UNIVERSITY OF AGDER

Lean Six Sigma in Cameron Sense

Examining improvement management in a highly technical environment for removing waste, defects and unwanted variations.

Alexander Rønningen

Supervisor
Terje Heskestad

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Executive Summary

Lean Six Sigma is a methodology that relies on a collaborative team effort to re-design business operations by systematically targeting issues and business problems. The method use lean management to remove waste and other non-value adding activities, whereas Six Sigma is a proactive statistical based method to eliminate defects and unwanted variations. The thesis has studied Cameron Sense AS, the first drilling equipment provider that has implemented the combination of Lean Six Sigma in order to handle their improvement processes. The drilling equipment industry is a highly technical environment that combines mechanical, hydraulic and electrical technology with large amounts of resources used on compliance, quality and safety. Interestingly, this industry deviates from other successful Lean Six Sigma applications that are normally found in manufacturing environments. The methodology have a broad toolbox that include problem solving techniques, decision-making tools, process mapping tools, statistical tools and communication tools for creating understanding in a structured way. The thesis have examined Cameron Sense's environment and tried to understand the success factors for running the improvement program. There are several factors that are making the improvement processes challenging in Cameron Sense's environment: multi-discipline work; many suppliers and products with long lead times; high degree of cooperation; project and divisional barriers that hinder cooperation across lines; unpredictable demand schedules and industry variations. From literature, the most mentioned success factors for a Lean Six Sigma program is management involvement, alignment of goals and incentives, having a bottom-up management and good communication throughout the organisation. The findings for Cameron Sense's improvement program is that they need to review their current motivational factors for project managers; build up more competence in Lean Six Sigma for handling future projects; increase involvement of project champions; create transparency throughout the organisation for improved cooperation.

The thesis highlights effective use of measurement and a fact-based environment for understanding the complexity of their processes and products in order to implement correct solutions or changes. Furthermore, having project management skills are very important when improvement projects are competing against other on-going projects' attention and can easily be down prioritized. With great project management skills, project managers can push through projects in a hectic and complex environment with good results. This requires good project planning, management, communication, involvement and facilitation for being able to progress effectively. However, in this technical environment it generally takes years of experience to understanding what needs to be done, how to make good plans and how to effectively communicate that message to a broad range of people from different disciplines that are involved in the improvement project and simultaneously several other on-going projects. Therefore, two important strategies are selected in Cameron Sense, their people selection strategy and their project selection strategy. The business leader and project champions select Lean Six Sigma training to employees that are driven, motivated, experienced and actually have time to do side projects, while they are selecting projects that are applicable to the project managers skills and expertise. The project selection strategy also involves stopping projects that fail in order to avoid wasting resources, and is rather common for Lean Six Sigma programs. One of the experiences from Cameron Sense is that the option of splitting a project in several parts when complexity is high or meeting obstacles is a favourable alternative. By doing this, complexity is reduced and project time spans are not unnecessarily increased and preferably completed within three to six months. Finally, the management of the improvement program need to manage the program communication across all divisions, as they are required to optimize the entire organisation and build cooperation. Often we see that project and divisional barriers are giving the largest potential for redesigning and optimising business operations. In order to create support across organisational lines, the program need to communicate that improvement processes are for the greater good of the organisation. This vision need to be communicated and implemented when cooperation and teamwork is the critical factor for the drilling equipment industry.

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1.0 Introduction

1.1 Field of Study

The field of study in this Master Thesis is the Lean Six Sigma program at Cameron Sense. The program is a systematic approach for managing Cameron Sense's improvement projects, and a business tool for management to increase the firm's competitiveness in an industry that are strongly challenged by upstream cost pressure and volatile demand schedules. In order to respond to owner's requirements for higher effectiveness, reduced cycle time, cost reductions and improved customer experience, Cameron Sense has found the program to be a good tool for operating their internal improvements and obtaining their improvement goals. The master thesis tries to go in-depth of how the program works and especially questions the programs applicability to a project oriented company in the drilling equipment industry. Lean and Six Sigma are two philosophies that have been present for several decades, and the combination of the two approaches have been increasingly popular. However, Cameron Sense is the first of the drilling equipment companies in Kristiansand to use the application of Lean Six Sigma. The majority of successful Lean and Six Sigma applications are found in production companies, whereas Lean originated from the Toyota Production System, and have later developed into many different industries. Six Sigma was developed after Lean and originates from Motorola. To give a few examples, we can see a many successful lean applications in financial services, health care, logistics firms, telecommunications, retail, call centres, and interestingly we see majority of Six Sigma in technology manufacturers (Snee, 2010). The thesis will continue looking into what the operating issues for the Lean Six Sigma program, and reflect on the successfulness of the application to Cameron Sense.

1.2 Topic

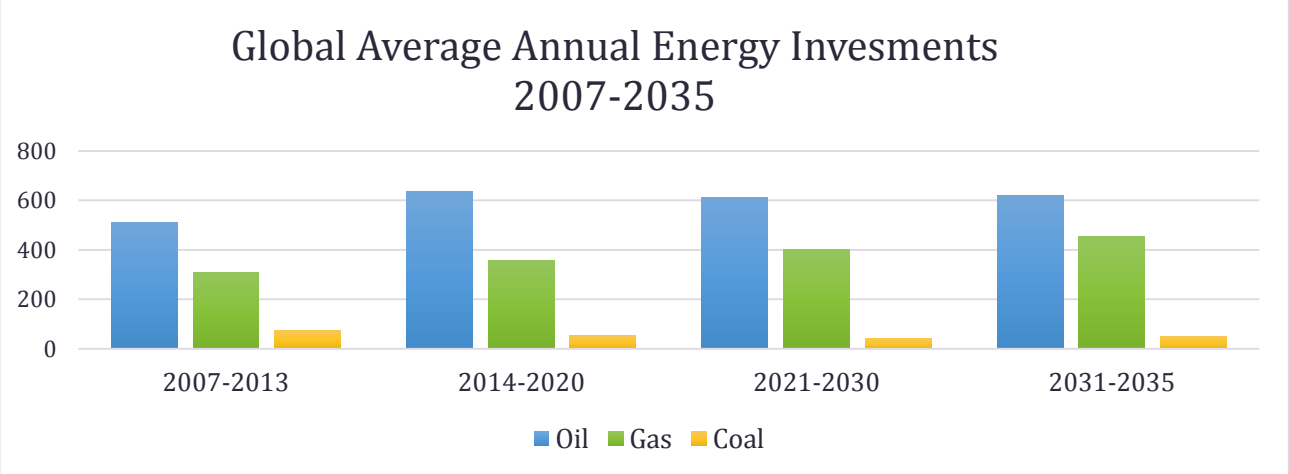
The thesis focuses on the application of Lean Six Sigma to a project-oriented company in the drilling equipment industry. The research question is the following:

What are the critical factors using Lean Six Sigma for improvement management in Cameron Sense?

1.3 Industry Background and Framework for Topic

Kristiansand has emerged as the global heart of drilling equipment technology and is often referred as “Drilling Bay”. This is due to the work of Bjarne Skeie, who founded most of the technology used in the industry today and have founded the three companies that later have been acquired by other companies and are named today National Oilwell Varco, MHWirth (separated from Aker Solutions) and Cameron Sense (EnergyBoardroom, 2013; NON, 2008). The three companies compete fiercely for market share and for winning drilling equipment contracts, and thus create a need for Cameron Sense to be effective and efficient. The industry forecast show that investment levels are to continue at a steady pace in the long run. Oil investment are forecasted to have average annual growth of 0,5 % the next 20 years, while gas investments are forecasted to increase annually by 1,6 % (International Energy Agency, 2014). The oil and gas industry will always have short-term difficulties, nevertheless in the view of the next 20 years, the oil and gas industry is forecasted to be stable. Uncertainty about the oil price development and increased focus among operators to be able to present free cash flow are among the primary explanations behind the lower growth in the forecasted investment levels the last three years, as it has forced operators to revise their investment plans, leading to postponement of projects (EY, 2013). The investments levels of the oil and gas industry are directly linked to the drilling technologies market. When the oil and gas industry invest in rigs or drillships the market for drilling technologies follows. Therefore, by having a long-term view of the next 20 years, Cameron Sense should use their Lean Six Sigma program to be creating long-term competitiveness. Table 1 shows the investments levels from 2007 to 2035:

Table 1: Global Average Annual Energy Investments



(Source: International Energy Agency, 2014)

Furthermore, the oil and gas industry is heavily regulated and large resources are used on compliance. In fact, testing and compliance to standards are up to 50% of total product cost on some Cameron Sense products. Scenarios where equipment fails when in operation are catastrophic and are the reason for heavy regulation and compliance. Nevertheless, the oil service industry is in constant change and looking for new innovative way to improve. In this industry, a small improvement of just 1% efficiency in a process can give extreme savings and profits, or a 1% improvement in risk reduction can give large amounts of value to customers. In essence, the Lean Six Sigma program can be of great service to the organization if used correctly.

2. Research Methodology

The research methodology refers to the systematic collection of data with the purpose to solve the research question, and have many different techniques, experiments and procedures. These methods are used to gather data and then analysing the data for answers. Generally, there are two basic distinctions of research methods named quantitative and qualitative research methods. The distinction is considered to be that quantitative researchers use numerical measurements, whereas qualitative researchers do not (Ghauri & Grønhaug, 2005). Qualitative methods are emphasized on understanding, usually from a respondent's/informant's point of view and have an explorative orientation. Quantitative method is emphasized on testing and verification, preferably through hypothesis testing. Although most researchers chose to emphasize one or the other, the methods can be combined and used in the same study. The topic of Lean Six Sigma was chosen by the director of project, Tor Oscar Askilsen and Business Black Belt, Nils O. Plathe, and can be characterized as a complex topic involving the entire organization. Therefore, the thesis have chosen an emphasis on qualitative research method and is supported by Ghauri & Grønhaug (2005) when suggesting a qualitative approach when the nature of the problem is unstructured and complex. Qualitative research tends to be more resource expensive compared to quantitative, and often uses interviews and observation as a tool. A qualitative data approach places few restrictions on the answers a respondent may provide and the uniqueness of each respondent is emphasized. The problem with this method is that it is resource intensive and often takes time to execute; few respondents are therefore often used. This can lead to problems with the representativeness of the interviewed respondents, and questions about the validity of generalization can occur.

To be able to provide good information and a reflected thesis I have spent five months and more than 100 hours in project meetings at Cameron Sense's facilities in Kristiansand. This will help me to understand how the Lean Six Sigma system works and get first-hand information. During project meetings I have been mostly observing, whereas in meetings with business black belt and project managers I have been allowed to ask questions and to challenge their opinions. In theoretical term, the observation has been in a free and unstructured way.

After more than three months of observing in project meetings and researching relevant literature, I was confident that I was able to design a questionnaire that target the correct root causes of my research question and were able to ask the right questions that respondents would understand. 14 project managers responded to the questionnaire and gave a good basis for argumentation. The questionnaire had three qualitative questions with a fill in tab for answers, and fourteen quantitative questions using a Likert scale ranging from one to seven of how they agree to a statement (Appendix B). The Likert scale is valuable for presenting opinions in a quantitative way and gives values to the level of consent. The questionnaire was held anonymous with the purpose of having open and honest opinion that they might be afraid of telling otherwise.

Throughout the research process, the thesis has followed these main goals for giving direction and obtaining good results:

- Understand how employees and managers think and react to the program.
- Understand the factors that are unique to a project-oriented company in the drilling equipment industry.
- Note all observations in project meetings
- Attend progress meetings
- Find information on how their program is working
- Use my own perspective on how I see the processes.

The qualitative research method have been resource expensive for Cameron, and mostly in form of having Nils O. Plathe for guidance, support and collecting empirical data. In addition, all improvement project managers for interviews, progress meetings and questionnaire. Hopefully, they can find the thesis valuable and that they have been learning in the process.

Validity and Reliability

There are a possible weaknesses with the questionnaire due to the entire sample collect were participating in the Lean Six Sigma program. From the chosen sample we could draw good information, but some of the questions would be more valuable if a sample was collected from outside participants without a direct link to the Lean Six Sigma program. In addition, the researcher might have been influenced by the Cameron Sense employees to favor the program and its benefits after a long and intensive five month period that could cloud the judgment. However, the long and detailed stay should more likely increase the validity and reliability in many aspects due to a better understanding of the Lean Six Sigma program.

The generalization of these findings to other firms needs to be assessed independently by each firm, as business environments differ greatly. There is a section describing the company with guidelines of generalizations to others. In short, the thesis would recommend large technical firms to be advised by the findings.

3. Lean Six Sigma

3.1 Development

The development of Lean and Six Sigma started with the idea of measurement and quantification that have been in use for many years and can be traced back to Fredrick Winslow Taylor when he presented the principles of scientific management that revolutionized the world (Taylor, 1911). Scientific Management is a theory of management that analyses and synthesizes workflows, where the objective is to improve economic efficiency, especially labour productivity. This is where the industry started to include the use of analysis, logical reasoning, rationality, best practice of work ethic, the elimination of waste, the used of standardization of best practices and being more focused on efficiency (Aitken, 1985). In short, this gave the foundation to the modern organization and beginning of today's decision theory.

Forty years later, Total Quality Management (TQM) was introduced and is based on William Edwards Deming's work (Deming, 1966). TQM stressed the need for organization to improve the product and process quality, implying that every employee in the organization is responsible for improvements and especially improving the firm's

ability to deliver high-quality products and services to customers through quality control. Total Quality Management introduced these key concepts that are used in Lean Six Sigma today (Houston, 1988):

- Quality need to be defined by customers' requirements
- The use of systematic analysis of work processes and quality for improvements
- The use of steering committees to lead quality improvements
- The idea that quality improvements are a continuous effort

After TQM, Michael Porter introduced the view of the creation of companies in the 1980s. The philosophy served as a revolutionary mindset for creating value chains and competitive strategies that went across functional and hierarchical divisions, connecting together the whole organization (Porter 1985). Suddenly the strategic areas of businesses became more important and companies could no longer rely on the economic boost from the industrial revolution, because the intensity of competition from other firms increased. This created the need to show guidelines and have the right strategic visions for the firm to would results in long term competitiveness. Today, Lean Six Sigma is used to control businesses strategies and vision by using the tool to re-design and re-engineer the business processes.

Not late after came an approach from Japan called Just-in-Time focusing on improving a business' return on investment by reducing in-process inventory and associated carrying costs (Hutchins, 1999). Popular techniques in Just-In-Time include reorder point and signalling techniques. The application of JIT is very sensitive to Cameron Sense due to the consequences of not delivering on time are damaging. Cameron Sense has a high priority to on time delivery and is valued by their customers, which is one of the ways they are customizing the Lean Six Sigma theory to their organization. The philosophy of JIT is applicable to Cameron, but is should be applied carefully. I quote Nils O. Plathe, Business Black Belt: *"Cameron Sense should be careful to perform Just-In-Time, our philosophy should be Not-Too-Late".* This is mostly due to large upstream revenue loss of delivery delay.

Simultaneously as Just-In-Time, Toyota introduced lean manufacturing through their production systems. Lean production philosophy considers the expenditure of resources only acceptable if the action will give end customer direct value and should be eliminated if considered wasteful. In Cameron Sense, this philosophy was adopted in

2004 in addition to Six Sigma that was adopted in 2000. Today these two philosophies are combined and incorporated and is somewhat implemented or aimed to be implemented throughout all departments in Cameron. Following is a more detailed explanation of Lean.

3.2 Lean

Lean Management was transfered to western companies after Womack et al. (1990) presented the findings of their study showing that Japanese companies, managing with Lean principles outperform western companies by far. Lean Management progressively found their way from applications in mainly manufacturing environments in the beginning, into a system for the whole value stream involving every stakeholder from customer to supplier. Lean Management later adapted into the service industry and we can today see a presence in the banking and financial services, health care, high technology manufacturers, telecommunication, retail and many others (Snee, 2011). The goals of lean is to use resources more effectivly, to get more satisfied customers and to create a better workplace for the employees. Lean aims at creating more value for customers with fewer resources and to create a perfect value creation processes that has zero waste. The challenge for management is to optimize technologies and their assets, and how to coordinate vertical departments for optimizing the flow of products and services through the entire value streams that flow horizontally across technologies, assets, and departments to customers.

To successfully achieve these results, it is important to establish and develop a culture for lean (Womack et. Al 1990; Womack & Jones, 1996; Hamed, 2012; Snee, 2010). The development of a culture within a organization will be crucial for the effectiveness of the lean program, and if done right the culture help employees to stay motivated and eager to make continous improvements. Following table show how lean have defined two different categories of value:

Table 2: Definition of Value

Value added:	**Non-Value added:**
• Anything the customer is willing to pay for, that is performed “right” the first time, that changes the form, fit or function to meet customer requirements.	• Anything that has to be “re-done” or a “do-over” • Activities that consumes resources or time that does not satisfy customer requirements.

To improve your understanding of waste, the different kinds of waste that originated from Toyota Production Systems are modified for Cameron's Lean Six Sigma Program and are shown below:

Table 3: The 8 different types of waste

Waste	Description
Inventory	Waste by storing parts, pieces, and materials not being processed.
Talent	Underutilizing capabilities or delegating tasks with the inadequate training.
Transport	Waste by moving people, products & information.
Motion	Unnecessary movements by walking, turning, reaching, lifting.
Overproduction	Making more than what is immediately required.
Over processing	More work or highest quality that is required by customer
Defects	Rework, scrap, incorrect documentation
Waiting	Wasted time waiting for parts, information, instructions, equipment.

