Preface

This is a Master Thesis made in collaboration with Grundfos Manufacturing, Tatabánya, Hungary in the period July 2008 – April 2009 during the completion of an internship.
This Master Thesis constitutes the 9th and 10th semester in International Technology Management at Aalborg University.

I would like to thank the following people for their involvement and contribution to the making of this report:

Factory Manager Jim Toft Nielsen for his help introducing me to the organization and the countless project discussions;
PT-Engineer Miklós Tomor for his endless help in obtaining the needed data and documentation required for the making of this project and for his help overcoming the language barriers;
Test-Engineer Anders Lerbak for his help to make me understand the Hungarian culture vs. the Danish culture and for the use of his great insight and understanding of MG-Large;
Non-Production-Storekeeper Lars Peter Sørensen for the endless discussions over lunch in the attempt for me to understand the Hungarian mentality and work ethics;
Production Technician Niels Jørgen Christensen for his technical support and insight in the mechanical issues related to the production.

and finally;

Professor Harry Boer for his excellent guidance throughout the writing of my Master Thesis

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Rasmus Urban

"I cannot say things will get better if we change; what I can say is they must change if they are to get better"

Georg C. Lichtenberg
German Scientist, 1742-1799

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1 Introduction

The increased speed of globalization has created a (hyper) dynamic competitive landscape [Daniels et al., 2002]. This dynamism, and increased competition, implies that companies are required to undergo changes in order to keep up with the market and meet the demands of the company's shareholders [Cameron & Green, 2004].
Faced with this hyper competitive landscape companies start to question the old notions of mass production and scales of economic. Drastic actions are to be taken in order to stay competitive or to sustain their competitive advantage and. One way to do so is the rethinking of business processes and here has lean emerged as a powerful weapon during the last decades. Lean offers a way for companies to produce what customers, want when they want it, while still keeping costs at a minimum.

But what is it lean actually does? Womack and Jones (2003) describes in their book "Lean Thinking" how converting a classic batch-and-queue production system to continuous flow with effective pull by the customer, will, as a rule of thumb, double labor productivity all the way through the system, while still cutting production throughput times by 90 percent and reducing inventories in the system by 90 percent as well. Faulty products reaching the customer and scrap within the production processes are typical cut in half. After the initial radical realignment of business processes companies can typical double the production productivity one more time through incremental improvements within two to three years.

Lean provides companies with endless possibilities of optimization and cost reductions, so why don't every company diving into the pool of lean to capture these significant benefits?
Many have tried, and many have failed. Lean is not something that can be implemented overnight or used ephemeral to solve performance problems. Lean is a full scaled philosophy that must, when implemented, permeate the organization and becomes part of an organizational culture, where focus is on creating value for the customer. Though lean provides a wide variety of tools to reach the golden fruits of lean, they are only for limited use if the fundamental understanding of lean and its principles are missing. The tools must be used in cohesion with lean as a philosophy and an endless journey towards perfection, if organizations are to harvest the full potential of lean.

Performance leaps of the magnitude described above are surely a bit hard to accept, particularly when accompanied by the claim that no dramatically new technologies are required or a total renewal of the production equipment is needed. Lean is about doing things differently and most important of all; only to do what adds value for the customer.
This can, however, be a difficult process to achieve and requires a new way of looking on the existing business processes. This report will venture into the universe of lean to uncover some of the ideas and concepts of lean by contextualizing it through the case company used in this report. This case company will be presented in the following chapter.

Happy reading!

2 Empirical Settings

This chapter will briefly describe the case company in terms of general history, background information, products, production and organizational structure.

2.1 Company Information

The case company of this project is Grundfos. A well known established and respected Danish pump manufacturing company with sales companies in every major country spread across the world, and manufacturing divisions in eleven countries outside Denmark.

The manufacturing company in question in this report is Grundfos Manufacturing in Tatabánya, Hungary. A city with a population of approximately 75,000 people and is located 50 kilometers vest of Budapest. The Hungarian division of Grundfos was inaugurated in 1999 and produces electric motors for a variety of pumps manufactured and assembled in Hungary and Denmark. Three years after opening the first factory an additional manufacturing plant was build next to the existing factory. The factory build in 1999 is named GHM1 and its neighbor is named GHM2[1]).

In 2007, Grundfos opened a third manufacturing plant in Székesfehérvár (GMH3), approximately 100 kilometers from GMH 1 and 2. This factory, GMH3, produces CR-pumps[2] to cover the demand from Eastern Europe and several line transfers from Bjerringbro and GMH1 to this factory are already planned within the current strategy period (2008-2012).

The focus of this report will be on GMH1, more precisely a production unit within GMH1, which is presented in the following sections.

2.2 The Organization

The majority of leading position in Grundfos, Hungary is occupied by Hungarians, though this has not always been the case. From the outset, many of the leading management position was occupied by Danes stationed in Hungary, but during the last few years the Danish managers have been replaced by Hungarian coming either from other positions internally in Grundfos or from leading positions in other international companies located in Hungary.

The organizational structure is based on a normal functional structure where each department has its own manager and an area of responsibility. The focus of this report will only be on the production unit “MG-Large” and the functions directly related to this unit, such as engineers, supervisors, planners etc. The areas in focus in this project are marked as blue in the organizational chart depicted below.

The grey boxes in Figure 1 are the assembly line and the four productions islands constituting the MG-Large production system, which is included in the focus of this report. When using the term “MG-Large production area or system” it refers to the actual physical area or machines in these production islands. When merely using the term “MG-Large” it refers to the production unit MG-Large as a whole and the relating functions such as Engineering, Logistic etc, depicted as blue boxes in Figure 1 below. For a larger version of the chart see Appendix C2.

[1] **G**rundfos **M**anufacturing **H**ungary factory **1** and **G**rundfos **M**anufacturing **H**ungary factory **2**
[2] Internal notation for a certain type of pump

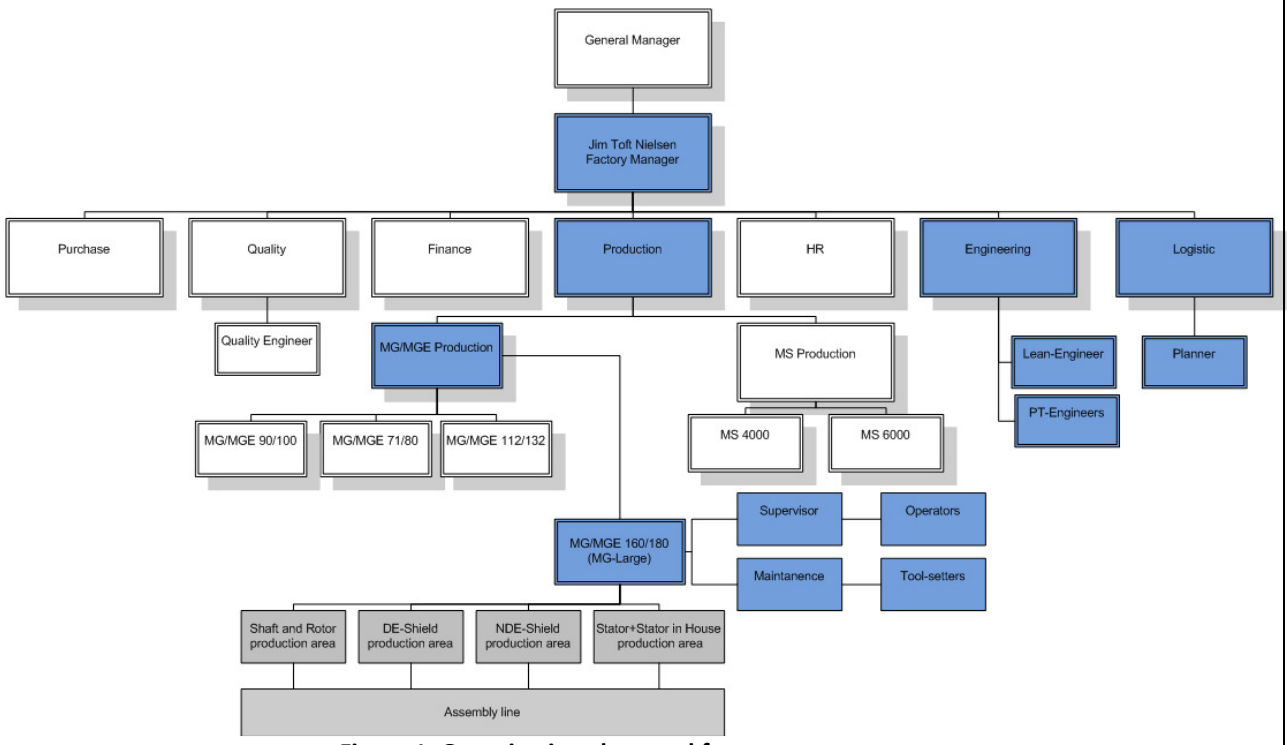

Figure 1: Organization chart and focus area

2.3 Production

The MG-Large production unit consists of four production islands and one assembly line. The four production islands are producing the components used in the assembly of a MG-Large motor and grouped accordingly to the four major components of a MG-Large motor – Shaft/Rotor, DE-Shield, NDE-Shield and Stator In House. The three first production islands are also producing components to other motors, but these motors are assembled at different assembly lines in GMH1. The last production island – Stator In House and the assembly line is only dedicated to the production of MG-Large motors.

Though not utilized at the moment, the different productions islands are designed to deliver components directly to the assembly line. Each production islands and the assembly line run a two shift schedule with a workday of eight hours each. It is possible to add an additional shift if the demand increases, thus having a 24 hours production.

The MG-Large production system is not more than two years old and the majority of this period has been concentrated on designing, developing, installing and adjusting the system. The different production islands and assembly line is now fully operational, though adjustments are still being performed on the system.

2.4 Products

The MG-Large electrical motor is a new product to the market and was only released for sale in April this year (2009). The MG-Large motor can either be sold as a individual product or mounted on a pump and then sold a complete product.

The development of the MG-Large motor, and the appurtenant production system, was initialized in July 2005 and was the first production line in GMH1, which was developed in Hungary and not transferred from Denmark. The MG-Large products were though designed in Denmark, but the design of the production system was in the hands of GMH1.

The MG-Large production area produces a wide variety of motors in terms of efficiency, kW, output and size. The different motors are specified within two categories; MG-Large motors and HM-Large motors. A MG-Large motor is the standard motor and the HM-Large motor is basically a MG motor with an E-box[3]. Most of the component-specifications of the MG and HM motors are the same, though the HM motor is slightly more complex due to the E-box addition.

MG and HM motors consists of six major components; shaft & rotor, DE (Driven End) shield, NDE (Non Driven End) shield, stator, and housing (HM motors also contain the E-box).

The rotor, DE-shield, NDE-shield and housing are all supplied by external suppliers, but undergo machining before used in the assembly process. This machining takes place in the different production islands – DE-Shield is machined in the DE-shield island, Rotor is machined in the Shaft & Rotor islands etc.

There will be made no distinction between MG-Large or HM-Large motors in this report as the products are very similar in regards to the production and assembly process.

MG-Large motor

HM-Large motor

[3] **E**lectronically Frequency Inverter

3 Project Objective

This chapter will present the project objective, but firstly, the problem that initiated this report, is described. In addition, management-stated goals are presented, and these will also serve as goals for this report. The management's idea for a solution to reach the stated goals is then presented and finally a short description of the report structure will be presented.

3.1 The Problem

The MG-Large production system was designed with a certain material flow and connection of processes in mind. The design of the production system is based on continuous flow with direct delivery of components from the four production islands to the assembly line. However, this design is not utilized as intended, which causes vast amounts of WIP (Work In Progress), high stock levels, extensive throughput times, and long lead times.
In addition to not utilizing the intended system design, the MG-Large production system is not performing as expected, in terms of output, flexibility and productivity. The utilization of space is also becoming a problem, as more and more space is used for inventory, WIP and transportation roads. This leaves less and less space for new equipment.
The assembly line is also not performing at the expected levels, which should be on approx. 80 motors per shift, according to management goals. The assembly line is currently[4] only producing between 35 and 45 motors per shift.
The performance problems concerning MG-Large can be boiled down to the following issues:

- High stock levels of both components and finished products
- Large amount of WIP in the production system at any given time
- Long throughput times
- Disruptive material flow
- Long changeover times
- Flexibility, but on the expense of time and large batch sizes
- Low productivity
- Lack of space (area utilization)

3.2 The Goals

The stated goals have been formalized in cooperation with management, in particular with the Production Manager, during the making of this project. The goals will be used to support the development of solutions to both solve the problems mentioned above and the facilitate MG-Large is becoming a production unit that fulfill the stated goals.

The management has stated[5] the following goals for MG-Large:

- Reduction of stock levels
- Flexible production system that allows for production of components both for MG-Large assembly line and other assembly lines in GMH1
- Low throughput time
- Continuous flow – one piece flow
- Flow of components directly from the productions islands to the assembly line

[4] Based on observation from January to April 2009
[5] Stated in December 2008 and reviewed in April 2009

- Reduction of WIP in all parts of the production system
- Costs savings – Reduction of capital locked in WIP and finished goods
- The MG-Large production system and area should serve as best practice in regards to lean production

The goal of this report is to develop solutions that will help reach the stated goals and solve the performance problems stated earlier.

3.3 The Solution – According to Management

The management has a vision of implementing lean full scaled across all three factories within the current strategy period, which runs until 2012. Lean has already been run as fragmented pilot projects in the three factories, but the results have not always been promising. This can mainly been attributed to a lack of involvement, resource availability and lack of competencies to run the projects. Despite these varying results, the top management is still unwavering in their strategy to implement lean in the MG-Large production system in order to reach the stated goals and solve the performance problems.

The initial goal of implementing lean was, according to management, to operate with a low lead- and throughput time, which was identified as having great customer value, especially for the internal customers (GMH2 and Grundfos in Denmark and China).
The initial idea was to make MG-Large a lean production system, but as the development and installation of the production system progressed it moved further and further away from being lean. Focus was directed towards solving the many quality problems experienced throughout the project instead of implementing lean principles and tools such as Kanban, pull production, SMED, continuous flow etc. The MG-Large production system and its daily operations have slowly, but steady moved away from the initial concept and design of the system. And this is causing many of the problems described in the beginning of this chapter.

But management is ready to make another attempt with lean, as they can see the need for a flexible and highly efficient production system with low lead- and throughput-times, producing only what the customer demand when they demand it. This would eliminate the need for large inventory levels of components and finished products, which are a major economic burden for the organization according to the Factory Manager in GMH1.

Based on the previous sections which described the problem, the goals and the management's solution, the objective of this project is to answer to the following questions:

"Will lean solve the performance problems and can lean help to reach the stated goals? If so, how can lean be implemented in MG-Large?"

To answer these questions a line of supporting questions has to be asked:

"How does the MG-Large production system look through the lenses of lean production?"

"How can solutions, based on lean best practice be designed to solve the performance problems?"

"How can these solutions be implemented taken the organizational characteristics into consideration?"

The goal of this report is to develop a set of answers to the questions asked, thus eventually also answering the main if lean is the solution and how it can be implemented if so. To answer these questions it is essential to analyze MG-Large using different frameworks, but before going into the analytical process a sound and solid research design is required to support the making of this report.

3.4 Report structure

Before the research design is presented, an overview of the report structure is visualized in order to give the reader a understanding of the different elements this report will go through.

