Lean Manufacturing at Volvo Truck Production Australia

Development of an implementation strategy

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Preface

This Master’s Thesis project is conducted in cooperation with Volvo Truck Production Australia in Wacol, Brisbane. The Master’s Thesis is the final part of the MSc Programme in Industrial Management and Engineering.

We would like to thank all the people who have helped us at Volvo’s production plant in Wacol, Brisbane. You have all been very helpful and interested in our project. Your openness and kindness made our work much easier. A special thank to our supervisors Justin Murphy and Lee Morphew, who have guided us during this journey. This project would not be possible without the support and confidence of Lars Färnskog. He believed in us from the beginning and his commitment made us perform at our best. We also want to thank our tutors Dr Jan Lindér at Chalmers University of Technology and Pär Brander at Luleå University of Technology for their supervision and support.

It has been a good experience for us to do this Master’s Thesis in a production plant in a foreign country. The Australian culture and their way of thinking have taught us to appreciate each day instead of just stressing.

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Gothenburg, May, 2005
Abstract

The world’s globalization and consolidation of multinational companies result in increased competition for manufacturing plants. A truck manufacturer in Australia, like Volvo, feels the demand from global shareholders as well as the local customers. A factory must always attempt to achieve world class manufacturing to survive in the long run. Therefore it is important for a local factory like Volvo’s Wacol plant to continuously develop their way of working. In order to become more productive and efficient, Volvo has decided to implement the Japanese production philosophy Lean Production. With consideration to this, Volvo wanted a comprehensive investigation of the current situation in the production. Volvo’s desire was that this Master’s Thesis report should end up in an implementation strategy that Volvo could use during the implementation. The project was to be based on a theoretical framework together with empirical studies in the factory. In consultation with Volvo and tutors from Chalmers University of Technology and Luleå University of Technology the report’s purpose was formed:

*The purpose of the Master’s Thesis is to develop a strategy for the implementation of lean production in the Wacol factory’s manufacturing area.*

In order to fulfill the purpose a thorough literature study within lean production was accomplished. This resulted in a theoretical framework that together with an empirical study of Volvo’s organization was the foundation of the report. In the empirical study a comprehensive questionnaire survey was accomplished among both white collars and blue collars. The survey was based on lean theories and the situation in the factory.

The analysis of the situation in the factory showed that the organization has to change their way of working in some areas, in order to be prepared for the implementation of lean. First of all the managers have to work with the gap between white collars and blue collars. This gap has its root in the Australian union culture and it will be a major obstacle if it is not taken care of. It is important to have the support from the whole organization when starting a large project like lean. The lean project group which has been operational for a year has to focus on the project plan and the project’s size. A big project needs a thorough and comprehensive project plan that clearly marks all the milestones, intermediate goals and external parameters that can have an impact on the project.

A major area that has to be taken care of before the implementation is the differences in the way of working in the factory. All the production teams has to work in the same way regarding team meetings, continuous improvements, missing parts, ordering parts etc. The development of standardized procedures is mainly the production department’s responsibility. The other departments have to contribute with their special skills in order to get a functional production. When all this is done the ‘real’ implementation of lean production with material distribution, pull systems, multifunctional teams and continuous improvements can start.

Most important is to organize a functional continuous improvement system, in order to preserve the changes towards lean. Secondly the team meetings and job rotation has to be improved. When these basic work procedures have been improved, the work with decentralizing responsibilities and developing the material distribution system can start.

This implementation and change of the present work behaviour might take as much as three to four years to accomplish. When the goals are reached the organization will hopefully stand stronger and be more productive than it is today. Lean production can never be fully accomplished; there are always things to improve.
1 INTRODUCTION .................................................................................................................................. 1

1.1 VOLVO TRUCK AUSTRALIA AND LEAN PRODUCTION ................................................................. 1
1.2 PROBLEM FORMULATION AND PURPOSE ..................................................................................... 3
1.3 DELIMITATIONS ................................................................................................................................ 3

2 THEORETICAL FRAMEWORK ........................................................................................................... 4

2.1 THE RISE OF LEAN PRODUCTION .................................................................................................. 4
2.2 ELIMINATION OF WASTE .................................................................................................................. 7
  2.2.1 Waste from overproduction .......................................................................................................... 7
  2.2.2 Waste of motion ........................................................................................................................... 8
  2.2.3 Transportation waste .................................................................................................................... 8
  2.2.4 Process waste ................................................................................................................................ 8
  2.2.5 Defective products ....................................................................................................................... 9
  2.2.6 Waste of time ............................................................................................................................. 9
  2.2.7 Excess inventory ......................................................................................................................... 10
2.3 PULL INSTEAD OF PUSH .................................................................................................................. 12
  2.3.1 Kanban ..................................................................................................................................... 13
  2.3.2 Two-bin system .......................................................................................................................... 15
  2.3.3 Kitting of parts in pull systems ................................................................................................... 16
2.4 MULTIFUNCTIONAL TEAMS ......................................................................................................... 16
  2.4.1 Team organization ....................................................................................................................... 17
  2.4.2 Team leadership .......................................................................................................................... 18
  2.4.3 Team meetings ............................................................................................................................ 19
  2.4.4 Education ................................................................................................................................. 20
2.5 DECENTRALIZED RESPONSIBILITIES ....................................................................................... 20
  2.5.1 Team responsibility and authority ............................................................................................. 21
  2.5.2 Organizational hierarchy .......................................................................................................... 21
  2.5.3 Vertical information .................................................................................................................... 21
2.6 CONTINUOUS IMPROVEMENT ................................................................................................. 23
  2.6.1 Zero defects ............................................................................................................................... 23
  2.6.2 Work with continuous improvement ......................................................................................... 23
2.7 PROCESS STABILITY ..................................................................................................................... 26
2.8 IMPLEMENTATION OF LEAN MANUFACTURING ...................................................................... 27
  2.8.1 Involvement of employees in the implementation ....................................................................... 27
  2.8.2 Senior management commitment ............................................................................................... 28
  2.8.3 Education during the implementation ....................................................................................... 28
  2.8.4 Communication and information .............................................................................................. 29
  2.8.5 Project management .................................................................................................................. 29

3 METHOD .......................................................................................................................................... 31

3.1 SPECIFY AND FORMULATE PROBLEM .................................................................................... 31
3.2 DEVELOP THEORETICAL FRAMEWORK .................................................................................... 32
3.3 DEVELOP QUESTIONNAIRE .......................................................................................................... 32
3.4 DATA COLLECTION AND DATA ANALYSIS ............................................................................... 33
3.5 VALIDITY AND RELIABILITY ....................................................................................................... 34
3.6 GENERALIZATION OF THE RESULTS ....................................................................................... 34

4 INVESTIGATION AREAS ................................................................................................................ 35

5 VOLVO TRUCK PRODUCTION AUSTRALIA ................................................................................. 37

5.1 FACTORY LAYOUT ....................................................................................................................... 38
5.2 PRODUCTION PROCEDURES ....................................................................................................... 40
  5.2.1 Order release planning .............................................................................................................. 40
  5.2.2 Material handling ...................................................................................................................... 41
  5.2.3 Procedures at the production stations ....................................................................................... 42
  5.2.4 Quality controls ....................................................................................................................... 43
  5.2.5 Meetings ................................................................................................................................. 43
1 Introduction

Manufacturing industries are always under pressure from their shareholders to improve the productivity. They are not only being compared with their competitors, but also within their own group of companies. Globalization and consolidation of companies increases. An organization can therefore not just look at the competition on their local market, but it has to compare itself with factories all over the world.

When it comes to improving productivity the Japanese philosophy lean production is a popular and respected method. A majority of the manufacturing companies that tries to become more efficient, sooner or later end up with some sort of lean thinking (Womack & Jones, 2003). The use of Japanese production philosophies as a mean to improve productivity has become increasingly common in western industries. One reason for this is that the Japanese industries during the last decades have far exceeded the western industries in productivity and quality (Womack, Jones & Roos, 1990).

Lean production is a philosophy for optimizing the performance of the organization in all functional areas, by utilizing the resources in a more efficient way and eliminate waste. Applied to the manufacturing area this means flow orientated production driven by customers demand, using small buffers and just-in-time production. It also emphasizes continuous improvements with involvement of all employees. According to many of its advocates, lean production is the best and most competitive way of organizing mass production. They mean that using lean is necessary in order to become competitive and profitable.

1.1 Volvo Truck Australia and lean production

Australia is a strategic and image creating market for truck companies with its large distances and huge trucks. Hence some of the larger truck manufacturers have their own factories in Australia despite the rather small market. Volvo has been selling trucks in Australia since 1967. Their only factory in Australia was built in 1972 and serves the markets in Australia, New Zealand and some of the markets in South East Asia. The factory is located in Wacol, a suburb to Brisbane, and produces Volvo and Mack trucks. There are currently only two factories in the world that produces both Volvo and Mack, New River Valley in the USA and Wacol in Australia. The Wacol factory manufactures twelve trucks a day, of which six to seven are Volvo trucks. The chassis for Volvo and Mack are assembled on the same chassis line. After that the line is divided into two separate lines, one for Volvo and one for Mack, where the remaining parts are assembled (Figure 1). At the moment there are about 500 employees at the Wacol factory of which 300 are working in the production area.

A Volvo truck is signified by the European culture and Volvo’s trademarks quality, safety and environmental care. It is a trustful truck built of mostly Volvo parts. A Mack truck on the other hand is signified by its American origin, trademark and customer focus. There are few Mack trucks that consist of only Mack parts. The American customers have always wanted to put together their own truck containing parts from different brands, like a Caterpillar motor on a Mack chassis together with a third and fourth brand on the axles and gearbox. This makes the situation in the Wacol factory unique.
The Wacol factory’s productivity has been rather low compared to other Volvo factories and the competition for future inward investments from the parent company has come to a critical stage. The parent company wants to invest in a new production line in one of its factories and if the Wacol factory is to get this line they have to create space for a new line in the factory. They therefore need to improve their productivity and increase the production capacity. To get inspiration for how to solve the problem some of the managers have been to other factories in order to gain ideas on how to improve productivity and capacity. Some of the other Volvo Truck factories already use lean production with good results. Using lean production to improve productivity was therefore an interesting alternative.