(Source: Cameron, 2012)

As Womack and Jones (1996) notes there are five central principles that we need to have in the mindset when performing Lean Management:

- *Specify value from the point of view of the customer*. Products and processes should be designed based on the needs of the customers and not on what the company finds convenient.
- *Identify and map the value stream.* For providing overview and thus make informed decisions.
- *Create flow*. The aim is to have no queues or delays, especially a value-adding step should never be delayed by a non-value adding step.
- *Pull*. Optimally customers have to pull the firm's value chain and respond to customer needs.
- *Perfection*. The firm need to pursue perfection and have continuous improvement.

To attain complete perfection should ideally never happen due to environments constantly changing, and is especially common in the oil service industry. Companies should still want to be the best to their abilities and strive for competitive advantage. Following is a more detailed explanation of Six Sigma that can be complemented to Lean.

3.3 Six Sigma

Six Sigma is another methodology created by Motorola around 1986 (Tennant, 2001). Six Sigma is a fact-based, data-driven philosophy of quality improvement that values defect prevention over defect detection. While Lean tries to eliminate waste, Six Sigma is a tool to identify and eliminate the source of the unwanted defect or variation. The main goal is to improve the quality of the business product by finding mistakes and fixing processes. To explain, the defect tied to a product goes down and therefore quality is increased. In the oil industry, customers appreciate reductions in defects and improvements in quality.

Six Sigma focuses on ways to measure quality and thereafter being able to see possible improving adjustments. The philosophy's goals is to strives for less than 3,4 defects per million on their products. This mean that the customers' requirements are satisfactory 99,99966% of the times, hence the name Six Sigma. The fundamental objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction through the application of Six Sigma improvement projects. However, in Cameron Sense Six Sigma is not always easy to apply due to their production is low volume and the data collected will not always provide rich enough information about the variations and defects to create preventive actions. In addition to low volume, Cameron Sense does not have as many processes that are repetitive compared to manufacturing companies. When volume is low the effectiveness of statistics and Six Sigma is reduced, but still useful. Six Sigma is focused on the bottom-line effect and strives to places values and statistics on all processes. This is quite the opposite of the experimenting nature of Lean, which does not have to evaluate or find values for each single process (Snee, 2010).

In Six Sigma, whenever a problem is identified a project team is assembled to carry out a project and solve the problem based on the DMAIC-cycle that will be explained in detail later. Many argue that the DMAIC model is more appropriate for project organizations, while the Lean approach have a more simple and continuous form of completion; plan, do, check and act. Therefore, in Lean Six Sigma the DMAIC model have been integrated as the main model (Cameron, 2012).

3.4 Lean Six Sigma

Both methodologies, Lean and Six Sigma, are based on the logic that every business process improvement opportunity has relationship as Y= F(x). Thus, the belief that

Cameron should be able to measure activities relatively accurate by using the right tools, key performance indexes (KPI) and techniques. As mentioned before, one key difference is that Lean has a more experimenting nature, while Six Sigma is a statistical and has a stronger emphasis on measurement before experimenting or implementing a solution. In the combination, project managers can evaluate the degree of experimentation for each project after what they see fit. In Lean Six Sigma, when you are 100% certain of what is a correct solution you are allowed to precede without going through the phases of analysis and measurement. However, in this event the project will not be completed as a Lean Six Sigma project, but a just-do-it project. A more detailed explanation of just-do-it projects will come later. Otherwise, you will need to do a proper measurement phase to understand what the problem is and what is causing it.

The combination of the two methodologies can be very powerful and is shown in the following table:

Table 4: Overview of Lean and Six Sigma

Objective	Six Sigma	Lean Production
Focuses on customers value stream	No	Yes
Focuses on creating a visual workplace	No	Yes
Creates standard work sheets	No	Yes
Attacks work-in-process inventory	No	Yes
Focuses on good house keeping	No	Yes
Have tools for reducing lead times	No	Yes
Attacks waste due to waiting, over processing, motion, over production, etc.	No	Yes
Focuses on reducing variation and achieve uniform process outputs	Yes	No
Effective use and application of statistical tools and techniques	Yes	No
Process control planning and monitoring	Yes	Yes
Analysing customer needs	Yes	Yes

(Source: Hill, 2008; Tennant, 2001; Womack et. Al 1990; Womack & Jones, 1996; Hamed, 2012; Snee, 2010)

The two methodologies focus on different aspects of a process. Lean's way of removing waste and creating flow most often improves material and information transfer between process steps. Thus, Lean has a focus on the interaction and connection of process steps. Contrasting that, an in-depth analysis of a process as performed in a Six Sigma context

most often tackles poorly performing process steps with regard to quality and variability. Therefore, the combination creates a total coverage of process management. Lean is covering the interaction of processes, while Six Sigma is targeting each process. Lean Six Sigma gives coverage of defects and quality through Six Sigma, while lean covers speed, efficiency, and waste in all processes. Lean provides tools to reduce lead-time in and in-between processes, and eliminates the non-value added cost identified. The Six Sigma approach does not contain any tools particularly to control or reduce lead-time, which have a large potential and is important for Cameron Sense.

Similar to both methodologies are the involvement of management and leaders. Both approaches stress the necessity of top management commitment and support. They use a top-down management approach to deploy the initiative and should involve all employees, some argue that Six Sigma is a more expert driven approach and need less involvement. However, the experiences from Cameron Sense are that involvement and cooperation is important when cooperation and interrelating technology is high. Without this involvement and communication there are several examples of projects that have become motionless. Most Lean Six Sigma projects are suggested to be completed within three to six months, to maintain progress and to avoid too many projects running at once. In order to guarantee the project length of three to six months, they need to have a well-defined scope and make adjustments if complexity becomes higher than anticipated. Normally the initial problem worked on by a project should not have an obvious solution, but it should neither be too complex to be solved within the defined period. To give an example for Cameron, the Top Drive Cost Reduction Project could have had one single improvement project, but it would take more than two years to complete. Instead, the preferred approach is to derive it into smaller pieces and gradually improve the product. Following is a explanation of Cameron's preferred model for completing Lean Six Sigma projects.

3.5 DMAIC Model: The central model in Lean Six Sigma

DMAIC is an acronym for Define-Measure-Analyse-Improve-Control. It is a data-driven improvement cycle used for improving, optimizing and stabilizing business processes. DMAIC has a much stronger focus on analysing the problems in depth. The extensive measurement and analysis explains the suggested duration of three to six months for Lean Six Sigma projects, as this can be time consuming. All of the DMAIC process steps are required and will proceed in the following order:

Phase 1: Define

Similar to normal project management theory, Lean Six Sigma Projects are required to start by clearly defining what the project scope, what the objectives the project has and when the project is preferred to be completed. The project initiator are to articulate the business problem, what the main goals are, which potential resources that is necessary to complete the project and what is included in the project scope and project timeline. In Cameron, this involves creating a project charter. The charter requirements are to define a business case for doing the project, state the problem, define the scope, set goals and spell out the roles and responsibilities of each team members. The define phase requires a mindset according to the Lean principle of specifying value for the point of view of customers. Project Managers should gather and identify information about the customer through a document called Voice of the Customer (VOC) and a document called 'Critical to Quality' (CTQ). VOC is a market research method aiming to captures the customer's expectations and preferences. Simple techniques such as asking customers questions, asking them for data or interviewing them is adequate and can give valuable information. CTQ are not to be confused with what customers want. CTQs are the factors that are important to the quality of the process or service to ensure the things that are important to the customer. Often we find that CTQs are information that engineers, process designers and managers possess. By having this kind of rich information, we can separate the non-value adding processes from the value adding ones.

Phase 2: Measurement

In this step, we develop a data collection plan and/or perform a baseline capability study to calculate the baseline for the project. This way we can validate and select root causes for elimination. The importance of this phase has been experienced in many of the interviews and project meetings that I have attended. With more than 600 employees, several different departments and high product complexity, Cameron has listed the measurement phase as a key importance for projects success. The need to create a fact-based culture in Cameron's complex environments is important for several reasons. First, with a complex environment, how can employees be sure that they know what is really causing the problem or how to resolve it? If the measurement phase is rushed, it can result in resources being wasted or that a project manager implementing a solution that makes the original problem even worse. Secondly, when employees identify and

report a complex problem without having information or the necessary argument for making actions, other employees and management will show little support or participation for making a change. Cameron Sense has several well-developed information systems that should be able to offer many different kinds of data, and have the ability to create valuable Key Performance Indexes (KPI) for their processes. When asking the Business Black Belt how accurate and trustworthy the measurement phase can be done, he replies that he trusts the measurement data and program savings and with an indication of variances rarely exceeding +/- 10-20%.

Examples of tool used in measurement phase:

- Value Stream Mapping
- Process Mapping
- Cause and Effect Matrix
- Root Cause Analysis
- Statistical Charts
- Correlation Measurement

Phase 3: Analyse

The analysis phase consists of using all information gathered in two previous phases. Project members should now be able to visualize and analyse the information for problems in the processes. In these analyses there are statistical reviews and techniques to determine which the significant contributors to the output are. All participants can now do an effort to narrow down and verify the root causes of waste and defects. Sometimes after analysing the project, the team need to revisit the project charter and the define phase, and the information can suggest something completely different from what originally thought. In fact, in June 2014, all project team members had just been though brainstorming of possible actions for improvement and suggested 25 different improvement opportunities. After the brainstorming, the team completed a cause and effect matrix to determine their effectives taking into consideration benefit, time, cost and ease of implementation by rating each of the improvement suggestions. It turned out that some of the improvements that evaluated most important in brainstorming scored low in the matrix and is after discussion dropped from the action list of the project. One of the reasons for this is most likely the input generated from the different technical disciplines with expert knowledge of resources, costs and time. Without this kind of

analysis and decision-making tools, there could have been many instances where less effective improvements would have been implemented. In addition, this is why project members are encouraged to keep their solutions, hunches and opinions until the analysis phase is completed. In Cameron, all project members are encouraged to write down their ideas of solution from project start, but then postpone further thought about the solutions until the improvement phase. This structured way of measurement and analysis can lead to innovative and elegant solutions if done correctly.

Some tools used in the analysis phase:

- Cause and Effect Matrix
- Statistical tests using probability values accompanied by visual graphs.
- Analysing Value Steam Mappings
- Identify how the process inputs (Xs) affect the process outputs (Ys). Data is analysed to understand the magnitude of contribution of each root cause.
- List and prioritize potential causes of the problem
- Prioritize the root causes to pursue in the Improve phase

Phase 4: Improve

Once the project teams are satisfied with their data and determined that additional analysis will not improve their understanding of the problem. The improvement phase selects and implements solutions that should improve, fix and stabilize the problems or processes. The implementation requires careful project planning considering logistics, training, documentation, communication plans and especially who are responsible for delivering the action. Once the team is able to show that the solution has resulted in measurable improvement, then the team can move on to the Control Phase.

Effective techniques and suggestions for improvement phase:

- Brainstorming
- Weighted Criteria Matrix helping teams to make best decisions when there are conflicting options.
- Action Plan & Implementation plan
- Pre-testing solutions

Phase 5: Control

The purpose of this phase is to sustain the new improvements through a robust control plan. The control plan differs from project to project and will depend on the initiatives that have been implemented in the previous phase. The control phase should include a plan specifying how they want to pass and maintain the new structure or process onto the employees who work within the process. The control plan wants to avoid having employees or processes slipping back into old habits, and is often underestimated by many firms.

Some tools used in control phase:

- Creating a contingency plan with responses to unwanted scenarios
- Reviewing measurement plan for improvement solutions

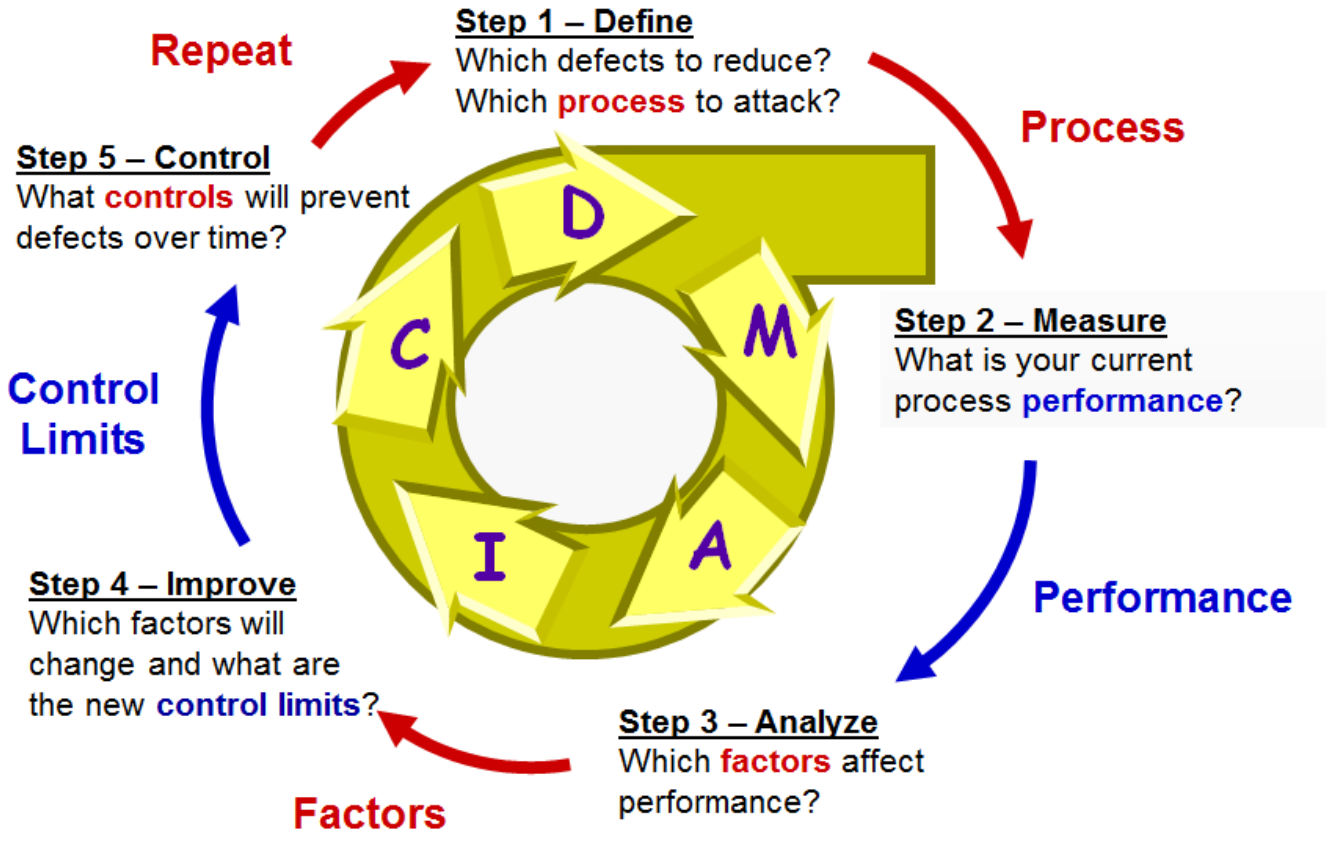


Figure 1: Overview of the DMAIC Phases

3.6 Criticism of Lean Six Sigma

Some literature suggests that Six Sigma, Kaizen, Lean, and other variations on continuous improvement can be hazardous to your organization's health. They are saying that organizations should look beyond Japan and their continuous improvement and question if it is affecting companies' ability to innovate, or if it simply is too time consuming. Often mentioned are iconic Six Sigma companies in the United States like Motorola and General Electric, which have in recent year struggled to be innovation leaders (Ashkenas, 2013). They are saying that the mindset for driving innovation is different to the continuous improvement methodology used, and preferably only parts of the organization should have Lean Six Sigma programs running. Organizations should also bring in the question that maybe it is more effective to eliminate or disrupt compared to improving the it? Further the criticisms are often that management is focusing the program on effective way to cut cost and improve profitability, while not adding enough attention to finding new approaches, maintaining functional quality, improving ideas rather than throwing them away and prioritising cross-functional teams (Crom 2010).

Lean Six Sigma is not only to blame as Arthur (2011) defends in his post 'Is Lean Six Sigma Killing Innovation'. Lean Six Sigma are looking for ways to redesign or re-engineer the business, by simplifying, streamlining and optimizing existing business operations, meaning that Lean Six Sigma cannot be an innovation killer. Lean Six Sigma is just another tool in the business toolkit. It is rather about creating the right business environment for the specific company that matches their specific strategies, and if innovation is a part of that strategy this need to be embraced under a continuous improvement umbrella. Simply put, Lean Six Sigma is not for everyone, but if Lean Six Sigma is causing failure it is a management failure and not the tool in itself. Therefore, it is extremely important to communicate the vision, strategy and objectives for the organizations and adapt after these guidelines.