To provide the best conditions for reading this report Figure 2 displays the report structure in general terms:

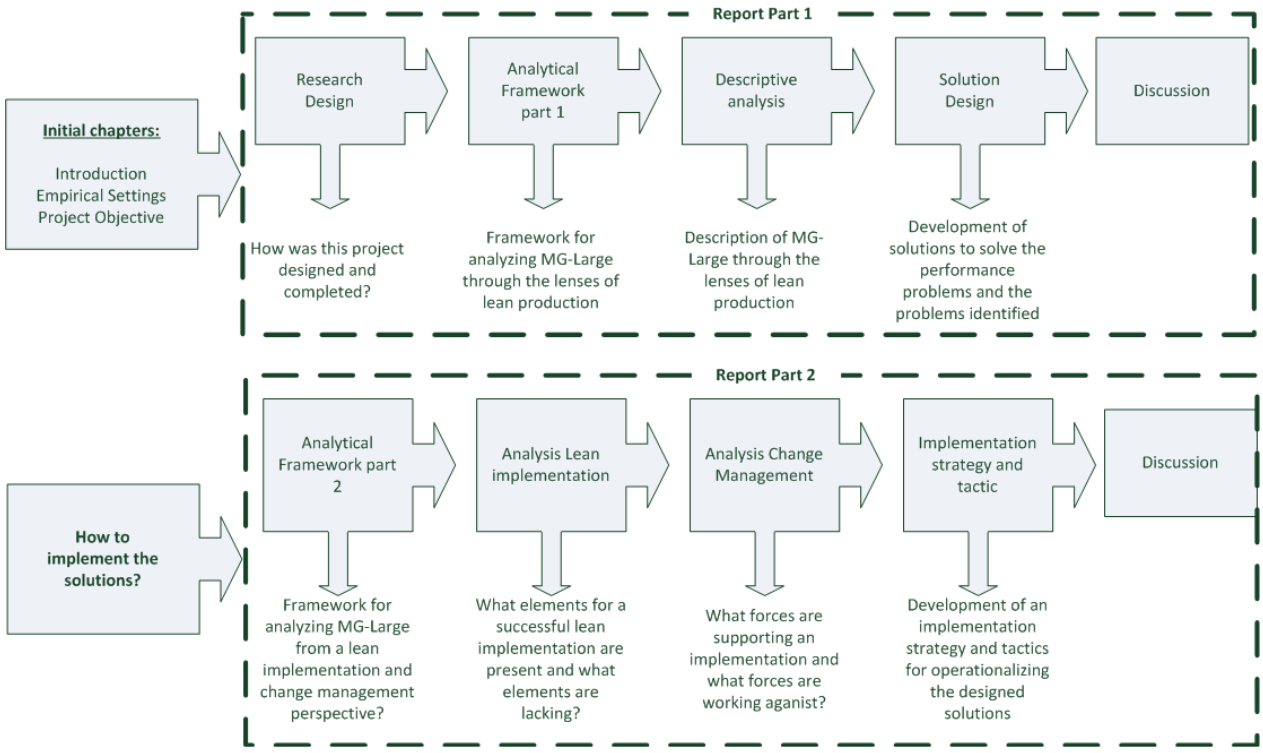

Figure 2: Structure of the report

The first part of the report will focus on lean as a solution and analyze MG-Large through the lenses of lean production. Based on the findings in this analysis a set of solutions to solve the performance problems will be developed.
The second part of the report looks at the process of implementing lean, both from a theoretical and more operational perspective. A strategy for implementing lean in MG-Large will be developed and different tactics for operationalizing the designed solutions will be described. The closing chapters will be a discussion of this report on two levels; a direct discussion of methods, findings, limitations and further research, and a more overall discussion of this report. The conclusion will serve as the final chapter in this report.

4 Research Design

This chapter will present the research design of this report. It will describe a structured approach for selecting, collecting, specifying quality criteria, and analyzing the data and information required for the different analyses conducted in this report.
The research design paragraph will also shed light on the establishment of validity and reliability in the data and information used. The different elements included in this chapter will be a theoretical perspective on how a good and sound research design should be constructed and how this is done in the context of this report.

This project is not a social scientific study, but a project engaged in the analysis, redesign and change of an existing production system, which has been described in the chapter on empirical settings and will be described further in detail in the descriptive analysis later in this report. Though not a social science study, the methods behind social science research are very useful in the conduction and completion of various parts of this report.
This chapter will not focus on the methodology, but more on the methods suggested by social science. For an elaboration on the research type and the social scientific research strategies utilized, see Appendix A1.

4.1 Important Components of Research Design

According to Yin [2002] five components of a research design, for case studies, are especially important. These components will indicate what type of data is to be collected by defining what the study is investigating, how it will investigate it and how it will interpret the findings. The five components are:

1. A study's question(s)
2. Its propositions, if any
3. Its unit(s) of analysis
4. The logic linking the data to the propositions
5. The criteria for interpreting the findings

Including these five components in the composition of the research design will indicate what data are to be collected – as indicated by (1) the study question(s), (2) its proposition(s) and the (3) unit(s) of analysis. The research design will also indicate to the research what is to be done after the data have been collected – as indicated by (4) the linking of collected data to the propositions (what is to be studied?) and (5) the criteria for interpreting the findings.
The *study question,* in this case the project objective, as stated earlier is focused on determining if lean is the solution and a line of how-questions in regards to lean. The task of this report is to answer these questions and find a solution to the problems in MG Large.
The *study proposition* direct attention to what should be examined within the scope of this study. The proposition of this study is to examine *if* lean will solve the performance problems experienced by MG-Large and if so, how to develop an implementation strategy. The *unit of analysis* will be MG-Large as a unit including all elements that are affecting the production, thus

both the production demand, and the assembly of MG-Large products. Included in the unit of analysis will be people, machines, procedures, processes, management, strategies, layout, and interactions of both people and machines.

The logic linking the data to the propositions and *the criteria for interpreting the findings* are the two components that indicate the data analysis steps in a case study research. In the case of this study it denotes the essential factor of ensuring that the collected data is related to and will support the answering of the project objective. This entails the development of an analytical structure, which can identify the required data and information. To determining if lean is the solution to the performance problems, data and information regarding lean production is required in order to answer the earlier stated questions. In addition to this, determination of organizational characteristics is required to support the development of a lean implementation strategy.

4.2 Project Limitations

Though this project was conducted during a 10 month period it still has some limitations. The majority of these limitations are related to the fact that the MG-Large production system relative late in the internship period became fully operational.

The project limitations are:

- Limited time with a operational production system – 3 month
- No actual implementation
- The production system was not completely operative when this project was initiated
- Limited documentation
- Limited standardized processes and procedures (changing all the time)

The first three limitations are closely connected, as the production system was not operational during a large period of the internship and data collection period. When it finally became operational there was not enough time to analyze, develop, design solutions and also implement them. The lack of an operational production system also made it very difficult at times to obtain the needed information or data on a given process or procedure. This was also the case for testing ideas and solutions related to solving the performance problems.

Due to the fairly new nature of the production system, the majority of data required for this project was not available or did even exist. This entailed that elements such as value stream maps, cycle times, changeover times and performance for individual processes had to be developed and/or measured during the writing of this project. Much of the existing documentation, data and information regarding the MG-Large production system were also outdated or incorrect, because the production system was undergoing continuous changes during the writing of this project.

4.3 Role of Theory in Research Design

Focusing on the before mentioned five components (1-5) will effectively force the construction of preliminary theory related to the topic of this case study. Put in different terms – focus on the development of a solid research design will automatically put focus on what theoretical basic to use when analyzing a particular condition or situation. Theory will applied to develop an

analytical framework, which the empirical settings can be filtered through and from this identify elements that will support answering the projective objective. The composition of theory will help understanding what is being studied and what theory will be beneficial and supportive in answering the research question, in this case the project objective.
According to Yin [2002] the complete research design embodies a "theory" of what is being investigated and the simple goal is to have a sufficient blueprint for the study, which requires insight in the theoretical propositions. Then, the complete research design will provide a strong guidance in determining what data to collect and methods for analyzing the collected data. For this reason, theory familiarization prior to any data selection and collection related to a case study is an essential step in doing case study research [ibid].

To overcome the barrier of developing, constructing or composing theory for the research design, a helpful way is to review the literature related to the subject being studied, which in this case is lean theory and asking challenging questions about what is being studied, why is the study commenced, what are the expected finding(s) and what are the learning objects hoped to be gained as a result of this study. This entails that a researcher, based on the research question, should form an idea of the literature on the subject being investigated, which will help him/her select, collect and analyze the correct data in order to answer the research question(s). The theory-review and research design will form the foundation for the data selection, data collection and data analysis, which all (especially data selection and collection) must be subjected to a set of quality criterions to ensure a high level of quality in the case study being performed [ibid].
The subject of data selection, collection and analysis will be elaborated in the dedicated sections later in this chapter.

4.4 Development of Quality Criteria

Quality is essential for any good research regardless of the subject or condition being investigated [ibid]. Yin uses the notion of "testing" to establish quality in any empirical social research and focuses on four tests relevant for a case study research:

- Construct validity
- Internal validity
- External validity (not essential in this project)
- Reliability

Yin links these four different quality tests to different tactics – more precisely, different phases in a research design where these can be utilized and how to utilize them. This linking is depicted in Table 1:

Test	Case Study Tactic	Phase of research in which tactic occurs
Construct validity	• Use multiple sources of evidence • Establish chain of evidence • Have key informants review draft case study report	Data collection Data collection Composition
Internal validity	• Do pattern-matching • Do explanation-building • Adress rival explanations • Use logic models	Data analysis Data analysis Data analysis Data analysis
External valitidy	• Use theory in single-case studies • Use replication logic in multiple-case studies	Research design Research design
Reliability	• Use case study protocol • Develop case study database	Data collection Data collection

Table 1: Quality tests and case study tactics (adapted from Yin, 2002)

Yin mentions that this list is more complex than the normal "validity" and "reliability" student often are exposed to. Yin continues to stress the importance of utilizing the different tactics throughout the research and not only deploying them in the beginning. Continuously using these tactics will ensure a high level of quality in this report and force one to question, check and double check any data collected throughout this study. The different tests will be elaborated upon in the following sections, but only in the context of this project. For a theoretical view on how to use these different "tests" see Appendix A2.

4.4.1 Validity

All the required changes were scrutinized before the solution design phase in order to ensure that every required change were related to the original object of the project.
Every time a certain piece of information or data was needed multiple sources of evidence was employed in order to create a triangulation of the data or information accuracy. An example of this is that the measured cycle times were compared to the data from SAP[6] and discussed with the relevant PT[7]-engineers. If the data or information was consistent, the data was concluded valid. If the data or information was conflicting, additional measurements were conducted and the result was once again discussed with the relevant people. If the second comparison still was inconsistent a discussion of which measurements were correct and valid was commenced and an agreement was reached. If the data from the SAP system was incorrect, this data was updated or corrected. To support the discussion of valid data or information the relevant documentation was compiled and linked to the measurements. By doing so, it was possible to establish a chain of evidence where one piece of data or information could be verified by validating data or information linked to the element being investigated and/or discussed.

By continuously using these three tactics 1) multiple sources of evidence/triangulation, 2) linking evidence to verify a given object and 3) having relevant people review and discuss findings and

[6] Grundfos' ERP system
[7] Production Technical Engineers

suggestions, a high level of validity was created. The majority of data and information used in this report has been questioned, challenged and discussed in order to ensure that the given information and data was correct and corresponding to the subject(s) being investigated.

4.4.2 Creating internal validity

Creating internal validity in a case study performed over a limited period is always difficult and has also been subject of great concern in this project. Consequently, to validate events, that could not be observed, the triangulation process, mentioned above, was used. These events, data or information was discussed and reviewed by multiple sources to paint a more nuanced picture of the reality and what actually occurred. Often data from the SAP system was included in the discussions. If the data and event descriptions were contradictory, people from Grundfos, Denmark, was involved (if possible) to verify or discard the data. Many of the major changes and events early in the MG-Large project[8] were supported and controlled by experts from Grundfos, Bjerringbro, making it possible to triangulated investigated events by interviewing these people.
To avoid concluding casual relationships between two or more events or situations, and making logical assumptions and conclusion, investigated subjects were illuminated from multiple perspectives. For instant, if low shop floor motivation was investigated, the relevant managers, PT-engineers and shop floor employees were all interviewed to create a more detailed picture of the fundamental reasons for this low motivation. This was then compared to observations made during the project.
The main tool to create internal validity was to obtain as much knowledge as possible during the period at Grundfos in Tatabánya. This was not only confined to the MG-Large project, but to all parts of the organization. Obtaining this detailed understanding of the organization, through involvement in several other projects besides this, often helped understand why processes or procedures were constructed in a given way or why people reacted a certain way in a given situation. Even though the knowledge and understanding of Grundfos as an organization was limited due to the time constrain, it was very useful being involved in other projects across the organization besides this project. This helped develop a more detailed understanding of Grundfos as an organization, which was an experience that could then be used in the work being conducted on the MG-Large project.
To maintain a high level of internal validity no conclusions or assumptions were drawn without discussing it with engineers, managers, shop floor employees or other personal. Observations were always presented in its original form and based on the discussions conclusions were drawn.

4.4.3 External Validity

The issue of creating external validity in this report is not very vital as this study only focuses on MG-Large and the surrounding organization. The findings in this project are very contextual dependent as they are based on the context of MG-Large, thus, it would be complicated to generalize these findings.

[8] Not this project, but the overall Grundfos project focused on the development and construction of the MG-Large motor and the appurtenant production system (commenced 2005)

4.4.4 Building reliability in this project

In order to build reliability in this project, it is very important to deliver a detailed description of the empirical settings, the methodological approach, the research design, the analytical structure, and the theoretical framework deployed.
To operationalize the question of reliability focus was directed to describing the empirical settings by introducing the case company, the project objective, the research design, the data treatment (data selection, collection and analysis), the utilized theoretical framework and the different analyses conducted in this report.

The overall approach to create reliability in this report was to operationalize as many steps as possible, describing each step before commencing the actual step. This can be seen in the development of the different analytical frameworks, which follows a described structure, but also describes how the given framework was developed.
Though generally it is important to have a high level of reliability, this project is focused on solving a set of problems in a certain context.
The question of reliability in the context of this report is to construct a report where the logic of the steps being performed is visible for the reader and creates no doubt of why the different analyses are conducted and for what purpose.

4.5 Operationalization – Data Treatment

Every type of empirical research has an implicit, if not explicit, research design. In the most unsophisticated sense, the design is the logical sequence that connects the empirical data to the initial research questions of a study and, ultimately, to its conclusions [Yin, 2002].

Basically, it is an action plan for getting from A to B, where A may be defined as the initial set of questions to be answered and B is some set of conclusions about the question. Between “A” and “B” may be found a number of major steps, or questions to be asked, hereunder the collection and analysis of relevant data [ibid]. These steps, which are elaborated below, identified by Yin [ibid] are in accordance with the framework adapted from Astrid Lassen [2008]. The steps are used to operationalize the research design:

1. What question to study?[Yin, 2002]
2. Selection of data [Lassen 2008]/ What data are relevant? [Yin, 2002]
3. Collection of data [Lassen 2008] / How to collect data? [Yin, 2002]
4. Analysis of data [Lassen 2008] /How to analyze the results? [Yin, 2002]

These four steps constitute important elements in this report and each step will be subjected to the set quality criteria (validity and reliability) described earlier in this chapter. The framework is visualized in Figure 3 below.
The development and ensuring of validity and reliability (trustworthiness) are treated in the individual sections on data selection, data collection and data analysis.

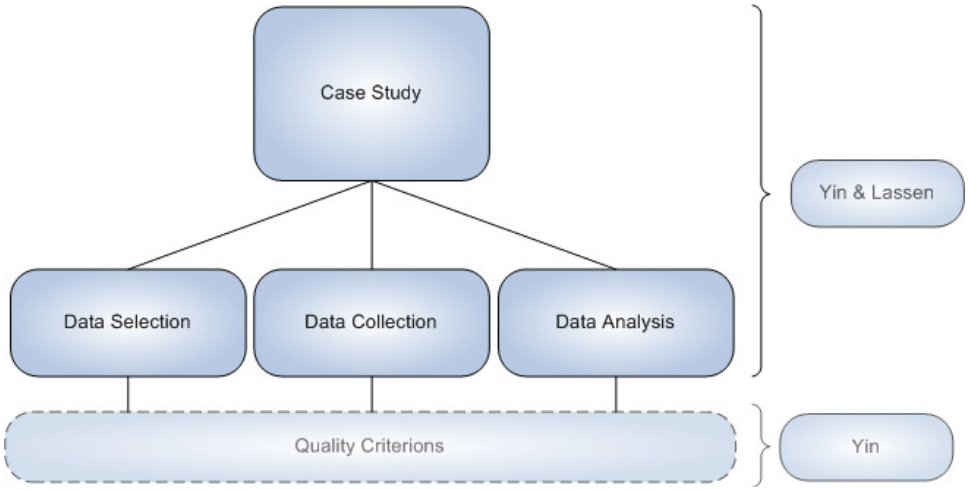

Figure 3: Disaggregated view of this case study

As the model suggests, the research design is made of three main branches. Each of these branches will be individually elaborated in the following section.

4.5.1 Data selection

Data selection will treat the matter of determining the correct type of data and information needed to perform the different analyses. Data selection is also focused on choosing the correct informants when searching for the needed information or data. Finally, data selection will be treated in regards to validity and reliability.

This data selection will focus on the following questions:

- What type of data is selected based on the analytical framework developed?
- Which informants are selected to contribute with data and the collection of data?
- How to maintain validity, reliability and trustworthiness in the selection of data?