In the beginning of year 2004 a project was initialized in order to investigate the possibility to implement lean production in the factory. The lean project was called Wacol’s Material Development Project and its main objective was to develop the material handling process. The reason for this was that the factory holds a lot of inventory in material and components. Inventory takes up a lot of space in the factory, and the time spent on material handling and administration is high.

Volvo’s objectives with implementing lean in the Wacol factory are:

- Improve the process for delivering materials to the line.
- Create space in the factory for a third production line.
- Develop the material packaging and material handling equipment.
- Reduce work in process and improve the visibility in the manufacturing area.
- Improve production quality.
- Increase delivery reliability.

The project team includes representatives from different departments such as logistics, production engineering and production. During 2004 the team has made initial investigations of the possibility to implement lean production in the factory. Some of the project’s members have visited other factories that already use lean to obtain inspiration and useful ideas. The sub-assembly station where steering boxes are assembled has been looked at as a pilot lean project. The station has been ‘put on wheels’ and moved to the production line instead of being a separate station beside the line and parts are delivered by using kanban. The station was chosen because it had high levels of inventory and low variation among the assembled parts. The pilot project turned out well; space was released and half an operator could be saved. The project team has decided to redesign the other stations in a similar way.

Wacol’s Material Development Project team has identified two major obstacles concerning the implementation of lean production; budget restrictions and factory layout limitations. The limited budget means that no major and expensive changes can be made in the factory. The obstacle with the factory layout is caused by lack of space and some fixed stations that can not be moved, such as the chassis and cab painting stations. In order to minimize the needed space for inventory along the lines the project team has considered picking the parts from the warehouse into kits before they are delivered to each station. The warehouse manning levels are therefore assumed to rise, since kitting will require more work in the warehouse. However the manning levels in the factory are supposed to decrease, because there will be less material handling in the factory.
1.2 Problem formulation and purpose

The factory is divided into one warehouse area and one manufacturing area where the trucks are assembled. The implementation of lean in the manufacturing area is planned to start during 2005, and a comprehensive strategy for this has to be developed. This Master’s Thesis is therefore supposed to develop a strategy and come up with recommendations for the implementation in the manufacturing area, with consideration to the project teams current plans. The report is supposed to act as a support for Volvo’s project team when they start the implementation. Introducing lean production in the manufacturing implies both the use and the implementation of lean principles. This report will therefore study both the content and the implementation of lean production in order to submit proper conclusions.

The purpose of the Master’s Thesis is to develop a strategy for the implementation of lean production in the Wacol factory’s manufacturing area.

The strategy will bring up important areas that should be included in the implementation. It will also contain recommendations concerning the different phases when implementing lean, i.e. in what order different tasks have to be done.

1.3 Delimitations

The Master’s Thesis is based on studies carried out during the end of 2004, and does not consider the lean project efforts that has been done after that. The report is delimitated to only investigate the implementation of lean production in the manufacturing area, which excludes deliveries to the factory, the warehouse area and dispatches. The manufacturing area includes all the stations where the trucks are assembled, deliveries of material to the stations and all kinds of internal transportations.

The report will investigate the implementation of lean at a comprehensive level, which means that the developed recommendations will be on an overall implementation plan. Therefore detailed studies of specific stations and flows will not be carried out. These delimitations are made because of the report’s time limit and the lack of detailed information about each individual manufacturing station.
2 Theoretical framework

Theories about lean production have been studied in order to fulfil the purpose of the Master’s Thesis, i.e. to develop an implementation strategy. The theoretical framework creates an understanding of the lean philosophy and brings up the theories that are needed when analysing the empirical study. The theory chapter begins with a brief history of lean production, which is followed by a detailed description of the content of lean. After that implementation issues like achieving process stability and lean project management are discussed.

2.1 The rise of lean production

Toyota is credited with being the birthplace of lean production, and their manufacturing philosophy has been evolved from ideas developed in the end of the thirties (Womack et al, 1990). After the Second World War Toyota and other Japanese organizations suffered from the effects of the war. The resources were straitened and Japan needed to rebuild its manufacturing industry (Askin & Goldberg, 2002). Many of the Japanese companies turned to the western industries to gain ideas and inspiration on how to build up their industry (Womack et al., 1990). In the United States, the call was for mass production to satisfy the needs of a large populace that had saved and sacrificed during the war. The Japanese market on the other hand was much smaller and investment capital was scarce. With smaller production volumes per part and limited resources, there was a need for developing a manufacturing system that was flexible and used less resources (Metall, 2002). The solution was to develop a lean production system, and the production genius Taiichi Ohno at Toyota is said to be the man behind the development of lean production (Sohal & Egglestone, 1994).

In the beginning of 1980 the western automotive industry began to realize that the Japanese way of manufacturing vehicles far exceeded the methods that were used in the European and American industries. Japanese companies achieved higher productivity and better quality using less resources (Metall, 2002). A major research project was therefore initiated in the end of 1980 by Womack, Jones and Roos at Massachusetts Institute of Technology. The project was called “The International Motor Vehicle Programme” (IMVP) and the aim was to investigate the Japanese automotive industry and compare it to the western automotive industries. The IMVP study showed a significant gap in productivity and quality between the Japanese vehicle assemblers and the rest of the vehicle assemblers in the world. The term “lean production” was coined in the report as a description of the victorious Japanese production philosophy (Sohal & Egglestone, 1994). The IMVP research describes lean production as follows:

“Lean production is lean because it uses less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever-growing variety of products.” (Womack et al, 1990). 

The IMVP report was recognised all over the world and ended up in the famous book “The Machine that Changed the World”. If lean production is the key to the Japanese superiority, then a reasonable consequence should be to try to understand how the Japanese companies manage to become lean and if it is possible to use lean production outside Japan.

Lean production is not confined to the activities that take place in the manufacturing function of a company, rather it relates to activities ranging from product development, procurement
and manufacturing over to distribution. Together these areas found the lean enterprise. The ultimate goal of implementing lean production in an organization is to have the customer in focus when improving productivity, enhancing quality, shortening lead times, reducing costs etc. These are factors indicating the performance of a lean production system. The determinants of a lean production system are the actions taken, the principles implemented, and the changes made to the organization to achieve the desired performance (Karlsson & Åhlström, 1996).

Several researches have investigated the content of lean production and the methods that are used to become ‘lean’. A number of models that describe the content of lean production have been evolved, and the one used in this report is based on a model developed by Karlsson & Åhlström (1996). Karlsson & Åhlström’s model was chosen since it has a close connection to the lean principles developed in the IMVP study (Figure 2).

![Figure 2. The content of lean production (Karlsson & Åhlström, 1996).](image)

Karlsson & Åhlström’s interpretation of the fundamental principles of lean, which go through all functions in the organization, is found at the bottom of the model. The fundamental principles are translated into specific principles for each function. The explanation of the fundamental principles below is adopted from Åhlström (1997).

The first fundamental principle is *multifunctional teams*. The teams can be formed on different levels in the organization, above all among operators on the shopfloor. The purpose of working in multifunctional teams is to develop multi skilled employees that can compensate each other in the teams, and that can achieve better solutions by taking advantage of different functional aspects when solving a specific problem. It also means that most of the problems can be solved within the group, without external help.
The second principle is the use of *vertical information systems*. This principle emphasises the importance of information flow. Accurate information flow is inevitable to manage the organization, and is also a mean for decentralizing responsibility. Employees that do not have information can not take responsibility and employees that have information can not avoid taking responsibility. An example on how information can be used in the company is the distribution of key performance indicators, such as productivity and quality measures.

The next principle is the *elimination of buffers*. The principle implies an ambition to reduce all kind of buffers, especially time buffers and inventory. The buffers are considered to hide problems, such as process instability, lack of quality and uncontrolled variation. Instead of solving the problems, buffers hide them.

The fourth fundamental principle is the *lack of indirect resources*. Instead of using specialists in for example quality control or problem solving, the problem should be solved where it appears. The objective is to move the competence to where the work is done, to achieve problem solving at the source.

The last principle is the *integration of networks*. There are many kinds of networks, of which one of the most important to integrate is the supplier network. Grouping different shopfloor operations together in cells or flows is another example of integrating networks.

The aim of this Master’s Thesis is to investigate the implementation of lean in the Wacol factory’s manufacturing area, which implies that the focus will be on lean manufacturing. The theory will therefore only consider the principles of lean production applied to the manufacturing area, which are shown in Figure 3. The following chapters explain the principles in lean manufacturing further.

**Figure 3.** The content of lean manufacturing (Karlsson & Åhlström, 1996).
2.2 Elimination of waste

The critical starting point for lean thinking is value. Value can only be defined by the ultimate customer, and it is only meaningful when expressed in terms of a specific product which meets the customer’s needs at a specific price at a specific time. Value is created by the producer. From the customer’s point of view, this is why producers exist (Womack & Jones, 2003). Everything that does not add value to the product is waste, and is something that the customer is not willing to pay for (Karlsson & Åhlström, 1996). Identification and elimination of waste makes it easier to focus on value adding activities and become more cost efficient (LEIS, 1999).

The Toyota production engineer Taiichi Ohno has described seven sources of waste commonly found in the industry (Askin & Goldberg, 2002). The sources of waste include:

- Waste from overproduction
- Waste of motion
- Transportation waste
- Process waste
- Defective products
- Waste of time
- Excess inventory

The seven sources of waste will now be explained in detail together with tools to detect and reduce them.

2.2.1 Waste from overproduction

Waste from overproduction is the most serious waste, because it contributes to the other six (Marchwinski & Shook, 2003). Production costs money and there is no reason to produce items that are not demanded. Traditionally, supervisors were judged by the quantity of production. The thought was that resource utilization was to be maximized. This leads to waste of overproduction. Machines and humans should only be busy when they have useful tasks to accomplish (Askin & Goldberg, 2002). The production rate should be set by the customers’ demand, external and internal, and products should not be pushed out to the market or through the factory (Rother & Harris, 2001). If more orders are released to the shopfloor than is not yet demanded, the products must be handled, counted, stored and so on (Segerstedt, 1999). Products stored too long in inventory run the risk of becoming obsolete and defects remain hidden in the inventory queues until the downstream process finally demands the products and discover the problem (Rother & Shook, 2003).