3.7 Beyond Budgeting Approach

Beyond Budgeting is a management technique that is an alternative to Lean Six Sigma, or can be treated as an additional approach applied to Lean Six Sigma. The two approaches have some principles in common. The following information is gathered from studies done by Bogsnes (2014):

Beyond Budgeting argue that during recent years the business environment has become far more complex, dynamic, turbulent and uncertain. Shorter product lifecycles coupled with technological advancement has focused greater attention on improvement as a determinant of corporate success. Therefore, by having an adaptive and agile management model that can respond to changes is the key for improving, seizing opportunities and fending against threats. The approach is taking a new view on traditional budgeting processes arguing that traditional budgeting processes tends to fix a company's thinking and response to events in a changing and complex world. The approach suggest to throw out traditional budgets and move towards continuous rolling forecasting to enable speedy and coordinated adaptations to actual and anticipated changes in the business environment. In addition, it suggest to have a more freely organization on doing improvement by enabling employees to initiate projects their selves. When the static budgets are thrown away, employees are asked to set their own targets, and preferably in relative terms instead of absolute. Relative targets can be measured for instance by comparing own results to competitors, or adjusting them to external factors that are beyond businesses' control.

Employees are measured throughout the entire organization on a balanced scorecard. The balanced scorecard is set by the managers together with the employees where they both agree on goals and targets. The scorecard can continuously be updated, but have to be notified the above management level with a message or report. It is important for the scorecard to have the correct Key Performance Index (KPI) and targets that capture what the organization want to happen. In addition, the management need to see the entire organization holistically and connect all goals to strategy. The approach stress for the application of reverse management where beneath divisions are asking how they can assist upper management to attain their goals. This holistic and cooperative view is making the organization more effective and adaptive. In addition, by setting the targets and goals in the balanced scorecards, employees develop a sense of ownership toward their targets, and are motivated by having a decentralised management models. The ownership effect is argued to increase the quality of work and motivation of the employees.

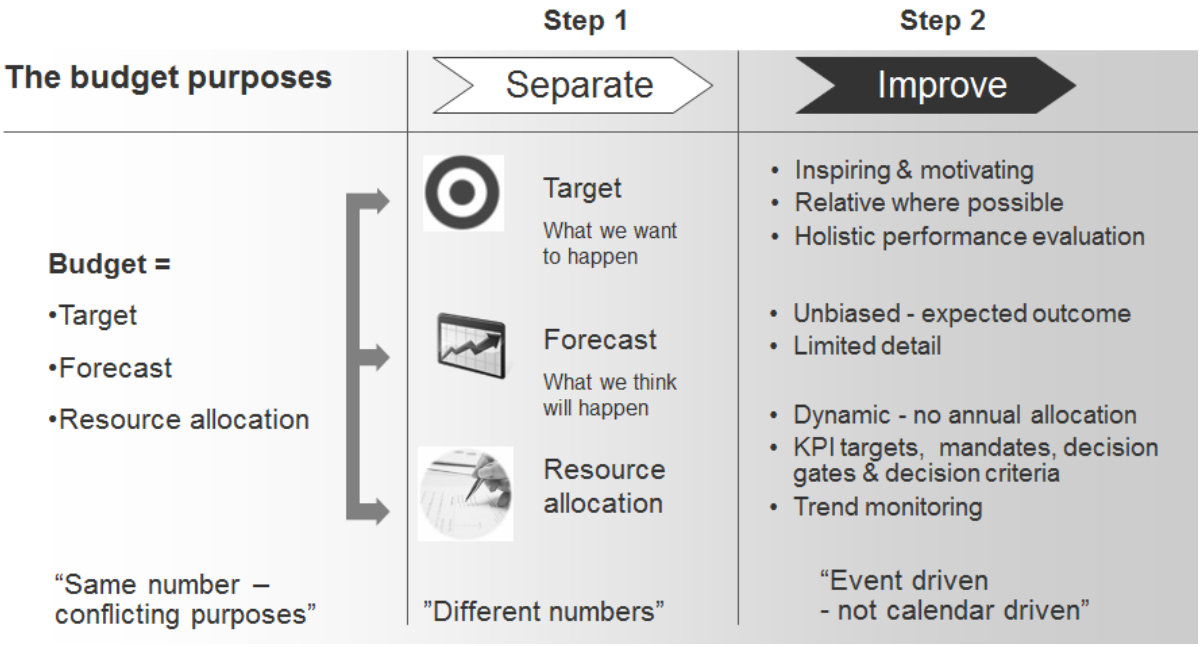
Beyond Budgeting is aiming for a more dynamic resource allocation which provides a more flexible decision making authority, where they invest in improvement more than once a year during budgeting decisions. Traditional management is criticised for being

too bureaucratic ability to make improvement investment to once a year in their annual budgeting procedure. With rolling forecasts and management, resource allocation is possible to be done in a dynamic way.

One of the major issues with having a decentralised management model is to open for transparency throughout the organization, and getting all employees and division to cooperate. In addition, many critics emphasis that this kind of management model for improvements are only for companies with exceptional employees that are capable for change. This unstructured way of doing improvements will also require employees to have execution power and a need for self-actualization. Often encountered is that proper motivation lacking by the incentive systems failure to properly motivate employees to make improvements. Even though this is hard and challenging, there are several examples of successful companies.

Here are several of the principles in Beyond Budgeting that can be applied onto the Lean Six Sigma program:

- Values should be implemented to govern with clear goals and boundaries. Employees should know these, and not be govern by budgets and rules.
- Transparency should open information for self-management
- Organizational structuring should be done in networks of lean accountable team, and not around centralized functions.
- Autonomy should give teams freedom and capability to act
- Set relative goals for continuous improvements instead of fixed performance contracts
- Rewards should be set for relative performance
- Planning should have continuous improvement as a goal and be inclusive for the entire organization
- Resources should be available as needed, not depending on what the department can afford.



Source: (Bogstad 2014)

Figure 2: Beyond Budgeting Overview

Figure 2 shows the budgeting procedure of Beyond Budgeting with a focus on the targeting procedure, forecasting and resource allocation. An interesting criticism to traditional management is that when employees are asked to prepare targets and forecasts for next month or next year, they are often being affected by their bonus setting. Normally their bonus is connected to their actual results compared to what is forecasted and will give the employee an incentive to set a less ambitious target to be able to achieve a higher bonus. This is not in the interest of the organization that wants ambitious targets and forecasts. This master thesis is limited to the improvement processes of Cameron Sense and the Lean Six Sigma program does not have responsibility or authority of the overall management model of Cameron Sense, including how the organization operates their budgets, forecasts or incentive strategies. Therefore, to question whether Beyond Budgeting is a better fit for Cameron Sense or not, is hard to say. However, the decentralised management model for doing improvements are giving valuable input to how improvement processes can be done.

One of the most famous examples of companies that have implemented the Beyond Budgeting approach is Statoil. In addition, there are many hundred other successful companies and you can question that there must be a reason for them to be doing this and that it is working. The Beyond Budgeting approach are applicable and most effective

to environments that possess Theory Y employees, meaning that employees are happy to work, are self-motivated and creative, and enjoy working with greater responsibility, This concept is based on studies done by MacGregor (1960). Without the Theory Y employees, the Beyond Budgeting approach is forecasted to fail substantially. Beyond Budgeting argue that it is more effective to developing a culture of cost consciousness instead of bringing cost cuts when aiming to reduce costs. This will require employees to be more involved and responsible. It devolves performance responsibilities to operational management who are closer to the action. This uses the 'know-how' of individuals and teams interfacing with the customer, which in turn enables a far more rapid adaptation to changing market needs. Involved individuals need to evaluate what is good enough and critically evaluate how much value is currently being created. If the approach is executed correctly, they should be authorized to implement the improvement. However, it requires critical consideration to whether the initiative is within the group's or the department's execution framework.

Several studies have shown that if the organization consists of involved and responsible people, the approach will motivate people by giving individuals challenges, responsibilities and flexibility. Studies have also show that bonuses and monetary rewards are far less effective on these types of people in comparison to giving involvement and responsibility. To what extent we can transfer experiences for Statoil into Cameron Sense depends on how similar their employees and working environments are. It is reasonable to argue that both companies have similar environments that possess highly intellectual and experienced workers, however there are major differences in their core operations. Statoil is in oil and gas production and is a rig operator, while Cameron Sense is in the drilling equipment industry. Statoil is much larger than Cameron Sense, but they are both project based organizations. With limited knowledge of the internal environment in Statoil, the thesis is unable to reach a conclusion whether experiences or results can be generalized for both companies.

Unfortunately, Beyond Budgeting does not offer the same variety and tools that Lean Six Sigma has to offer, such as decision-making tools, statistical tools, communication tools and other tools are important for a technical environment where cooperation and complexity is high. The development of Lean Six Sigma over several year have given a wide variety of tools that target different needs, while Beyond Budgeting is more of a management model. With the application of only Beyond Budgeting without Lean Six

Sigma there would be far less competence in data collection and data analysis, which is argued to be an important part in the current Cameron current training program. The measurement and collection of data in a complex system is hard to understand. In addition, it is unlikely to believe employees will start paying large attention to using measurement and statistical tools without managers intervening or without employees being trained. My research suggest that Beyond Budgeting is an interesting compliment as a management model applied to the Lean Six Sigma program, but not able to replace Lean Six Sigma.

4. Company Background

4.1 Cameron Sense AS

Cameron Sense is a part of the Cameron system with more than 27 000 employees spread over more than 100 countries. In 2013, Cameron had an annual turnaround of $9.8 billion, while the Kristiansand division that specializes in drilling technologies had an annual turnover of $1 453 million (CAR, 2013; Proff, 2013). Cameron works with drilling contractors, oil & gas producers, pipeline operators, refiners and other process owners to control, direct, adjust, process, measure and compress pressures and flows. Cameron Sense in Kristiansand specializes in complete drilling solution packages in the market for oilrigs and drillships. The thesis have a focus on the drilling technology department in Kristiansand.

Cameron Sense have approximately 600 employees with daily activities involving sales, engineering, project management, product assembly and aftermarket service. All departments of Cameron Sense are located in Kristiansand, Norway and give a unique opportunity for communication by housing them in the same building. Cameron Sense is defined as a “high value, low volume producer”, meaning their products are expensive and not produced in bulk or a large scale. To illustrate, Cameron Sense produces around 12 top drives each year for different projects with value of approximately $750 000 each. A top drive provides clockwise rotation to the drill string to facilitate the process of drilling a well. In the thesis it is crucial to understand that other Cameron divisions are not similar to Cameron Sense as they differ in their range from low to high value, and low to high volume manufacturers. For instance, valves productions in Houston, US requires different Lean Six Sigma techniques due to their high volume. The Lean Six Sigma program that is integrated into the Cameron System have the same training and same

worksheets being used, but different improvement managers with different areas and goals. The Lean Six Sigma programs are responsible for the internal improvement initiatives that the organization wish to pursue, but can also work together with external suppliers.

The thesis will address if a Lean Six Sigma program is appropriate for a project organization. Cameron Sense is a project-oriented organization with several line managers responsible for different products. There are seven Line Managers in total and reports to Management. The following lines are found within Cameron Sense:

- Hoisting & Rotating
- Pipe Handling
- Drill Floor Tools
- Blow Out Preventer Handling
- Drilling Controls
- Motion Compensation & Hydraulics
- Derricks & Structural

Each of these line are responsible for ensuring that they have the necessary expertise and capacities to deliver to each project that Cameron are contracted to deliver.

Cameron Sense's sales are expedited, handled and transformed into a project. A project start when the sales department lands a contract and the organization appoint a Project Manager and an Engineering Manager. Each project can differ in size and complexity, from involving a complete rig solution or an upgrade to a Top Drive on a platform currently in operation. The complete rig solution could cost up to $400 million and last up to two year, while an upgrade can be much less in regards to cost and time. In each project, there will be a project team responsible for all aspects for project management. Below is a figure of the project structure:

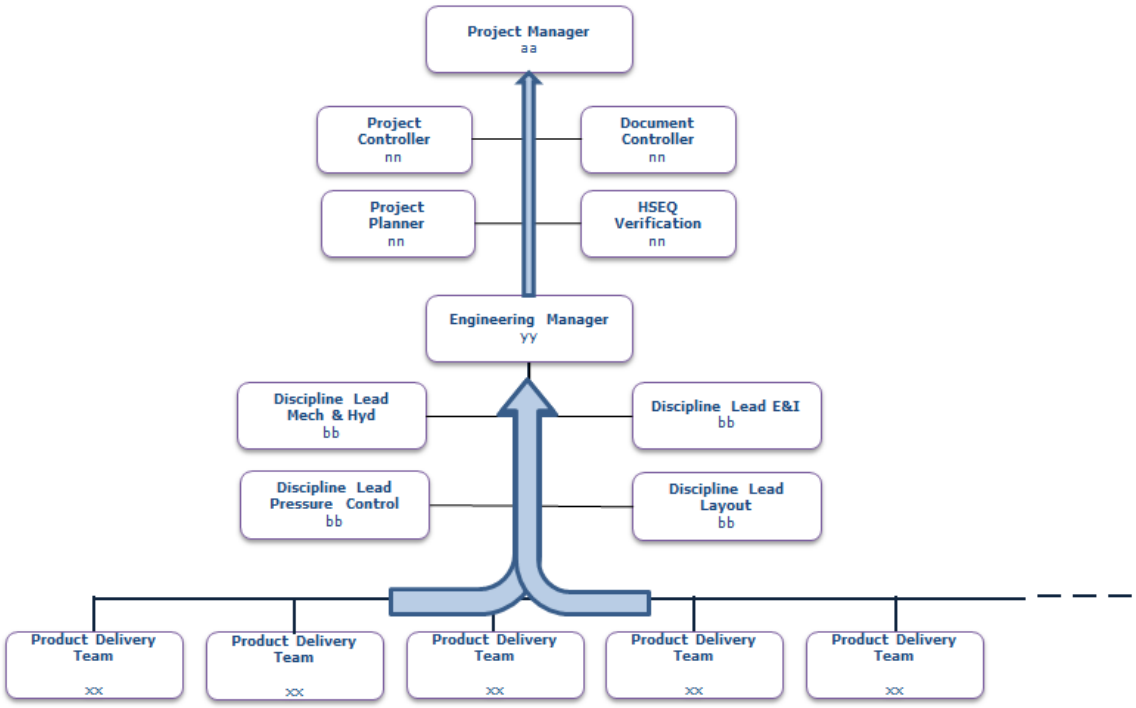


Figure 3: Cameron Sense Project Structure

In the project team, we can find a project controller assisting project manager on economic activities with financial analysis and monitoring budgets and forecasts. A project planner with project plans, schedules, work breakdown structures and is responsible for ensuring good project flow. The document controller ensure that all necessary documents are present for industry verification and that the project have complete security, availability and completes audits.

The engineering team are responsible for technical deliveries and that product are functions to customer's requirements, which can differ from project to project. The engineering team reports through an engineering manager up to the project team. The engineering team can consist of disciplines like electrical engineering, mechanical engineering and software developers.

Product Delivery Team (PDT):

The Product Delivery Team (PDT) is a new team structure implemented in Cameron aimed at assisting the project team with their responsibilities. When the scope of the project is determined, all the relevant Line Managers assemble available resources in order to form Product Delivery Teams (PDT). The primary focus of the PDT is to ensure

that a product is delivered to the project at the right time, with the right quality and at the right cost.

Product Team:

The product team have eight different team members involved. A product team are responsible for one specific product and have resources assigned to them. For instance, Cameron's Top Drive that provide clockwise rotation to the drillstring have a product team assigned to the product. The product manager is responsible for the specific product, and will reports up to one of the seven Line Managers. Assisting the product manager is a product engineer working with for the process of designing and developing the product, the assembly of the product and the functionality of the product. The product discipline engineers can be numerous depending on the product and their requirement for involving different disciplines. The technical writer produces technical documentation that assist the use of a product, such as requirements and specifications. The product purchaser is an assigned person from the supply chain division handling Bill of Materials (BOM) and Purchase Orders (PO). The product planner plans and prepares production schedules, draws up a master schedule to establish sequence and lead time of each operation to meet shipping dates according to project needs. The product controller is responsible for providing financial analysis of the product and monitoring budgets.

Figure 4: Product Team

Technical Team:

The technical team are responsible for leading production control support and have communication with top management, project managers and development responsible. The technical team oversee a strategic integration of their line. They ensure production support and

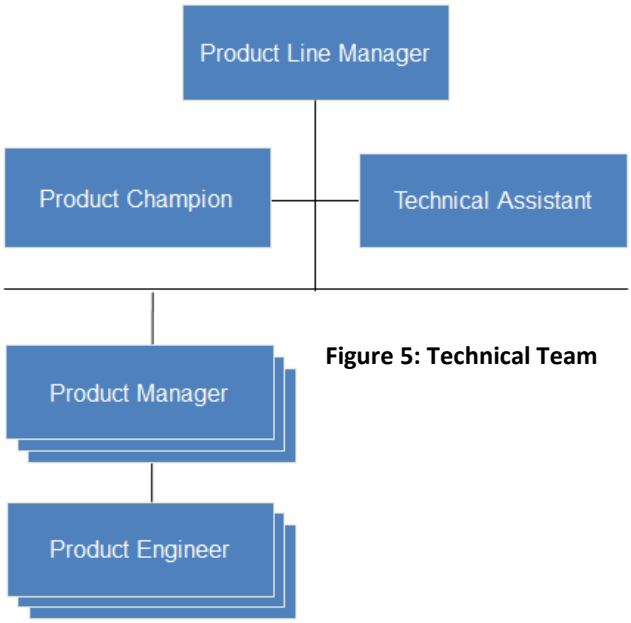


Figure 5: Technical Team

other technical aspects of the production control and support function. In Cameron, some of the Line Managers and Product Managers are involved in the Lean Six Sigma program for strategic purposes.

