suggest that systematic data collection throughout all processes within the organization enables a manager or improvement specialist to identify the critical problem. Linderman et al. (2003) state that reliable data based on objective measurements is required to make decisions during the improvement project and to know when a process performs as targeted.

**Human resources**

Training and commitment of employees regarding the Lean Six Sigma techniques are essential for a successful implementation of the methodology, but this also requires significant resources, knowledge and costs to establish such a structure within an organization (Kumar & Bauer, 2010). Lean Six Sigma uses the same hierarchical structure as the Six Sigma methodology which involves the training of Champions, (Master) Black Belts and Green Belts. George et al. (2004) stress the value of employee creativity and the understanding of customer demands and process characteristics.

## 3.3 Conclusions

This chapter has clarified the development of Lean Six Sigma as a new methodology by explaining where Lean and Six Sigma originated from. The TPS and TQM methodologies contain the most important underlying assumptions for respectively Lean and Six Sigma. The combination of these two has led to a methodology which incorporates among others the speed and waste reduction aspects of Lean, and the statistical process improvement and quality standard from Six Sigma. Further, Six Sigma's improvement specialist hierarchy is also utilized within Lean Six Sigma to be able to better manage the improvement initiatives and provide guidance to the employees on the shop-floor which still form a valuable source of idea's and process knowledge as they do within the Lean philosophy.

# 4. Managerial Aspects of Lean Six Sigma

With the main characteristics of Lean Six Sigma presented in the previous chapter, the literature study will continue in this chapter by providing insight regarding various managerial aspects of the methodology. First, the implementation process is described in detail. Further, projects selection criteria and strategic implications are discussed to provide a complete overview of the relevant aspects for managing Lean Six Sigma within an organization.

## 4.1 Implementation

As Chakravorty (2009) suggests, large continuous improvement program realizations may often fail because of a lacking structural implementation process. Further, the costs incorporated with such an implementation initiative are substantial (Fullerton & Wempe, 2009). Reason enough for firms to put effort in the implementation process itself when the decision has been made to adapt Lean Six Sigma into the organization. George (2002) implies that a Lean Six Sigma system implementation consists of three 'phases' of implementation activities: (1) Initiation, (2) Resource and project selection, and (3) Implementation, sustainability and evolution. In practice, overlap between the phases is possible. They will be shortly discussed below:

**Initiation**

The initiation phase encompasses the firm's leaders to become familiar with Lean Six Sigma and provide support to the initiative (George, 2002). High level management commitment is, as with any other implementation initiative, crucial for the success of the Lean Six Sigma implementation (Zu et al., 2008). A costs and benefits analysis regarding the implementation of Lean Six Sigma into the organizational structure is necessary for firms to create an overview of the advantages and limitations of a Lean Six Sigma program (Linderman et al., 2003).

Organization and its top management should carefully assess their current organizational culture before attempting to apply the Lean Six Sigma approach (McAdam & Lafferty, 2004). As concluded in paragraph 2.4, Lean and Six Sigma have a different effects on the organization's culture. This conflict between the bottom-up (for Lean) and the top-down (for Six Sigma) approach has been resolved within Lean Six Sigma by involving all employees into the methodology and by letting everyone generate improvement idea's, while the specialist structure functions as support for improvement initiatives and process control. These and other required resources for implementations are discussed next.

**Resource and project selection**

Within this phase, George (2002) suggest to employ people with leadership potential to create leverage throughout the organization and execute improvement projects which impact processes close to the customer or increase shareholder value. Because Lean Six Sigma also uses the hierarchical specialist structure similar to Six Sigma, it is suggested to create such a structure within the existing human infrastructure and train certain employees to become specialists regarding Lean Six Sigma (Zu et al., 2008), while still providing the basic awareness and problem-recognition training for all other employees on the shop-floor and in middle-management functions (Arnheiter & Maleyeff, 2005).

**Implementation, sustainability and evolution**

The final phase of the implementation process is revolved around creating a stable and healthy environment which is focused at improving company performance and shareholder value (George, 2002). The hierarchical specialist structure should be already in place for the first improvement initiatives to be successfully accomplished, this will eventually create an environment throughout the organization in which employees are motivated to work according to the Lean Six Sigma philosophy and methods, to achieve process improvements continuously.