Type of selected data
The type of selected data can be divided in to two categories:

- Data and/or information related to lean production or lean implementation
- Data and/or information related to the organization and its characteristics

Analytical frameworks, which are based on theory, for conducting the different analyses will be developed in order to ensure that the correct data is selected. These frameworks will identify what type of data to select in order to complete the analyses.
The second category will be used to determine, from a change management perspective, to determine the organizational characteristics. Again, theory will be used to determine what type of data is required.
By comparing the analytical frameworks to MG-Large the required data emerges. An example of this could be if the analytical framework describes value stream maps as important, data or information regarding the use of value stream maps in MG-Large is required. This data or information is then collected using a variety of methods, which will be described in the section of data collection.

Selecting informants

In the scope of this project the majority of selected informants were directly linked to the MG-Large production in one way of the other. This included people ranging from shop floor employees to the top management and specialists from Grundfos, Bjerrringbro.

Each informant was selected based on the data and/or information required; if information regarding the planning process was the object, informants from the Planning and Logistic department were chosen and so forth. If information of more general issues was the target, a more wide range of informants were selected, in order to ensure a more nuanced and hopefully valid description of the event(s) or the information required. This would also allow for an internal discussion, departments in between, of the investigated objects, hence leading to a triangulation of the data or event.

In order to maintain multiple perspectives on the subjects being investigated, several management layers were often included. In the majority of participated meetings, multiple managerial layers were present ranging from top management to supervisors.

To see a more detailed overview of the informants used in this project and what type of information they contributed with, see Appendix A3.

Validity and reliability

Several initiatives have been utilized in this report to ensure a high level of validity and reliability in the data selection:

- Selecting several informants on the same subject (triangulation)
- Selecting informants based on the type of data needed
- Selecting informants across the organization
- Selecting both old and new employees
- Selecting same type of data from multiple sources (Denmark and Hungary)

Each informant was selected based on the needed data and/or information, but at times also based on their knowledge of the organization. If information regarding pervious lean activities was required then not only the Lean-engineer was selected, because of his fairly new involvement in the organization, but also employees, that had been with the organization from the beginning, with some insight in previous lean activities.

4.5.2 Data collection

According to Yin [2002], the data selection can stem from one (or more) of six different sources. These are:

- Documentation
- Archival records
- Interviews
- Direct observation
- Participant observation
- Physical artifacts

All the six different sources have each some strengths and weaknesses. These are displayed in Table 2:

Source of evidence	Strenghts	Weaknesses
Existing Documentation	Stable – can be reviewed repeatedly Unobtrusive – not created as a result of the case study Exact – contains exact names and references Broad coverage – long span of time, many events and many settings	Retrievability – can be low Biased selectivity Reporting bias – reflectsbias of author Access – may ne deliberate blocked
Records	Same as above for ducumentation Precise and quantative	Same as above for documentation Accessibility due to privacy reasons
Interview	Targeted – focuses directly on case study topic Insightful – provides perceived causal inferences	Bias due to poorly constructed questions Responce bias Inaccuracies due to poor recall Reflexivity – interviewee gived what interviewee wants to hear
Direct Observation	Reality – covers events in real time Contextual – covers context of events	Time-consuming Selectivity – unless broad ceverage Reflexivity – event may proceed differently because it is beeing observed Cost – hours needed by human hours
Physical Artifacts	Insightful into cultural features Insightful into technical operations	Selectivity Availability

Table 2: Strengths and weaknesses of data collection, Source: Yin [2002]

A wide variety of data collection methods have been used in this report. Below, a list of the methods used in the data collection process of this project is portrayed. For a more detailed description of these methods, and what kind of data they were used to collect, see Appendix A4.

Data collection methods utilized in this report:

- Existing documentation
- Records
- Interviews
- Direct and participant observations

Each of these individual data collection methods has had its strengths and weaknesses. Existing documentation for example, were often outdated and inaccurate due to the changing nature of the MG-Large production system whereas interviews and direct observations created a much more precise picture of the reality. But because the existing documentation was either missing

completely or outdated it gave a perfect opportunity for either creating or updating this documentation. By doing so, a much more detailed and thorough understanding of the object under investigation was obtained, and often became extremely helpful in the later work at MG-Large.

Data collection and quality criteria
Each of the five data collection methods utilized in this report brings along some pros and cons in relation to the writing of this report.

Existing documentation: The advantage of existing documentation was that it enabled one to see e.g. how the material flow or a given process was designed. Though, this was also the disadvantage; it described how it *was designed* and not how it was actually working. It was also often difficult to obtain existing documentation either because it only existed in Hungarian or due to the protective nature of the engineers. Much of the documentation only existed on their personal computer and not on the common intranet, which at times, made it difficult to gain access to existing documentation.

Records: The same pros and cons found in the existing documentation are valid for records, not many records were accessible in relation to MG-Large.

Interviews: One of the main sources of data collection. Based on the fairly new nature of MG-Large observations and interviewing people were the most stable method of collecting data. Because of the bias nature of the informants, data or information obtained through interviews were always triangulated with either other informants or formalized data/information from the SAP system or intranet.

Direct or participant observations: Together with interviews, the major source in data collection and information required for the analyses was direct or participant observations. It was more reliable to directly observe or measure a process or procedure instead of looking on descriptions on the intranet, in the SAP system or talking to PT-engineers, supervisors, planners, etc. This data or information could then be confirmed either by using existing data in the system, by verification from engineers, or conducting the same measurement or observation several times.

4.5.3 Data analysis

The collected data was analyzed from two perspectives; lean and change management. The analytical work formed in this report was structured accordingly to an overall framework, which can be viewed in the following chapter. Each individual analysis was based on a theoretical framework either developed through reviewing literature on the investigated subject or using an existing model for analyzing.
The analyses were structured in three steps: The first analysis was focused on analyzing the data from a lean production perspective, whereas the second and third analyses were analyzing the data from a lean implementation process and change management perspective.

Lean production – step 1
To answer the first part of the project objective an analysis of MG-Large, from a lean production perspective, was required. The framework for this analysis was based on lean theory that served

as representative for best practice. Comparing MG-Large to best practice identified gaps, could which then be viewed as elements that must change in order to become lean.
The analysis used data and information obtained through the course of the internship. To ensure that the data utilized for this analysis was representing the context of MG-Large tactics for ensuring validity, as described in section 3.4, were used.
Having identified problems in relation to lean production and validated them through discussions with the informants presented in Appendix A3, the report moved into the solution design. The identified problems were solved on a theoretical basis, by returning to lean theory to develop the best set of solutions from a theoretical perspective merged with the reality of MG-Large.
Based on the findings from the initial analysis a set of solutions targeting the problems identified were developed. The problems identified could all, to a certain degree, be linked to the performance problems or the MG-Large stated goals.

The process of implementing lean – step 2
The purpose of the second analysis was to analyze MG-Large as a unit, from an implementation perspective; which organizational characteristics were present to support an implementation of lean and what a characteristics were lacking. Findings from this analysis were included in the development of an implementation strategy tailored to MG-Large and as input for the third and final analysis conducted in this report.

Driving and restraining forces – step 3
The third and final analysis was focused on identifying driving and restraining forces in relation to process of implementing lean. The driving forces were elements that would support the implementation of lean, whereas the restraining forces would complicate or even hinder the implementation process. The findings from this analysis were, together with findings from the second analysis, used as input to development of a lean implementation strategy and different tactics utilized when implementing solutions developed and design in this report.
All three analyses were conducted using an analytical framework tailored to the given analysis and described prior to the analysis.

The two lean analyses were conducted using two frameworks developed specific for use in this report. The theory used for developing these frameworks can be reviewed in Appendix B1 and E1. The third analysis on driving and restraining forces were completed using Lewin's Force Field analysis and a review of his model can be viewed in Appendix E2.

The analytical structure of this report will now be presented and provide an overview of the different steps this report takes in order to answer the project objective.

5 Analytical Structure

The objective of this chapter is to present the overall analytical structure of this report, more precisely the different steps taken in order to analyze, identify and design solutions to help reach the stated goals in chapter 3 (and to answer the main objective of this report.)

The analytical structure presented in this chapter, will take the reader through a logic sequence of analyses related to the issue of lean production and the process of implementing lean.
The first analysis conducted in this report focuses on characteristics of successful lean production and the comparison of MG-Large to these characteristics. By using lean production theory as representative of "best practice", gaps between MG-Large and best practice can be identified. Elements (problem areas) that must be changed in order to become lean in the production will thus emerge from this analysis. Following this analysis will be the design of solutions, based on lean theory, which are related to the performance problems experienced in MG-Large.
The first analysis will follow a four step approach in the process of answering if lean will solve the performance problems. The four steps are:

1. Review of lean theory to Identify characteristics of successful lean production and the creation of a framework from which MG-Large can be analyzed;
2. Analysis of MG-Large through the lenses of lean production theory;
3. Identification of gaps between best practice and MG-Large; and
4. Determination of what have to be changed in order to become lean in the production (Solution design)

Having followed these four steps enables the answering of the first part of the main question stated in the projective objective.

The second analysis performed in this report is focused on how lean can be implemented. This question will be approached from a change management perspective as implementing lean is a change process in itself.
The analysis performed in the second part of the report is based on a theoretical framework, which is derived from lean implementation theory and change management theory.
The analytical structure of the second part of the report will take the following steps:

1. Identifications of the characteristics of a successful lean implementation and development of an analytical framework to analyze MG-Large from
2. Analysis of MG-Large through the lenses of lean implementation
3. Analysis of the organizational characteristics in regards to driving and restraining forces for an implementation of lean

Having conducted the two different analyses the analytical work in this report will be finalized and the report can then move into developing an implementation strategy and different tactics for operationalizing the designed solutions.

The overall analytical structure of this report can be visualized in the Figure 4 below:

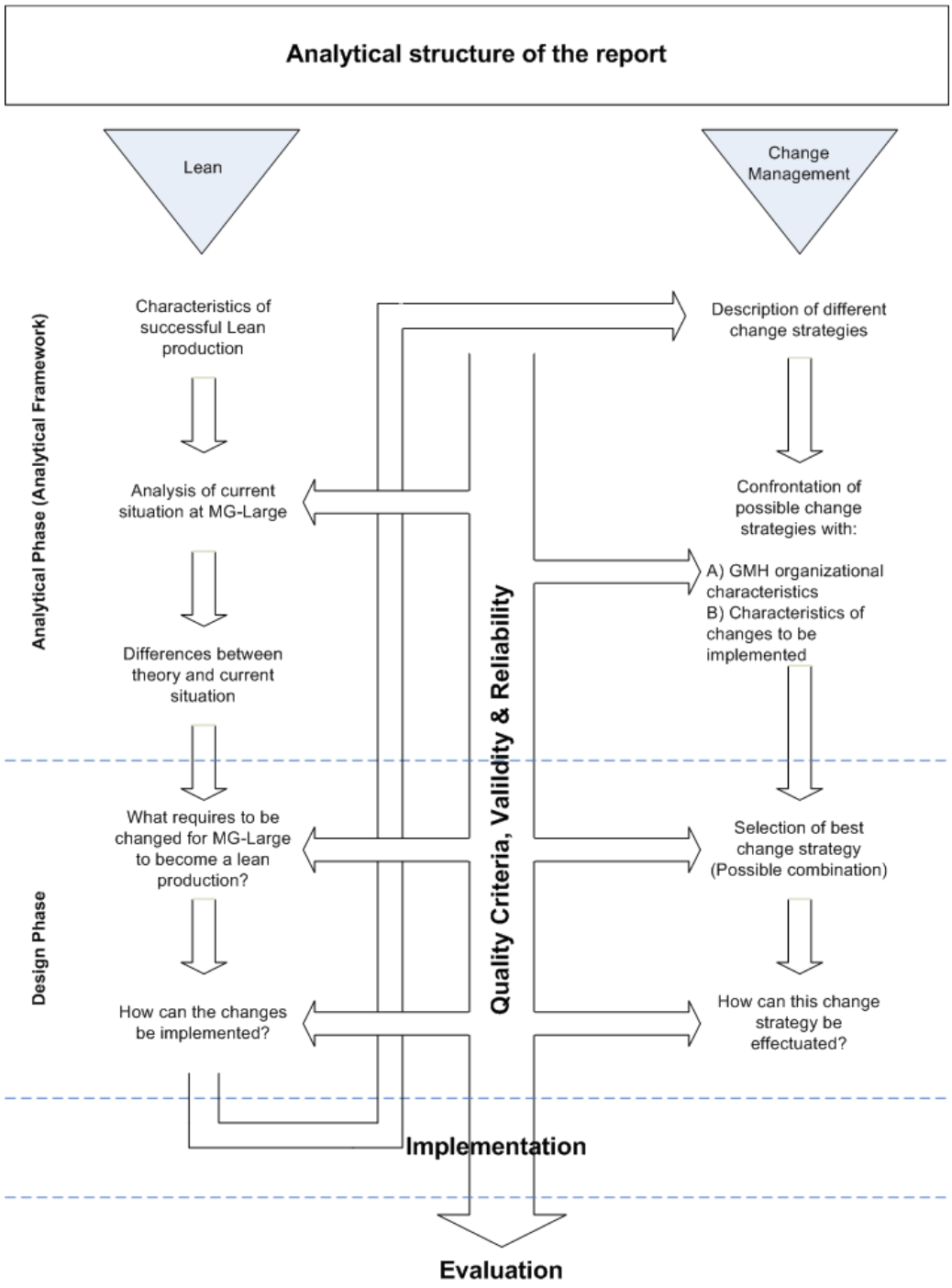

Figure 4: Overall analytical framework deployed in this project

The more specific structure of the individual analyses will be explained in the dedicated chapters.

6 Analytical Framework – Part 1

This chapter will describe the development of the first analytical framework used to answer, if lean is the solution to the performance problems in MG Large.

To develop the analytical framework for the first part of this report, lean theory has been reviewed in order to identify elements that should be present in a lean production. This is elements such as continuous flow, pull production, Kanban systems, focus on throughput time, short changeover times, flexible production system etc. The various characteristics have been clustered in six groups; production, management, processes, culture, people and technology.
Though management, culture, people and technology are not directly parts of lean production, these elements still have influence on lean production. This could, for instance, be willingness of management to allocate resources in making the production lean and subjects like this.
The theory used in this analysis is Womack, Jones and Roos (1990), Womack and Jones (2003), Slack, Chambers and Johnston (2004), Bicheno (2004), Rother and Harris (2001), and a review of this can be viewed in Appendix B1.

Table 3 displays the analytical framework utilized in this first part of this report:

Management:	**Production:**
• Customer focus • Understanding of lean and what it can be used for • Lean vision, lean strategy, lean direction, lean goals, and measurements • Continuous involvement in lean (commitment) • Continuous allocation of resources • Lean leadership • Understanding principles of value • Acknowledgement that lean is a philosophy and a journey • Clear communication • Definition of "lean production" • Alignment of lean with factory priorities	• Understanding of what waste is • Focus on elimination of the 7 forms of muda • Creation of a pull production • Focus on throughput time • Use of throughput time as a KPI • Use of Set-up time reduction (SMED) • Clear lean performance goals and measurements • Flexible production system • Use of Kanban systems • Focus on elimination of NVA-activities • Product layout (production layout based on the product) • Use of TPM • Stock area < 20%
Culture:	**Processes:**
• Supportive change culture • Long term focus • Proactive and sustainable change culture	• Focus on creating flow • Alignment of processes • Value Stream Mapping • Slowly integretion of 5s • Identification of the value stream • Focus on CI • House keeping • Kaizen events • Performance measurements • Focus on elimination of NVA-activities
People:	**Technology:**
• Involvement of shop floor employees • Motivation to change (no change fatigue) • Empowerment of the right personal • Sense of job security among shop floor employees • Feeling among shop floor employees that they are actually contributing to change and improvements • Focus on elimination of NVA-activities • Flexibility among shop floor employees • Continuous education in lean and lean principles • Understanding of why lean will improve the individual employees' daily work (Road maps)	• Use of ICT to measure lean progress • Dedicated lean change agents • Documentation of lean progress and use of lean tools (will be used to develop best practice)

Table 3: Analytical framework for lean production

The framework is here used as a long line of elements that have been identified as characteristics of lean production. By analyzing MG-Large based on the above framework, MG-Large is viewed through the lenses of lean production. Furthermore, the gaps between what *should* be present and what *is* present can be identified, which then will be treated in the solution design later in this report.

7 Findings of the Descriptive Analysis

This chapter will present the findings from the descriptive analysis. The findings are grouped according to the analytical framework used in the descriptive analysis. The findings will be used as input for the solution design, found in chapter 8.

The descriptive analysis of MG-Large can be found in Appendix C1. As the descriptive analysis is only focused on analyzing the context from which the performance problems emerges (MG-Large), only the findings and not the actual analysis is included in the main body of this report. The goal of this project is to solve the performance problems, not to give a comprehensive explanation of why they are there.