Cameron Sense consists of a highly technical environment with a more than 190 engineers. In addition, the fragment of employees that are not technical are required to have a good technical understanding, In fact, many of the commercial positions have technical backgrounds. Compared to other organization that have applied Lean Six Sigma program, this is the large difference and requires that the Lean Six Sigma program to be customized and not copied from other companies. Initially Cameron Sense started the Lean Six Sigma program in 2012. In the start of 2014 the program was intensified and given more resources. Currently there are one person called a "Black Belt" working full-time on the program, and 15 "Green Belts" that will devote 20% of their work time to continuous improvements. Black Belts and Green Belts is a hierarchy function that the program uses to distinguish employees' level of expertise and time devotion, where Black Belt have more training and work more devoted to the program compared to Green Belts. Cameron Sense in Kristiansand have inherited the Lean Six Sigma program from the Cameron global system, and from what I can understand the opinion is that the program is well developed and provides well established toolkits and training. Cameron is able to send their employees to Bezier, France for training at the local Cameron office. A majority of the greenbelt projects today are lean oriented, however we can see an increasingly important of getting statistical information and deploy more Six Sigma projects in Cameron Sense. To do this, competence and practical experiences in operating Six Sigma projects need to be improved, as currently many of the greenbelts are inexperienced using Six Sigma.

In October 2014, eight executives have gone to Amsterdam on Cameron Executive Black Belt training, with the intention of becoming better ambassadors for the Lean Six Sigma program. This involves training the eight executives to be able to assist the greenbelts and to correctly initiate relevant projects in their departments. Several researchers have expressed that top management support is key for success and may be the most important of them all for fostering a company culture (Tan, 2014; Hamed, 2012; Snee, 2010). This is a positive signal and suggests that Cameron is starting to embrace a culture for continuous improvement.

4.2 Cameron's Lean Six Sigma Program: The Three Pillars

Cameron have created three pillars that the Lean Six Sigma program should be based on and to provide direction for all employees:

Cost Reduction: Cost reduction is the process used to reduce company costs, improve margins and increase their profits. Cameron aim to increase their competitiveness and to provide maximum value to shareholders. Typically, engineering companies launch new products without focusing too much on costs and is later given the challenge to make their products more efficient. Cameron have several improvement projects focusing on lowering costs and increasing their margins. Examples of initiatives:

Figure 6: Cameron's Strategic Three Pillars

- Changing processes and materials
- Supplier consolidation (Steel Construction Top Drive)
- Cost driver analysis
- Product benchmarking
- Design for assembly (HPU & SmartRacker Project)

Cycle Time Reduction

Cycle time simply means the time spent on a process or several processes. The program goal of cycle time reduction aims to guide employees into designing and examine processes in each step of a process and to redesigning the process to make it more effective, more efficient, more flexible, and less expensive while maintaining or improving quality. Improved and agile lead times will have a large impact on reputation, hence their ability to land contracts in the future. This is due to the large financial impact a delivery delay will have downstream in the value chain for the rig operators. Therefore, cycle time is extremely important for Cameron.

By reducing cycle time in all processes of the organisation, Cameron are able to:

- Improve their ability to deliver projects on time
- Able to use low cycle time for project delivery as a sales argument
- Improve manufacturing and inventory effectiveness. The employees will work on less projects simultaneously and will reduced handling and holding costs for both work in process and finished goods of inventories.

- Improving effectiveness in-house by reducing multi-work and handling costs between departments.
- Improved employee morale by reducing stress and multi-work.

Examples of techniques for cycle time reduction:

- Perform activities parallel and copy effects between projects
- Change sequences of activities: E.g. optimal handling of document control avoiding transportation back and forth.
- Reduce interruptions from delay and especially in critical business processes
- Improving timing

Customer Experience: A company's ability to deliver an experience unique to customers will serve to increase the amount of consumer spending with the company and, optimally, inspire loyalty. To increase the customer experience Cameron want to deliver outstanding customer value, customer interaction and customer service. Reducing multiple touch points with customers and keeping customer up to date are some of the selected improvements. In essence, by improving the customer experience Cameron aims to develop loyal customers, improve customer satisfaction and improve global reputation to land more contracts.

Techniques for increasing customer experience:

- Use Lean Six Sigma tools to understanding and specifying the customer's needs.
- Applying right features to the product and projects
- Give excellent support
- Keep customers up to date and satisfied

4.3 Project Selection in Cameron:

Following is a matrix showing how Cameron select and assign resource to their improvement projects:

Table 5: Project Selection Strategy

Potential projects	Project Value: HI	Project Value: MED	Project Value: LOW
Project Risk / Complexity: Low	GB	GB / JDI	JDI
Project Risk / Complexity: Med	BB / GB	BB / GB	???
Project Risk / Complexity: High	BB	BB	???

JDI – Just-do-it project
GB – Green Belt project
BB – Black Belt project
??? – No project needed

Black Belt Projects: With high project value and high project complexity, it is likely the company will assign a black belt to the project. Company greenbelts normally handles lesser projects and projects with lower complexity. Currently, Cameron only have one person able to initiate Black Belt projects, which are projects with higher impact and higher complexity. This person, Nils O. Plathe, with more than 20 years' experience from the industry, has the support from management and a personal steering committee for the Lean Six Sigma program with several key personnel that can free resources and make important decisions. This way, a black belt have more potential for closing a complex project and making more savings to the organization. Usually, black belt projects involve cross-divisional issues that increases the project complexity substantially.

Examples of black belt projects:

- Top Drive Cost Reduction: Multi-discipline work
- Copy opportunities across projects
- Document handling across divisions
- Strategic merging of product lines

Green Belt Projects: Cameron Sense have about 15 Green Belts with 3 days training in Lean Six Sigma, and are able to start a small or medium improvement project. These 15 employees are selected strategically across divisions and should initiate projects where they have relevant experience and the technical 'know-how'. The complexity of the project should not be too high, as a green belt most likely will not have the influence, power or time for such a project. Green belt projects can receive assistance from senior employees if progress is stopped.

Example of greenbelt projects:

- Warehouse ordering and sorting systems
- Specific improvement on a special product
- Reducing logistic lead times
- Hydraulic power unit assembly in-house

Just-Do-It-Project: A Lean Six Sigma improvement project transfers into a Just-Do-It projects if the solutions are obvious, and the organization does not want to waste resources investigating issues. In this case, the measurement phase and analysis are

skipped and project manager will go straight to the project implementation. A weakness is that project managers can be wrong and resources can be wasted. However, there are scenarios where managers are forced into corners and need to make decisions where Just-Do-It project are appropriate.

Examples of Just-Do-It-Projects:

- Changing phone plan to employees
- Changing suppliers on a simple product
- Removing a function without other impacts
- Remove ID-Run on SmartRacker testing

5.0 Lean Six Sigma in Cameron

The following figure shows a complete list of tools used in Cameron Sense, developed by their own Business Black Belt:

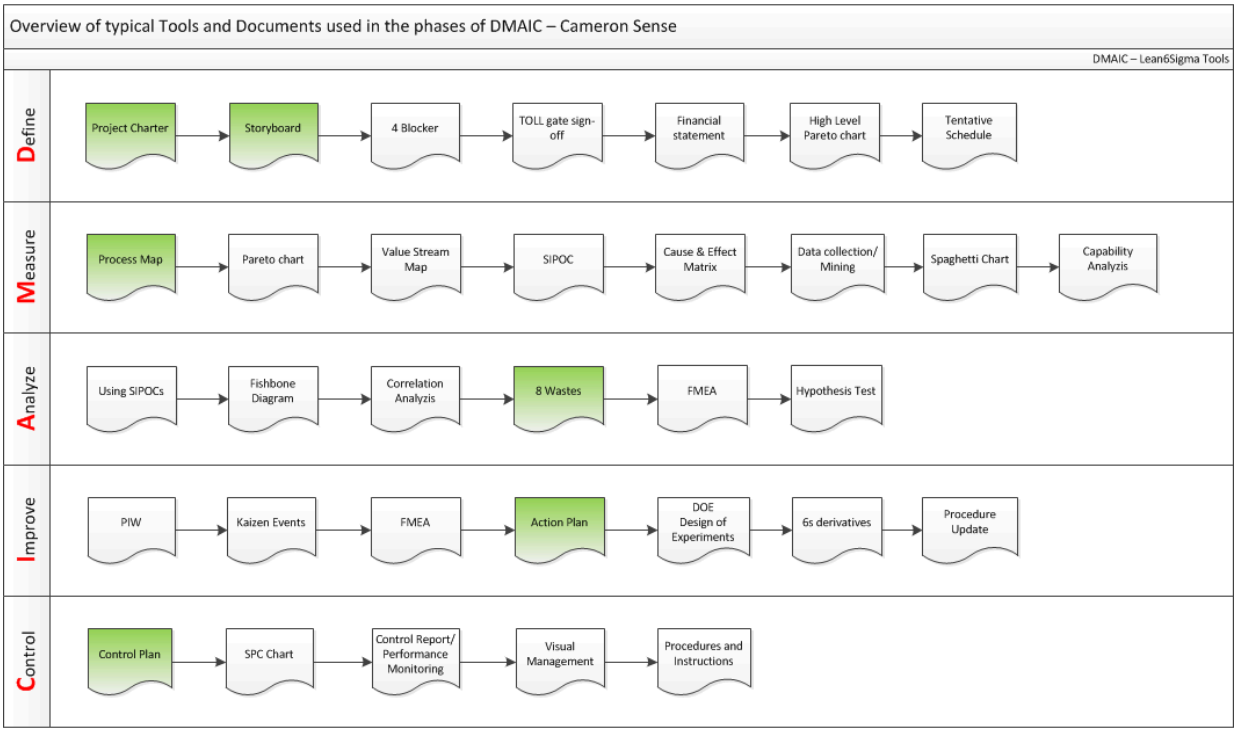


Figure 7: Overview of Lean Six Sigma Tools

5.1 Lean Six Sigma Toolkit:

Project Charter: A project charter is a preliminary statement of roles and responsibilities, a clear outlining of the project objectives, information about the stakeholders, and should define the authority of the project manager. The charter should contain reasons for why the project is being undertaken, what challenges might occur and provide

direction for the project team. In Cameron, the documenting processes in the Lean Six Sigma program should be effective in itself. Nils O. Plathe has a requirement that the documenting should be short and precise. Therefore, Project charters can be as short one or two pages. Same requirement is for all other documenting procedures such as action plan, control plan and final report.

Like many every other company we can see that Cameron employees differ in documenting and project management skills. Possible factors can be that some project managers are busy, and others simply is poor at their documenting processes. Nevertheless, we can see that the documenting process is important for communication purposes and have impacts on project progress. The Lean Six Sigma is giving all employees a toolkit with completed templates for action plans, control plans, report and other tools to make reporting more effectively.

Baseline Process Performance: The next tool we are looking into is the baseline performance as a measurement tool. Each project will try to measure their baseline in phase two, using real metrics and by the help of Enterprise Resource Planning programs and other data software. In Lean Six Sigma, the statistical idea is that we need to see processes and activities mathematically in a function of f(X) = Y. The idea is to measure projects "Y" and how you are currently performing. Further the measurement what to understand the drivers to your "Y" and their size. This will form a baseline for the targeted project and give valuable information in your analyse phase.

Examples of "Y"s in Cameron:

- Cycle time
- Inventory days
- Item prices
- Man Hours
- Process Cycle Efficiency

Value Stream Mapping (Process Mapping): Process mapping is an effective way to get an overview of what the business entity does, how a business process currently is being completed and who is responsible. Process mapping is a tool to help an organization be more effective, by improving organizational overview and decision-making. Many employees wish to use process mapping when complexity is high. This is especially

applicable in Cameron's large and complex processes. From the information given by process mapping, we can analyse for critical improvements and help our decision-making. We can illustrate the argument with a process mapping of a morning ritual:

Table 6: Process Mapping

Process Step	Time
Alarm Rings	**10 seconds**
Get Up	**30 seconds**
Take Shower	**5 minutes**
Get Dressed	**10 minutes**
Eat Breakfast	**15 minutes**
Brush Teeth	**3 minutes**
Grab Keys	**10 seconds**
Leave/Lock	**30 seconds**
Get In Car	**1 minutes**

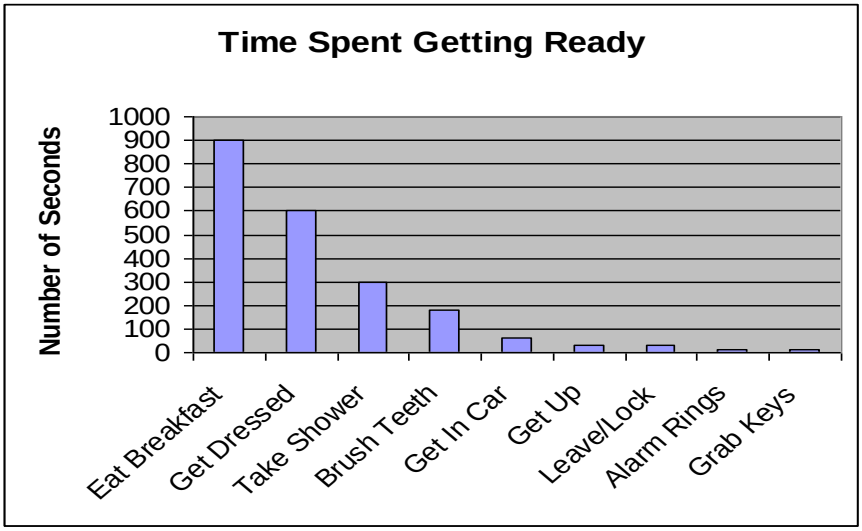


Figure 8: Process Map Overview

Let us evaluate a scenario where you are late for work. By analysing this chart, we can easily understand that being more efficient at eating breakfast and getting dressed will have the most potential for making it on time.

Cause and Effect Matrix (C&E): The cause and effect matrix follows the same logic as many other familiar ranking and decision-making tools. The C&E method starts by listing all the possible input factors as individual rows of the matrix. It provides a way of mapping out how value is transmitted from the input factors of your system to the process or product outputs. With these relationships visible and quantified, you can discover the most-influential factors contributing to value.

The relationships values are given by placing a relationship score of 0 to 9 in the matrix. Cameron have chosen to give scores of strong cause-effect relationships as 9s; moderate

cause-effect relationships get 6s; weak relationships are 3s; and having no relationship means a score of 0. The matrix has listed rating of importance to customer on top of the matrix. This affects the final score of the initiatives as they are multiplied with customer importance and customer requirement. Following is an example of a Cause and Effect Matrix:

		Rating of Importance to Customer ➡	10	4	10	7	5	8					
			1	2	3	4	5	6	7	8	9	10	
		Customer Requirements	Sleep longer	Eat good food	Be on time	Look nice	House clean	Let spouse sleep					Total
	Process Step ⬇	Process Input ⬇											
1	Prep food	Food	1	9	0	0	3	3					85
2		Microwave	3	3	3	0	0	3					96
3		Clean dishes	9	0	3	0	0	3					144
4	Eat food	Food temp	3	3	1	0	0	0					52
5		Portion size	9	1	1	0	0	0					104
6	Clean up	Dirty dishes	9	0	3	1	9	3					196
7		Empty sink	3	0	1	0	3	3					79
8													0
		Total ➡	370	64	120	7	75	120	0	0	0	0	

Figure 9: Cause and Effect Matrix

If we analyse "Prep food", it scores high on the eating good food requirement, but its score is diminishing by its effect on sleeping longer because food prep takes more time in the morning. Hence, the score is not too high. In the process of cleaning up, the score is high due to several of the requirements from customer like the house being clean and preference for sleeping longer. This is a very practical and simple example, but can be applied to very complex industries and projects if you have the right key personnel to rate the importance of each initiative.