Overproduction is more common when producing towards forecasts. It is often difficult to develop a forecast that exactly matches the customers’ demand (Mattson & Jonsson, 2003). Therefore the ambition should be to produce to customer order instead of using forecasting. However this is not always possible if the customers’ demand on delivery speed is shorter than the lead time for producing the products (Segerstedt, 1999). Forecasting must be used, and overproduction can only be avoided with accurate forecasts, which is not always easy to evolve. However the customer order point should be moved upstream the production flow as far as possible, which means that the products are dedicated as early as possible to a specific customer order. On the other hand the lead time from where the customer order point is placed can not exceed the customers demand on delivery speed (Mattson & Jonsson, 2003).
2.2.2 Waste of motion
Motion consumes time and energy. Eliminate motions that do not add value, such as stretching for tools and moving material within the station. This objective should be guiding when designing workplaces, processes, operation procedures etc. Reducing waste of motions encompasses everything from describing detailed hand motions in assembly to selection of machines and design of fixtures to reduce the time for set-ups and material handling (Askin & Goldberg, 2002).

2.2.3 Transportation waste
Transportation waste includes all the unnecessary transportations of material, work in process and components, which do not add any value to the product. It also adds manufacturing lead time (Karlsson & Åhlström, 1996). In a well designed system, work and storage areas are positioned to minimize the transportation work (quantity*distance) (Askin & Goldberg, 2002). It is necessary to distinguish between rationalization of transportation and a removal of the need for transport (Shingo, 1981). Automating transport is fine, but eliminating the need for transport is even better. For instance, if machines can be grouped together in a cell-based layout, the physical connection of the flow of products renders a faster truck useless (Karlsson & Åhlström, 1996).

Unnecessary transportation is often a consequence of bad layout (Segerstedt, 1999). However it’s not easy to find the optimal layout and a lot of trade-offs has to be done. The layout in many factories is designed from a mass production perspective. Equipment and machines are often grouped together on a functional basis, e.g. milling in one area and iron sheet presses in another. The functional layout often causes a lot of transportation between the functional areas (Slack et al, 2001). In lean manufacturing, the layout is rather designed to create a smooth flow of products through the factory with less transportation between different workstations. Grouping products into product families and dedicate equipment to each family is sometimes necessary in order to achieve a flow with as little transportation as possible. The product families should be the basis when designing the factory and not the function of the equipment (Lindström, Rydbeck & Helling, 2002a).

A tool that can be used for analyzing transportation waste is spaghetti mapping (LEIS, 1999). Spaghetti mapping is a tool that maps physical flow of material, products and humans. Basically all the movements are drawn on a current layout map, in order to reveal unnecessary transportations. Distances can be measured and information about transportation times can also be included. The map often looks like a pile of spaghetti before the layout is improved, and is therefore called a spaghetti map (LEIS, 1999).

2.2.4 Process waste
Incorrectly designed processes are a source of waste (Askin & Goldberg, 2002). The processes in the organization must therefore continuously be reviewed and improved. Activities in processes can either add value to the customer, be necessary for the function of the process or non value adding. Figure 4 show how process activities can be classified and treated in order to reduce non value adding steps in processes (Egnell, 2003). Changing design of parts, limiting functionally unnecessary tolerances and rethinking process plans can often eliminate and simplify process activities in the manufacturing process (Askin & Goldberg, 2002).
A tool for identifying and eliminate non value adding activities in processes is process mapping (Brassard & Ritter, 1994). A process map identifies each step in a process by using graphical symbols for different activities and links them together with arrows. For example an action of some sort is recorded in a box, and a decision is recorded with a diamond shape. The purpose of this is to ensure that all the different stages in a process are included before the process design is analyzed and improved (Slack et al, 2001). A detailed map of a process often reveals unnecessary stages and sequences, and can be used to improve the process design (Brassard & Ritter, 1994).

2.2.5 Defective products

Lack of quality is another source of waste. Manufacturing parts and products that are defective and therefore need to be reworked is wasteful. Even worse is the scrapping of parts, which certainly does not add value to the customer (Karlsson & Åhlström, 1996). Defective products incur cost, deplete resources, and negatively impact customer perception (Askin & Goldberg, 2002). Lean manufacturing emphasises the importance of identifying the root-cause when a quality problem appears. The source of the problem must be taken care of and not only the symptom (Bergman & Klefsjö, 2001).

The possibility of quickly detecting a quality problem is closely related to the levels of inventory kept between operations (Jones & Womack, 2003). Using big lot sizes increases the time until the next downstream operator can detect the problem. This can cause an entire batch to be scrapped. A flow of one part at the time implies that a problem is detected when it occurs and the operator causing it can get instant feedback from his downstream ‘customer’ (ibid).

2.2.6 Waste of time

Waste of time occurs in many different forms. Waiting for correct information, products waiting to be processed, machines waiting for their operator and waiting for material to arrive are examples of waste of time (LEIS, 1999). One of the most common waste of time is products waiting in inventory. An investigation of a product’s flow through the factory often shows that it is only being processed a few percent of the total throughput time. The rest of the time is waiting in inventory, which is pure waste (Rother & Shook, 2003). Reducing inventory is an important issue when reducing waiting time (Jones & Womack, 2003).

A tool for identifying the products flow through the factory is value stream mapping. Value stream mapping is a variant of process mapping adapted to the manufacturing process. Processing times, throughput times, set-up times, inventory levels etc. are mapped with standardized symbols. The map reveals the relationship between waiting and processing time. It is not uncommon to find that the value creating processing time is only a few percent of the waiting time.
2.2.7 Excess inventory

Keeping parts and products in inventory do not add value to them. In manufacturing, inventory in the form of work in process is especially wasteful and should therefore be reduced (Hayes, 1981). Apart from being wasteful itself, inventory also hides other problems and prevents their solutions. The effects of reducing work in process therefore go beyond that of reducing capital employed. However, it is not advisable to eliminate inventory mindlessly. Instead, the reasons for the existence of inventory must first be removed (Karlsson & Åhlström, 1996).

Two types of inventory are common in manufacturing; work in process (WIP) and part storages. WIP is the inventory kept between operations or products being processed. The definition of WIP is here narrowed to only include the inventory kept between operations, and not the products being processed. Part storages are the raw material and components that have been delivered from the main warehouse out to the workstations, and are waiting for being processed (Mattson & Jonsson, 2003).

So why do WIP and part storages exist? No matter what is being stored as inventory or where positioned in the production flow, it will exists because there is a difference in the timing of supply and demand (Slack et al, 2001). The inventory level in both WIP and part storages is composed of buffer inventory and cycle inventory (Figure 5).

Buffer inventory is held to absorb variations in supply and demand, and is a security towards the risk of running out of parts (Mattson & Jonsson, 2003). WIP buffers are there because of variations in processing time, both in the supplying operation and in the demanding operation. The variation can be caused by:

- variation in product models
- variation in skills between different operators
- defects in material or components
- problems that occur during assembly or processing

Hopp & Spearman (2001) have empirically showed the relationship between WIP buffers, throughput time and production rate (Figure 6). Throughput time is the time for a specific product to go through the production flow, and the production rate is the rate at which the products leave the production.

![Figure 5. Inventory levels.](image)

![Figure 6. WIP, throughput time and production rate.](image)
Figure 7 shows that the maximum production rate is reached when the WIP buffers are increased to a level where they absorb all the variation in the operations process time. This means that an operation never has to wait for products from the preceding operation to be ready (starving), or wait for the following operation to be ready (blocking) (Segerstedt, 2003). A high level of buffers eliminates the waste of time for operators waiting for work and maximizes the production rate. However the throughput time for the products increases when the WIP increases, which is waste of products waiting in inventory (ibid). This implies that deciding the amount of WIP is a matter of balancing two different kinds of waste. Segerstedt’s conclusion is that the WIP should be enough to reach the maximum production rate, but not bigger. Increasing the WIP above this will cause excess in inventory (Figure 8).

Instead of using WIP buffers, time buffers on each operation can be used (Ellegård et al, 1992). This means that the takt time for an operation is set longer than the actual process time. The variation in process time will be absorbed by the excess in time, instead of the WIP buffer. However the same waste problem occurs when using time buffers. Setting the time buffer level too low will cause imbalance in the flow when operations are not finished in time. Setting the buffer time too high means that the operation takt time is much longer than the actual process time (ibid). This means that the operators must wait for work, which is waste of time.

In part storages the buffer mainly exists in order to even out variations in demand from the workstations. If the station that the part storage is supposed to supply uses takt time, the demand will be deterministic and variation low. The buffer can be held at a low level, and the inventory should almost reach zero between the replenishments (Slack et al, 2001).

**Cycle inventory** occurs when the inventory is replenished with a batch of parts. The reason for doing this is the trade off between the fixed cost of delivering or producing one batch (set-up cost), and the cost incurred by the level of inventory (holding cost) (Segerstedt, 1999). The batch quantity that minimizes set-up cost plus holding cost is called the economical order quantity.

Lean manufacturing emphasises the importance of reducing inventory, since it is considered to hide productivity problems caused by unwanted variation and complicated set-up procedures (Figure 9) (Slack et al, 2001). Inventory can be reduced by either reducing buffers (buffer inventory) or batch sizes (cycle inventory). Buffer inventory is reduced by eliminating unwanted variation and cycle inventory is reduced by decreasing set-up costs and bath sizes.
The positive effects of reducing inventory are many. Some examples are:

- Less capital tied up in inventory
- Shorter throughput time
- Lower cost for material handling
- Less risk for obsolete material and components
- Smoother production flow
- Faster detection of quality problems
- More space and better visibility
- Lower space rental costs

The list above shows that the effects of reducing inventory are related to several other sources of waste, such as waste of time, defective products and transportation. This implies that reducing inventory is an important issue in order to reduce waste in the manufacturing.

2.3 **Pull instead of push**

Using pull systems to control the material and product flow in the factory is a common approach to achieve just-in-time on the shopfloor (Lai, Lee & Ip, 2003). If just-in-time is the objective, then pull systems is a mean to reach it. The principle of just-in-time in its basic meaning implies that each operation should be provided with exactly the right part, in the right quantity, at the right place and at the right time (Karlsson & Åhlstrom, 1996). The ultimate goal is that every process should be provided with one part at a time, exactly when the part is needed (ibid).