7.1 Management

The following elements were identified when analyzing the MG-Large management:

- No formalized lean vision, strategy, direction, goals or measurements
- Limited understanding of lean and its principles
- No support for implementing lean at the moment (April 2009)
- Sees lean as a set of tools and not a philosophy or a journey
- No mutual definition of a lean production
- No communication regarding lean
- Lack of involvement in regards to lean
- Limited resources allocated to perform “lean tasks”

Even though the MG-Large products have been released for sales and the production is classified as running normally, little attention and energy have been put into looking at the production system from a lean perspective. Top management has though expressed a desire to implement lean in MG-Large, but so far actions to fulfill this desire are very limited.
Though management has stated that lean is the solution to solving the problems, very limited work have been done to actual operationalize or commit to this statement.

7.2 Production

The descriptive analysis of the MG-Large production identified the following elements:

- Push production
- No focus on throughput times
- No focus on reduction of changeover times
- No use of SMED
- No performance goals or measurements in regards to lean
- Limited use of Kanban systems
- To some degree a flexible production system, but is flexible on the cost of time and productivity

- Limited focus on elimination of NVA-activities
- Approx. 11% of total production area used for stock, 53% space used for walking and transportation and 36% for production
- High levels of inventory (stock)
- Large amount of WIP in the production system at any given time

Production of components and the assembly of products are disruptive and inconsistent and a truly continuous flow only exists on the stator production line. There is little focus on eliminating waste and the levels of components, both components to assembly and finished products, are staggering. When talking through the production, the first that strikes the eye is the amount of WIP, the fragmented production and the number of shelves (6-8 meters high) for components.
The focus on utilization of capacity, due to long changeover times, creates large batches as batch sizes are set very high in order to keep changeovers at a minimum. This creates tremendous amounts of components in the production system at any given time.
Though the production was designed to support continuous flow, this is not utilized on many of the production islands. Each machine is working as an individual unit producing to stock, instead of producing to the next machine. The components are then moved back and forth from the stock to the production many times, even though the next machine is only a few meter away.

7.3 Culture

When describing the MG-Large culture the following elements were identified:

- Change is possible, if shop floor employees feel that they are contributing to the change or the change process
- The MG-Large change culture is not proactive, but more reactive in nature. Problems are only dealt with when they appear in the production and very little is done to take precautionary measurements against problems arising in the production
- Change initiatives must follow the hierarchical structure when decisions are required, if the changes will have any chance of being implemented, which is very time consuming

The culture among the operators at MG-Large is quit ambiguous sometimes. If approached with involving the shop floor employees, changing procedures or testing new ways of performing the daily operations are unproblematic and the operators are happy to participate and contribute. However, if they fell forced into doing things differently, the change is doomed.
The culture is not very proactive in regards to changes; if problems occur they are solved, but the root-causes to why the problems occur are rarely identified and solved.

7.4 Processes

The following problem areas were identified when the processes at MG-Large were analyzed:

- Continuous flow is used in part of the production such as the stator line and the assembly line, but not in the remaining part of the production
- Value stream mapping is not a integrated part of MG-Large yet and only very sporadically used
- No focus on CI or application of Kaizen events
- Implementation of 5s in parts of the production, but due to the changing nature of MG-Large 5s is not sustained and often only used in a limited period
- Very limited focus on elimination of NVA-activities, primarily due to lack of formalized tools to identify and analyze NVA-activities

As mentioned earlier, the MG-Large's flow of components are very disruptive and not following the paths for which the system was designed. Only the assembly and stator line displays continuous flow, though these two lines are not connected to each other. Components are put on stock directly after being produced in the different production islands, where the assembly line pick the needed components weeks or months later. Components do not flow from the production islands to the assembly line.
The production system is designed in a way so the different processes are fairly aligned supporting and allowing for a continuous flow, but this is not utilized in any way. This vast quantity of NVA-activities does not seem to concern management at the moment and it does not seem that any initiatives to change will occur in the near future.

7.5 People

Based on the descriptive analysis of MG-Large the following elements were identified:

- Low involvement of shop floor employees in the work of optimizing the MG-Large production system
- Low empowerment. The majority of decisions must be made high in the hierarchical structure
- Low motivation among the shop floor employees
- Low feeling of job security, especially among the operators due to the current world wide economic situation

Even though many of the operators possess much tacit and expert knowledge of their own process, they are very rarely included in discussions on how to optimize a given process or procedure. Operators are often only viewed as a set of hands used to perform simple tasks and not capable of contributing to any optimization discussion or event. This causes low motivation among the operators and creates negative feelings towards participating in CI or Kaizen events.
Low motivation is also identified among people higher in the hierarchy such as PT-engineers, planners, test-engineers etc. The main cause for this can be found in the organizational structure and the power structure that follows this. The majority of decisions are made by top

management, which often is a time-consuming and frustrating process that leads to a lack of motivation to be involved in projects, where decisions are a necessity.

7.6 Technology/Other

When describing the technology/other of MG-Large the following elements were identified:

- No dedicated change agents. The person responsible for a given change is often selected based on which department the change are related to and not who is best suited at performing the change
- Documentation is used as an integrated part of MG-Large, though it is only documentation such as work descriptions, CAD-drawings and process descriptions. Documentation such as throughput times, changeover performance, cycle times were only very limited.
- The SAP system is not utilized to measure elements such as throughput time, log changeover performance, monitor stock levels etc.

The MG-Large production has no dedicated lean or change agent. A lean-engineer is connected to the system, but the engineer is also responsible for running lean activities on the other seven production areas, so therefore it, again, is difficult to implement lean.
The MG-Large production system has been documented fairly well, though much of the documentation is work papers, drawings and descriptions on how to operate a given process, task or procedure. Only limited documentation exists on cycle times, changeover performance, lead times, throughput times and value identification. This type of documentation is yet to become an integrated part of MG-Large.

8 Solution Design

The objective of this chapter is to visualize and design solutions to the problems identified in the descriptive analysis in Appendix C1 and described in the previous chapter.

8.1 The Approach

The previous chapter illustrated the performance problems of MG Large. The management is aware of performance problems and therefore they, as mentioned earlier, stated that lean could solve these problems. The next step is to solve the problems theoretically (since an implementation is not possible at the current situation both in GHM 1 and worldwide). Lean and operations management is presented as best practice, and forms the foundation of the solution design.
The first step in solving the problems is to compare them with best practice. By doing so, a set of solutions are identified in regards to the individual problems, though, still at a theoretical level. The next step is to actually design a solution to a given problem by finding a balance between best practice and reality.

The developed solutions must be subjected to a set of quality criteria, which will determine if the designed solutions are actually implementable *and* usable to MG-Large, based on the currently situation, where the economic situation is heavily effecting the entire organization. This situation has some implications in regards to possible investments, commitments to any projects, management priorities and so on, that must be taken into consideration when designing and validating the solutions.

The designed solutions will be grouped in accordance to their relation to the performance problems. Lack of focus on changeover performance is in itself not a performance problem, but long changeover times are, and the solution to this problem lies for example in the implementation of SMED. A lack of pull in the production is not in itself a problem, long lead times, throughput times and WIP are, and the solution to this lies in the introduction of a pull production system. The designed solutions will be structured based on this line of thoughts

The solutions developed in this chapter are based on Operations Management [Slack *et al.*, 2004] and lean theory [Womack, Jones and Roos, 1990 and 2003]. The suggested solutions are developed by reviewing operations management and lean theory in order to find the best solution to the problem being investigated.

8.2 Quality Criteria

In order to ensure that the developed solutions are valid and exploitable for MG-Large, it is crucial to develop a set of quality criteria, which the solutions can be subjected to.
The set of quality criteria utilized in the solution design are the following:

- **Validity** – are the designed solution (or set of solutions) solving the identified problem?
- **Feasibility** – what effect will the change have versus cost of implementation?
- **Robustness** – what will happen with the implemented change when we turn our back?
- **Compatibility** – can the change be implemented with the current organizational characteristic?

Each designed solution is filtered through this set of quality criteria so the solutions for MG-Large are both valid and exploitable for the organization.

The following sections will be devoted to design solutions to the problems identified in the descriptive analysis and presented in chapter 7. Each problem will be treated individually, though if two or more problems are related, or have the same characteristics, they will be grouped and treated collectively.
As this report focuses on solving the MG-Large performance problems, the first focus of the solution design will be on the problems related to the production.

8.3 Production

Quite a few problems were identified in regards to the MG-Large production when looking through the lenses of lean production. Many of these problems can be linked directly to the performance problems and solving these problems should give a more lean production.

The problems identified were the following:

- **Very limited focus on eliminating the 7 types of waste**
- Push production
- No use or focus on throughput times
- No focus on reduction of changeover times; no use of SMED
- No performance goals or measurements in regards to lean
- Only limited use of Kanban systems
- To some degree a flexible production system, but flexibility on the cost of time and productivity
- Limited focus on elimination of NVA-activities
- Approx. 11% of total production area used for stock, 53% for walking and transportation space and 36% for production
- High levels of stock
- Large amount of WIP in the system at all times

Performance problem: Long throughput times

No focus on throughput time

To change this lack of focus on throughput times, MG-Large needs tools to measure the various throughput times. These tools were formalized as part of this project.

According to both Slack et al. [2004] and Womack and Jones [2003], the Value Stream Map[9] is a good tool to monitor the development in throughput times and can be used fairly easy. The developed VSM can be viewed in Appendix C7. As a procedure for calculating the throughput times were missing in MG-Large, this have also been developed and distributed to the relevant PT-engineers. With VSM, the processes which are adding significant time to the throughput time can be identified and actions can be taken to reduce these. The long throughput times adds to the long lead time, so by focusing on reducing the throughput times, the lead times will automatically also decrease.

It is advisable to use throughput time as a KPI[10], which will then force attention on this subject. Throughput time should be systematically and continuously measured and visualized in order to identify critical areas where actions are required to in order reduce the total throughput time.

Push production

According to Slack *et al.* [2003] and Womack and Jones [2004], the issue of push production can be solved if the system is changed into a pull system. This entails that the production of components are not started before there is a demand either from the following station or the assembly line. This will pull the components through the production system and dramatically reduce the WIP. Components will not be produced just because the machine is available or to utilize the capacity, but are produced because there is an actual demand further down the supply chain. For MG-Large this would entail that the component production does not produce any components before there is a demand for the components from the assembly line.

This can also be achieved by using simple Kanban systems with the right Kanban sizes. By utilizing such systems nothing is produced without a demand and only the required components are produced, which can also reduce stock levels. Slack *et al.* [2004] has a good visualization (Figure 4) of how a push system builds WIP and why a pull system does not.

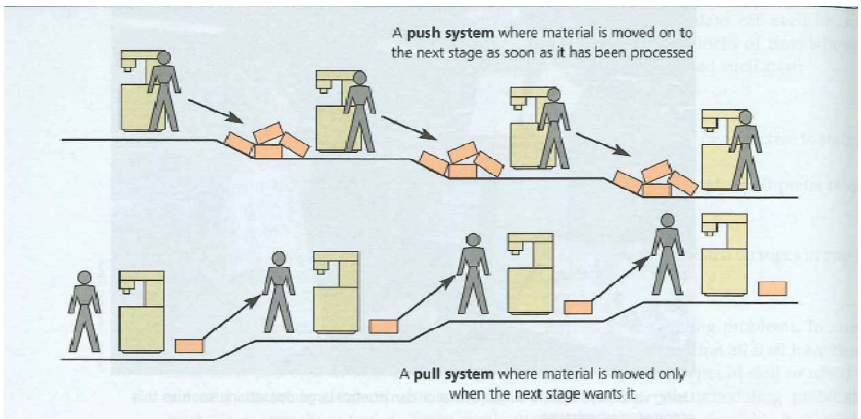

Figure 4: Pull vs. Push production

[9] VSM
[10] Key Performance Indicator

In a push production components are pushed down the slope to the next process, which causes components to accumulate before each machine or process. In a pull production each component is pulled through the system by each machine or process signaling to the previous machine that it is idle and ready for a new component. This way accumulation of components is non-existing and WIP is minimal.

Performance problem: High stock levels and WIP

Limited use of Kanban systems

The Kanban system is a perfect tool to prevent overproduction of components. By using the Kanban system components are only produced when there is an actual demand. The use of these systems together with a flexible production system will reduce stock levels, WIP and throughput time. Kanban sizes can be adjusted after the implementation phase to fit the demand. One of the prerequisites for introducing Kanban systems is a flexible production system and here SMED is an important tool. The use of Kanban will also support a pull production.

High levels of stock and WIP

The high level of components kept on stock and the large amount of WIP is closely connected to all the problems described in the beginning of this section. Solving issues such as the long changeover time and material flow (this will be treated later in this chapter) will automatically create stock reduction and less WIP. Low changeovers times and a flexible production system together with a sound planning will reduce stock levels and the WIP. Creating continuous flow within the different productions islands and connecting this to the assembly line will also reduce the WIP and stock levels significantly.

Performance problem: Long changeover times

Long changeover times and lack of focus on reduction/No use of SMED

The total lack of focus on changeover performance and reduction of set-up times are very critical for the MG-Large flexibility and productivity. One of the goals from the management is to have a flexible production system, that can produce components to two assembly lines (MG 112/132 and 160/180), but this requires a focus on changeover performance that are currently completely lacking.

The implementation of SMED on the machines with long changeover times should solve the problem of long changeover times and also allow for a more flexible production system. By reducing the long set-up times the batch sizes can also be reduced, which will decrease the WIP and also the need of stocking large quantities of components produced on machines with long set-up times. A SMED framework has been developed and tailored to fit the context of MG-Large. This framework illustrates how SMED should be used in MG-Large and provides a structured approach for applying SMED. This framework can be viewed in Appendix D1.

Performance problem: Area utilization

Area utilization

More than 50 percent of the MG-Large production area is used as walking and transportation space. Currently, this is not at problem, but on a future basis the area can be utilized much more effective. If continuous flow is established between both machines and production islands, the area required for truck lifts and others can be reduced significantly, which releases more space for the installation of new machines or other production equipment. Mapping the MG-Large area in terms of space used for inventory, walking and transportation space, and space for production equipment can visualize which areas could be utilized more efficiently. A map over MG-Large is included in Appendix C5 and it visualizes what the different areas are utilized for.

Performance problem: Low production productivity

No performance goals or measurements

Performance measurements should not only be limited to the bottlenecks and assembly line. Each machine and/or process should have a target and a mean of measuring its performance. By doing so, it will forces the engineers, supervisors and shop floor employees to optimizing each process and machine in order to achieve the performance goals.

Measuring bottleneck only shows how the critical machines are performing, but not the remaining part of the production. The production should be measured in regards to performance both on an overall level and on individual machines. This will allow for a much more detailed picture of the production and where optimization is required in order to meet the overall goals and demand.

Limited focus on NVA-activities

The lack of daily focus on eliminating non-value-adding activities just builds to the pile of redundant activities being performed in the daily work. Eliminating these activities is something Grundfos themselves, according to the lean forum on Grundfos Insite, views as an important part of lean production. Employees must be trained in identifying and systematically reducing or eliminating NVA-activities. By training operators and production people to focus on the subject of waste reduction (all 7 types), elimination of NVA-activities will become a natural part of the daily operations. This means that improvement suggestions will become part of the MG-Large mentality and thus will CI also become an integrated part of MG-Large.

Performing “waste walks” would also be a helpful tool. Waste walks are when following the route of a product and identifying all the processes that are not adding value to the product (transport, stocking, wait etc.) and subsequent developing solutions to eliminate the problem areas.

8.3.1 Production solution design vs. quality criteria

The suggested solutions are mainly focused on developing a more flexible production system in MG-Large, which produces components and motors when, and only when, there is a demand. This requires focus on issues such as changeover performance, pull production, use of Kanban systems and many more. In general terms; focus on eliminating waste and NVA-activities.

Validity: Implementing the just described solutions design to MG-Large will improve the production performance and help the management reach their stated goals. Stock levels will decrease, flexibility will increase, WIP will be reduced dramatically and the throughput time will also be reduced as the components are not kept on stock, but are pulled directly through the production system.

Feasibility: The designed solutions do not require major investments as they are focused on changing processes and procedures, not technologies or the purchase of addition production equipment. The resources required to implement these solutions are minute compared to the possible benefits. As the problems are directly related to the production it would be natural to include solving these issues in the job description of the PT-engineers.