**An additional implementation model**

Chakravorty (2009) has created, similar to George's (2002) Lean Six Sigma implementation phases, an implementation model for Six Sigma programs, this model can also be utilized for the implementation of Lean Six Sigma programs because the organizational structure has to be rearranged a comparable way. The model has the following steps:

- Perform strategic analysis;
- Form cross-functional improvement team;
- Choose improvement tools;
- Execute high-level process mapping and prioritize improvement;
- Develop detailed implementation plan;
- Implement, document and revise.

As Chakravorty (2009) implies, the implementation model for a (Lean) Six Sigma program does not always generate increased customer value or satisfaction because firms can be implementing the program while aiming to increase operational efficiency and create a competitive advantage instead.

**Conclusions about the two models**

The implementation models by George (2002) and Chakravorty (2009) share a number of vital aspects regarding the program implementation process. Both emphasize a top-down structural approach which involves high-level management commitment and understanding before the methodology is distributed further throughout the organization. The resources required for implementation should carefully be selected which also means that human resources should be trained and placed within teams with members from various disciplines (cross-functional) to generate further leverage throughout the firm. Prioritizing on improvement initiatives is also highlighted by both models, projects that improve processes which are 'critical to quality' for the customer that cost the least effort are primarily sought after. Finally, both models stress the consequence of proper communication throughout the actual implementation process. Also, the authors suggest that, with the methodology successfully in place, the implementation is still not over because of constant evolution of the methodology and revision of tools, methods and processes.

Even though the organization's culture is taken into account within both implementation models, the impact of Lean Six Sigma on the existing organizational structure is not emphasized thoroughly. The entire process of implementing the Lean Six Sigma program into the existing organizational culture puts pressure on the existing workloads of employees within all layers of the firm (Detert et al., 2000). As Lean Six Sigma's specialist hierarchy will support and manage most projects on the shop-floor level of the organization, the supervisors on that organizational level are likely to have to temporarily rearrange the available worker capacity and resources to cope with the effort that is demanded by the improvement initiatives (see figure 4.1).

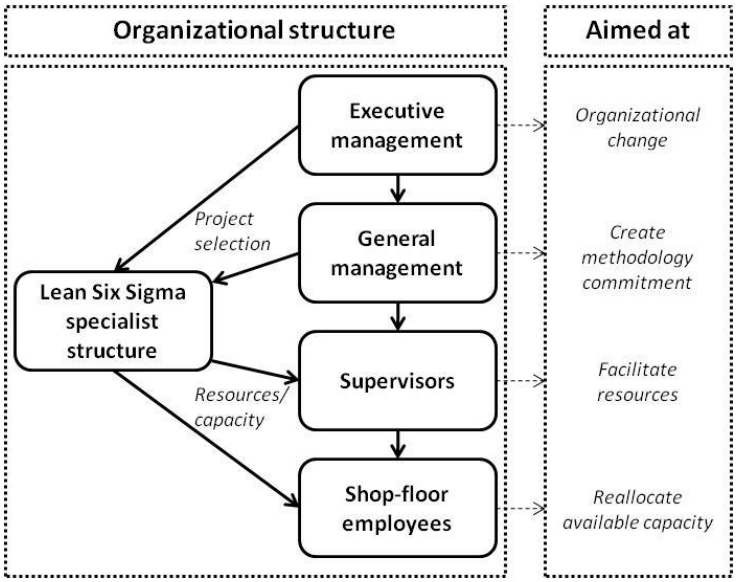


**Figure 4.1: The function of each organizational layer within the Lean Six Sigma methodology**

## 4.2 Project selection

The right strategy should be handled in order for the correct priority on improvement projects to be taken within an organization (George et al., 2005; Spector & West, 2006). Similar to the implementation process, George (2002) suggests a top-down identification for the improvement initiative idea generation and improvement initiative selection (see figure 4.2 below).