Excess of inventory is highly interrelated with just-in-time. First there is the case when parts are produced or delivered in batches, which causes cycle inventory. The just-in-time principle argues that parts should be delivered one at a time in order to reduce the cycle inventory. Secondly, buffer inventory is held to absorb variations in delivery and consumption. According to just-in-time, the right components and material should be provided exactly at the time they are needed. A prerequisite for reducing buffers to achieve just-in-time is therefore to reduce variation. (Karlsson & Åhlstrom, 1996).

Just-in-time manufacturing in its most elaborated form is when parts are delivered one at a time to the workstation with reference to the specific product being processed. This is called sequential just-in-time (Karlsson & Åhlstrom, 1996). An example of sequential just-in-time is when an engine arrive just-in-time to the line for being assembled on a specific truck. However not all parts have to arrive in sequences. Parts that are common for several products do not have to be dedicated to a specific product when they arrive, and small inexpensive parts are rather delivered in batches than one at a time (ibid).

Implementing pull systems is a strategy to reach just-in-time. Pull methods simplifies coordination through physical demand linkage between workstations, and the pace is set by the ‘customer’ workstation which pulls work from the preceding ‘supplier’ workstation. The customer acts as the only trigger for start of new work (Slack et al, 2001). Since parts are only moved if a request is passed back to the preceding operation, pull systems are less likely to
accumulate inventory between workstations (Segerstedt, 1999). In a push system, the parts are moved to the next station when they are ready. Any delay or problem at that station will cause accumulation of inventory. Activities are scheduled by means of a central system and completed in line with central instructions, for example in an MRP-system. Each workstation pushes out work without consideration to whether the following workstation needs it or not (Slack et al, 2001). Push systems rely on accurate and timely demand forecasts and shop execution data to coordinate workstation actions (Askin & Goldberg, 2002). In practice however, actual conditions often differ from those planned in the central system (Slack et al, 2001). A consequence of this is idle time, excess of inventory and queuing, which often characterizes push systems.

### 2.3.1 Kanban

A pull method used in lean manufacturing is kanban, which ensures that material and products are pulled through the factory when they are demanded (Lai et al, 2003). A study accomplished by Jonsson & Mattsson (2000) showed that the use of kanban as a material planning method in manufacturing companies has increased during the last decade. Most of the companies used kanban for in-house material control and were rather satisfied with the method (ibid). Kanban is the Japanese word for card. In its simplest form, kanban is a card or device used by a customer workstation to send a signal to the preceding supplier station that it needs more parts (Slack et al, 2001). Each part type produced at a workstation has its own set of kanbans, and each kanban authorizes a particular number of that part type. The kanban card includes information about part type, number of parts authorized by the card, location of the workstation etc. The parts are usually stored and moved in kanban trolleys, which are designed to carry the parts authorized by one card (ibid). However several trolleys can be used for one card, if the parts are too big to fit into one trolley. An example of a kanban card and trolley is given in Figure 10.

The *single-kanban* system is used when the workstations are close together (Askin & Goldberg, 2002). Figure 11 shows the flow of kanban cards and parts in a single-kanban system. When the operator at the customer station empties a trolley, he moves the card and the trolley to the supplier station and puts the card on the schedule board. The card is put on the board in order of arrival, and signals to the operator at the supplier station to start producing. The supplier is supposed to produce whenever there is a card on the board, and when a trolley is filled up he moves the corresponding card and puts it on the trolley. The card shows that the trolley is ready to be moved to the customer station. This is usually done by the customer station operator at the same time as he leaves an empty trolley at the supplier station (ibid).
The dual-kanban system is used when large distances between the workstations dictate the need for an input buffers at the customer station in addition to the output buffer in the single-kanban system. The distance implies that it is not economical to let the production worker move one trolley at the time (Askin & Goldberg, 2002). While parts and trolleys are transferred by the operator in a single system, dedicated material handlers transports several kanbans at a time in the dual system. The material handler picks kanban cards and trolleys from many stations at the same time in periodic time intervals, for example every second hour or twice a day. Dual kanban is often used in more general systems where there are several supplier stations and customer stations (ibid).

The system has two loops and two types of kanban cards are used for each loop; production kanban and withdrawal kanban. The withdrawal kanban signals that parts or material can be withdrawn from inventory and transferred to a customer workstation, and the production kanban signals a supplier workstation to start producing a part to be placed in inventory (Slack et al, 2001). Figure 12 shows the flow of kanban cards and trolleys in the dual-kanban system. The operator at the customer station puts the withdrawal card in a collection box at
the station when he picks the last part from a trolley. The withdrawal cards in the box signals to the material handler that the input buffer should be replenished. He picks up the cards from the collection box and the empty trolleys, and moves them back to the output buffer. When he arrives to the output buffer, he puts the withdrawal card on a full trolley that is ready to be moved to the input buffer. The signal to the material handler that the trolley is ready to be moved is the production kanban card that already are on the trolley. The production card is removed from the trolley before it is moved, and is put on the schedule board. The production cards on the board signals to the supplier station to start producing parts for the output buffer. When a trolley is filled up the operator moves the corresponding card and puts it on the trolley. The trolley is then stored in the output buffer until the material handler picks it up.

There are basically two parameters that have to be specified when designing a kanban system; number of kanban cards and the number of units authorized by each card. It is often convenient to set the number of units per card to the quantity that fits into a material delivery trolley or container. This definition is easy to implement and a simple verification that the system is operating properly can be made from visually checking that each container has an accompanying kanban card (Askin & Goldberg, 2002). The inventory levels are rather influenced by the lead time for the replenishment loop than the number of units per card, and inventory becomes a secondary concern when it comes to specify units per card. Because of that the number of units is often determined by material handling factors such as container design and delivery frequency possibilities (ibid).

The second parameter to determine is the number of kanban cards in the delivery system. The most important factor to consider when deciding how many cards to use is the lead time for replenishment, when a kanban card has been released from the customer station. Essentially the number of kanbans must be enough to cover the demand from the customer station during the lead time for replenishment (Segerstedt 1999). If \( n \) is the number of units per card, \( D \) is the demand at the customer station (units/day), \( k \) is the number of kanban cards and \( t \) is the replenishment lead time (days), then the minimum number of kanbans can be calculated as:

\[
k \geq \frac{t \cdot D \cdot (1 + s)}{n}
\]

Where \( s \) is a safety factor (as an example Toyota uses \( s=0.1 \)). If \( k \) is calculated with this formula, the number of kanbans should be enough to cover the average demand.

### 2.3.2 Two-bin system

The two-bin system is a simple pull method that is suitable for small and inexpensive parts (Slack et al, 2001). In a two-bin system, the parts are stored in two similar bins at the workstation (Figure 13). Parts are picked from the first bin (1), and when the first bin is emptied the operator puts it in a collection box. The second bin (2) slides down and the operator continues to pick parts from the second bin. The material handler picks up the empty bin from the collection box and refills it. He then returns it to the station and puts it at the upper position (Mattson & Jonsson, 2003).

Information tags with part number, refill quantity, and station number are usually attached to the bins. The tag tells the material handler what to pick, how much and where to put it (Slack...
The two bins are always refilled with the same quantity, which must be determined before the system is implemented. A large quantity will cause a lot of inventory at the workstations, but less frequency of replenishment. The opposite occurs if a small quantity is chosen. However the minimum refill quantity that can be used depends on the lead time for the replenishment. There must be enough parts in the bin to cover the time it takes for the material handler to fill up the empty bin.

2.3.3 Kitting of parts in pull systems

Material and components that are distributed with a kanban system to the workstations might be picked in kits before they are distributed. A kit contains the parts needed for a station to perform the work on one product (Askin & Goldberg, 2002). The kanban trolley capacity is specified as a number of kits, instead of number of parts.

One advantage with kits is that less space is needed for material at the workstation. Distributing each part type in separate kanban trolleys requires a lot of space, if many different parts are assembled at the station. Delivering in kits can therefore reduce the number of trolleys at the station (Ding, 1992). Kitting also simplifies the material handling at the workstations and reduces search time (ibid). The operator does not have to pick the parts from several trolleys or bins. Instead all the parts are already collected together. A disadvantage with kitting is that it requires more work in the warehouse before the parts are distributed and the space required for material handling in the factory increases.

Considerations of kitting in a pull system are part sizes, lot sizes (number of kits/trolley) and kit sizes (Ding, 1992). Under the part size consideration, for example, there are kittable parts and non-kittable parts due to size restrictions. Even within the kittable parts the size must be considered, in order to design proper trolleys. The parts in a kit can be grouped on the basis of size and geometry, sequence of assembly operations and ease of packaging, e.g. grouping hardware components together (Sundarraj, 1997). It is important that the operator that uses the kit is able to identify the parts in the kit. Putting to many small parts together makes it harder to distinguish between the parts. The risk of assembly error increases if parts are poorly marked or mixed together (ibid).

A case study performed by Ding (1992) at a tractor plant, showed that the implementation of kits delivered in kanbans increased productivity, created space and reduced WIP. The factory used three types of trolleys depending on the size of the kits. Most of the trolleys were delivered to the stations with a dual-kanban system, with three kanban withdrawal cards for each type of kit. The kits were picked from a storage and delivered to the workstations.

2.4 Multifunctional teams

In the book “The machine that changed the world” the creation of teams are presented as a crucial role. They “emerge as the heart of the lean factory” and are called “hallmarks” of lean manufacturing (Womack et al, 1990, p. 9). The creation of multifunctional teams among the shopfloor workers is one of the first and most important steps in the implementation process towards lean manufacturing. The implementation towards lean manufacturing does not have to start with the creation of teams but it will certainly help when implementing the other steps (Sánchez & Pérez, 2001).

Lean manufacturing demands creative workers that are interested in their work situation (Forza, 1996). This means that the individual worker has more demand and pressure on himself. A Swedish study done by the Swedish union (Metall, 2002) shows that most of the
work with eliminating waste and improve the workplace environment makes sense to the labour, but they are pointing at the risks with more intensive and simpler work tasks. Because lean is about making the production more efficient it may result in a shorter cycle time with simpler assembly tasks.

2.4.1 Team organization

Creating multifunctional teams is a good tool against hierarchical systems, as teams often achieves better results than individuals working on their own, according to Katzenbach and Smith (1993). Levelling the organization might lead to a more flexible production, as tasks can be decentralized to the shopfloor workers. Teamwork is not only about production tasks but also indirect functions like maintenance and material handling (Sánchez & Pérez, 2001). By delegating tasks to the team on the production line, indirect labour costs can be reduced. The minimization of indirect work is one of the main issues with lean manufacturing (Karlsson & Åhlström, 1996).