Robustness: If the solutions are implemented correctly, the principles of should become part of the daily operations and the way things are done in MG-Large. Involving shop floor employees early in the implementation processes would facilitate the robustness of the changes, though the changes would presumably need monitoring in the beginning. If the changes can be visualized for the shop floor employees in regards to how it would make their daily work easier, the changes would be embraced more easily.

Compatibility: Things have to change if the changes are to be implemented. Focus on eliminating waste must become a natural part of the daily work and management must be willing to allocate the required resources for doing so, if the stated goals are to be reached and if MG-Large is to be transformed into a lean production system.

8.4 Management

Though management is not responsible for the low performance, they are still responsible for changing this problem. They are responsible for allocating resources, creating strategies and directions for MG-Large and they must define the goals and exercise the supported required to changing the production system.

In regards to the MG-Large management the following problems were identified:

- No formalized lean vision, strategy, direction, goals or measurements
- Limited understanding of lean and its principles
- No support for implementing lean at the moment
- Sees lean as a set of tools and not a philosophy or a journey
- No definition of lean production
- Lack of alignment of lean with factory priorities
- No communication regarding lean
- Lack of involvement in regards to lean
- Limited resources allocated to performing “lean tasks”

The problems are grouped accordingly to which performance problem they relate to.

Problems: Missing focus on lean and lean principles

No formalized lean vision, strategy, direction and goals

If a lean production is the goal for the management, it requires a set of guidelines such as a vision, strategy, goals and a direction to keep lean on the right track. The solution to this issue is fairly simple; develop a set of conditions that can lead lean. This means developing a lean vision, strategy and directions showing how MG-Large will look from a lean perspective, how it should be implemented and utilized, and what goals management expects to obtain through the implementation of lean.

Formalizing a definition of lean production will also help employees understand lean and how it can benefit both the production performance and their own jobs. A definition of lean production could be something in the line of:
"To be a lean manufacturer requires a way of thinking that focuses on making product flow through value adding processes without interruption (one piece flow), a pull system that cascades back from customer demand by replenishing only what the next operation takes away at short interval, and a culture to improve" (articulated by Liker, 2007).

Limited understanding of lean and its principles

It is vital for the success of lean that the management understands what lean is capable of and how it can be utilized. To understand lean and lean principles requires training, education and a willingness to explore unknown areas. Literature on lean is endless growing and an easy accessible source of creating fundamental knowledge of lean and what lean is actually about. Readings such as Womack and Jones' "The Machine That Changed the World" and "Lean Thinking", creates a solid foundation for understanding lean and its mechanisms. Their books explain the fundamental principles of lean, and then operationalize the principles through case studies of Toyota and other successful "lean companies". This will also help eliminate the current way of looking at lean; as a set of tools that can be utilized in an *ad hoc* fashion to solve performance problems, which is not the correct understanding of lean.

Alignment of lean with factory priorities

If lean is related to factory priorities such as low lead time, low stock levels, low throughput time, and high delivery performance etc., lean becomes the solution to reach these goals, instead for an "idea" being tested in the corner of the factory. Development of road maps showing how lean could and will improve each of these individual elements, will create a natural link between lean and "the way we do (or should do) things around here".

Problems: Involvement and resources

Lack of involvement

Management involvement in lean activities is very important if they are to stand any chance understanding the benefits of the different lean tools.

The management must be involved in lean to show support and commitment, but also to keep lean on the right track. Management involvement shows that lean is something the company commits to and is determined to pursuit. Besides this, if managers are involved in various lean events they would also display interest, which is often a source of encouragement and often will make people work harder in the pursuit of great results to show management. This involvement will also allow the managers to much more clearly communicate results both within the organization and to the outside world.
The solution to lack of involvement is simple: managers should attend meetings (not all of them), observe tests or discusses approaches, methods, goals etc. with the involved people, which would display involvement and interest without having to allocate vast potions of their time.

Resources
Resources are required to reach the stated goal. Implementing tools such as SMED requires time, which must be taken from the engineer's, tool-setters, and operator's and various others schedule. If the management is not willing to release these resources and accept that production could suffer momentarily during the implementation phase, lean will ever be implemented. Every change, small or large, requires resources to be executed.

8.4.1 Management solution design vs. quality criteria

These solutions are not directly related to increasing the MG-Large performance, but will create the right conditions for implementing lean as a mean to improve the performance. The solutions are related to a change in attitude and the development of guidelines. Management must show a high degree of commitment, interest and willingness to allocate resources and they must move away of the short term focus on the bottom-line and focus more on what is beneficial for the company in the long run.

Validity: The solutions are not directly related to the performance problems, but will diffidently create the right conditions for solving the performance problems.
Feasibility: The implementation of these solutions requires no investments financially speaking, only the management's investment of involvement, commitment and interest.
Robustness: The changes relate to attitude and behavior, so when first changed they should stay the same.
Compatibility: As the solutions are focused on changing the organizational characteristics the compatibility is fairly low at the moment, but based on the knowledge of the organization, the suggestions should be implementable.

8.5 Culture

The MG-Large culture cannot be related directly to the performance problems, but do still have a certain effect on the problems and especially the solution to the problems.

The analysis on the MG-large culture identified the following issues:

- Change is possible if shop floor employees feel that they have contributed to the change or change process. If not, the change process becomes very difficult
- The MG-Large change culture is not very proactive, but more reactive. Problems are only dealt with then they appear in the production and very little is done to take precautionary measurements against problems arising in the production
- Change initiatives must follow the hierarchical structure when decisions are required, if they must stand a chance of being implemented, which is very time consuming

Problem: Changing things

Reactive change culture

Managers and PT-engineers must be made accustom to discover initial signs of problems before they occur and not only react to problems after they have occurred. If problems with material flow to the assembly line are problematic now, it will definitely become larger when the demand increases. Solving the material flow problem when the demand is still low, even though maybe not essential to solve now, creates the right conditions for the assembly line to meet the demand when it increases.

A different solution to the reactive change culture can also be to involve the shop floor operators on matters of continuous improvement. The operators are the closest people to the daily operations and the first to discover problems with the production. Having close relations to the shop floor employees allows the managers and engineers to quickly discover, and thus also quickly act on production issues affecting the performance level.

Problem: Hierarchical structure

Decision making process

As described earlier, the decision-making process is close related to the hierarchical structure, causing a lengthy decisions-making process. Empowerment and the deployment of autonomous teams are the solution to this problem. Any decision should be made on the lowest level and as close to the problem as possible to ensure a quick decision and often also a correct decision. Management must empower people further down the hierarchical structure to make decisions within their field of responsibility. This will also reduce the quantity of decisions having to be made by managers, hence also allowing them to spend more time of elements such as development of lean strategies, goals, measurements and involvement in lean activities.

8.5.1 Culture solution design vs. quality criteria

Cultural aspects are always difficult to change and the MG-Large culture is no exception. Management need to empower people further down the organization to make decisions close to the problems. Doing so will also allow for a more proactive change culture where issues are solved before turning into large scaled problems requiring major resources to solve. Delegation of power is the key word and solution.

Validity: The solution will create the right conditions for implementing changes (e.g. lean) that will solve the performance problems.

Feasibility: The solutions are cost free to implement, but requires a shift in mentality both on the shop floor and among the managers.
Robustness: When the changes are implemented they automatically become a natural part of the culture, e.g. that decisions are made on the shop floor and not in the manager's office.
Compatibility: The solutions are changes in the organizational characteristics, so currently the compatibility is low.

8.6 Processes

The process issue can only partly be linked to the performance problems, but are yet again essential for creating conditions for solving the performance problems.

From the analysis of processes the following problems were identified:

- Continuous flow is only utilized in production areas such as the stator line and the assembly line, but not in the remaining part of the production
- Value stream mapping is not a integrated part of MG-Large yet and only used very sporadically
- No focus on CI or Kaizen events
- Implementation of 5s in parts of the production, but due to the changing nature of MG-Large 5s is not sustained and often only used in a limited period
- Very limited focus on elimination of NVA-activities primarily due to lack of formalized tools to identify and analyze the NVA-activities

Performance problem: Disruptive material flow, stock levels and WIP

Continuous flow and CI
The production system was designed to support a continuous flow of components between the different processes and to the assembly line, and in order to solve the problem of a fragmented material flow the design of the production system must simply be utilized as intended.
Instead of having each individual machine produce components that are then put on stock, components should flow directly from one process to the next, just as the system was designed. The concept of continuous flow has been tested on the Shaft and Rotor Island without any major problems[11]. When continuous flow has been reached within the different productions islands, the assembly line can then be connected to the flow. This entails that components flow through the productions islands and directly to the assembly line. This will also reduce the stock levels and WIP as produced components are used immediately in the assembly line.
Continuous improvement can also be utilized to create a better material flow and to develop ideas to how stock levels and WIP can be reduced. It is the operators whom are closest to the problem and have often many ideas on how the solve them. Improving material flow, stock levels and WIP in small steps will also ease the implementation process in regards to the operators.

[11] Continuous flow tests were conducted on several occasions in the production in April 2009

Performance problem: Long throughput times and high stock levels

Value Stream Mapping (VSM)

By utilizing VSM, the sources of the extensive throughput times can be identified and actions can be taken to reduce these sources. When operating with throughput time as a KPI it will automatically direct attention to the subject and actions to reduce throughput time can be taken in order to reach an acceptable KPI level. Value stream maps for MG-Large have been developed (Appendix C7) and instructions on utilization has been distributed to the relevant PT-engineer. The value stream maps will be used in the future as a tool to reduce the throughput times and monitor inventory levels.

Using value stream maps will also identify stock levels of the individual components and what group of components must be reduced, or where components are accumulating. Actions towards reducing inventory or optimizing the bottleneck(s) can then be taken.

Performance problem: Low production productivity and area utilization

CI, 5s and focus on elimination of NVA-activities

By introducing CI, and systems to support CI, many of the minor problems and issues experienced in the daily operations can quickly be solved and it only requires a small amount of resources. Shop floor employees are trained to solve problems before they develop and affect the production performance. If the shop floor employees have formal channels to utilize when spotting problems or developing ideas for improvement, the given subject can quickly be discarded, subjected to further investigation or simply be implemented.

5s is a useful tool when standardizing work and can ensure that different procedures and processes are performed identically every time. 5s has been implemented in certain areas, but due to design changes in the procedures and processes, 5s is not maintained or utilized. The 5s techniques should be used in conjunction with improving workplace layouts.

Managers and supervisors have to be vigilant to make sure the proper habits are created and maintained.

Focusing on the elimination of NVA-activities will slowly eliminate all activities that are not adding value to the product, and will in return improve the performance by only performing work that are actually adding value to the end-product. Eliminating NVA-activities will allow components to flow through the production without being put on stock, waiting to be processed, transported back and forth or similar, which in return improves the performance, eliminates the demand for shelves and space dedicated for stock. This space can then be utilized for production purposes.

8.6.1 Processes solution design vs. quality criteria

The solutions are targeted on implementing functions that will help increase the production performance by taking small steps and using tools that will identify where focus, in regards to optimization, can and should be directed. Elimination of NVA-activities and CI will then focus on

improving these areas and create the conditions for increasing the production performance on an overall level.

Validity: The solutions will put centre on solving the performance problems, but is also contributing with tools to solve these problems. Value Stream Mapping and CI are two important factors in this process.
Feasibility: As the solutions are process-orientated it only requires that engineers and managers are willing to spend time on mapping and discussing current processes and procedures and then afterwards change and implementing new procedures and processes.
Robustness: Elements such as value stream mapping and CI cannot be left alone. Value stream maps must be updated due to the dynamic nature of the production and CI must be utilized and maintained. Implementing the designed solutions requires monitoring and continuous use and it must become a part of the daily and weekly operations in order to maintain robustness and validity.
Compatibility: The designed solutions can be implemented, though it requires a shift in mentality among supervisors, engineers and managers to maintain and use tools such as VSM, 5s and CI.

8.7 People

People are an essential factor in improving the performance. Certain conditions must be present to facilitate people's pursuit for better performance so in order to create these conditions the following issues must be solved:

- Low involvement of shop floor employees in the work of optimizing the MG-Large production system
- Lack of empowerment, the majority of decisions is made high in the hierarchical structure
- Low motivation among the shop floor employees
- Low feeling of job security, especially among the operators due to the current economic situation, which is also effecting MG-Large and its employees

Many of these issues have been treated before in the previous suggested solutions, so repetition can occur in this section. In this section though, the issues are directly related to the performance problems.

Performance problem: Low production productivity

Shop floor employee involvement
Involving the shop floor employees in CI and other optimization projects and events will create focus on improving the performance and create a culture where the people on the factory floor are capable of identifying problems and develop solutions, instead of showing no interest in optimizing the production. Involving operators and other shop floor employees in continuous improvement will also provide training in identifying and eliminating waste across the production and thus improve the production performance.

Empowerment

To allow problem solution at the lowest level possible, empowerment is essential and usable for problems being solved quickly without the use of too many resources. Management must delegate power to people further down the hierarchical structure, which will also reduce the amount of decisions managers have to make on a daily basis.

Empowering shop floor employees, engineers, supervisors etc. allows for problems to be solved before they can have an impact on the performance and will often also facilitate the correct solution and decision to be made.

Motivation

Motivating people to perform better can have a direct impact on the performance and also create a better work environment, where involvement and interest in improving the production is encouraged by managers and engineers. People "above" the factory floor must motivate shop floor employees to take interest in their work and personally contribute to the improvement of their area of responsibility and to the general production performance. Managers, engineers, supervisors etc. can do this by showing interest in what the shop floor employees have to say, if they have any improvement suggestions or if they see any immediate problems in their work area.

Job security

Creating a sense of job security among the shop floor employees could be a key to improving the performance. If people on the factory floor feel that their job is fairly secure, they are often more motivated to get involved in changes and contribute to finding ways to improve the performance.

Having a sense of job security allows engineers, supervisors, planners etc. to test different configurations of e.g. material flow, processes, procedures, planning systems etc. by trial and error without the fear of losing their job due to a temporary decrease in performance.

8.7.1 People solution design vs. quality criteria

The solutions are focused on involving employees in improving the production performance and providing them with tools and power to do so, without having to follow the hierarchical structure on each individual decision having to be made. Motivation and empowerment are two important factors in the pursuit of improving the overall production performance. It has been mentioned before, but as lean is about changing the current situation people are a essential part of the solution.

Validity: The designed solution will facilitate the creation of conditions supporting an improvement of the production performance and the creation of an environment, where decisions can be made fast and close to the problem.

Feasibility: The implementation of solutions will create conditions allowing for a fast solution of production related problems, but requires a shift in mentality and attitude towards the shop floor employees and their involvement in improving the performance.

Robustness: The changes must be maintained in the sense that e.g. empowering shop floor employees or engineers are not a temporary process, but a shift in company culture. Motivating people are a never-ending process and involvement of shop floor employees should be natural.
Compatibility: Implementing the designed solution requires management to delegate power so the employees can make decisions, which is currently not a characteristic of the MG-Large management. The management must also develop their skills in regards to motivate people and encourage their employees to motivate people further down the organizational structure.

8.8 Technology/Other

Technology is a helpful tool in the pursuit to improve performance, where e.g. ERP systems can provide data to target where improvements are required or most urgent.

From the analysis the following problems were identified:

- No dedicated change agents. The person responsible for a given change is often selected based on which department the change "belongs" to and not who is best suited at performing the change
- Documentation is an integrated part of MG-Large, though very focused on work description, work sequence, drawings etc.
- The SAP system is not utilized to measure elements such as throughput time, log changeover performance, monitor stock levels etc.

Performance problem: area utilization, low productivity, long throughput times, disruptive material flow, high stock levels

Change/Lean agents
Having dedicated change or lean agents will ease the implementation of the solutions suggested throughout this chapter and ensures that there is constant focus on the elements mentioned in the designed solutions. Though it is quite a resource to allocate one employee to change the current situation, it will prove beneficial in the long run having an employee pursuing optimizations as the main tasks. Experiences obtained through pervious work on optimizing MG-Large could then be used in other production areas.

Documentation
Optimization projects such as SMED, creating continuous flow, developing Kanban systems etc. must be documented, so the knowledge and experiences is converted from tacit knowledge to explicit knowledge, which then can be utilized by the entire organization in the future. It will also allow for a much more structured approach to optimize production elements, by formulating objects, goals, strategies etc. before commencing the actual change.

SAP system as tool to measure
SAP contains much of the data required to start implementing some of the suggested solutions such as VSM, overview of stock levels, measurement of throughput times etc. SAP has a function that can be configured to automatically measure throughput times, which can then save

resources doing so. Stock levels can easily be measured and actions can be taken to reduce the components with high stock levels.
Changeover performance can easily be feed into the system so it can be monitored in regards to improvements and ensure that the performance do not decrease for instance after a SMED event on a given machine.