Risk Assessment Matrix (FMEA): FMEA is an abbreviation for Failure Mode and Effect Analysis and is a systematic technique for failure analysis. FMEA follows a logical flow after the Cause & Effect Matrix with initiatives first evaluated, and then the FMEA considers the riskiness to the initiatives. The analysis should be a living document during development of the project and constantly revisited. Same rating rules apply as the C&E matrix, where nine is a strong relationship, six is moderate, three is weak and zero is no relationship. The purpose is to review as many components, assemblies, and subsystems

as possible to identify failure modes, and their causes and effects. Following is an example of a complete FMEA of an ATM transaction for a bank:

Process Step	Potential Failure Mode	Potential Failure Effect	SEV[1]	Potential Causes	OCC[2]	Current Process Controls	DET[3]	RPN[4]	Action Recommended
What is the step?	In what ways can the step go wrong?	What is the impact on the customer if the failure mode is not prevented or corrected?	How severe is the effect on the customer?	What causes the step to go wrong (i.e., how could the failure mode occur)?	How frequently is the cause likely to occur?	What are the existing controls that either prevent the failure mode from occurring or detect it should it occur?	How probable is detection of the failure mode or its cause?	Risk priority number calculated as SEV x OCC x DET	What are the actions for reducing the occurrence of the cause or for improving its detection? Provide actions on all high RPNs and on severity ratings of 9 or 10.
ATM Pin Authentication	Unauthorized access	• Unauthorized cash withdrawal • Very dissatisfied customer	8	Lost or stolen ATM card	3	Block ATM card after three failed authentication attempts	3	72	
	Authentication failure	Annoyed customer	3	Network failure	5	Install load balancer to distribute workload across network links	5	75	
Dispense Cash	Cash not disbursed	Dissatisfied customer	7	ATM out of cash	7	Internal alert of low cash in ATM	4	196	Increase minimum cash threshold limit of heavily used ATMs to prevent out-of-cash instances
	Account debited but no cash disbursed	Very dissatisfied customer	8	• Transaction failure • Network issue	3	Install load balancer to distribute workload across network links	4	96	
	Extra cash dispensed	Bank loses money	8	• Bills stuck to each other • Bills stacked incorrectly	2	Verification while loading cash in ATM	3	48	

Figure 10: Failure Mode and Effect Analysis

The total score is calculated from multiplying the effect for the customer, the frequency and the possibility of detection. With this score, we can separate the highest from the lowest scores, and is giving us information about which risks that are important and which risks that should prioritized. Ideally, the risk that show high scores should get customized contingency plans. With information about the failure probability and a good understanding of the failure mechanism, business entities can implement good contingency plans that will reduce risk. For instance, the banks is giving the proposal of making a contingency plan to increase the minimum cash threshold limit of heavily used ATMs after this FMEA.

Visual Workplace: 6S Event

The goal of the 6S events are to create a visual workplace where anyone will know the frequent questions of who, what, when, where, why and how within an area. This is done by creating complete clarity between workers and processes. Essentially, we want to avoid events where workers do not know who is responsible and what goals we are trying to accomplish. Following is a description of the 6S:

Sort: First, you start by separating those things needed for the job from those that are not needed. Examples include obsolete and expired procedures, damaged and expired inventory, and non-functioning/old equipment. This should save time and reduce confusion.

Set in order: Secondly, for the things needed to do the job, put them in a logical order or logical placement to enhance the work process and reduce the chance of defects. The order should contribute to the reduction in excess movement, excess transportation, over processing, over production, excess inventory, excess delays and defects.

Shine: Third, the work area is cleaned and equipment and systems are calibrated to optimal settings, making the process in its ideal state. At this point, measurement of the system may begin and the measurements will capture the variation of the process rather than that of the environment or the measurement system. This allows better understanding of process variation.

Standardize: There are many ways to do processes and activities, but the idea to find a good solution and then standardize the process in order to give efficiency benefits. This should include a description of how to do the work and how to replenish the work. For instance, setting standards about the thresholds to reorder and management of inventory.

Sustain: It is critical that the new system to be maintained or to avoid that the efforts and costs put into developing the new system will be pointless. By putting a formal system in place that includes regular training and communication, employees will be able to conform to the new standard.

The original lean theory only have 5S, but Cameron have implemented one more S for their customization:

Safety: Continuously evaluate if the processes are in a state of protection against all risk of failure, damage, error or accidents. The oil service industry is well known for high priorities to safety, because a failure in operation when in drilling operation can be catastrophic. In addition, oil is very flammable and can result in horrible events like Deepwater Horizon, estimating costs of US$ 560 million (Transocean, 2010).

During the 5S event, you are free to apply any other tools found in Lean Six Sigma to root out waste and streamlining the processes.

This procedure of 6S can be implemented in many settings:

- Daily routines for workers
- A banking transaction
- Work area in a call-centre
- The baggage claim area of an airline
- A laptop computer for private use

Action Plan

All improvement projects in Cameron are required to have an action plan and are simple lists of all of the tasks that you need to finish to meet an objective. Action Plans are useful, because they give you a framework for thinking about how you will complete a project efficiently. They help you finish activities in a sensible order, and they help you ensure that you do not miss any key steps.

The action plan will show who are responsible for performing the task, creating and giving clear communication. In addition, it has monitoring purposes like showing which tasks are completed, and what still need to complete. Therefore, the action plan is used to report progress back to business black belt. Following is an example of an action plan for my master thesis, similar to the one used in improvement projects:

Action Steps	Responsible	Deadline	Resources	Potential Barriers	Progress	Comment
Identify ways that Cameron Sense deviates from orginal LSS theory	AR	October	Attend meetings	University	50 %	Many meetings have been observed. More than 40 pages of notes collected
Attend bi-weekly meetings	AR	N/A	Attend meetings	University	0 %	
Create questionaire based on the deviations/issues	AR	15.sep		Professor disagree	20 %	Need to work more on this step.
Get qustionaire approved by professor and NOP	AR	15.sep	Meeting with NOP & Professor	Professor disagree NOP disagree	20 %	Professor said that what I have collected so far is better than most students.
Perform questionaire on greenbelts	AR	20.okt	Greenbelts	Greenbelt and other CS employee busy	0 %	
Analyse and discuss results	AR	November		University	0 %	

Figure 11: Action Plan Master Thesis

Control Plan

A control plan lists all product and process inspection points required to continuously delivering the project outcome, and is essential for maintaining process control over the long run. The control plan will complete depend the size and severity of the improvement project.

A control plan is:

- A summary of all of the control activities for the process.
- A method of identifying holes in the control system.
- A list of control activities yet to be implemented.

Some projects have a more simple control plan compared to others. One example can be to check the Enterprise Resource Planning software and control if product costs maintains the same level as prior, while others require routines-inspection to make sure employees are following their new process routines and activities. The control plan should clearly specify what control actions should be made, who is performing the control, how it should be measured and which reactions are appropriate.

There are several more tools available for Lean Six Sigma, however these are selected as some of the most important used in Cameron Sense. The next chapter of the thesis will move into an evaluation and discussion of how Cameron is operating and how they have implemented the Lean Six Sigma Program. To do this, we have conducted a questionnaire with 14 employees working with the Lean Six Sigma program.

5.2 Lean Six Sigma Questionnaire Evaluation

Appendix B shows the form that was given to 14 employees internally at Cameron Sense with background as either project managers or project champions. The respondents are familiar with Lean Six Sigma and have been listed as a possible weakness to the study. Prior to the questionnaire I have spent many hours understanding the Lean Six Sigma program, been taking the greenbelt training course, attended several project meetings and attended progress meetings. This was for the purpose to ensure that the questionnaire targeted information accurate and relevant for the thesis, and that respondents would understand the questions asked.

Time Spent on Lean Six Sigma

The first question in the questionnaire addressed how much time each employee spent on doing Lean Six Sigma projects and other related work. Respondents used a clickable box with four different alternatives as shown in Appendix B. In figure 11, all responses are added up and presented in each of their category.

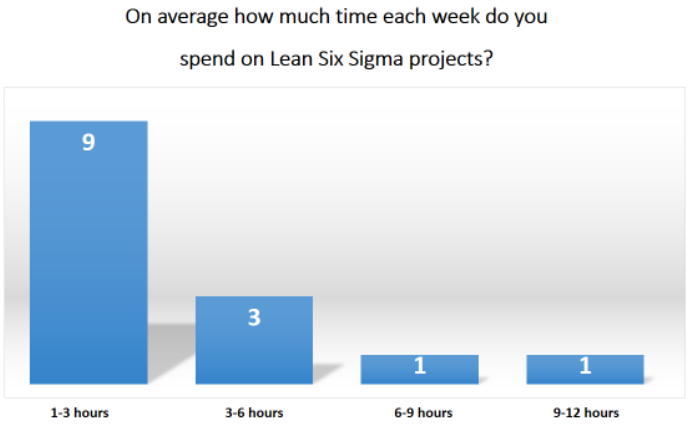


Figure 12: Results Question One

Employees are using less time than originally thought. The job description specifies that greenbelts are intended to dedicate 20% of their workload into the Lean Six Sigma program. When presented the results some of the respondents express that projects are often delayed, waiting for other or on hold. Without certainty there are some hypotheses developed to why this is based on observation and interviews. One of them is that project planning and management is crucial, and that project managers of improvement projects can improve in their communication, involvement and planning to avoid waiting or interruption. Also, when project progress is staggering project managers are supposed to turn to Project Champions for assistance if possible. Nevertheless, the majority of employees are not working as much as they should on Lean Six Sigma projects and will be affecting the overall results and progress.

The remaining questions are answered using a Likert scale placing values on statements and questions from a scale of one to seven. Question two asked whether their total workload and focus spent on Lean Six Sigma is too much:

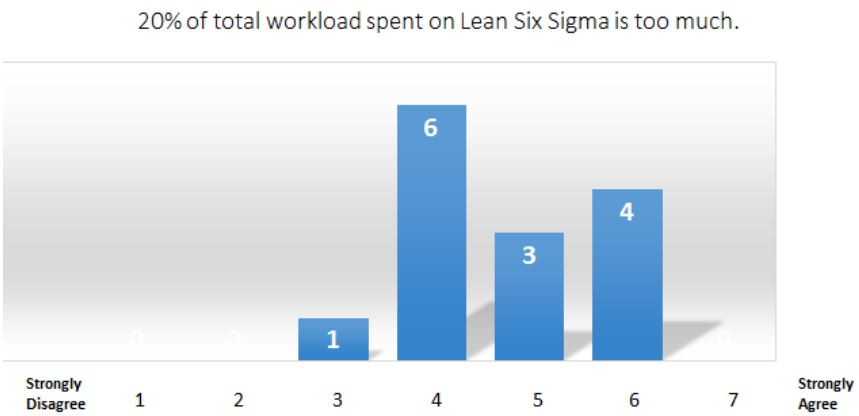


Figure 13: Question Two Results

Six of the respondents are neutral to the statement, three slightly agrees and four agree that current workload is too much. On average they are leaning towards being neutral and slightly agreeing to the current workload, which is a good result. Recently the progress meetings have been intensified, so the expectations for the question were that some might think it was too much. For Greenbelts it is important to balance the time spent on improvement projects and other daily responsibilities, to keep in touch with your department and your expertise while also being an improvement agent for your department. 20% of total workload seems to be a suitable amount, and Cameron Sense should rather have a right project selection and people selection than increasing the time spent on Lean Six Sigma. With people selection Cameron Sense want experienced employees with available time to facilitate projects and with the right skill set. Often we can see that experienced employees are too hold up in other on-going projects that Lean Six Sigma project can be down prioritized.

Lean Six Sigma Interference with Other Daily Responsibilities

Following is a question about if the Lean Six Sigma is interfering with other daily responsibilities. Keep in mind that workers in Cameron have a demanding schedule and are working on several projects at the same time:

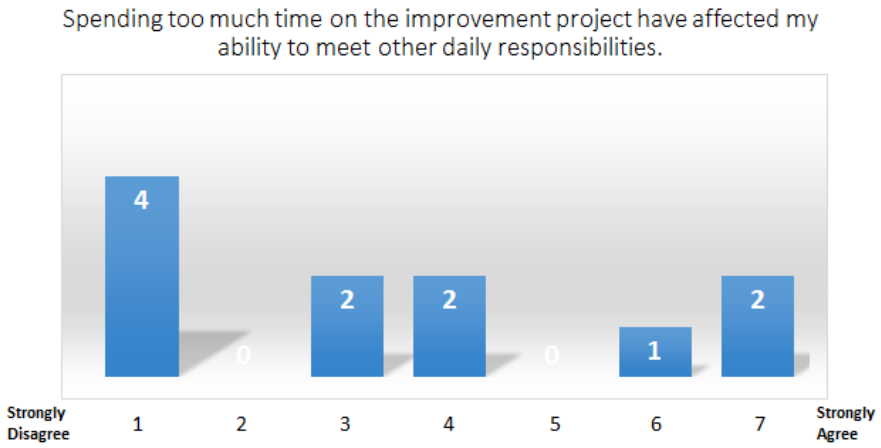


Figure 14: Question Three Results

There is a rather large spread in the results. Four of the respondents strongly disagree with the statement, signalling that they are able to combine both improvement projects and other daily responsibilities. On the negative note, there are three respondents that feel they are not able to combine the work and are affected. Lean Six Sigma needs to work alongside other daily responsibilities, so the results are not shocking.

The large spread might be explained by the different abilities of project managers to cope with several projects and project planning. We can conclude that some of the involved feel that this is an issue, but not the majority. Potentially, project champions or managers can investigate those struggling and look for opportunities to facilitate or assist. Cameron Sense should try to evaluate cost versus benefit of each project using their information systems and should exit projects that are not profitable or too complex, for the purpose of free up resources.

The applicability of Lean Six Sigma to Cameron Sense

Further, the questionnaire wanted to understand whether employee perception is that Lean Six Sigma is applicable to Cameron Sense. In some engineering environments, improvement programs are seen as cost saving programs ordered from management, and some even see it as a creativity destroyer. However, the results are quite surprising:

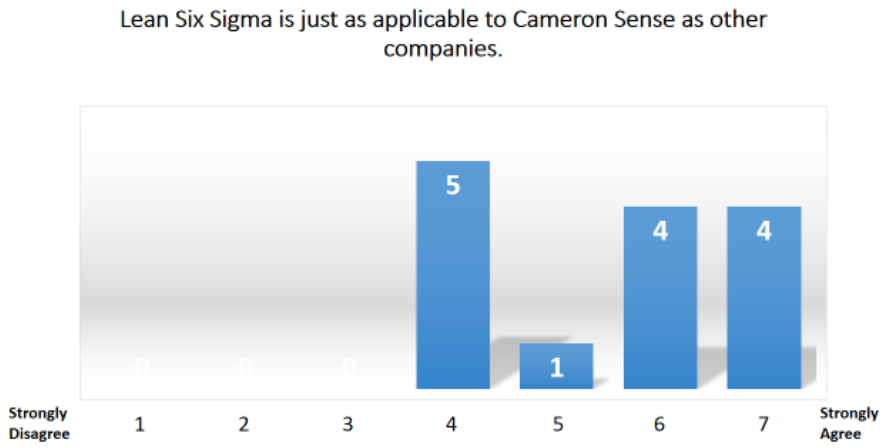


Figure 15: Question Four Results

Four respondents strongly agree, four respondents agree, one is slightly agreeing and five respondents are neutral. Overall, there is a positive attitude that the program is applicable for the organization as a tool. The theory section discussed that Lean Six Sigma have originated from large manufacturing companies, and that many believe that it needs customization or simply does not fit engineering environments due to their low output levels. The results explain that those involved in the program feel it is an applicable tool to handle improvement changes. However, it would be interesting to have a larger sample of the entire organization of their attitudes of the program's applicability. Unfortunately, this was too resource demanding and technically difficult due to internet security reasons to attain.

Project Champion's Involvement

As discussed earlier project champions are sponsors for the improvement projects with higher hierarchical influence and available resources. They are to help project managers when progression is slow or if people are resisting initiatives and to show guidance. Following are the results when asked if they think that project champions are enough involved in the process of Lean Six Sigma:

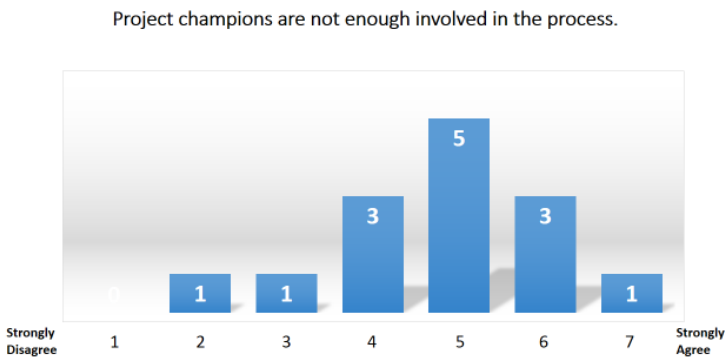


Figure 16: Question Five Results

Overall, we see a small tendency of project champions not being enough involved in Lean Six Sigma projects. On average respondents slightly agree to the statement and want more involvement from project champions. Only two responses out of fourteen feel some disagreement. Lacking involvement can be that project champions are not adequately asking for project updates or pressuring project managers, setting Lean Six Sigma to priority or personally not recognizing the value. Project champions are normally higher in the hierarchy and involvement can be an important motivation factor for greenbelts if project champions give some attention or recognition for their efforts and results. If Cameron can involve project champions even more it is reasonable to expect that the program will progress faster and giving higher results, since Project Champion are intended to be motivator, facilitators and mentors. Even though, it is understandable that champions are very time restricted and might not have time, motivation or resources for projects. If that is the case, Cameron Sense needs to look further how they can increase their involvement and give motivation by finding other solutions or even assign several project champions to a project even though this is introduces several more communication channels.

Documenting Processes in Cameron Sense

Next question evaluates greenbelts perception about the documenting process during Lean Six Sigma projects. Earlier in interviews and conversations, many greenbelts have expressed that it is hard to concentrate and to complete all necessary documents due to time stress and that many are located in shared offices for cooperating reasons. The question tries to address if the documenting process is demotivating.