In multifunctional teams all team members are to be trained to become multi-skilled workers. To achieve this, the managing perspective will have to change from looking at smaller assembly functions to look at larger processes of the production flow (Biazzo & Panizzolo, 2000). According to Karlsson and Åhlström (1996) the teams are often organized along a cell-based part of the production flow. The objective is that the individuals in each team shall be able to replace each other so that the production can proceed without interruptions (van Amelsvoort & Benders, 1996; Rubenowitz, 1994). This expanding of the worker’s knowledge will open up for job-rotation and thereby an enlargement of the workers job environment, besides increasing the flexibility along the production flow (Biazzo & Panizzolo, 2000; Sánchez & Pérez, 2001). Most workers find it more fun to work in teams, then by their selves. As the team members overcome barriers and obstacles together, they will reach a higher level of performance (Katzenbach & Smith, 1993).

With the creation of multifunctional teams it is important to get the horizontal information system within each team to work. It is also important to get the team to communicate with other teams and persons that affect them (Barker, 1994). Teams are a good way of working with production problems. When doing this the degree of communication and cooperation is crucial. Katzenbach and Smith (1993) also emphasize the importance of having team members that complement each other. A satisfying communication climate often means that the team’s social contact is good. A good social climate between the members affects the performance level, according to (Thompson, 2004).

The creation of teams does not automatically mean success. Teams need a clear problem to work with otherwise they might be just a social forum (Katzenbach & Smith, 1993). When the managers have decided to use teams in their production they have to ask them selves what the teams are created for. What is the company’s purpose? After that they have to decide how many teams they need and what skills that are necessary (Thompson, 2004). It is important to have a clear purpose and all the necessary knowledge within each team, as groups become teams with discipline and clear objectives (Katzenbach & Smith, 1993). A team should have a proper amount of members to be functional. A team of ten people is far more likely to succeed then a team of fifty. If a team consists of to many people it is better to break it into sub-teams (Thompson, 2004). Katzenbach and Smith (1993) recommends that a team is created by shaping a common purpose, all members should agree on performance goals, define a common working approach, develop high levels of complementary skills and hold
the team members mutually accountable. A set of demanding performance goals will lead to both performance and a good teamwork (Katzenbach & Smith, 1993).

To visualize the team members’ progress a board with all the team members’ names and the different work tasks should be created. When a team member learns a new task it is noted on the board. This so-called ‘flexi-matrix’ is used for assessing the team members’ individual skills and the teams’ total skill. The first goal is to make sure that each task can be performed by at least two individuals (van Amelsvoort & Benders, 1996). One obstacle that might occur is that some of the workers have done the same task for years and now has to learn several new ones (Sohal, 1996). To work in teams often motivates and supports creative workers according to Katzenbach and Smith (1993). With the increased focus on multi-skills, the company should introduce a reward system based on performance or skill to encourage the employees (Biazzo & Panizzolo, 2000; Karlsson & Åhlström, 1996). Volvo do Brazil uses the Swedish ‘competence based’ pay system and all the employees are satisfied with it according to Wallace (2004). There may be some problems introducing this kind of salary system in some cultures because it needs to be politically approved, by for example the union. One positive effect of group bonuses is that the workers are likely to watch one other’s contributions (van Amelsvoort & Benders, 1996).

When the production teams are ready they should be given the responsibility of all the tasks along their part of the production flow (Karlsson & Åhlström, 1996). It is the present team leader that is responsible for checking the team and make sure that all the duties are taken care of (Rubenowitz, 1994). Katzenbach and Smith (1993) recommend that a new team starts with easy tasks in order to unite the team members. Groups do not become teams just because someone labels them as teams. All teams and especially new ones need a lot of support and commitment (Thompson, 2004). This responsibility relies on the managers and team leaders. In a well working lean organization the team members will be involved in activities like maintenance, quality control, production planning and safety. When the workers on the shopfloor learn how to deal with new duties and how they interact with each other, the management support is of decisive importance for the outcome (Katzenbach & Smith, 1993).

2.4.2 Team leadership

Lean manufacturing recommends that each team uses a rotational leadership. The leaders should be elected among and by the own team members. Volvo’s factory in Brazil uses this rotational leadership with a good result according to Terry Wallace (2004). A research made by the union in Sweden shows that a rotating leadership is preferred (Metall, 2004). The advantage with a rotational leadership is that each worker has to learn the ‘leader’ tasks and thereby gets a greater understanding for the production process. If the team leadership is going to work the managers have to give the proper education, training and support for the new team leaders (Karlsson & Åhlström, 1996). The negative part with a rotational leadership is that the leader’s duties have to be set according to the ‘worst’ members qualities. This means that the organization will lose some of the potential with the team leader position.

In the beginning of the implementation towards self-directed teams it is important to find the right person for the leader position. The leader’s actions and commitment can help the change process on its way if he can influence the members (Emeliani, 1998). According to Karlsson & Åhlström (1996) it can be difficult in the beginning to find volunteers and this may lead to a gap between the old and the new organization. It is best if the team already has a champion that can take the leader position naturally and continue to influence the members in a good way (Sohal, 1996). Sometimes it is too much focus on the team leader and what skills he
should have. Almost every team member could become the leader with the right support. It is better to help them to succeed after, then before the selection (Katzenbach & Smith, 1993).

The management personal should act like ‘donors’ in the empowering process of the workers (van Amelsvoort & Benders, 1996; Karlsson & Åhlström, 1996). Sohal (1996) recognized that simple methods like clear structures, practices and decision-making processes provide a solid base for the team members and helps them to get into a standardized way of working. Lean production generates increased inter-dependency between the actors in the production process. To manage this intensified dependency successfully, there has to be a complex support system (Biazzo & Panizzolo, 2000; Sohal, 1996). The team needs support from different departments and functions during the creation process.

The main problems with decentralization of work tasks are that the donor might have a problem with giving his work away. He is giving some of his power and knowledge away and thereby some of his position in the company. Now the donor has to find his own new roles and perspectives (van Amelsvoort & Benders, 1996). He might talk about helping the new worker, but he is not really helping because he does not want to give away his habits. To prevent this and other obstacles, the vertical information has to be improved. It is easier to delegate work tasks if the donor and the worker have a good and open communication climate (Biazzo & Panizzolo, 2000).

It is important to have active and constructive leaders. The leaders should give continuous feedback on the team’s performances (van Amelsvoort & Benders, 1996). To make sure the company is developing its work with multifunctional teams they should measure them selves on a regular basis and compare the results with earlier measurings in the company and perhaps with some competitors (Sánchez & Pérez, 2001). If the leader makes everyone focus on the team’s performance, then it will be easier for everyone to go in the same direction and focus on the same thing and hopefully accept each other socially (Katzenbach & Smith). The team leader should motivate the team by keeping purposes and goals relevant and meaningful (Thompson, 2004).

2.4.3 Team meetings

If the team never has worked together in a group it is important to have some starting team meetings. The meetings should take place during ordinary working hours and on regular basis (Sohal, 1996). The first meetings should be led by the current team leader in cooperation with some sort of mentor. The mentor can be an external consultant or someone from the company with meeting experience. If the team members have worked individually before, the team leader and the mentor has a great responsibility in the beginning. He should treat everyone as an individual in the beginning and give them appropriate tasks and when they are ready they should be given more team based duties (van Amelsvoort & Benders, 1996). In the whole process of creating teams it is important to have a supporting leadership (Katzenbach & Smith, 1993).

On the first meetings questions like “why work in teams?” and other team start-up issues should be discussed. It is important that all the team members understand the seriousness of team building and lean manufacturing in general (Rubenowitz, 1994). The team members’ motivation to become lean and their understanding of the lean concept are factors that must be handled in the early steps of the implementation (Robbins, 2003). The managers should be aware of that individuals are being motivated in different ways, which means that motivation needs a lot of commitment (Coté & Helling, 2002).
After a few meetings different kind of operational problems can be discussed and solved in order to teach the members what team meetings are for (van Amelsvoort & Benders, 1996). It is important that there is a clear structure at the meetings, so that everyone knows what will be discussed. In a study of Italian manufacturing companies Forza (1996) found that lean manufacturing companies used more teams in problem solving, that the workers performed a higher variety of tasks and that the proportion of implemented suggestions was higher than in non-lean companies.

### 2.4.4 Education

To achieve good results with teams they have to receive appropriate training and education (Rubenowitz, 1994). An American study found that lean companies invested more money in training and facilities to make teams work properly than other companies (Boyer, 1996). Building up trust and faith in the team should be the main focus in the beginning of the education. To do this the vertical communication with managers and teachers are the most important one. An intensive and good vertical communication is supposed to discover all kinds of resistance against the change towards becoming lean. The resistance can for example consist of mental blockades among the individuals, fear of the unknown or common resistance against all kinds of change (Robbins, 2003; Åhlström, 1997). The managers have to be aware of that there will be some persons in the organization that will work against the change process (Côté & Helling, 2002). A good communication in the early stages of the implementation will help to identify resistance and start appropriate actions towards it (Åhlström, 1997). Sohal’s (1996) Australian research on Trico shows that one of the major problems in the beginning was to make operators realize that the way they had been doing their job for the past 20 years was not necessarily the best way. Another problem was to change the attitudes and maintaining discipline among the workers, to become more predictable and responsible.

When the operators go from simple tasks to more complex ones with increasing responsibility and authority it is necessary to build up the team member’s confidence in their capacity of handling their new work situation (van Amelsvoort & Benders, 1996). Figure 14 describes four different situations a team or an individual can be in. According to Csikszentmihaly (1990) the objective is to stay in the flow channel and this can be done by changing the challenge or skill levels. If a worker achieves a high work skill without being given the proper responsibility he might get bored. To prevent boredom and get back into the flow channel the challenge level must be increased. It is the same relationship if the challenge gets to high compared to the skill level.

### 2.5 Decentralized responsibilities

The decentralization of responsibilities to the shopfloor workers is one of the key factors in the lean manufacturing philosophy (Sánchez & Pérez, 2001). All work tasks that workers can
handle on their own or in their teams, should be given to them. It is a waste of managers’ and
supervisors’ time to handle duties that the workers can perform. To achieve this, the
organization has to improve its vertical information system, as it is a critical factor to change
in order to achieve sustainable effects in the organization (Åhlström, 1997). If there is a strict
and bureaucratic channel in which the information is communicated, it will lead to a slow and
inefficient organization. Improving the vertical information is supposed to make the
organization more efficient in its way of exchanging information (Sánchez & Pérez, 2001).