8.8.1 Technology/other solution design vs. quality criteria

Implementing the changes will create useful tools that can be used to optimize the performance. Especially, the deployment of change agents to facilitate the development and implementation of changes would be a useful tool. Documentation is also an important factor in capturing learning and experiences, which could be beneficial to others.

- **Validity:** Implementing the designed solutions in this section will create conditions for improving the performance problems.
- **Feasibility:** Though the solutions require some resources, the return on investment will be far greater and very beneficial for MG-Large in the long run.
- **Robustness:** The changes must be utilized and exploited to prove its value
- **Compatibility:** Currently, management is not willing to use the required amount of resources, which has to change if the suggested solutions stand any chance of being implemented and used.

9 Discussion of Solution Design

The objective of this chapter is to discuss the solutions designed and described in the previous chapter. The discussion will answer the first part of the project objective before moving into the second part of the report.
This chapter will answer the following questions:

Is lean the right solution and will lean actually solve the performance problems?

Will lean help MG-Large reach the stated goals?

Lean *will* solve the majority of performance problems by implementing lean mentality, principles and utilization of lean tools to create the conditions needed to reach the stated goals. Implementing the designed solutions and making them part of the daily operations will create a flexible production system that only produces what is demanded when it is demanded – Just In Time. Stock levels will be reduced, WIP kept to a minimum, continuous flow of components within the production islands and continuous flow to the assembly line, significant reduction of throughput times and flexibility due to short changeover times. These elements will all become a reality, if implementing lean in MG-Large. The majority of the designed solutions can be implemented with a minimal use of resources, because it is a matter of doing things differently, not buying new machines or technologies.
But it all comes at a prize: Implementing the designed solutions and becoming a lean production requires a shift in mentality and attitude on all levels of the organization, if lean is to stand any chance of succeeding.
One of the problems in the implementation of lean can be the culture of the Hungarian management, they needs to share their power with the employees, however, this might be a difficult process due to the nature of Hungarians. (This will however not be analyzed in this project, since it is a topic of its own). The organizational characteristics could both support or prevent an implementation of lean and this is a matter that must be treated before trying to go lean. This subject will be treated in the following parts of the report.

Lean is not a quick-fix to solve momentary performance problems and reach short-term goals; it is a way of thinking that must imbue the organization from top to bottom.
Transforming MG-Large into a lean production requires a major effort from all the employees connected to the MG-Large unit and a willingness to change the-way-we-do-things. MG-Large must be viewed through the lenses of lean, focusing on identifying and eliminating every possible source of waste in every single process, procedure and task going into producing the MG-Large products.

Implementing the solutions is not an easy task and requires just as much effort as developing the solutions, if not more. If the implementation strategy is wrong or the operationalization tactic is a misfit between the solutions and the organizational characteristics, implementing and maintaining the changes stand little chance of succeeding. And this is what the next part of the report will focus on – developing an implementation strategy and tactic tailored to fit the organizational characteristics of MG-Large.

10 Now What?

Until this point the focus has been on lean and what is requires running a lean production. The MG-Large production system has been analyzed through these lenses and critical elements linked to the performance issues have been identified. Solutions to overcome these problems and issues have been developed and subjected to a set of quality criteria to ensure that the solutions are actually exploitable for MG-Large.

The next step is now to focus on the implementation process. One thing is developing the solutions; to implement them is an entirely different process. The remaining part of this report will be devoted to this given subject; the development of an implementation strategy tailored to MG-Large.
In order to develop this implementation strategy, answering of the following question from the project objective is required:

"How can the lean production solutions be implemented taken the organizational characteristics into consideration?"

To answer this question, two additional questions must be asked. These questions will help elements that will be used in the development of a lean implementation strategy, which is tailored to MG-Large. The questions are:

"What are the organizational characteristics in regards to lean implementation?"

"Which of the organizational characteristics are working to support a lean implementation process and what characteristics are working against such an implementation?

By answering these questions, which is done by analyzing MG-Large through the two analytical frameworks presented on the next page, an implementation strategy for implementing the designed solutions will emerge to support MG-Large in an implementation process.

The report will now move into describing the development of the two analytical frameworks used to analyze MG-Large in a change management perspective.

11 Analytical Framework – Part 2

This chapter will describe the development of an analytical framework used in the second part of this report. The focus will be on change management, more specifically lean implementation and determining organizational characteristics.

11.1 Lean Implementation – The Process

This first analytical framework (descriptive analysis) was focused on characteristics of successful lean production, whereas this framework focuses on the process of implementing lean, more specifically the characteristics of successful lean implementation. This framework, which serves as representative for "best practice", is compared with the description of MG-Large and elements identified as essential for the implementation process.
The characteristics of successful lean implementation are derived from lean implementation theory and for an elaboration of the depicted framework below (Figure 5) and the utilized theory, see Appendix E1.

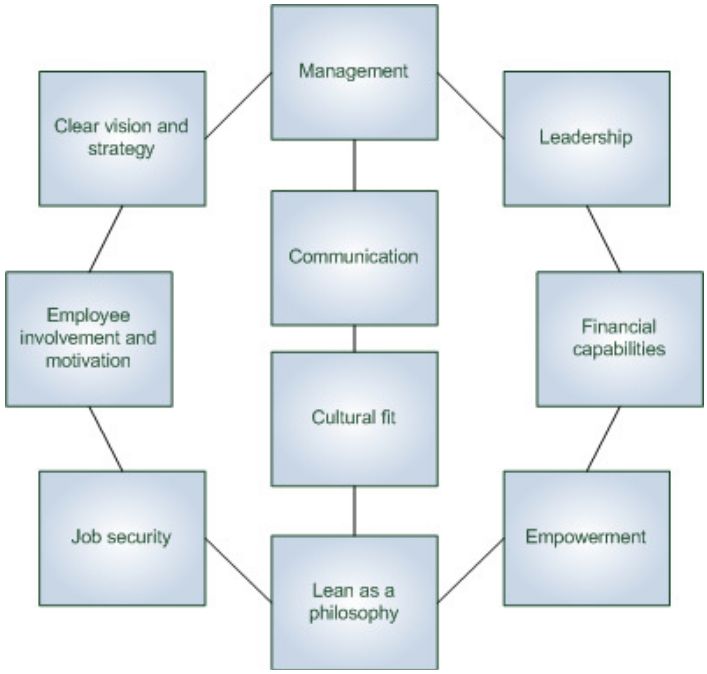

Figure 5: Analytical Framework - Lean Implementation

Each box represents an element/subject important to a successful implementation of lean.
This analytical framework will identify the gaps between "best practice" and the current situation at MG-Large. The findings from this analysis will then indicate where changes are to be made if the best conditions for a lean implementation are to be created. Findings from conducting the analysis, for which this framework has been developed, will be used in the third and final analysis, which will focus on the organizational characteristics and what forces (organizational characteristics) are working for and against an implementation of lean.

11.2 Change Management

Change management will be utilized to determine the right strategy and/or tactic for a lean implementation process. In order to determine what strategy or tactic is best suited for implementing lean on MG-Large an analysis of the organization is required. For this purpose Lewin's Force Field analysis is utilized in this report.
The Force Field analysis will use the findings from the previous analysis to structure driving and restraining forces in regards to a lean implementation process. With these forces identified it is possible to commence the development of an implementation strategy by focusing on the characteristics of the suggested changes and the forces working against implementing such changes. The task then becomes to reduce and/or eliminate the restraining forces and boost the driving forces.

Lewin's Force Field analysis will determine the organizational characteristics, which then can be taken into consideration when developing a tailored strategy or tactic for implementing lean in MG-Large. The Force Field analysis will build on the findings from the descriptive and implementation analysis, but also include subjects that are not directly related to these two analyses. This can be subjects that have not emerged from the previous analyses, but can be characterized as a driving or restraining force.

Lewin's Force Field analogy is depicted in the following figure (Figure 6):

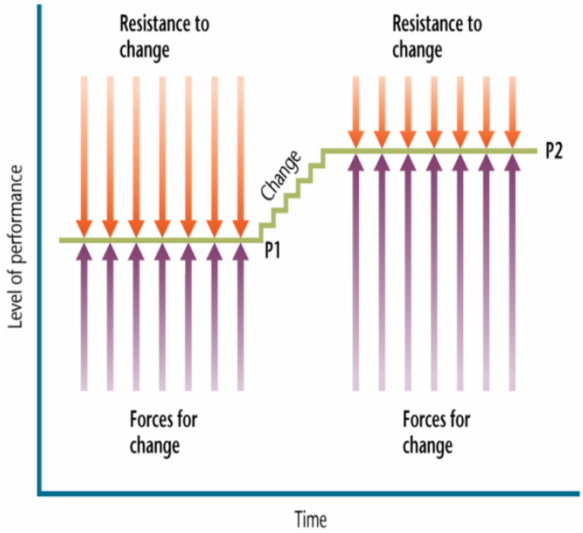

Figure 6: Lewin's Force Field analysis

Lewin's methodology is fairly simple to follow. The analysis consists of seven steps that will identify driving and restraining forces, discusses how they correlate and how the driving forces can be strengthened and how the restraining forces can be eliminated. To see further elaboration of the steps and the model, see Appendix E2.

12 Analysis – Lean Implementation

This chapter is devoted to the analysis of MG-Large compared to characteristics of success lean implementation in order to determine what characteristics for a successful implementation process is present and what elements are lacking.

12.1 Lean Implementation – "Best practice" vs. MG-Large

This analysis is based on the framework presented in chapter 11 and Appendix E1. MG-Large is filtered through this framework and the gaps between best practice and MG-Large is identified. The analysis identifies what elements of successful lean implementation are present at MG-Large and what elements are not. These gaps will be used as input to the Force Field analysis and the following discussion and development of a change and implementation strategy or strategies.
To avoid iteration of the same elements described in the descriptive analysis, references to that analysis (Appendix C1) will be used.

12.1.1 Management

As mentioned in section 7.1, there is a big gap between best practice and the MG-Large management, which is the same picture drawn when analyzing the management in terms of a possible lean implementation process. The MG-Large management is currently neither committed, involved nor very supportive in regards to implementing lean. Their focus is on finding the path through the current economic situation, which is affecting GMH1 in a high degree. The only manager that has truly expressed support to a lean implementation is the Production Manager and General Manager. Though lean do not collect much support at the moment the General Manager of Grundfos, Hungary, has expressed his support to implement lean on MG-Large in the near future or when the economic situation loosens its grip and thus also the restraints it is effecting.[12]

12.1.2 Leadership

Lean leadership is not part of the Hungarian or MG-Large culture. The managers manage the lower hierarchical layers and the power structure is an important factor in that relation. MG-Large bears no characteristics of lean leadership or leadership in general, which mainly can be contributed to a lack of understanding of lean and lean principles among the managers. Managers do not motivate or encourage their employees to get involved in activities, such as an upcoming lean implementation, they merely orders the employees to participate. Through interviews one got the feeling (and sometimes told directly) that many of the employees were frustrated due to a lack of good leadership. Directions, guidelines, messages etc. is/was unclear and ambiguous. One day the managers wanted one thing and next day they wanted the exact opposite.

[12] The support of lean from the Production Manager and General Manager was expressed in several interviews conducted during the internship

12.1.3 Clear lean vision and strategy

Due to the lack of focus on lean so far, thus also the implementation process, no lean vision or implementation strategy exists. Based on interviews only the Production Manager has a vague idea on how lean should be utilized, but have far from any strategy for how to implement it. Without a formalized lean strategy, the implementation process has no direction and currently nothing is being done to formalize any lean or implementation strategy.

12.1.4 Financial capabilities – Allocation of resources

Lean implementation is currently far from a top priority at MG-Large, hence no resources have been allocated. None of the PT-engineers dedicated to MG-Large have any thought, what so ever, on lean or implementation of lean. The attached Lean-engineer's primarily task is mapping and measuring of different processes, which can be utilized in a future lean implementation (though the measurements are possibly outdated). None of the people involved in MG-Large have (both from themselves and management side) allocated any time daily, weekly or monthly dedicated to discuss lean or an implementation process, strategy or tactic. All their time goes to execute the daily work and the continuous rise of problems and obstacles to overcome.
Though currently no resources are allocated to focus on lean, the management has previously displayed willingness to initiate projects demanding large amounts of resources[13] both internal and externally. On several occasions the Production Manager and the Factory Manager stated that if a project such as lean was presented under the right conditions (project plans, goals, strategy etc.) they would support such an initiative with the required resources.

12.1.5 Communication

Communication on issues related to MG-Large is fairly good due to the OP-team[14] and their daily morning meeting. During these meetings they discuss problems, new information, changes, concerns etc. and communicate them to the involved parties so everybody is informed on the current situation. The management is though not represented at these meetings, so if decisions are to be made this is done on meetings afterwards. If the management needs to distribute information on general issues or on decisions made, the general approach is by email, talking the each individual person or by a meeting. The general picture, based on interviews and observations, is that the management (Production, Engineering, Logistic and Quality Managers) is not very well-informed in regards to the daily problems or issues in and with the production or other departments, and the employees are also not very informed in regards to what management are doing in regards to solving some of the more overall problems.

12.1.6 Employee involvement and motivation

As lean is still far from becoming a reality, shop floor employees are not currently included in any lean activities and people above the factory floor are similar not included in developing a lean and implementation strategy and tactic.

[13] Time, money, training, education and consultant
[14] Operations team – Consists of PT-engineers, planners, representatives from the production, supervisors and maintenance

Engineers and supervisors are equally not encouraged to implement lean principles or perform lean activities. The management is currently also doing nothing to motivate its employees in regards of thinking lean.

12.1.7 Job security

Job security is a big issue at GMH1 and MG-Large at the moment. Several layoff rounds have already been completed and more are yet to come if the economic and demand situation for GMH1 do not change. This makes the job situation highly unstable.
Not much is being done to create a sense of job security, actually sometimes the opposite. On several occasions operators were informed that they were the first in line to be sacked, if a new round of layoffs was required. This creates a high degree of insecurity among the operators and was highly demoralizing on their motivation and attitude towards implementing any change or testing new procedures.
The management has done no effort to clarify for the operators or other employees how lean can actually increase production and thus create more jobs. It is not in the managerial way of the managers related to MG-Large to create and/or enhance a sense of job security among their employees and especially among the operators.

12.1.8 Empowerment

Empowerment and autonomous teams is virtually non-existing at MG-Large and especially in regards to the production. Practically all decisions must follow the hierarchical structure and ends at the Production Manager. In few cases decisions can be made by supervisors, planners or PT-engineers, but the majority of cases decisions or at least verification of decisions is the task of higher management. To exemplify this low level of empowerment engineers at Grundfos, Denmark can make investments below 25.000 DKK without having to verify it with their respective manager. In Grundfos, Hungary this amount is 1.500 DKK[15]. This amount is more than 16 times smaller, which is a good picture of the low empowerment in the organization.
The employees linked to MG-Large are, generally speaking, reluctant to take decisions or have a standpoint as they then can be made accountable for that decision if something goes wrong. At numerous interviews with PT- and Lean-engineers, if asked to take a stance on e.g. throughput times or changeover performance, they all refer to the Production Manager for these numbers. This is the general attitude found in MG-Large.

12.1.9 Cultural fit

As described in culture under lean production, the MG-Large culture bears to some degree characteristics of a change culture, where employees are willing to change if they are either involved in the process or if the benefits of the change can be linked to their area of responsibility. Though, as mentioned in the solution design, many of the organizational characteristics have to be changed if lean is to stand a chance of succeeding.

12.1.10 Lean as a philosophy and journey, not a tool box

Management views lean as a set of tools such as JIT, SMED, VSM etc. and not a philosophy. Discussing lean with the management results in a discussion on what tools can be utilized, how lean can be used to reduce stock and make the production system more flexible. They grasp the concept of lean, but lack the understanding of the principles behind it (Value, Value Stream, Flow, Pull and Perfection) and the dominating focus on elimination of waste.

[15] This information was obtained through interviewing project managers from both Denmark and Hungary

13 Analysis – Change Management

This chapter will analyze and structure the findings from the previous analysis of implementing lean. The findings from this analysis will be used in the development of an implementation strategy.

This change management analysis is based on the framework presented in chapter 11 and Appendix E2. The Force Field analysis will be utilized as a structural tool and as a mean to visualize if the restraining forces are dominating or vice versa.