**Figure 4.2: The strategy for selecting improvement projects (George, 2002)**

George's (2002) top-down strategy for selecting improvement initiatives consists a system of decisions based on corporate strategy, organizational processes, financial aspects and the Voice of the Customer. What the top-down approach suggests is that all initiatives for process improvement must be derived from what the customer desires and values (or what does not add value), and what can have a positive impact on the stakeholder value (Spector & West, 2006). Because the customers and stakeholders are also main inputs for the corporate strategy (Naveh & Erez, 2004), this strategy acts as a filter of selection for improvement initiatives. Only those projects are accepted which generate a growth in revenue and/ or a profit within operations. This approach is clearly focused on the organization's external environment and is closely related to how Six Sigma projects are selected (Schroeder et al., 2008).

However, in addition to the top-down strategy, George (2002) also implies that a bottom-up approach to generate project initiatives can be beneficial in certain cases. The bottom-up does not necessarily involve more shop-floor commitment, but the idea's are produced by the employees on

the shop-floor. This approach, in contrast to the top-down approach, has a number of pros and cons which are described in figure 4.3 below.

| | Pros | Cons |
|---|---|---|
| **Top-Down** | Intrinsically linked to strategy/goals: yields a high NPV<br>Involves a "fresh eyes" approach, gets you "outside the departmental box" by design<br>New insight gained from a fresh look at markets and customers | Requires a new diagnostic process that champions must learn, execute, and educate others on<br>Requires a cross-functional team |
| **Bottom-Up** | Good mix of quick hits and projects<br>Allows a wide audience to contribute<br>Self-generating | Bias towards what you already know<br>Tends to surface "pet projects"<br>Typically not driven or supported by data<br>Many ideas are the "persistent pain"—irritants that may have little connection to important value streams |

**Figure 4.3: The pros and cons of either a top-down or bottom-up approach (George, 2002)**

As George (2002) suggests, the bottom-up approach has the risk of generating improvement initiatives that have little impact on the actual value chain because of a lack in overview (across the department or supply chain). Thus profit increase and customer value are not maximized while still much effort is put into improving processes. What makes the top-down approach hard to implement and maintain is the fact that cross-functional teams are necessary to assess each improvement initiative. This generally requires much alignment within the top layers of the organization.

## 4.3 Strategic implications

As McAdam and Lafferty (2004) imply, there are two different developments of Six Sigma: one where the methodology stands for statistical measures and one where it stands for strategic (organizational) change. This differentiation can also be interpreted for Lean Six Sigma, besides the actual improvement methodology, it is also influencing the firm's strategy and culture as a business philosophy.

Zu et al. (2008) discuss the critical aspects of high-level management regarding organizational strategy. They state that management must communicate thoroughly with the (Master) Black Belts

within the Lean Six Sigma specialist structure as they have the ability to translate the organizational strategy into the correct approach to improvement initiatives. Also, management's focus on Lean Six Sigma's metrics will ensure the organizational strategy to be taken strongly into account while improving the business' processes.

Spector and West (2006) discuss the managerial aspects of Lean (and) Six Sigma programs, more specifically how such programs should be aligned with the organization's strategy and objectives. They too strongly emphasize the importance of communication of the organization's objectives and how the Lean Six Sigma program can be utilized to reach such objectives. Chen et al. (2010) suggest that firms should adopt the continuous improvement methodology as an ongoing business strategy to reach a competitive advantage within the branch of industry.

**Employee motivation**

A goal for any organization applying the Lean Six Sigma program is for all employees to follow at least a basic awareness training which creates understanding of the methodology and its advantages for the business (Arnheiter & Maleyeff, 2005). According to Detert et al. (2000), the majority of employees working within a continuous improvement environment are intrinsically motivated to do a good job, but poor systems prevent them from reaching their targets. De Treville & Antonakis (2006) suggest that the degree of Leanness has an effect on various psychological states of workers' intrinsic motivation being meaningfulness, responsibility, knowledge of results and self-efficacy. They further imply that these intrinsic motivational factors have a positive influence on work outcomes and organizational performance. Additionally, the root cause for process bottlenecks should be searched within the systems, not the employees (Detert et al., 2000).