2.5.1 Team responsibility and authority
Decentralization of responsibilities and the creation of multifunctional teams are closely
connected. The lean philosophy is that workers on the shopfloor should be formed into teams,
who can solve upcoming production problems. Lean manufacturing involves more
responsibility and authority on the production workers (Karlsson & Åhlström, 1996). First
they get to learn more assembly tasks and after that they are successively given more
supervisor tasks. According to lean they are even supposed to get the authority to stop the line
if a major problem appears (Forza, 1996). Among the first supervisor tasks the workers take
over, is the quality control. The workers are supposed to control their own work before they
send the part to the next station (Åhlström, 1997). As the team gets more and more
independent the supervisor position is supposed to disappear. The teams are supposed to
handle tasks that affect them, both direct and indirect ones (Karlsson & Åhlström, 1996). This
decentralization of responsibility and authority is supposed to end up in fewer production
stops and quicker solutions (Forza, 1996).

2.5.2 Organizational hierarchy
One of lean manufacturing’s well known marks is its elimination of the supervisor position.
The organization should try to move all the supervisor tasks on to the teams and perhaps some
to the production manager in order to get rid of one hierarchic level (Karlsson & Åhlström,
1996). The organization’s climate and change history are critical factors for how smooth this
process will proceed (Åhlström, 1997; van Amelsvoort & Benders, 1996). The organizations’
hierarchical levels of power and the managers’ unwillingness of giving away their power, can
slow down the process of levelling the organization’s hierarchy (Karlsson & Åhlström, 1996).
The managers have to realise that their power is not in their hieratical position but in their
actions (Coté & Helling, 2002).

According to Karlsson & Åhlström (1996) the number of levels in the organization depends
on the organization’s size. This implies that the lean philosophy still can be followed, even if
levels between the workers and the production managers exist. Indirect functions like quality
control and some support functions can be removed or minimized as the teams in the
production can handle some of these duties (Åhlström, 1997). The point with these
reorganization activities is that the organization should be able to make faster and better
decisions (Forza, 1996). To highlight the organization’s hierarchical level problem the
managers should do a continuous measure of the number of levels and continuously inform
about the results (Karlsson & Åhlström, 1996).

2.5.3 Vertical information
When trying to decentralize responsibilities in an organization the vertical information system
is a critical factor to improve. If the shopfloor workers are to perform more and different tasks
compared to before they have to be given the correct information.
The teams’ current delivery precision, quality audit scores and productivity scores are examples of information that has to be given to the teams continuously. This kind of feedback must be sent to the concerned teams as soon as possible so they can evaluate their current way of working (Åhlström, 1997). The teams can compare this information with their own goals and with the company’s overall goals. This comparison should be visualised on key performance indicator boards near the teams working area, also named ANDON-boards, if the organization is following lean (Åhlström, 1997; Marchwinski & Shook, 2003). ANDON-boards are supposed to show the production cell’s status compared to the set goals. ANDON is the Japanese word for ‘light’ and its first purpose was to visualize when something went wrong in the production. When an operator identifies a problem, he contacts the support team by lightening a lamp (Metall, 2004). An Australian research made by Sohal (1996) shows that the implementation of ANDON-board at Trisco turned out well and the team could use them to highlight production problems like quality and material shortages. When the company is setting goals they often set numeric goals. There is a risk in using numeric numbers and that is that the teams can reach them too easily or they may never reach them. Therefore the goals have to be updated continuously and both parts should agree about the goals (Coté & Helling, 2002).

In the vertical information systems it is not only the information that is interesting but also how and when it is communicated. The objective is to provide a timely and continuous information flow direct to the production line with the necessary information (Karlsson & Åhlström, 1996; Sánchez & Pérez, 2001). Information can be communicated in written text or verbally. Written information is common in the industry in the communication between managers and shopfloor workers. The advantage of verbal communicating is that the receiver can comment and discuss the information immediate (Åhlström, 1997). When using written texts there is a greater chance of misunderstanding compared to verbal communicating. The advantage with written text is that the information can reach many people at the same time on different locations and the information can be documented. Lean manufacturing prefers verbal communication because it brings the organization together (Karlsson & Åhlström, 1996).

Managers should act like they want the rest of the organization to do. As an example Forza (1996) thinks it is a plant manager’s duty to almost every day walk through the shopfloor and meet the workers, which is known as ‘Management by Walking Around’. In some organizations the workers never even see their managers except from when they are in the office. The Swedish union’s research shows that it is important to have managers with a positive outlook on mankind or the organization may loose creative employees as time goes by (Metall, 2004).

The information flow in an industrial organization consists of operational and strategic issues. The frequency by which the information is communicated is important in lean organizations and especially the operational information like measuring and process issues (Karlsson & Åhlström, 1996). The operational information has to be communicated on a daily basis, other than the strategic that can be communicated weekly (Sánchez & Pérez, 2001). For most organization this will result in more communicating if they go from two newsletters per year to a continuous communication of news every week (Karlsson & Åhlström, 1996).

One problem with traditional plants is that they have too many strict information channels. In lean organizations the information should not reach persons that it does not concern. Sánchez & Pérez (2001) takes reclamations and quality problems as an example. If something is assembled wrong the responsible operator must receive the information so he can correct his
own fault. The information should not go through a number of different levels and departments before it comes to the shopfloor and the responsible worker (Åhlström, 1997). It is the same problem if the operator on the line comes up with a solution on a problem and he does not tell the product developers (Sánchez & Pérez, 2001). All these information problems are to be solved if the organization adapts the lean vertical information system. In the lean organization every department must inform concerned departments or teams what they are doing. The share of information must increase instead of that everyone keeps his information to himself (Åhlström, 1997). In time the vertical integration will affect the company’s costs, flexibility, quality etc according to Slack et al. (2001).

2.6 Continuous improvement

Continuous improvements in lean manufacturing means that everyone in an organization continuously work to improve the production process (Karlsson & Åhlström, 1996). Increasing demand from customers and harder competition makes continuous improvements necessary. Lack of quality is often a considerable cost in many organizations, which is another reason for working with improvements (Bergman & Klefsjö, 2001). In lean manufacturing the work with continuous improvements is often carried out within multifunctional teams on the shopfloor and in cross-functional groups. A cross-functional group consists of people from different areas in the organization, for example some specialists, a team leader and some operators (Metall, 2002). The point is that every function in an organization can contribute with something. According to Sohal & Egglestone (1994) it can be a mistake to exclude the shopfloor in developing and improvement projects.

2.6.1 Zero defects

The objective with the continuous improvement work is to achieve perfection, which means that every product, part or process never should be defective at any time (Karlsson & Åhlström, 1996). The employees must understand that it is their responsibility to improve the quality (Forza, 1996), because they are often the ones that know the process best (Helling, 2002). The shopfloor workers are also the ones that should correct the products when a defect occurs. If they do that they are the ones that know what went wrong and can come up with solutions (Karlsson & Åhlström, 1996). It is the same thing if there is a machine break down. Major stoppages like machine break downs can be prevented by letting the operators handling the daily maintenance of the machines (Nakajima, 1988).

According to Karlsson & Åhlström (1996) lean is about achieving a higher process control, which is achieved by focusing on the processes instead of the products in the production flow. Lean is about discovering the systems weaknesses before it results in defective products (Sánchez & Pérez, 2001). Lean wants to move the quality control of the products and the processes down to the operators, which will release people in the quality departments and create space in the factory when the adjustment and repair area can be reduced (Karlsson & Åhlström, 1996). The Japanese term *poka-yoke* means error proofing and it is a way of finding the defect products before they leave the station. Defects can occur if the operator is choosing the wrong part, leaving out a part, installing a part backward etc. To prevent this, the products can be designed with a physical shape that makes it impossible to install parts in incorrect orientation or the stations can be designed with some sort of automatic control system etc (Marchwinski & Shook, 2003).

2.6.2 Work with continuous improvement

The continuous improvement work should be done in the multifunctional teams and in cross-functional groups. According to Karlsson & Åhlström (1996) the number of suggestions and
the interest in making improvements rises notably, if the employees are gathered together in small groups at pre-planned occasions instead of the old ‘suggestion boxes’.

The multifunctional teams along the production line might consist of many people depending on the operations. If the teams are large they may have to be divided into smaller groups when working with problem solving issues (Forza, 1996; Sánchez & Pérez, 2001). The optimum group size for problem solving groups is about six persons (Metall, 2002; Sohal, 1994). If there are too many persons in a group some individuals might ‘disappear’ in the group. The groups should meet regularly, for example once a week for 20 minutes, and work in a standardized way (Kossila & Jeppsson, 2003). The groups should work according to the PDCA-cycle (Figure 15), plan-do-check-act, that William Edward Deming created (Metall, 2002; Imai, 1991). First the group find a problem, and then they plan what to do about it. After that they do the changes and check what effect the change had. The last step is to act according to the result, either they go through every step again or they are satisfied with the result and make it to a new work standard.

![Figure 15. The PDCA-cycle.](image)

The problem solving groups should be educated in problem solving and be given clear structures, standards, time and practices for how to work in the groups (Sohal, 1994). It is important that the members are motivated and feel that their work with problem solving means something for them and the company as a whole, otherwise the group might find it interesting in the beginning and successively get bored (Rubenowitz, 1994). Barker (1994) points at the risk with motivated problem groups that do not have the necessary knowledge of the value flow in the production, they might do none value adding changes without knowing (Ohlsson, 2002). This kind of system is based on that the operators come up with suggestions and that the managers give them continuous feedback and some sort of reward for good suggestions (Lindström et al, 2002b).

It is important that the groups are focusing on the root cause of a problem instead of just changing the visible problem. To prevent this and other mistakes every group has to continuously communicate to the organization what they are doing and how it turns out. One way of communicating is to use information boards, like ANDON-boards, in the factory. On these boards the groups should have one list over ideas, one over ongoing projects and one over performed projects. Together with this lists there should be results from measuring that shows the improvements that each project has accomplished (Kossila & Jeppsson, 2003). To get this process going the managers can set a good example by starting their own problem group and show the organization what they are accomplishing (Lindström et al, 2002b).