13.1 Driving forces

One of the essential driving forces in regards to an implementation of lean is the support it meets from the General Manager. Though he is not directly in charge of GMH1 he would still encounter great support if he was to initiate such a project. The majority of managers would automatically support a lean implementation if such an initiative was to come from the General Manager or the Factory Manager of GMH1. This is due to their high status in the hierarchical structure of the organization

Though currently no resources are directly allocated to implementing lean elements or principles, the management has previously displayed a certain degree of willingness to allocated resources to projects such as e.g. implementation of lean in a production area. If a given project has the right circumstances and the conditions allows for such a project to be commenced then management have shown readiness to support such an initiative with the allocation of the required resources.

As described earlier, MG-Large, as a production unit, is fairly new which entails that the people linked to MG-Large are yet to find "the way we do things around here" and the mentality that the same process have been performed the same way the last 10 years, "so we keep doing it this way".

The last four years MG-Large has seen countless changes in every possible connection; layout, procedures, technologies, processes, people etc, so the people involved with MG-Large are familiar with changes. This could prove beneficial in a lean implementation process.

So changes are nothing new for the people in MG-Large and if approached correctly change is not a difficult task. If the operators feel as they have contributed to improving a given process or procedure implementing or anchoring the change is an easy task. Involving the shop floor employees in any given change makes the new procedure/process much easier to operationalize.

13.2 Restraining forces

Though described as a driving force, management is to some degree also a restraining force. The idea of implementing lean is lacking a united front in regards to management, where all the managers support and commit to the implementation of lean. Currently each manager has their

own personal agenda and if lean does not fit in this agenda or cannot support the achievement of their goals, they have no interest in committing or supporting to an implementation of lean.
Currently leadership is lacking in the organization, where managers “manage” their employees instead of leading them. The Hungarian culture is very focused on the hierarchical structure where people in the top of the system gives orders, directions and delegate tasks to people further down the structure. Encouragement, motivation and guidelines are seldom utilized by managers to great frustration among the employees.
The lack of a clear lean vision and strategy for implementation is also working against implementing lean. Though discussed loosely in the organization lean lacks to be formalized so employees can understand what it is and what it will be used for. This lack of formalization is currently alienating the employees towards lean because they do not understand it and just sees it as another mean to more work.

The lack of dedicated resources to implement lean is one of the critical retraining forces. The management must yet again display their willingness to allocate the required resources if lean is to be implemented. It cannot be done using the current resources, where implementing lean becomes an additional task of supervisor, PT-engineers and other people related to MG-Large. A dedicated lean implementation team must be constructed and management mustcan commit to lean by allocating resources to construct such a team.

Involving, motivating and empowering people are also important in regards to the lean implementation, but is currently lacking when looking at MG-Large as a unit. Management must remove this restraining force by motivating people to get involved in implementing lean and empowering them to make decisions without having to follow the normal decision-making procedures. Motivating and involving shop floor employees, supervisors, engineers, planners etc. will also help to develop a sense of job security when they see how lean can improve their work and how it can actually create more jobs in the long run.

The last restraining force is the view on lean as a set of tools and not a philosophy or a never-ending journey. Management must understand that utilizing the tools provided by lean will only solve the problems on the surface and not the root causes and if doing so, the problems will surface again continuously until the root causes are solved. Lean is first of all a way of thinking and when people realizes this, then, and only then, can the various lean tools be utilized to solve problems and optimize performance.

The following paragraph, on the next page, will visualize the driving and restraining forces.

13.3 Sum up

The analysis portrayed some of the restraining and driving forces in the possible implementation of lean in GHM1, MG Large. These forces, in regards to implementing lean, are visualized on the following Figure 7:

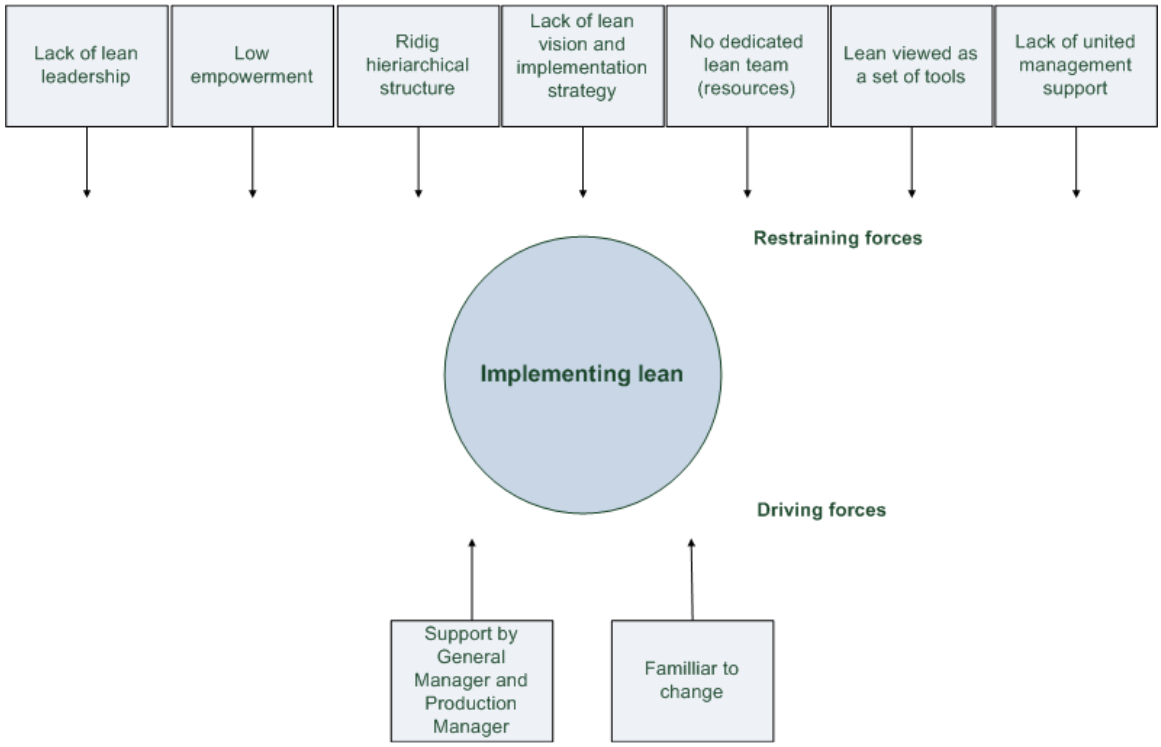

Figure 7: Driving and restraining forces in regards to implementing lean

Implementing lean requires focus on reducing or completely eliminating the restraining forces, meanwhile boosting the driving forces. These forces are characteristics of the organization and will be used as input to the development of a lean implementation strategy and tactics on how to operationalize the designed solutions.

14 Implementation Strategy and Tactics

The objective of this chapter is to develop a strategy for implementing lean based on the organizational characteristics, driving and restraining forces, as identified in the previous chapter. Additionally, tactics for operationalizing the solutions designed in chapter 8 will be developed.

14.1 Implementation Strategy

Implementing lean requires focus on the forces identified in the previous analysis and willingness to change some of the organizational characteristics that are working against a lean implementation process. An implementation strategy should focus on how to roll out lean by decreasing the restraining forces and fuelling the implementation process on the supporting forces such as top-management commitment, having a change culture etc.
The first step in developing an implementation strategy to MG-Large is to focus on the restraining forces identified. If the implementation of lean must stand any chance of succeeding the organization, especially the management, behind MG-Large must change to create a set of conditions allowing for the designed solutions to be implemented successful.

Management is the first focus-point and also one of the essential factors in the development of an implementation strategy. The MG-Large management must unite on the subject of lean creating a common lean vision and goals. This will create a direction for lean which the people responsible for implementing and maintaining lean can relate to when encountering obstacles or problems along the implementation path. Having a united management in regards to lean will also display commitment and support, which are crucial for the success rate of lean. Having created a “united front” the management can then move onto developing both quantitative and qualitative goals for lean, which will give lean direction and focus-areas. The management must agree on how to implement lean, who will be in charge of the process, timeframes, allocated resources etc. before the project is commenced. This will minimize the risk of leading the implementation process in multiple directions and creating confusing on what the managers actually expects from lean.
It is also essential that the management creates a common understanding of lean, which they then can formalize and communicate to the employees. To create a common direction, a common understanding and agreement is required, which in terms will be clearly displayed to the employees management’s view and understanding of lean.

Having created this common front and understanding, the management can then move onto leading lean instead of managing lean. Though lean leadership is currently not included in the organizational characteristics identified, this is an important part of implementing lean. The people responsible for the implementation process must be able to turn to the management in search for directions and answers to problems encountered during the implementation process. Though maybe not capable for answering the questions, the management should display commitment and leadership in and of lean by supporting the quest for answering the question instead of displaying indifference. Managers must be able of displaying good leadership by

providing guidelines, giving directions, support, shoving interest and commitment in the implementation to their employees at any given time. This is part of being a good manager regardless of national identity.

Having solved these managerial issues the implementation strategy now moves into determining the team of implementation and what members it should consist of. Constructing the right team can have great effect on the implementation process and the focus of improvements. If the main goals, for instance, are to create improved material flow, increase the production flexibility and optimize production processes then PT-engineers, tool-setter, supervisors and also operators could be very beneficial for the process and good on the team. The team should consist of independent and motivated employees with a mix of competencies that covers the length and width of MG-Large as a unit with a link directly to the Factory or General Manager to ensure progress and quick decisions on larger subjects.

With the above mentioned elements in place the implementation strategy now moves onto deciding where to begin the implementation process. It is important not to launch a full scaled lean implementation, taken the organizational characteristics and solution design into consideration. Lean attacks all the performance problems, but targeting all at once is often too overwhelming for both the implementation team and the effected people in the production. The implementation of the designed solutions can with benefit be broken down targeting different problems at different times. Focusing on the long throughput times could e.g. be the mean to direct attention on the changeover performance followed by focus on the stock levels, WIP, flexibility etc.
It would also allow lean to “grow” in the production slowly showing how it can improve the daily operations and make MG-Large a better place to work, thus gaining more and more support as the implementation progresses. Just like a snowball rolling down the mountain getting bigger and bigger along the way.

As the implementation team advances its work, the management still has important tasks to perform in relation to their employees. They must communicate the lean progress, preliminary results, experiences, adjusted targets and many more, so the implementation process is not forgotten in the remaining part of organization. In addition to this, creating job security is an essential task. If the shop floor employees, or employees above the factory floor, fells that lean could lead to the discharging of them or their colleagues, motivation to contribute or participate in getting lean to work are exceedingly low and they will often counteract or directly sabotage the implementation process. Management must show how lean will lead to more production orders due to being able to meet any demand at all times.

To sum up the implementation strategy should pursue the following steps:

1. Create a united management
    a. Develop a common understanding of lean, what it is, what it will be used for and how it will be use
    b. Understand what forces are working against and supporting a implementation of lean in order to foresee what obstacles the project could encounter

   c. Display commitment, support and involvement to lean (leadership)
2. Construct a implementation team
   a. Include members from the production unit, covering the different functions represented in the production
   b. Allocate sufficient resources to the team (not part time work)
3. Determine where to start the lean implementation
   a. Dependent on goals and problems targeted
4. Commence the implementation of designed solutions
   a. Start with one subject and solve the issues related to this
5. Ensure that employees; have a sense of job security, take interest in the implementation process and optimization projects, are encouraged to participate and are shown that how lean will lead to a better work place and possibly more jobs
6. Communicate results to the organization

14.2 Operationalizing the Designed Solutions

Now that the implementation strategy has been developed, the focus turns to the issue of operationalizing the designed solution from chapter 8.
Different tactics can be deployed when implementing the solutions, where each has its own strength and weakness. Tactics such as Big Bang, pilot projects or stepwise approaches can be utilized when implementing the solutions.
In all its glory Big Bang is about doing it all at one time, just like when Grundfos upgraded their MRP system to SAP3[16]. The big key is turned on Monday morning and problems are then solved on the way.
Pilot projects are where certain optimization projects are deployed to see how the organization reacts to the changes and results of the change. This is kind of a trial and error approach.
The stepwise approach are somewhat similar to the pilot projects, but are applied on a more continuous basis. One optimization event overlaps the next until all the performance problems have been targeted or the goals reached.
The two latter tactics bears much characteristics of single and double loop learning, where experiences from one project is captured and formalized in order to harvest the obtained knowledge in later similar projects. The process of capture and formalize means that the experiences can then be subjected to improvements.

Choosing the right tactic for MG-Large is highly dependent of the character of the change and the organizational characteristics. Changes in attitude and mentality cannot be implemented by using a Big Bang tactic, but must be changed over time using e.g. pilot projects and a stepwise approach to slowly change people's attitude or mentality. Whereas, something like value stream mapping, measurement of throughput times etc. can be utilized immediate by implementing it.
So for creating the best conditions for implementing the designed solution tactics for each individual solution will be developed in the following sections.

[16] According to Harry Boer

14.2.1 Production

Focus on throughput time

The utilization of Value Stream Maps can easily be deployed using a Big Bang tactic, though it requires some initial work preparing the maps and determining that they will be used for. The focus on throughput times must be incorporated into the responsibility of the engineers, so it is up to management to decide what to focus on and then delegate the work to the relevant engineer(s).

Pull production

The deployment of a pull production can be approached using different tactics where actually all three described tactics can be utilized.

Using the Big Bang requires extensive preparation and safety mechanisms if the pull mentality proves difficult to implement.

Utilizing pilot projects or a stepwise tactic would be a more advisable approach, where parts of the production system can be changed to pull for a period of time and afterwards evaluate on the results. It will also allow for testing lean tools such as Kanban systems, continuous flow and JIT.

Kanban systems

It will be recommendable to use pilot projects as a tactic when implementing the use of Kanban systems. Kanban could be implemented on a range of preselected components and based on the results Kanban could be adjusted and improved to fit the context and characteristics of MG-Large. The use of pilot projects in order to see how the production system reacts to the implementation of Kanban is advisable and would provide a smooth transition to only producing what is demanded.

High stock levels and WIP

Reducing stock levels and WIP will be a result of implementing elements such as continuous flow, Kanban, pull production, flexibility etc. and as described earlier to would be recommendable to use pilot projects and a stepwise approach.

Changeover times and use of SMED

Focus on changeover performance is a subject that can be implemented immediately, whereas tools to reduce them such as SMED must be implemented using a stepwise approach where the use of SMED spreads throughout the production.

Area utilization and focus on NVA-activities

Both elements require long term focus and a stepwise approach to solving the issues. The utilization of space follows the production optimization progress, where reduction in stock levels, WIP etc. allows for more space to be utilized for production instead of stock and WIP. Focus on NVA-activities must be a continuous focus on all the employees connected to MG-Large and requires a shift in mentality and attitude, which is a long and difficult process. Pilot projects to show how NVA-activities can be identified and eliminated are advisable to create focus on the subject.

Performance goals

Having production goals for the individual production units within MG-Large (production islands) are recommendable and requires only the determination of realistic performance goals developed by management in cooperation with engineers, planners and supervisors. The performance goals should follow an ascending structure so forces focus on improving the production performance by implementing the designed solutions.

14.2.2 Management

The majority of issues related to the management are mental and cultural and requiring a shift in mentality and attitude. These changes do not happen overnight, but are a slow and painstaking process essential if lean is to stand a chance of being implemented and surviving for longer than the initial period.

Management must shift from the concept of managing people by control and restrictions to leading their employees by commitment, guidance and support. They must develop the right conditions for lean to flourish becoming an integrated part of the organization.

14.2.3 Culture

Yet again, these issues are related to mentality and attitude and cannot be changed using a Big Bang tactic. If the management creates the right conditions and circumstances the culture will most likely also change in the right direction eliminating the problems identified in relation to the MG-Large culture. Though can a problem such as the decision making process be changed if the managers willingly empower people further down the hierarchical structure. Here an immediate change can be deployed changing the power structure from one day to the other.

14.2.4 Processes

Continuous flow

Continuous flow should be implemented by using either pilot projects or a stepwise tactic. Pilot projects could be used for visualizing that continuous flow is possible and its effect on WIP and possibly stock levels as the produced components can be used directly in the assembly process. Implementing continuous flow on a more sustainable level could be done by using a more stepwise tactic where flow is created within the different production islands and then linked to the assembly line.

Value Stream Mapping

See section 13.2.1 – production – focus on throughput time

CI and 5s

CI builds on a culture where people focus on improving and continuously develops ideas to how the daily operations can be improved and is to a high degree a mentality of “how can we do what we do better?” Such a culture cannot be implemented or developed by the push of a button, but must be grown over the cause of time making it an embedded part of the company culture. Events or pilot projects focused on developing such a culture can be used, but must

have the right support if not running the risk of alienating shop floor employees and others towards such initiatives.