The degree of Leanness, as mentioned by De Treville and Antonakis (2006), has been suggested to influence the intrinsic motivation of workers. This heavily depends on management decisions regarding the initial design of the Lean (Six Sigma) program (Conti et al., 2006) and its implementation. Employees should be stimulated to an externally oriented view as this encourages the search for new information regarding customer demand, stakeholder value, external benchmarks and ways for the firm to create a competitive advantage within the branch of industry (Detert et al., 2000).

## 4.4 Conclusions

The implementation process of Lean Six Sigma can be considered as a highly important factor for the success of the methodology within an organization. Management must put large efforts in the planning and design of the program and its implementation. A top-down approach is recommended to fully prepare all layers of the firm to work with Lean Six Sigma's methods and tools. This means that the organization's strategy should be assessed, cross-functional teams should be set up, improvement tools should be selected, awareness should be created throughout the firm and a detailed implementation plan should be made before the actual implementation can be initiated.

Implementation of the Lean Six Sigma methodology can cause an organization's culture to change significantly, management should therefore carefully evaluate the organizational culture in order to reveal any possible discrepancies that can occur when managing the operational Lean Six Sigma program. The objective for managers is to create an environment where continuous improvement is encouraged and employees are intrinsically motivated to improve their own work outcomes and ultimately positively develop the organizational performance.

Improvement initiatives can be selected using a top-down or a bottom-up approach. Both approaches have their advantages and disadvantages, the organization's management should therefore choose the approach which fits best within the organizational culture and its strategic goals. This means the Lean Six Sigma methodology should be thoroughly aligned with the organization's strategy. Communication during improvement initiatives proves to be a valuable way for management to align the improvement project leader (the (Master) Black Belt) with the organizational strategy and objectives.

High worker motivation is a valuable requirement for Lean Six Sigma programs to be successful. Management must not only invest in the specialist hierarchy structure which will mainly focus on improvement initiatives, but also put effort in creating awareness and understanding regarding Lean Six Sigma throughout the organization.

# 5. Conclusions, Limitations and Recommendations

## 5.1 Conclusions

This thesis has researched the following problem statement: *"How can firms successfully apply Lean Six Sigma to achieve an environment of continuous improvement in process (re)design?"*. In order to be able to answer this question, the research started by conducting a literature review regarding Lean Manufacturing and Six Sigma as separate methodologies.

The main characteristics of Lean and Six Sigma have been put off against each other which revealed a number of important differences between the two methodologies. Lean is more suited for organizations producing a standardized product with a stable market situation. The emphasis is on total employee commitment, efficiency improvement, standardization and waste reduction. Lean can be identified as a bottom-up approach because improvement projects are initiated on the shop-floor. Six Sigma's main characteristics can be found in its improvement specialist hierarchy, extensive use of performance metrics and statistical decision making. Because the customer and stakeholder value are the starting point of each Six Sigma project, the methodology can be identified as a top-down approach which seeks to reduce process variation by improving processes on those parts which are critical to quality according to the Voice of the Customer.

Lean Six Sigma has been developed by combining the complementing aspects of Lean and Six Sigma into one methodology. The most important characteristic of this new methodology is that it incorporates the speed increasing and waste reducing philosophy of Lean, as well as the statistical approach to process improvement and the quality standard from Six Sigma. Further combination of the two methodologies can be recognized within Lean Six Sigma: Six Sigma's improvement specialist hierarchy has a managerial and supportive function to improvement projects which are influencing the shop-floor employees' workflows. These shop-floor employees form a valuable source of information within Lean Six Sigma because they are process experts and can generate idea's for improvement initiatives, this philosophy is obviously derived from Lean.

The implementation process can be seen as one of the most important factors which influence the success of the Lean Six Sigma program within the organization. A top-down approach to the implementation is recommended to structurally distribute the philosophy throughout the organization and develop the required resources. Organizations must be aware that the implementation of Lean Six Sigma has a large impact on the existing organizational culture.