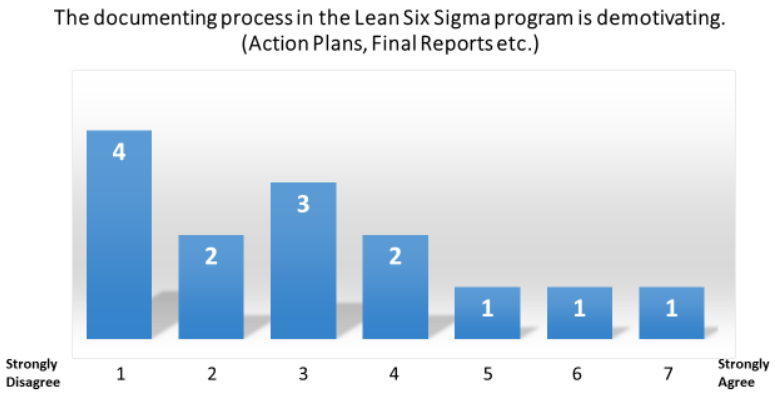


Figure 17: Question Six Results

There is a rather large spread in the responses and can suggest that the question asked was not clear. We can see that there is a tendency for respondents to disagree to the documenting process being demotivation. Only three respondents agree to the demotivation by documentation. Later when presented the results in meeting, several greenbelts expressed that the documenting process is important for overview and progress in the projects. Therefore, it was motivating and expressed as crucial.

In retrospect, the thesis will not include question six as basis of recommendation due to ambiguity and question being unclear.

Employee Likelihood for Reporting Faults and Suggesting Improvements

One of the key advantages by having several greenbelts is their expertise in their specific area. They are likely to have knowledge and experience in their area or discipline, and are important co-operators to the Business Black Belt by contributing and giving valuable feedback. Another advantage with this question was the anonymity of the survey and the possibility that greenbelts did not feel comfortable suggesting improvements to a very experienced Black Belt.

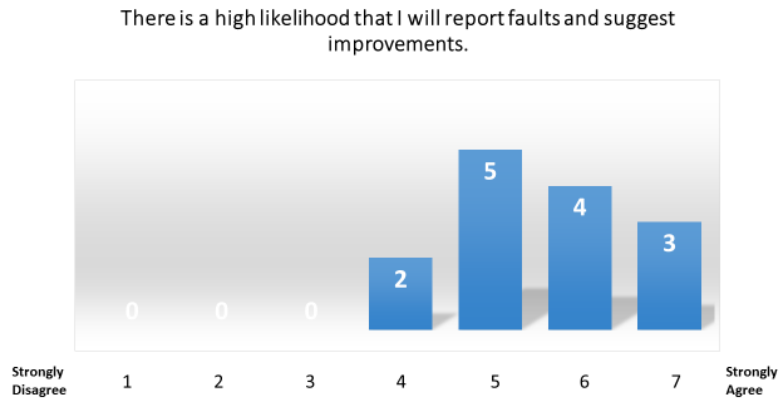


Figure 18: Question Seven Results

The results are quite clear. The respondents will report faults and improvements. In addition, after being in several project meetings between greenbelt and the business black belt I have personally seen several discussion of what are possible improvements and initiatives that are currently not working, which support the finding of the questionnaire.

Encouragement and Discouragement by Earlier Projects

Next up is a question is based on studies done by Chakravorty (2010) showing that that project managers that successfully close projects are more likely to continue with similar results due to a motivation boost. Simultaneously, it shows that project managers with failure have fewer chances of complete successful projects in the future. For reference, the study was completed in an aerospace manufacturing company. Cameron's Greenbelts were asked if they are encouraged or discouraged by the failure/success of earlier projects:

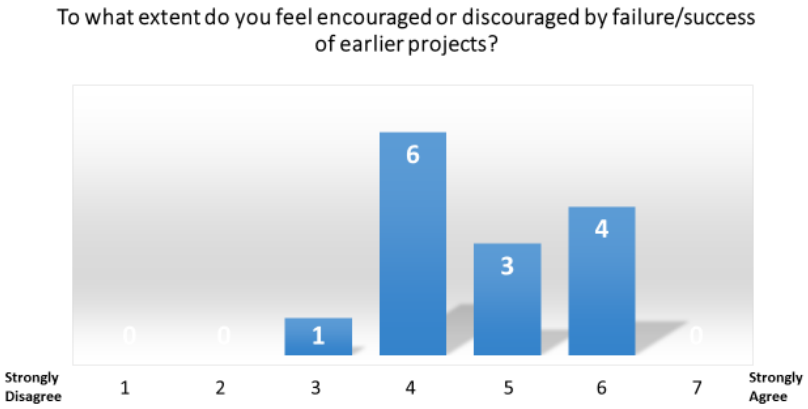


Figure 19: Question Eight Results

There is a small tendency that they agree to the statement. There are six respondents having no preference and seven respondents that agree. The results are not clear enough for us to draw the conclusion that earlier success of projects are indication of motivation for completing more.

Improvement Culture and Cost Awareness in Cameron Sense

Next question is aiming to evaluate the culture, moral and opinion of employees about the introduction of the Lean Six Sigma program. The question specifies two year ago,

which was the time of implementation of Lean Six Sigma. Employees were asked if they believe that improvement culture and cost awareness have increased dramatically in the last two years. The following results are quite impressive:

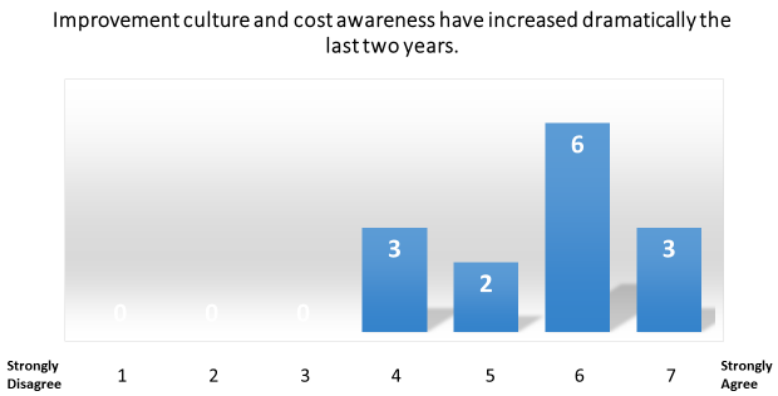


Figure 20: Question Nine Results

There are 11 out of 14 respondents that agree to the statement that culture and cost awareness have increased dramatically, while three respondents are neutral. This can also be interpreted as a measure of how successful employees find the program. The three respondents that are neutral should indicate an opinion that the culture and awareness is about the same compared to two years ago. However, the majority feel there has been an improvement the last two years, which is a good signal for management. Besides, we can also evaluate the Lean Six Sigma program results from the spreadsheet that is provided by the Director of Finance, which shows that savings are higher than what was expected from the program prior to implementation. These savings have over the last two years assisted in several of their key products to become more competitive in a very competitive market.

Employee Performance Appraisals for Improvement Projects

Next question is targeting greenbelts motivation for completing projects. Currently their performance appraisal is their normal salary with a group bonus attached to organizational wide goals. After completing three Lean Six Sigma projects, greenbelts will receive a 1000 dollar bonus. Today, none of the greenbelts have managed to close three projects, due to high project complexity and longer project time durations. In the questionnaire employees are asked if Cameron have tied enough employee performance appraisals to improvement projects to make you motivated:

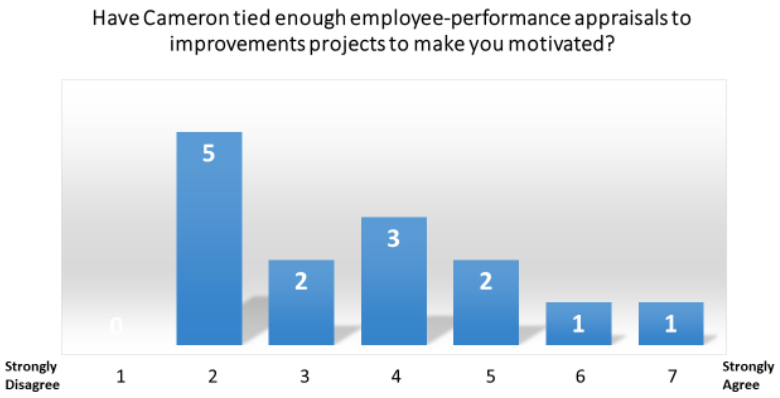


Figure 21: Question Ten Results

There are five respondents disagreeing and two slightly disagreeing to the statement, suggesting that they are missing motivation for completing projects. Only 2 out of 14 respondents agree to the statement, and two are slightly agreeing. These results are somewhat surprising, and should be taken into consideration by management. Specifically, having a review of employee motivation and finding some factors for motivation that can be improved or new incentives that can be implemented. Some of the personal motivational reasons mentioned in interviews are that they can use the greenbelt projects results when in their yearly employer discussion and an argument for a salary raise. In addition, they can add project management experience and Lean Six Sigma training to their resume. Nevertheless, the results show employee dissatisfaction and an incentive system that is not working optimally. Especially, several greenbelts expressed when shown the survey results that the incentive for successfully closing three projects and claiming 1000 dollar is not working.

Cross-Departmental Issues in Cameron Sense

Earlier the thesis have mentioned that Cameron Sense have a large degree of cooperation between departments compared to many other companies. Consequently, there will be more cross-department issues that need to be addressed. One of the key differences to normal Lean Six Sigma companies is that Cameron Sense has greenbelts working on cross-departmental projects. Originally it is suggested that black belts should be in charge of these cross-departmental projects. The results is Cameron Sense greenbelts are initiating projects with higher complexity due to work being across departments and requires consensus of different disciplines and departments. This is very challenging and requires excellent project managers that are can facilitate the

required communication, cooperation and make departments work together. In addition, another issue in cross departmental work is that often senior managers need to take decision and projects can easily be put on hold or be waiting for decisions. Project managers need to push for progress and call inn meetings between the departments and managers. In the survey, greenbelts are asked if they feel that the Lean Six Sigma program is addressing cross-departmental issues that would remain a problem without the program:

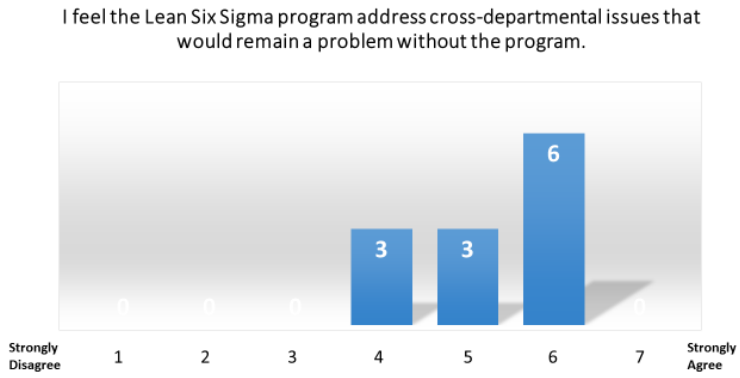


Figure 22: Question Eleven Results

The results are not too hard to interpret. Nine of the respondents agree, while three are neutral. It can be argued that Lean Six Sigma program is a structured way to handle cross-department issues, and without the program these issues would not be addressed unless top management addressed it, or someone addressed it on their own initiative.

How troubling are Cross-Departmental issues?

As a follow up, employees were asked if these cross-departmental issues were troubling. As discussed earlier in Lean theory as benefits of simplicity is less tension in the work environment by improving communication issues. Otherwise this tension can potentially reduce productivity by being dissatisfied or irritated, and worst case scenario increase employee turnover. An example of irritation factors from cross divisional issues can be the high cycle times of processes between divisions, or an unusual high amount of document overdue. Following are the results when asked if employees are troubled by cross-departmental issues:

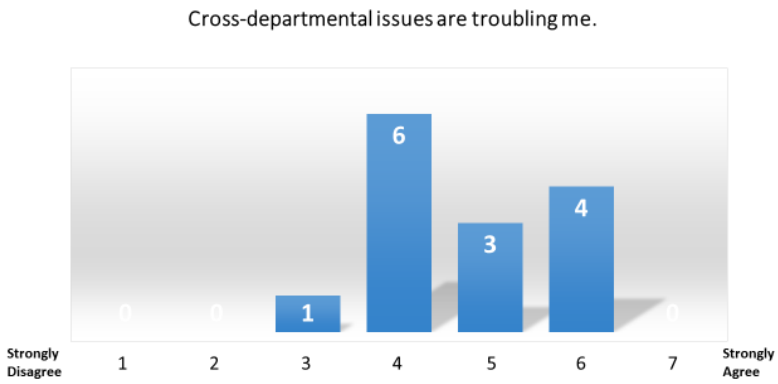


Figure 23: Question Twelve Results

Seven of the respondents agree, six respondents are neutral and one is slightly disagreeing. Overall, the cross-departmental issues are slightly troubling employees and can be causing tension, but nothing dramatically. Hopefully the Lean Six Sigma program is contributing to resolving some of these issues for Cameron Sense.

Motivation for Continuing Improvement Projects

Next up, the survey asks if greenbelts want to continue doing Lean Six Sigma projects for more than two years:

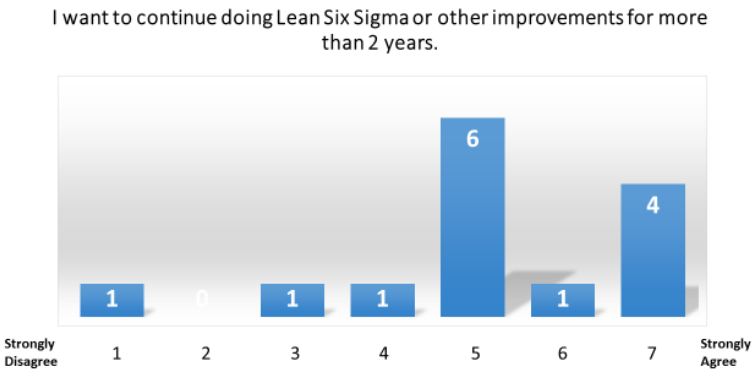


Figure 24: Question Thirteen Results

There are four respondents that strongly agree and are long term dedicated Lean Six Sigma practitioners. Six of the responses are slightly agreeing to the statement, while one is disagreeing. There are start-up costs for initiating these Lean Six Sigma projects in form of training employees and gaining experience to successfully complete them. Therefore, it is in Cameron Sense best interest to keep the greenbelts doing projects for a

longer period of time. It can be interpreted that some of the respondents cannot see a future doing improvement projects. Preferably, these should be consulted.

The Intensity of Follow-Up Meetings

Right before we did the survey, the Business Black Belt had just decided to intensify the follow up on greenbelts and is currently doing bi-weekly meetings. Even though they do not have new progress they are asked to come into the office for a chat. Therefore, the survey asked if they though that the Black Belt needed more intensive follow-up:

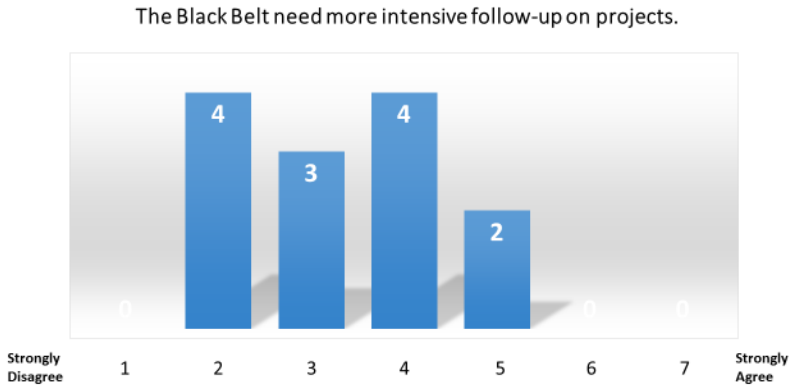


Figure 25: Question Fourteen Results

Overall, the respondents actually disagree to the statement and is either happy with the current intensity or they want less. When asking the Black Belt about his thoughts he responds: *"Less follow up gives a chance that progress will slow. When coming into the office for a chat they are reminded and motivated to pursue progress"*. In conclusion, the greenbelts might not want more follow up, but for progress purposes it can be effective.

5.3 Discussion and Challenges

The thesis has discussed relevant theory, the industry background and how Cameron Sense operates their Lean Six Sigma program. Following is a discussion and evaluation of the challenges that Lean Six Sigma faces in an environment with high product complexity and a project structure. Keep in mind that Lean Six Sigma is an alternative to handling improvement processes in a structured way, and that each specific challenge might need to be addressed in their own way. Cameron knows this and will transfer improvement projects out of their Lean Six Sigma system if the tools are unnecessary or inefficient.

The thesis provides three key characteristics suggested for other companies to apply the findings into other settings:

- Large number of employees and several divisions (250+ employees)
- Project oriented
- Technical and handling complex technology

The needs for improvements in cross-division collaboration increases when the organization has a large number of employees. Large organizations tend to create barriers across divisions or barriers across projects, and are a result of more leadership, division of responsibilities and job descriptions. In a project-based organizational structure, a company is organized around each particular project. In most cases, these project-based organizations have project managers running different teams of employees. These employees are often from different departments and have different job titles, and typically there are many teams operating at once. One of the issues is that projects do not always necessarily need to interact with other projects, because each team is focused on completing its own project. This can result in suboptimal cultures inside organisations and an overall lower productivity than what potentially could be achieved in the organisation. Therefore, these companies often have many improvement opportunities and needs for a structured process for improvements, hence a reason for for implementing Lean Six Sigma. The goal is to make better use out of cross divisional resources, reducing lead times between divisions, improving work design and processes across divisions and improved the communication internally in the company. Often we find these types of cross-divisional issues handled by Lean Six Sigma.