14.2.5 People

Shop floor involvement

To harvest the good ideas and utilize the competencies the shop floor employees possesses they must be involved in projects or events where these elements can be exploited. A tactic such as pilot projects can be utilized, so the shop floor employees can see their contributed being exploited or operationalized and would automatically create growing support to elements such as CI, SMED and other optimization events.

Empowerment

Empowering people is a managerial decision, but the management can utilize pilot projects to see the effect of the empowerment. It could e.g. be a SMED project, where all decisions are made internally in the team without management interfering in the decisions. Evaluating such a project would give important clues on how the people would react to this empowerment, but also how the managers tackle this transition from managing to leading.

Motivation and job security

Yet again things do not change overnight and yet again is a managerial task. The tactic here is to encourage and support employees to perform a better job. Or simply use rewards as a tactics to motivate.

The tactic to create a sense of job security among the employees could be open communication and action plans how to avoid dismissing employees. Motivating people is also a mean to create a sense of job security.

14.2.6 Technology/Other

Change agents

The tactic here is simple. It is a matter of just doing it. Lean is about changing the way things are and to do so change agents are needed. People that can facilitate the implementation of designed solutions are a must and a tactic for management to display commitment to lean could be the allocation of resources in the form of change agents.

Documentation and SAP

For these issues a Big Bang tactic is advisable. Documentation should be a natural part of any project or optimization event conducted in the MG-Large unit. Goals, approaches, findings and results should be documented and made accessible for the entire organization. SAP is a useful tool for collecting data used in e.g. value stream maps, so it is just a matter of agreeing on using and saving data in the SAP system.

14.3 Sum Up

The implementation strategy is a set of steps the management must take before commencing the actual implementation of the designed solutions from chapter 8. Following these steps will create conditions that are supportive towards a lean implementation process and will provide people with tools to deal with obstacles encountered on the path to implement lean.
Different tactics have been linked to the various solutions in regards to the operationalization. Some of the solutions can "just" be implemented, whereas others requires a more slow and stepwise approach. The table below sums up the different tactics for the different solutions.

TACTIC PROBLEM	BIG BANG	PILOT PROJECTS	STEPWISE APPROACH
Production			
Throughput times	Use throughput times as KPI and make it part of the daily operations		
Pull production		Use pilot projects to investigate effects of pull production on WIP, throughput times, lead times, WIP etc.	When implementing pull production full scale use a stepwise approach where the different production islands are slowly connection to the assembly line
Kanban System		Implement Kanban on preselected components to measure effect and usability. Kanban sizes can then be adjusted to fit demand	
High stock levels and WIP			Use pull production, Kanban, flexibility and continuous flow to reduce stock levels and WIP
Changeover times	The use of SMED can be implemented immediately, but requires preparation	SMED can be tested on a number of machines to see effect, before utilizing on a full scale	
Area utilization			As the MG-Large production area is optimized more space is freed and this space can then be used for production purposes
Performance goals	Just have to be developed by management and used as targets for optimization events		
Management			
			The different elements in regards to management are

			related to a change in mentality and attitude, which is a process that requires time to change
Culture			
			The changes are yet again related to mentality and attitude, and can only be changed over time which the right support from management
Processes			
Continuous flow		Can be implemented using both tactics. It is advisable to test continuous flow with the use of pilots projects and then implement it full scale using a stepwise approach, where each production islands is connected to the assembly line	
Value stream mapping	The use of value stream maps can easily be implemented, if management either dictates or support the decision		
Continuous Improvement		Advisable to implement CI using pilot projects to see how the production reacts	
People			
Shop floor involvement		Use pilot projects or stepwise approach in order to familiarize employees to participate in Kaizen events or SMED event focused on optimizing the production	
Empowerment	Management just have to empower the relevant people in the organization		
Motivation and job security	Yet another tasks management can start immediately		
Technology / Other			
Change agents	Management must allocate the needed resources		
Documentation	Can be implemented as a requirement from management in any optimization events or projects		

Table 4: Different tactics for implementing different solutions

Each solution can be implemented using the tactic or the solutions can be grouped according to the different tactics and then be implemented at the same time for instance implementing Kanban, continuous flow, pull production, SMED and so forth by parallel pilot projects.

15 Discussion

This chapter is the finial discussion in this report and will be taken on two levels; the first level is a direct discussion of this report; the findings, the solutions, the methods, the project limitations and issues for further research. Generally speaking it will be a complete discussion of the content of this report. The second level will be a "helicopter view" of this report, looking back on the approach to this project and reflecting on what could have been done differently.

15.1 Discussion of this report

This first part of this paragraph will focus on the following elements for discussion:

- The methodological approach used to answer the project objective
  - What consequences did the utilized methods have for the outcome of the analyses and the product of this report?
- The findings from the different analyses
  - Were the findings consistent with the purpose of the analysis and the expected output?
- The limitations of this project
  - What consequences did the limitations have for the making and the output of this report?
- Issue for further research
  - What elements would be interesting to subject for further investigation?

By discussing these four elements the circle of analyzing, identifying, solving and discussing will be completed. The actual implementation, or lack of, will be discussed in the section on limitations.

15.1.1 Methodological approach

The methodological approach used in this report – the concept of using theory as representative of best practice and then comparing it with a given context – has its advantages, disadvantages and consequences for the outcome.
The advantages of using this method are the solid structure and straightforward approach of the analyses and the focus on lean and the implementation process. Using theory as a foundation for developing the analytical frameworks ensures that, when analyzing MG-Large, it is only the elements which the theory pinpoints as important that are analyzed. This entails that the analyses identifies elements which are essential for the success of lean production or lean implementation. Gaps between best practice and MG-Large can then easily be identified and used as input for the solution design. Elements that are not present, according to the analyses, can then be recommended to implement in order to become lean.
An additional advantage of the methodological approach is the very concrete and tangible way of analyzing and then solving the problems. When the analytical frameworks have been developed, it is straightforward to filter the context of MG-Large through this framework and then end up with a range of elements that must be changed in order to become lean.

The disadvantages of using this methodological approach is the rigid structure of the analytical frameworks, where only the elements identified as important according to theory are included in the framework and the following analysis. This requires a very narrow focus of the elements being analyzed, as it would be very complicated to analyze the context of MG-Large from all aspects of lean production and the lean implementation process. That would require an enormous analytical work being conducted and even then it would not be certain that the different analyses will cover all aspects of a successful lean production and a successful lean implementation process.
As MG-Large cannot be analyzed from every lean aspect, only the elements related to a lean production and the implementation processes were selected, which possibly left out elements that could have significant influence of the implementation process or the process of converting MG-Large into a lean production system.
One of the aspects not treated particularly detailed in this report is the cultural aspect or the relationship between the management and the remaining part of the organization. During the 10 month internship several examples were observed where employees discarded directions outlined by the management due to personal issues with a given manager. Such an issue could be undermining for the implementation of lean, but were not treated in details due to the methodological approach used in this report. The question of culture and lean is a project in itself and scrutinizing the culture aspect did not fit in the broad analytical scope of this report.

15.1.2 The findings

The findings from the different analyses are very consistent with the reality faced during the 10 month internship in GMH1, and the findings were not only found in MG-Large. The findings are a general picture of how the daily operations are performed and the kind of problems the employees have to tackle every day, week after week. The total lack of interest in solving the root-causes instead of continuously fire-fighting all the small problems is a very explanatory picture of the reality in GMH1.

In regards to the actual findings, there is no doubt that lean can help solve the root-causes in relation to the performance problems, thus also solving the problems on a more fundamental level. Lean will force the organization to rethink the daily operations in a totally different way, at least if lean are to work, but this is not an easy process.
If the suggested solutions are to be implemented it requires a commitment to changing the daily operations, which have not been seen during the internship or found to be part of the culture in GMH1.

15.1.3 Limitations

The limitations in this project had both its advantages and disadvantages in terms of a detailed level and focus areas. The limitation in regards to the late operationalization of the production system opened for the opportunity to use a more theoretical approach to solving the problems. The disadvantage was the limited timeframe in which the designed solutions could be tested in order to measure the effect and investigate if the solutions were compatible in reality. This lack of a fully operational productions system during a large part of the internship also affected the validity of the problems identified. It was difficult to determine if problems such as long

throughput times, large inventory, material flow, long changeover times and so forth was the result of a poorly designed production system or due to the fact that the daily operations were not familiarized or standardized.
With limited time to actually test the designed solutions on the production system, it is difficult to validate the suggestions from a practical point of view. If is difficult to generalize the validity of all the solutions based on the few suggestions, such as continuous flow and involvement of shop floor employees, that could actually be tested.
The lack of documentation also provided both advantages and disadvantages, where the majority of data and documentation used in the making of this report had to be developed, which was a very time consuming process. On the other hand, this presented the opportunity to observe the subject being investigated and develop a good understanding of many of the daily operations in MG-Large. By having to personally measure, observe, describe and developed the majority of data utilized in this report, the question of usability, due to outdated data or information, could be eliminated as the collected data was validated through repeating the measurement or observation several times.

15.1.4 Further research

This report was focused on investigating if lean could solve the performance problems and how lean could be implemented. Lean was never questioned as the solution nor was solutions besides lean investigated or discussed. Questioning lean and investigating other solutions would therefore be a suitable object for further research. A production philosophy such as Agile Manufacturing could be scrutinized to investigate if, with the culture found both in Hungary and in GMH1, it be could more suitable to implement instead of the lean philosophy. Agile Manufacturing could prove to be more suitable for MG-Large if the demand is very fluctuating or if the production system has to be more flexible in order supply several assembly lines with components.

An investigation of the organizational culture and work mentality found in GMH1, could be interesting and of value to Grundfos, if they decides to implement lean. Implementing lean and running lean successfully, requires a certain culture and it could be interesting to investigate if this culture or the conditions for creating such a culture was present in GMH1. Several international companies, such as Audi and Bridgestone, have factories located in Hungary which have successfully implemented lean. An investigation of their organizational culture compared with the culture found in GMH1 or Grundfos Hungary, could provide indications on the compatibility of lean and the culture found in Grundfos Hungary. Many of the problems identified in this report were the result of the mentality found among employees, both on the shop floor, in the offices among the engineers and supervisors, and among the management. Based on this knowledge it could be interesting to dig deeper into the cultural aspect and investigate if this mentality and attitude was general for Hungary or if it was only found in Grundfos Hungary or in GMH1.

In addition to this, it could be interesting to compare the culture of GMH1 and GMH3, as GMH3 has had significant more success implementing elements of lean such as Kanban systems, continuous flow and pull production. Because GMH3 is a new factory and located far away from

GMH1 and GMH2, its culture might not be influenced by the embedded culture found in these two factories and could possibly be more suitable for implementing lean. Conducting identical experiments in all three factories would indicate if the culture is different and if so, which culture supported the achievement of the best results.

15.2 Reflection

Reflecting on the making of this project and the report, several elements could have been done differently. As mentioned earlier, this report did not question the choice of lean, nor did it challenge the approach to use lean to solve the performance problems. Limited effort was done to identify and solve the fundamental reasons for the performance problems or look into the culture to find the root-cause of many of the problems. Faced with having to do this project all over again, a different approach would possibly have been chosen. Instead of accepting lean as the solution, I would rather have challenged this view and asked to following question: "what should the characteristics of MG-Large be in the future? Is the goal to have a production system with a high degree of flexibility, low throughput times, minimal inventory levels and so forth?" This discussion could help to create a TO-BE scenario for MG-Large and based on this picture identify what should be changed to the reach this state and how. So instead of taking a starting point in the current problems, I would focus on how MG-Large should look in future and then investigate how to get there.

If lean is sustained, by management, as the solution challenging their view on lean and how to operationalize lean would be the first step. It seems that every time Grundfos Hungary is involved in a project such as implementing lean, they try to reinvent the wheel all over again. Grundfos, as an organization, has a tremendous amount of experience in implementing both lean full scaled and elements of lean, and a complete data base on experiences with, and models on how to approach, almost every single tool in the lean tool-box. Best practice models, does and don'ts, lean strategies, tools tailored to fit Grundfos, guidance and so forth, have been developed by Grundfos in Denmark and are fully accessible on their intranet Insite. Even so, the same work is being done in Grundfos Hungary over and over again. Grundfos Hungary has no problem using vast amount of money and resources on consultants hired to developed strategies, tools, best practice models and lean approaches, but allocating internal resources for SMED projects, Kaizen events, Kanban system and so forth encounters great reluctant from the management.
So if this project was to be repeated, the first step would be to challenge management's reluctant to use existing knowledge and best practices and then try to unify the lean resources already present in Grundfos Hungary and combine it with resources from Grundfos Denmark. So instead of reinventing lean, make the GMH1 management understand the benefit of using the resources available internally in the organization and using ideas and concepts already tested and implemented in other parts of the company.

16 Conclusion

This chapter will provide the closure of this report. The chapter will answer the main question stated in the project objective and briefly summarize the solutions this report has recommended should be implemented in MG-Large.

The project objective is re-stated below:

"Is lean the solution to the performance problems and can lean help to reach the stated goals? If so, how can lean be implemented in MG-Large?"

Yes, lean was found to be able to solve the performance problems MG-Large is experiencing and if lean is implemented, it could help to reach the MG-Large goals stated by management.
By analyzing MG-Large through the lenses of lean production, a range of problems and issues was identified, which could be related, directly and indirectly, to the performance problems. A set of solutions, founded in lean and operations management theory were then developed and subjected to a set of quality criteria to ensure that the designed solutions were both valid and exploitable for MG-Large. These solutions were not only directed towards solving the performance problems, but also create the right conditions for an implementation of lean.

The second part of the report was focused on solving the issue of implementing lean. MG-large and the organization behind were viewed through a framework of characteristics of successful lean implementation. Gaps between what "best practice" says should be present in order to successfully implement lean and what actually was and was not present in MG-Large and the organization were identified. These findings were then structured in regards to driving and restraining forces for an implementation of lean. Based on these findings and the structuring, a lean implementation strategy tailored to fit MG-Large was developed. This strategy focused on boosting the driving forces and reducing or completely eliminating the restraining forces. The implementation strategy consisted of six steps to follow in order to implement lean.

The final part of the report developed a set of different tactics to use in order to operationalize the designed solution from the first part of the report.
Each individual solution was paired with one or two different tactics depending of the characteristics of the designed solution. Some solutions required a Big Bang tactic where the solution was implemented quite rapidly, some solutions required pilot projects in order to see and measure the effect of the change and finally, some of the solutions required a more stepwise approach, where the solutions were slowly implemented in the organization.

So to conclude on this report; Yes, lean can both solve the performance problems and help reach the stated goals, and lean can be implemented using the implementation strategy and the different operationalization tactics, though it will be a long and difficult process.

Hoped you enjoyed the reading!

17 References

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18 Résumé

This chapter will serve to fulfill the requirement from Aalborg University to include a short resume of the project in the report.

This Master's Thesis is written as part of the 9th and 10th semester in International Technology Management at Aalborg University. This report is the final product of an internship conducted at Grundfos, Hungary is the period of July 2008 – April 2009.
The unit of analysis is a production unit within one of the three Grundfos manufacturing factories. This production unit is MG-Large, which produces the MG-Large motor, the biggest motor produced in Hungary to this date. This project was initiated to analyze and solve the performance problems the production unit was experiencing. The MG-Large management had the belief that lean would solve the performance problems and help in the achievement of some stated goals.

This report set out to investigate if lean was the mean to solve the performance problems and if lean could help MG-Large reach the management-stated goals. In addition to this, it was investigated how lean could be implemented given the organizational characteristics.
The approach to answer this set of questions was to develop two different theoretical frameworks, which could be used to analyze MG-Large through the lenses of lean production and the process of implementing lean. This lean production analysis identified a wide variety of gaps between best practice, in regards to lean production, and MG-Large. The identified gaps could all, directly or indirectly, be connected to the performance problems, so the object became to develop solutions to close these gaps between MG-Large and best practice. The designed solutions were subjected to a set of quality criteria to ensure that the solutions were valid and exploitable for MG-Large.

The next step was to analyze the organization using a framework consisting of characteristics of successful lean implementation. This analysis was used to determine what organizational characteristics for implementing lean were present and what were lacking. The findings from this analysis was then structured in driving and restraining forces, for this lean implementation process, using Lewin's Force Field analysis.
Based on the findings from the lean implementation and Force Field analysis, an implementation strategy was developed describing how, from a managerial and operational perspective, lean should be implemented in MG-Large. In order to operationalize the suggested solutions, different tactics were recommended to each individual solution, which then could be used in the implementation process.

The conclusion of this report was that lean could solve the performance problems and help reach the management-stated goals. Lean could be implemented by using the developed implementation strategy and be operationalized using the recommended tactics. In addition to this, a set of tools were developed to aid MG-Large in the process of becoming a lean production.