Improvement initiatives can be selected using a top-down or bottom-up approach, either way has its advantages and limitations. Whichever is chosen, it is vital for management to communicate clearly with the improvement specialists in order to align them with the organization's strategy and objectives. All employees get a basic training in the essentials of Lean Six Sigma regarding problem recognition in addition to the improvement specialists' specific training regarding the methods and tools of Lean Six Sigma. Worker motivation is essential for Lean Six Sigma to be effective on all levels throughout the organization.

Taking the results of the scientific literature review into account, the following conceptual model has been concluded:

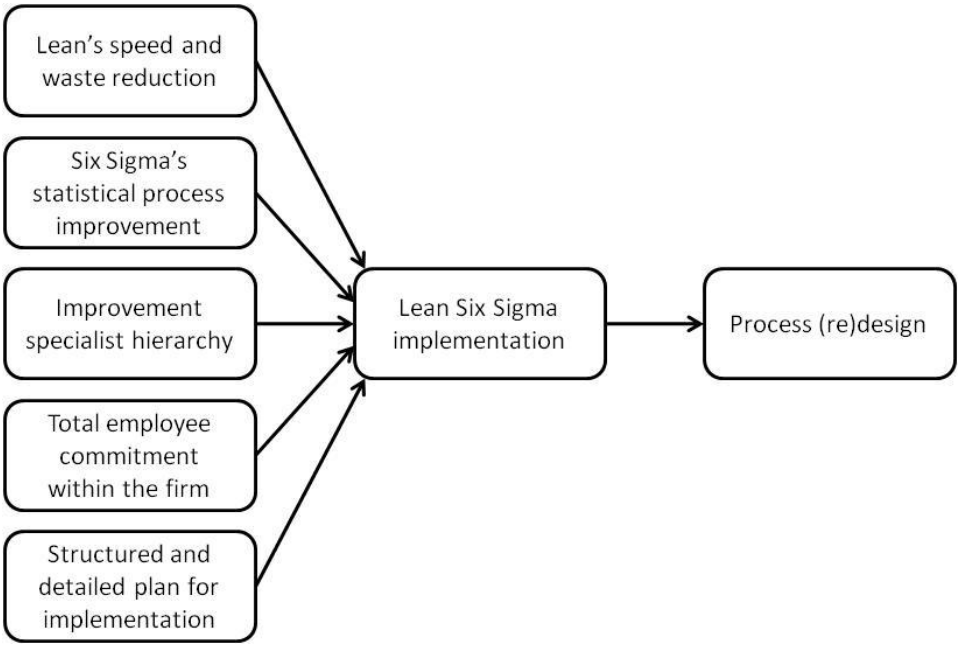


**Figure 5.1: The conceptual model for the research**

## 5.2 Research limitations

This research has several limitations which need to be taken into account. The thesis contains a literature study of a variety of Lean, Six Sigma and Lean Six Sigma papers found in contemporary scientific journals. This means no empirical research has been conducted to statistically support the proposed relationships in the conceptual model and various topics which were discussed throughout the thesis.

Further, there is still a limited amount of scientific literature available regarding the actual combination of Lean and Six Sigma into Lean Six Sigma. This resulted in some of the sub topics discussed in this thesis being based on a small number of scientific papers. To solve this problem, literature regarding Lean and Six Sigma has been adapted to make assumptions about how Lean Six Sigma could cope with the various aspects discussed in the thesis.

## 5.3 Recommendations for further research

The proposed relationships suggested within the conceptual model in paragraph 5.1 should be statistically tested to determine if the relationships are indeed significant. Empirical research is required to do so.

As implementation is a crucial step for the success of Lean Six Sigma programs, a comprehensive structural approach or model should be developed which is also examined by applying it to various case studies. The effect of Lean Six Sigma implementation on changes in the organizational culture is especially interesting to research.

Insufficient scientific literature is currently available regarding Lean Six Sigma, further research is required to extend the overall knowledge and understanding regarding this methodology throughout the academic world, which ultimately helps organizations to better implement and apply Lean Six Sigma successfully within their organization.

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