Another popular and effective tool to use is 5S (sort, set in order, shine, standardize and sustain). 5S is a method divided into five steps for organizing and visualizing workstations (Lindström et al, 2002c; Kossila & Jeppsson, 2003). In the sort step the group is to separate out what is needed for their operation. Set in order is to organize the work area and make it easier to find what is needed. In the shine step the workstation is to be cleaned, made shining. When this is done the group should standardize, establish schedules and methods of performing the cleaning and sorting. In the last step, sustain, the group is to implement
mechanisms to sustain the gains through involvement of people, introduce a performance measurement system, discipline and recognition.

Every gain that the continuous improvement work accomplishes should be visualized in some way (Wallace, 2004). If there is a release in production space its importance can be emphasized by putting a symbolic object in the empty area, for example a flowerpot. The managers should have some kind of an overall measuring system that measures parameters like; suggestions per employee, number of employees working with quality and control work, savings and benefits from suggestions etc (Sánchez & Pérez, 2001). These figures act like indicators for the managers for how the continuous improvement work is proceeding but above all the figures shows the employees what they can accomplish and what it results in.
2.7 Process stability

Stability in the organization’s processes is a prerequisite for successfully implementing the different lean principles (Vasilash, 1999). The lean enterprise must be built on a stable foundation, which is illustrated in Figure 16. Every time a problem has to be solved, there has been a failure in having stability in the process. A stable process should have a robust design that prevents problem from occurring. It is therefore important to identify the root-cause when a problem occurs, and not only come up with temporary ‘fire fighting’ solutions (Bergman & Klefsjö, 2001).

![Figure 16. Building up an organization according to the ‘lean temple’.](image)

A standardized process means that everyone is performing the work in the same way. The current best way to perform a work task should be documented as a standard and be used by all employees. The standard is a mobile limit that must be improved continuously together with the workers (Forza, 1996). A new standard is set when better work procedures have been developed and acts as a new base for future improvements (Figure 17). Standardized processes are necessary to achieve stability, and the risk of having a process failure is much higher if everyone uses different more or less suitable work procedures (Praetorius, 2004). Examples of areas where stability and standardization have to be achieved are production teamwork, workstation layout, information systems and management processes (Figure 16).

![Figure 17. Continuous improvement of standards.](image)

The organization is ready for lean when a stable foundation has been built up. The focus when implementing lean manufacturing must be on several areas, which are all interacting (Karlsson & Åhlström, 1996). It is hard to build the lean temple with only one or two pillars,
but all the lean principles must be considered to achieve a successful and sustainable work with lean (Figure 16). Those areas that are less developed in the organization must be emphasized during the implementation. Involvement of the production workers is crucial, since they to high extent are affected by the implementation and often have a lot of knowledge of the production process (Atkinson, 2004). When the organization starts to build the ‘lean temple’ they will gradually increase the company’s strength and thereby the customer satisfaction. The temple of lean manufacturing will get better and more stable the more each part of it is improved.

2.8 Implementation of lean manufacturing

Changes in the organization are often met by suspiciousness and resistance from employees. People are afraid of the unknown and might think that things are already just fine and do not understand the need of changing (McNamara, 1999). The resistance towards new ideas is to high extent dependent on the culture in the organization, which can repel attempts to implement lean manufacturing. It is therefore vital to understand the culture in order to create an appropriate and cost-effective implementation plan (Franklin, 2004). Several factors must be considered to successfully implement lean manufacturing, and some of the most important are discussed below.

2.8.1 Involvement of employees in the implementation

In every organization where changes are desired, one needs to deal with people. The motive for a change must be understood and accepted by the individual, in order to achieve sustainable improvements in the organization (Magnusson, Kroslid & Bergman, 2003). Lean thinking comes not by only focusing on process design, but by looking at process design together with those who produce the product or service. Calling upon, and more important, listening to how the production teams want to design and improve a process is crucial for lean. This means that lean thinking can only exist in a ‘listening’ culture where process design is created by those who produce the product, not by an analyst in the office far away from where the product is created (Atkinson, 2004). Sohal (1996) made a research on the Australian company Trisco and its implementation of a just-in-time system. According to Sohal the implementation went well mainly because of the close involvement of the employees. They were involved in activities like standardization of tools and the introduction of trolleys.

Human beings are very habitual and tend to do things the way they have been trained to do, or just as they have always done (Magnusson et al, 2003). The problem is that there are some employees who, even after sufficient training in lean principles, are not able to perform at the expected levels (Hancock & Zayko, 1998). The reason for this can be:

- They do not agree that changes are necessary (everything is fine the way it is).
- They are going to retire in a few years and do not want to do more than necessary.
- They have been through many improvement projects that have failed (believe that changes are not sustainable).
- They do not want reallocate their time from production work to improvement work.

The approach that seems to be necessary is that a pre-specified period is set for the employees to attain the necessary performance. If it does not occur during this period, they have to be reassigned. Lean manufacturing is dependent on everyone doing what is expected and there is no room for employees who can not or do not want to perform (Hancock & Zayko, 1998). It is important to find those employees that really are interested in participating in a change, and
involve them in the implementation process. Those real enthusiasts can inspire their colleges and motivate them to participate in the change (Atkinson, 2004).

2.8.2 Senior management commitment

The focus of senior management commitment is critical, and it is important to win the heart and mind of a major sponsor from the top team (Atkinson, 2004). The entire management team must support the implementation and it is important to achieve unity before the project is communicated to the organization (Hancock & Zayko, 1998). Top management should set the direction for the project and establish the vision and mission (Stamm, 2003a). They must practise what they preach and know what they are talking about. Case studies show that senior management commitment is often absent or vague in organizations where major improvement projects have failed (Magnusson et al, 2003). According to Miller (2004) good management during the implementation is characterised by credibility, consistency and support. It is important that top management not become the ‘owner’ of the project, and that employees feel forced to change without understanding why or how they are expected to change. If they are given the opportunity to participate in the decision-making they will instead be the ‘owner’ of the project, which is crucial when creating motivation (Magnusson et al, 2003).

2.8.3 Education during the implementation

Lean manufacturing involves principles that might not be familiar to many of the employees. Appropriate education and training is therefore needed at different levels in the organization before and during the implementation. Top management must be taught enough to be convinced that lean production is worth their attention and to create unity. Workers in the affected area need both theoretical education and practical training, since they must understand both why and how to use lean (Hancock & Zayko, 1998). Others that may have to be educated are union managers, process engineers and middle management (ibid).

If possible, it is highly desirable to implement a pilot area prior to or during the training that the students can examine and that can be used as a classroom example (Hancock & Zayko, 1998). It is vital to choose pilot areas that have a great chance to success and where clear improvements can be achieved. Failures in the beginning of the implementation process are often discouraging and the resistance towards the project can increase (Stamm, 2003a). The often dramatically improvements that can be achieved in the beginning, will after a while decline and give way to the more modest results that come from incremental continuous improvements (ibid).

Many organizations do not have enough knowledgeable people with sufficient experience to initially teach the in-house courses effectively. Fortunately there are many consultants that can be retained for this purpose. However it is important that the consultants just act as a support and not accomplish the entire implementation with little involvement from the resident staff. Too much involvement of consultants often leads to failure, because they do not have enough knowledge about the internal processes. Another risk is that the sense of ownership for the project declines (Stamm, 2003b).
2.8.4 Communication and information

Comprehensive information before and during the implementation is important in order to avoid confusion and create motivation. The focus should be on the results and benefits rather than the use of particular tools (Atkinson, 2004). Different levels of information are needed during different phases in the implementation. General information to large groups should be held before the operational changes take place and more specific information to smaller groups during the change (Franklin, 2004).

Communication can be very complex in today’s organizations, and it is therefore important that any change process applies one language and strives for a common understanding (Magnusson et al, 2003). The meaning of words and expressions used in lean manufacturing must be understood as intended, and create the right mental model among all involved employees (ibid).

2.8.5 Project management

There are two kinds of projects; complicated and complex ones. Complicated projects can be led in a structural way since all the parameters depend on each other in a countable way. Complex projects like a lean project needs another type of leadership and planning. The project’s complexity depends on the insecurity of the project. A ‘master leader’ that ‘does it all’ can lead these projects. Afterwards this project will feel like one man’s work. It is only the project’s top members that have control and understand where the project is heading (Marmgren & Ragnarsson, 2001). The other leadership variant has no clear leader. In this project there are many members involved in the planning and performing phases. An organization that uses this kind of structure has to have a good communication climate with trust between the members (Marmgren & Ragnarsson, 2001).

Marmgren and Ragnarsson (2001) also describe hard and soft processes. A hard process is when everything is predictable and there are few surprises. Soft processes often involve people and a change in behaviour and attitudes. These processes can not be controlled in the same way as a hard process, but instead it can be supported. Most projects are a combination between hard and soft. This means that it will need different kind of leadership in different phases. It also means that the plan continuously must be evaluated and updated.

When starting a project it is not only important to have clear and good project goals, but also to have part goals. Part project goals are goals that different departments or people want to achieve during the project. These goals will help the project on its way, especially if it is a big and comprehensive project (Marmgren & Ragnarsson, 2001). Apart from the project goals the project’s plan is important. The plan is the core of project management according to Packendorff (1995). All projects have to have a plan with all part goals, milestones and activities pointed out. When the implementation starts it is important to have a detailed plan. During the project this plan will have to be updated and changed as factors changes and new solutions might come up. The important thing is to have a plan with fixed dates when part goals should be reached (Slack et al, 2001). When creating a project plan one has to remember that it will not be evaluated for its logical elegance, but for its part in the success of the project (Packendorff, 1995).

To get a good start on the project Marmgren and Ragnarsson (2001) points at four classical and major obstacles; divided members, to many meetings, project leader focus and passive project members. Divided team members occur when the members can not focus just on the project because they have other duties as well. There can be too many and of course to few
meetings. If the project leader wants to have full control everything goes through him, which will slow the process down. Passive project members that just want to be informed instead of performing something will have a bad influence on the group. The project management will overcome these obstacles if they can create a good communication climate between the team members. According to Packendorff (1995) studies of communication in and around projects have generally concluded that project effectiveness is strongly correlated to the quantity of communication in the project organization and the quality of the communication with the project environment.