Furthermore, if the company have a complex technological environment, the need to use effective tools for organizing, measuring and creating overview for employees are essential for improvements. Complex environments today have technical and social issues together in a highly integrated way as companies continue to design flexible, adaptable, robust systems that can be easily be modified and reconfigured to satisfy changing requirements and new technological opportunities. The result is a highly complex sociotechnical system that becomes too hard to understand just by looking at it. Without using tools to understand the complex systems you will not be able to execute accurate decision-making or implement the right solutions. The applicable techniques

can be involve everything from decision-making tools, statistical tools, communication tools, group meetings, discussions and further.

In Cameron Sense, this is experienced on a daily basis. Interestingly we can see project meetings that discuss complex improvement projects and observed that project members from different departments have different assumptions from coming into meetings and afterwards change their assumptions after discussing. Especially when presenting statistical facts and bringing in expertise knowledge of several areas. In their latest Black Belt Project of copy effects across projects, they have complied large datasets into valuable statistics for several specific purposes. Firstly, they are not sure about what is wrong or where the issues are located. Two, it is not according to their fact-based environment to act after guesses or hypotheses. Third, it is demanding to conduct change management when project manager are unable to show statistics or facts to back up their arguments and gain support from other employees. There is no doubt that companies need to access more tools to create understanding when they are operating in complex environments, where Lean Six Sigma is offering it.

When the environment is highly technical and the organization has many employees across departments and projects, there are suddenly some barriers and challenges for Lean Six Sigma that should be explained further:

- The Green Belt/Black Belt operating as project manager must have good knowledge of the business system, workflows in order to successfully direct, guide and start a project. This introduces a requirement for the project manager to be experienced, and reduces the pool of possible resources that the company have. In addition, many of the experiences employees are already in important positions and unavailable.
- The time duration is often increased when project complexity is high and the work involves cross-departmental work, resulting in more resources being used. Cameron Sense has found it more effective to splitting their large complex improvement projects into smaller projects to be able to close projects and keep employees' focus.
- An increasing number of divisions or a sense of belonging to a specific project will reduce the willingness to cooperate and increase communication complexity.

Cameron Sense has modified their Lean Six Sigma program letting their greenbelts doing smaller projects that involves cross-department work. Original theory suggests that greenbelts should only work within their department or project. Most of the improvement initiatives that Cameron Sense has targeted involve cross-department or cross-discipline initiatives. This has resulted in greenbelts working some projects across departments and should work fine if the right greenbelt selected for the project. This is a difference internal in the Cameron System, where most other locations around the world are production oriented and will not have greenbelts on projects that are involving several departments. Another noticeable difference is that Cameron Sense has a longer average closing time per project caused by higher complexity compared to other locations, but they are also reporting a high average cost saving per project. This can suggest continuing the strategy of splitting projects to reduce complexity of each single project as explained with the Top Drive project earlier.

The last bullet point shows the challenge of increased division of labour and belonging to a project like discussed in at the start of 5.3. More divisions create barriers to work flow due to factors like performance management, job description inflexibility and belonging to a division. Similar, the project structure creates a belonging to each project. The challenge is how to address the issues of reduced willingness to cooperate due to barriers across division and projects. In order to increase the transparency in the organisation and to improve cooperation the communication need to be improved. In the starting of each Lean Six Sigma there is a focus on bringing everyone onto the same page by communicating to stakeholders with information. This involves; defining issues, creating understanding of how this affects different divisions, and agree on a solution that targets what is best for the entire company. This is found difficult many times as different employees have different incentives, thus even more need for Lean Six Sigma. Often higher management need to set a decision when different managers are unable to reach consensus or if it is out of their authority. The process of working with cross-divisional projects is important to target these issues, and especially when the divisions are interrelated in technology, products and support functions. What we can see in Cameron Sense is that each department can be very specialized in a discipline, technology or a function, leading to less transparency throughout the organization because they are specialised. Still, their work and decisions affect the others employees through their parts, products, technology, document handling, waiting and solutions.

Understandably, when companies have a strategy of delivering complex technology it is necessary to have specialisation in disciplines, products and technology. It is rather about how to operate a company with specialisations and having the right communication that gives transparency and optimal solutions for overall organisational success. Bringing in cross-divisional meetings to discuss the initiative and understand what this will mean for each division or function is what Lean Six Sigma can do. The limited understanding of what other division and functions are doing will create less transparency and potentially makes conflicts or irritation. Therefore, never push through improvement projects without consulting all involved parties and bringing everyone into speed.

Another one of the challenges specifically for Cameron Sense is to implementing a good Lean Production System based on the term "Takt Time". Defined as the rate at which you need to produce to meet customer demand, and then attempt to balance resources and equipment to that rate. To optimize total takt time and introducing a pull system that lean strives for is challenging for Cameron to accomplish, due to high variation in demand, multi-discipline work, large need for coordination and long lead times accommodated by suppliers and in house. This complex supply chain system makes it extremely hard to forecast and plan, but even though it is hard and demanding to find solutions should never be ignored. Cameron Sense will never be able to control the industry demand and have to follow industry variation to their best abilities, but have benefits of being agile and adaptable through using Lean Six Sigma.

Success Factors from Literature

Hamed (2012) have discussed the top 10 challenges for Six Sigma initiatives that are stated in his article, and these are discussed in the light of Cameron Sense:

1. Selected Six Sigma projects are not connected to the corporation's goals

The importance of connecting goals is to avoid dual alignment between employees and corporation goals. Employees need to understand what is important for organizational success and what is expected from them. Cameron has rooted their program in their strategy of 3Cs; cost reduction, cycle time and customer experience. These are supposed to guide and direct all employees into understanding and doing the right Lean Six Sigma initiatives. From what I can understand after six months is that these the goals are very

important and provide a good coverage, and there have never been any mention of ambiguity from management.

2. The corporation is deploying Six Sigma for the wrong reasons

Cameron originally deployed the Lean Six Sigma program as a strategy in order to become more competitive and to implement a structure way of doing improvements. What literature often characterizes as the wrong reason is when owners or management set goals of a certain percent cost reduction, and then just leave it to the Lean Six Sigma program to complete it. In Cameron Sense, what is positive is that the program is not pushed by an annual percent of saving.

3. Six Sigma project goals are not aligned with Champion's Goals

The Lean Six Sigma program is implemented with project champions that have ownership and authority over the projects. Champion does not necessarily have extra incentives towards Lean Six Sigma projects, other than improvements in their department is positive and managers might have bonuses tied to how well their department is going. The divisional and project barriers can lead to this misalignment. For instance, picture a project that is creating value for the company on an overall level, but causing a specific division more work. The challenge becomes to align champions division and champions with the Lean Six Sigma program goals, which should be aligned with overall company goals.

4. A bottom-up rather than top-down project selection methodology

Lean Six Sigma wants to avoid too much emphasis on top-down project selection methodology. Often management know very well how the organization works, but in complex technological environment they are reliant on input from bottom level experts. Effective solutions are to include and listen to lower levels in the organization. In Cameron Sense, there is a bi-weekly meeting for all the greenbelts together with the Business Black Belt about the progress of their Lean Six Sigma program, where they address potentially new projects and update about the current projects. Greenbelt are allowed to choose their projects, but are influenced by the Business Black Belt. This influence might be strong due to Cameron's very experienced black belt with more than 20 years in the industry.

Optimally, there should be top-down and bottom up management that are complementing each other and together reaches consensus. Cameron seems to have both selection methods and need to continue utilising their greenbelt discipline experts for information in the future.

5. No clear financial benefits

The questionnaire established that Cameron's current improvement appraisal system is not motivated based on the financial benefits. Employees are not responding to the 1000 dollar bonus for closing three projects. It is very clear that there are other intrinsic values that are driving the project managers. The thesis argues in accordance with McGregor (1960) theory of motivation that Cameron Sense employees are not adequately motivated by the financial bonus, and should therefore focus more on intrinsic benefits like recognition, respect and job advancements.

6. The corporation does not have clear processes to support customers

Referring back to previous discussion of value added effects and waste, listening to customers are important for being effective and efficient. Gathering information about the customer enables the organization to do the right decision making, and without it many of the Lean Six Sigma initiatives will be less effective. In Cameron Sense, most of the customer contact is through project managers, technology officer and sales managers. Therefore, it is important that they collect information about preferences and that they communicate these to the rest of the organization. In addition, there are many service engineers that are constantly supporting when needed, and are on site getting first-hand information about preferences. I have been told that Cameron Sense was very good at placing their engineers first as service engineers and later on be placed to work in house. This gives them valuable experience for working processes in-house and is something Cameron have criticise themselves for starting to lose this advantage.

7. Poor or wrong Metrics

In a complex environment using metrics is important for creating understanding. One of the program priorities should be to increase the competence in using measurements. This motivates and improves for a fact-based culture that the thesis argues is important for the success of the program. To do this, a proper measurement phase according to the DMAIC model is stressed to all employees in the organization. In Cameron Sense, the use

of several support programs are used for detailed metrics; NA-Vision & SAP: Enterprice Resource Planning, Safran: Project Planning Software, ProArc: Document Control and several other database programs.

8. Projects has ineffective charter

Cameron Sense is operating with a project charter with information about the scope, goals and an explained business case. For goal settings they are instructed to use SMART Goals:

- Specific – To targeting a specific area
- Measureable – Being able to measure pre- and post-project
- Agreeable – Agreed who will do what actions
- Realistic – State a realistic goal to what resources you have
- Time-related – Specify when the results can be achieved

The importance of a charter is to provide direction and scope, which clearly explain what to be done and who is doing it to the entire project team. In fact, the thesis argue that the entire project management technique of updating team members, giving supporting documents, communication and clear guidelines throughout the entire project is important and can be improved. Most of the improvement project managers in Cameron Sense are technical oriented and not all are natural leaders.

9. Solution is obvious

Especially in complex technological environments you cannot always be sure of your solution. What Lean Six Sigma wants to avoid is that people act on instincts. Therefore, Cameron's Lean Six Sigma program states that unless you are 100% confident, you are to complete a proper measurement phase to ensure that you know what is causing the issue or problem. When there are so many different technical disciplines working on the same product it should be difficult to know what is causing the problems without correct tools. In Cameron, you have mechanical, electrical, hydraulic and software engineers working on same products, making this multi-discipline environment wherein it becomes difficult to cooperate and finding right solutions.

10. Focusing on output measures

Hamed (2012) highlights that when companies focus too much on the output measures in dollar amounts, they often tend to get lost. To elaborate, customer experience improvement projects might be very hard to quantify, whereas cost saving projects can be easier. Nonetheless, the customer experience project might be just as profitable. Each completed improvement project need to be approved by the Director of Finance, and there is some focus on output. On the other side, output measures are also important for progress and earnings when used the correct way.

In conclusion of Hamed (2012) research, we see improvement potential, but all the major issues are currently identified and being handled. Cameron Sense have adopted their Lean Six Sigma program from their American mother company that have been experiencing and developing these issues for more than 15 years, so it seem that Cameron Sense are getting some benefits from the 15 years of experience.

Success Criteria from Tan (2014)

Miragroup is a consulting company specializing in program and change management, and have more a lot of experiences in improvement projects such as Lean Six Sigma. The article highlights that Lean Six Sigma assumes that the entire organization understand the purpose and mandate of the method and how it will integrate to other methods such as the system development life cycle, organization design methods and change management methods. This is often not the case, resulting in confusion and failure of the program (Tan 2014). A possible issue can be improvement projects that increase workloads for specific departments and how the organization accepts these changes. If the system is not understood and respected, the progress and results will be heavily reduced. In addition, the article express that a certain level of knowledge and culture within the business including an awareness of the business strategy, understanding of process and confidence with changes to process and systems are essential for running Lean Six Sigma projects. This supports my earlier arguments that Cameron Sense needs to continue dedicating resources, and especially the Project Managers/Champions with experience of the system and business strategy.

Miragroup summarizes a few bullets points for success criteria that I would like to highlight:

- A clear understanding of the high level business process model

- An agreed ownership and control for managing and changing processes;
- A standardised approach to analysing, evaluating and redesigning processes;
- An integrated approach to systems development, organisation change, change management and process improvement is essential to avoid conflicting methods and rework within a project
- A simple method to measure costs of processes and, therefore, benefits achieved through redesigning processes
- A business that understands the reasons for improving processes and how it will support business strategy and have the core skills internally to improve the processes.

Having a standardized approach to handling improvement projects in Lean Six Sigma is achieved through the DMAIC process, referring to section 3.5. This is also a criticism to Beyond Budgeting that was discussed as an alternative tool to Lean Six Sigma or a complement. If Beyond Budgeting were to replace Lean Six Sigma it is lacking a structured process for handling improvements like the DMAIC cycle. However, having a standardized approach for analysing, evaluating and resigning through the DMAIC cycle is important for project organizations where employees are working on several projects simultaneously and are often occupied. Having a standardized approach will make it easier to plan the project and project members can be booked for meetings, which is important for transparency and communication to all stakeholders. One issue I have noticed in Cameron Sense is the time span from where you want to call inn a meeting to the point where all project members are available. This can vary from a few days to three weeks. Therefore, project planning and project progress is important to be handled by the project managers of improvement projects.

Tan (2014) suggest a simple method for measuring costs of processes. Finding good KPIs and knowing the cost drivers are a challenge in itself, and is something that will require special knowledge. Cameron Sense agrees to this suggestion and wants to keep their measurements as simple as they are allowed, while keeping their accuracy. After project finalization the Director of Finance will approve the measurements used and verify the KPIs, which is good. However, the majority of improvement project managers have little educational background for understanding and implementing KPIs, without excluding

the possibility for employees to have learned it through practical experience or self-study. On the positive side, they are technically experienced and should be able to understand the systems and products. Therefore, having a supervisors assisting and evaluating measurements are important if project managers are lacking these skills. In the Lean Six Sigma program this should be performed by the Business Black Belt that should have a good understanding of measurements. Measurement can also detect improvements that are slipping back into all habits. The important of sustaining improvements are something that need to be taken into consideration and requires a control plan as explained earlier.

Lessons Learned from an Aerospace Company

Chakravorty (2010) have shown their experiences from implementing their Six Sigma program into their aerospace company. The discussion that follows is based on what happened at this aerospace company that implemented more than 100 improvement projects, only to determine less than two years later that more than half had failed to generate lasting gains (Chakravorty 2010). They have summarized the experience in three phases:

Stretching phase: The people involved in a process-improvement project generally find themselves stretching and willing to tackle all necessary tasks in the start of the improvement project.

Yielding phase: When the improvement project is closed and is supposed to maintain the gains. This is where the program has turned its focus to another group of workers or processes. Possibly the implementation starts to wobble, and teams may find themselves struggling to maintain the gains they achieved early on. In the company, some teams started spending too much time on the improvement project, which affected their ability to meet production quotas and other daily responsibilities. Others had much confusion and were facing pressure from managers to keep up with day-to-day duties, resulting in some team members started reverting to old habits.

Failing phase: For the aerospace company it was clearly that the program fell back into normal levels as shown in the figure below. In this phase team members became increasingly discouraged by their failure to sustain the gain and became demotivated to start new initiatives or modifications. In addition, when morale staged and no one

stepped forward to take leadership of the improvement project after the improvement expert had left, the team lost interest in looking for ways to improve their current work environment.

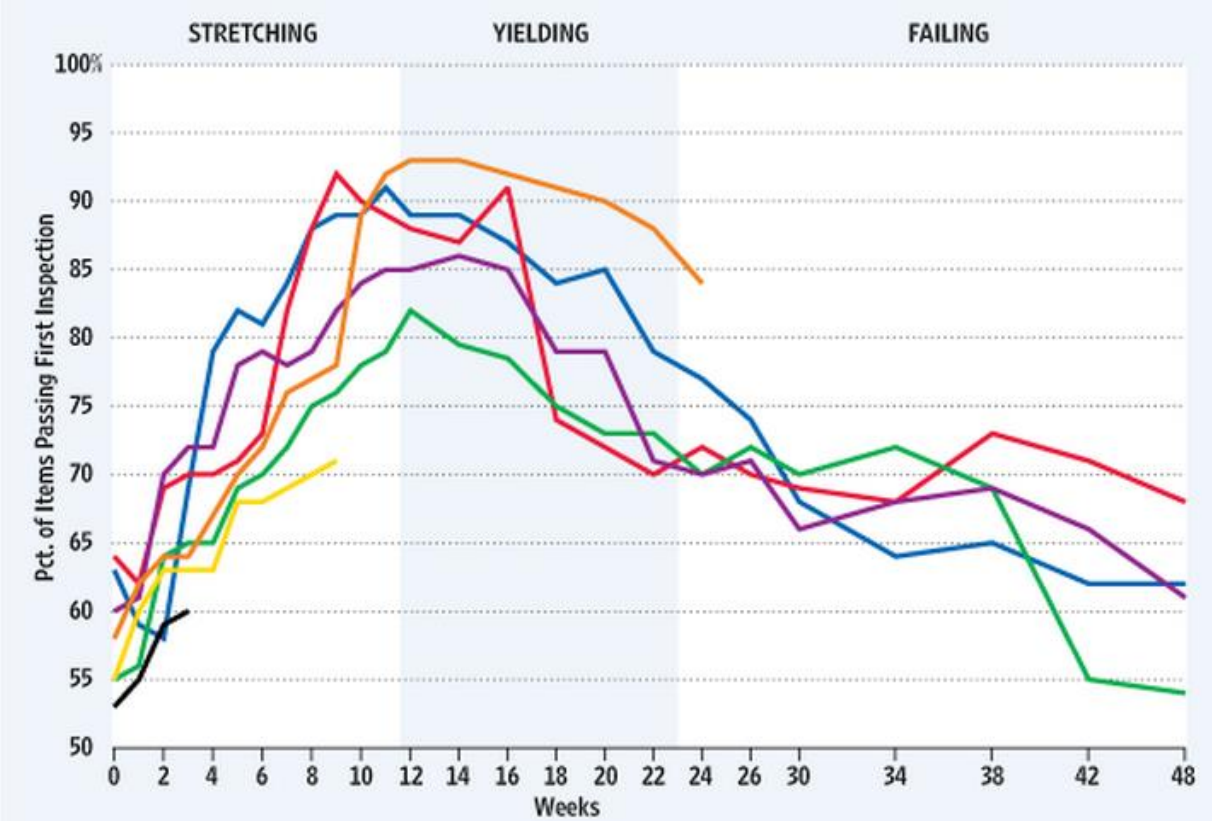


Figure 26: Overview of Aerospace Company's Lean Six Sigma Results

(Source: Chakravorty, 2010)

The figure shows how the aerospace company increased their percent of improved inspections from approximately 60% to 90%, then yielding results in ten weeks and afterward managed to return into old procedures.

In their lessons learned, they highlight three reasons:

- Improvement director need to continue to re-motivate the members and stay involved.
- Performance appraisals need to be tied to successful implementation of improvement projects, including sustaining the gains.
- Executives need to directly participate in improvement projects, not just support to make accurate decisions as to which projects are worth continuing.

- The improvement director, whose salary and bonus depended on the success of the company's Six Sigma initiatives, highlighted projects that were showing great progress and ignored those that were not. As a result, company executives were unaware that some improvement teams were slowly starting to crack under the pressure.
- Improvement teams should have no more than six to nine members, and the timeline for completing a project should be no longer than six to eight weeks.

Take into consideration that there are some differences to an Aerospace company and Cameron Sense. The aerospace company is a manufacturing company and have different kind of processes and workers. Whereas Cameron Sense have a higher degree of collaborate between different disciplines and is not a manufacturer. This case study was shown to demonstrate a worst case scenario of what can happen when gains are not sustained. The purpose is to highlight their lessons learnt and transfer the knowledge. The lesson of having executives involved is something Cameron have improved, and maybe can be criticized for not having the kind of involvement they have now since the start of the program in Cameron Sense in 2012. Referring to October 2014, when eight executives went to Amsterdam on Cameron Executive Black Belt training, which will hopefully contribute to good results in the future for the program.

Conclusion & Recommendations

Lean Six Sigma is a structured way of handling improvement projects that were originally from manufacturing environments and have later expanded into many different kinds of environments, such as high tech, telecom, banking, service industry and consumer goods. The thesis is looking at the application of Lean Six Sigma to Cameron Sense, which is the first drilling equipment provider to apply the combination of Lean Six Sigma. Specifically looking into which factors that are important for good results in an environment with many different technical disciplines, many suppliers, high product complexity and high level of cooperation within the organization. The combination of Lean and Six Sigma gives coverage of defects and quality through Six Sigma, whereas Lean covers speed, efficiency, and waste in all processes. Lean provides tools to reduce lead-time of any process and eliminate non-value added cost, while Six Sigma offer many statistical based analysis tool for understanding the complexity and creating simplicity. One of the main reason argued that Lean Six Sigma in Cameron is

working is the broad toolbox offered by the methodology, such as decision-making tools, problem solving techniques, process mapping tools, statistical tools and communication tools. These tools are helping Cameron Sense to simplify their complexity and re-designing their business processes for maximised shareholder return. However, Lean Six Sigma has constantly been targeted for criticisms and other reasoning why it should not be implemented. One common statement is that Lean Six Sigma can contribute to killing creativity in organization and reducing quality in products, while others simply suggest it is too time consuming and rather should be done in an unstructured way whenever desired. Lean Six Sigma literature argue that improvements are unlikely to happen in an unstructured environment without the right kind of motivated people or a well-designed incentive system that effectively targets general business goals and improvement goals in a holistic way. Still, this is possible to achieve in an unstructured way and you have successful companies like Handelsbanken and Statoil that claim to have implemented systems that are working. Using a structured process in Lean Six Sigma is important for three main reasons: Firstly, within their complex technological environment it is crucial to have understanding of the root causes of the problem before the organization can be sure they are implementing the right solution. Secondly, when they have a better understanding of the problem they are getting better results and progress in the improvement projects by tackling the correct root causes and avoiding waste. Third, the methodology is creating agreement through using a fact-based environment by presenting everything systematically and having genuine discussions. Generally, in many engineering environments the functional issues are first addressed and then later are optimized for commercialisation, which is making the Lean Six Sigma program important and especially when competition increases such as in the drilling equipment industry today.

The industry is using complex systems and structures, there are different technical disciplines working on the same products, great time and resources are used on measurement to really understand the root causes of an issue. This is also due to heavy compliance and risk management in the oil industry that is differencing drilling equipment from many other industries. The Lean Six Sigma improvement program with direct authority and champion's links to management are resolving many important issues that otherwise would be lacking the required support and be hard to solve. Specifically, the improvement projects are hard to accomplish due to these issues:

- Multi-discipline work on same product that increase complexity
- Long lead times and waiting due to multi-discipline work
- Many suppliers and products that have long lead times due to manufacturing complexity, size, logistics and documenting processes.
- The organisation have a high degree of cooperation
- Project and divisional barriers that hinder cooperation across lines
- A large number of employees that need coordination
- Hierarchical structure that slows project progress through slow decision-making
- Unpredictable demand schedules and industry variation

The thesis highlights these bullet points as important success factors for running a Lean Six Sigma program in high complex environments:

- A well conducted measurement phase & developing fact based environments
- Correct project selection and people selection strategy
- Good project management skills
- Building up competence in Lean Six Sigma
- Improved Champion Involvement
- A good strategy for program motivation and recognition
- Communications and transparency that connect the entire organization

A Well Conducted Measurement Phase & Developing Fact Based Environments

The measurement phase in Lean Six Sigma is important when complexity in the business environment is high. In Cameron Sense, we have several projects that spend several months on collecting data which is reflecting the complexity of some projects. This phase is important for creating the fact-based environment and for targeting the right root causes of the issue. The different disciplines need to cooperate and create agreement as they are interrelated in technology and they need to make sure they are implementing correct improvements and creating transparency. It may take several discussions to create understanding of what kind of data that needs to be collected and to define what actually the problem is. In Cameron Sense, it shows that by using more time investments and planning in the measurement phase is paying off through better results and progress in the improvement projects.

Project Selection and People Selection

Two important strategies are selected in Cameron Sense, their people selection strategy and their project selection strategy. The business leader and project champions select Lean Six Sigma training to employees that are driven, motivated, experienced and actually have time to do side projects, while they are selecting projects that are applicable to the project managers skills and expertise. Another successful factor is that Cameron Sense is able to independently select improvement projects and is a program that can define value and find the optimal projects their selves, and avoiding a scenario where management are ordering cost cutting programs that can be disintegrating. In addition, they have the opportunity to shelve or split some projects that are too complex. In Cameron Sense the majority of the improvement projects involve cross-departmental work, and have resulted in the decision that less experienced greenbelts are able to perform cross-departmental projects that has higher project complexity that others divisional projects. This completely deviates for normal Lean Six Sigma theory that is suggesting that greenbelts are too inexperienced for these projects. Therefore, it is even more important to recruit experienced and bright people for the demanding role as project managers.

Project Management Skills

Project Management is a demanding position and it generally takes years of experience to understanding what needs to be done, to make good plans and how to effectively communicate that to a broad range of people involved on a project. The Lean Six Sigma program requires excellent project management skills and people that can lead projects using different project management techniques. One of the key points from the Business Black Belt has been that greenbelts need to be better at calling in meetings, documenting the actions and processes. Thereafter, create minutes or summaries of the consensus in the meetings with clear guidelines for who is responsible for what and when actions are due. Cameron Sense wishes to improve communication by having genuine discussions and creating understanding together, especially in cross-departmental projects. One of the issues encountered is that projects often are stopped when the correct managers are absence, and is required for approval and project advancement. By calling inn more meeting and improve communication in project management the goal is to develop the

fact-based environment and create a common understanding throughout the organization.

Building Up Competence in Lean Six Sigma

There are many excellent tools in the Lean Six Sigma portfolio that should improve and assist progress in improvement projects. Note that even after they have received Lean Six Sigma training they still need to practise using the methodology and tools. The organization will benefit in the future by having higher competence and expertise in Lean Six Sigma. Cameron Sense is expecting an increasing amount of Six Sigma improvement projects in the future, which is a more statistical based methodology and appropriate for handling complexity. Six Sigma projects require competence to handle and is one of the reasons Cameron Sense would want to invest in Six Sigma competence preferably through practical experience. The Business Black Belt is more experienced in Six Sigma and might want to consider bringing more of the greenbelts into Six Sigma projects for learning purposes, or start by issuing simple Six Sigma projects.

Champions Involvement

The questionnaire established that Lean Six Sigma project managers feel that Champions are not enough involved in the improvement projects. Champions' involvement is important for facilitating, guiding, bringing in expert knowledge and giving appropriate resources to an improvement project. Especially when in a project-structure improvement projects are competing against other on-going projects for attention and sometimes require manager's attention to gain support from the rest of the organization or division. When improvement projects' progress is stopped Project Champions need to be involved and together with project manager come up with a plan to either pursue new ideas, split projects or even put projects down to avoid wasting more resources.

Motivation, Recognition and Incentives

Another important effect from Champion's involvement can be increased motivation to project managers by simply giving recognition for their work. The questionnaire established that in Cameron Sense the current motivation levels from the project managers have a wide spread and on average is not completely motivated. Therefore, the recommendation is to review how the organization gives motivation, recognition,

celebrating success and the financial incentives that are currently not working. Hopefully, this will improve projects managers' motivation and results.

Communication and transparency that connect the entire organization

The entire organization need to keep well established communication for connecting organizational goals to Lean Six Sigma goals and for balancing other ongoing projects with improvement projects. Communicating why Lean Six Sigma projects are being undertaken to the entire organization will also assist in gaining support from other individuals that might not otherwise have incentives to contribute. This is a common problem with the project structure when individuals have a sense of belonging to a specific project and are lacking the correct incentive to contribute in other projects. Often we see that project and division barriers are giving the largest potential for redesigning and optimising business operations and have a goal that is for the greater good of the organisation. This vision need to be communicated and implemented when cooperation and teamwork is the critical factor for the drilling equipment industry for future organizational success. It is important to state that it is not only management that need to communicate. Bottom-up expertise will continue to be important to absorb, especially when so many different disciplines are working on the same products and the complexity is high. This is done by letting lower levels in the hierarchy have project selection, including lower levels in project meetings and constantly asking for advice from lower level experts. Management can impossibly understand the holistic picture without help from bottom up knowledge.

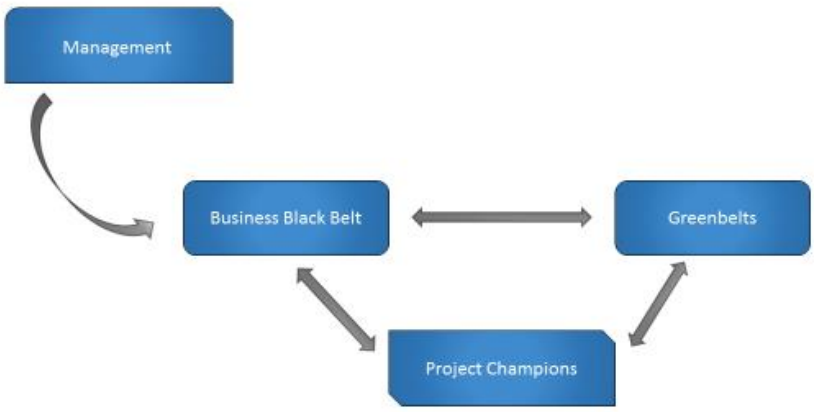


Figure 27: Holistic Communication Plan

Further Studies

The time required understanding both the drilling equipment industry and Lean Six Sigma is challenging within five months, and there are several factors that could be studied more closely. The thesis were not able to collect a sample of the entire organization on the questionnaire targeting the applicability of Lean Six Sigma to Cameron Sense and how the improvement culture and cost awareness have developed the last two years. However, the internet security difficulties internally in Cameron Sense and large time resources required make this difficult. It would be interesting with a larger sample that including those not involved in the Lean Six Sigma program for increased validity and reliability.

Future studies could go further to investigate and try to measure the impacts of:

- Continue measuring cost awareness and improvement culture to compare with the questionnaire results in this thesis and how it develops after the Executive Lean Six Sigma training.
- Investigate what kind of involvement greenbelt want from project Champions
- Impacts of the project structure and divisional incentives issues
- How to improve the Lean Six Sigma project communication
- Further investigation of what is stopping many of the projects

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Appendices

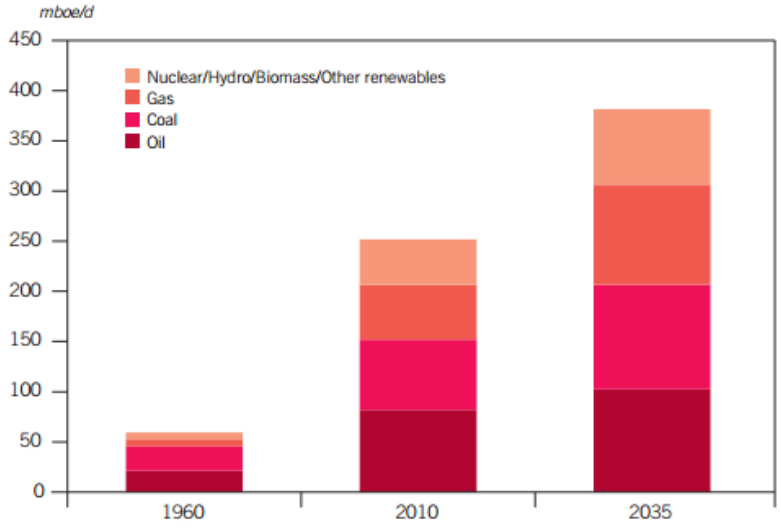
Appendix A: World Oil Outlook Forecast 2035

Note: Several assumptions of the real GDP growth and population growth are made to forecast these energy needs and are not completely accurate.

Table 1.7
World supply of primary energy in the Reference Case

	Levels *mboe/d*			Growth *% p.a.*	Fuel shares *%*		
	2010	2020	2035	2010–35	2010	2020	2035
Oil	81.2	89.7	100.2	0.8	32.2	30.0	26.3
Coal	69.8	84.9	104.0	1.6	27.7	28.4	27.2
Gas	54.8	69.0	99.8	2.4	21.7	23.1	26.0
Nuclear	14.3	16.0	21.6	1.7	5.7	5.4	5.7
Hydro	5.8	7.4	10.1	2.3	2.3	2.5	2.6
Biomass	24.4	28.0	35.2	1.5	9.7	9.4	9.2
Other renewables	1.8	3.6	10.7	7.5	0.7	1.2	2.8
Total	**251.9**	**298.6**	**381.7**	**1.7**	**100.0**	**100.0**	**100.0**

Figure 1.9
World supply of primary energy by fuel type



Source: (World Oil Outlook 2013)

Appendix B: Lean Six Sigma Program Questionnaire

We are collecting information about employees' perception concerning the Lean Six Sigma program. Responses that are critical and honest will deliver the best results for my master thesis and for Cameron Sense. All answers are anonymous.

1. **On average how much time each week do you spend on Lean Six Sigma projects?**

☐ 1-3 hours
☐ 3-6 hours
☐ 6-9 hours
☐ 9-12 hours
☐ More

2. **Spending too much time on the improvement project, have affected my ability to meet other daily responsibilities.**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

3. **20% of total workload spent on Lean Six Sigma is too much.**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

4. **Lean Six Sigma is just as applicable to Cameron Sense as other companies.**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

5. **Project champions are not enough involved in the process.**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

6. **The documenting process in the Lean Six Sigma program is demotivating. (Action Plans, Final Reports etc.)**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

7. **There is a high likelihood that I will report faults and suggest improvements.**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

8. **To what extent do you feel encouraged or discouraged by their failure/success of earlier projects?**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

9. **Improvement culture and cost awareness have increased dramatically the last two years.**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

10. **Have Cameron tied enough employee-performance appraisals to improvements projects to make you motivated?**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

11. **I feel the Lean Six Sigma program address cross-departmental issues that would remain a problem without the program.**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

12. **Cross-departmental issues are troubling me.**

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

13. I want to continue doing Six Sigma or other improvements for more than 2 years.

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

14. The Black Belt need more intensive follow-up on projects.

	1	2	3	4	5	6	7	
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree

15. What is stopping you from closing projects?

Please fill in a few words

16. What is your motivation for performing improvement projects?

17. Approximately 75% of workers are engineers in Cameron Sense. What are the implementation issues of a Lean Six Sigma program in CS?