When the project plan is accomplished it is important to get feedback and influence from similar projects. Unfortunately project teams tend to evaluate the projects that have failed and not the successful ones (Packendorff, 1995). It might be even more interesting to find out why a project was a success instead of just concentrate on mistakes. Too often the lean techniques are wrongly identified as the solutions. Instead the specific organization’s needs and situation must be guiding when implementing lean (Atkinson, 2004). Many organizations still do not know what to do once they get past relatively easy steps like implementing 5S and drawing current state value-stream maps (Womack, 2005).
3 Method

This chapter intends to describe the way the Master’s Thesis has been performed in order to give the reader a possibility to make his own opinion on the Master’s Thesis reliability. The report has been created in the steps described in the figure below (Figure 18).

![Figure 18. Visualization of the report’s progress steps.](image)

3.1 Specify and formulate problem

The Master’s Thesis was a part of a bigger project concerning the implementation of lean production at Volvo Truck Australia. Therefore the study had to be concentrated on one part of the implementation. The manufacturing area was chosen because of the time when the implementation in that area was to start, and because it was of suitable size for a Master’s Thesis project. The first step in the report was to specify and formulate the problem together with tutors at Chalmers University of Technology and Luleå University of Technology in Sweden together with the assigners at the Wacol factory.

The report has used a quantitative approach in order to fulfil its purpose. The aim of using a quantitative method is to explain a scenario or prove something (Gunnarsson, 2004). It is characterized by objective and systematic studies involving surveys and data analysis (Bryman, 1997). A quantitative method has two main advantages; first of all it results in an objective measure of the possibility that the drawn conclusions are correct, and secondly a quantitative method is often easier to accomplish and needs fewer resources than a qualitative method (Gunnarsson, 2004). An alternative to the quantitative approach would be the qualitative approach, which aim is to understand a scenario and put it in a broader context.

The used research methods are often unstructured interviews and observations that are not as easy to quantify as quantitative methods. Since the Master’s Thesis was to be based on comprehensive studies, the quantitative approach was chosen. The quantitative approach made it easier to accomplish extensive surveys and most importantly, it created a clear description of the scenario that is easy for the reader to understand. In addition, using a quantitative approach makes it easier to get a high validity and reliability.

The report is based on an empirical study performed at the Wacol factory’s manufacturing area together with a theoretical framework studying lean manufacturing. The report’s problem formulation and purpose way created with consideration to Volvo’s ideas about the implementation, and after that the theoretical framework was evolved. The main approach for the empirical study was to collect data by using questionnaire surveys accomplished among both blue-collars (employees in the production) and white-collars (office employees). The survey was complemented with observations and interviews. To perform the empirical study, the theory had to be transformed into questionable dimensions and areas that had to be investigated to make conclusions about the implementation of lean.
3.2 Develop theoretical framework

The objective with the theoretical part of the report was to develop a theoretical framework that would describe the phases when implementing lean, together with the meaning of lean manufacturing’s different principles. It was important to create and establish the theoretical framework early in the process, because it acted as a foundation for how to consider the problem and created an understanding for lean manufacturing.

The further objective with the framework was to develop areas and dimensions that would be investigated in order to fulfil the purpose of the report. The dimensions must be measurable and operationalized in order to be used in the empirical study (Carlsson, 1990). Operationalizing the dimensions was a tricky and time consuming process. It was performed through developing questions for the empirical study that was related to the different dimensions. The clear connection between the theoretical framework, the dimensions to investigate and the questions for the empirical study made this process iterative which is symbolized in the figure above (Figure 18).

The theory has mainly been collected through literature surveys in ProQuest, Emerald and EBSCO. ProQuest gives access to the databases ABI/INFORM Global, ABI/INFORM Trade & Industry and Academic Research Library, while Emerald gives access to MCB e-journals. The words that have been used in different combinations when searching literature are mainly “lean production”, “lean”, “manufacturing”, “JIT”, “TPM”, “waste”, “Australia”, “kitting”, “station design” and “kanban”. Articles and books from different university courses regarding lean production and logistics in general have also been used. The main source has been Christer Karlsson’s and Pär Åhlström’s (1996) article, “Assessing changes towards lean production”, and it has been a useful source when finding other interesting articles. In order to perform a scientific empirical study of high quality, which includes a well constructed questionnaire, internet pages from the University of Gothenburg, books from Chalmers University of Technology and Queensland’s University of Technology have been studied.

3.3 Develop questionnaire

As mentioned above the theoretical framework acts as the foundation for the dimensions that were to be quantified through the questionnaire survey. Interviews also assisted in the creation of questions for the questionnaire survey. The aim was that all the workers, both white-collars and blue-collars, would be able to understand and answer the questionnaire. In addition to this secondary data was used from Volvo that gave an understanding of the project’s work so far.

Before the questions for the survey were created some general methods for how to design questionnaires were studied. A good questionnaire should be easy to understand, clear and uniform, so the selected persons are able and willing to answer it (Carlsson, 1990; Synodinos, 2002). Closed questions were chosen because they have fewer missing data than open questions and thereby increase the possibility of the questionnaire participators to answer. They are also easier to quantify than open questions since they have fixed alternatives. According to Synodinos (2002) open questions should be used sparingly because they require substantial respondent effort. Closed questions on the other hand are hard to design if you do not want to miss any important information, which increased the demand on the answer alternatives quality (Carlsson, 1990).

For most of the questions an ordinal scale with five answer alternatives was used, which demands that the answer alternatives are placed in order of rank. A nominal scale was used for questions that had answers that did not relate to each other (Gunnarsson, 2004). All
questions used a ‘verbal descripting scale’, which means that there is a square to mark in for each answer alternative, which makes it easier for the respondent (Gunnarsson, 2004). The questionnaires did not include a ‘do not know’ answer alternative, since questions that provide nonsubstantive opinions may discourage respondents from reporting their meaningful opinions (Synodinos, 2002).

When formulating the questions it is important to consider each word, since the wording of questions can have pronounced effects on the results (Synodinos, 2002). The questions should contain words that are familiar to the respondents and their situation (ibid). The questionnaire was held short because the research considered about 100 employees in the factory, and the shopfloor workers had limited time for participating in the questionnaire survey. The questionnaires consisted of about 50 questions and they took approximately 20 minutes to answer.

The questions and the questionnaires’ cover letter were pre-tested together with some Volvo employees. The cover letter presented the survey’s purpose and objective. It also included information about privacy and how the survey’s results were going to be presented (Synodinos, 2002). Attachment A and B contains two questionnaire surveys, one for blue-collars and one for white-collars. Most of the questions are the same or similar in the two questionnaires, which made it possible to compare the two respondent groups.

3.4 Data collection and data analysis

The questionnaires response rate can be improved by increasing the number of contacts with the respondents (Synodinos, 2002). This was done by continuously walking around in the factory for two months before distributing the questionnaires. One of the report’s authors was present when the respondents accomplished the questionnaire and could answer questions and explain the surveys’ purpose further. It also made the survey look more professional and trustworthy. The respondents had ordinary work tasks that they had to perform each day. Because of that each production team could only spare one worker at a time. Therefore all the workers did not fill out the questionnaires at the same time. One of the authors stayed with the respondents, while the other one was in the factory to find new workers that could answer the questionnaire. In order to get a stratified selection that represented the population the authors cooperated with the section leaders when selecting workers. Each section leader picked out about five of his workers that were to participate in the questionnaire survey. When selecting the workers each section leader was to consider the workers’ age, background, attitude etc. in order to get a representative group that answered the questionnaires. There were about 230 workers in the production, including section leaders that constituted the questionnaire’s population. All the 13 section leaders plus 53 of the workers participated in the survey.

The empirical study was not a comprehensive investigation of the whole population. About 30% of the blue-collar workers participated in the survey and therefore the results had to be analyzed considering their significance level. All the white-collar workers that were to be affected by the implementation of lean participated in the survey (29 respondents), which made it a comprehensive study. The authors choose to study mean values, standard deviation and correlations between questions. Differences between blue-collars, white-collar and different production areas were also analyzed.

In addition to the questionnaire surveys interviews with all the managers, some of the supervisors and all the project members were made (attachment C). The employees that were interviewed were chosen considering their influence in the project, their knowledge of lean
manufacturing and their attitude to the project. The purpose was to get a comprehensive view of all opinions. During the whole project open observations and daily discussions were performed in the factory and with the employees. These observations and discussions gave a good and rather neutral description of the organization and the current situation.

### 3.5 Validity and reliability

A data collection’s validity indicates how well it measures the areas that are to be investigated (Carlsson, 1990). The questions in the questionnaire surveys and the interviews were designed with consideration to the developed investigation areas, which were created to fulfil the purpose of the report. The investigation areas were therefore well defined, but to reach a high validity the questions that are asked in each area has to be relevant (Gunnarsson, 2004). The questions in the questionnaire were redesigned several times after reviews made by managers at Volvo and mentors at the universities, which increased the validity in the study.

The validity is a critical factor since the empirical study is based on questionnaires. The respondents could understand the questions differently, as they have different backgrounds and experiences of lean manufacturing. Preventive measures have been done as each question has been discussed with people that have a good view of the project and the organization. When respondents were selected for the blue-collars’ survey all the section leaders were gathered in a room and the authors explained the survey’s purpose and the importance of getting a representative population to answer it. These actions should have minimized the negative input on the study’s validity of not doing a comprehensive investigation.

Reliability indicates the accuracy and safety that can be reached with the measuring instruments (Carlsson, 1990). In order to reach a high validity and reliability it is common to use well-tried questionnaires with established reliability and validity (Gunnarsson, 2004). This advice was fulfilled by looking at other questionnaires that the respondents had answered before. Since the empirical study is based on a project that is running, there is a risk that the respondents are influenced by the project’s current situation. Volvo’s project leader indicated that the knowledge about lean in the organization was limited, which should improve the reliability. Furthermore the surveys reliability is increased since the questionnaires contained several questions within each investigation area (Gunnarsson, 2004). This made it possible to compare results from several similar questions, which neutralized hazard faults.

### 3.6 Generalization of the results

A high validity and reliability is important if the results are to be general (Carlsson, 1990). An implementation of lean manufacturing is unique, considering the current organizations circumstances. But, all implementations will have to consider and go through each step in the lean temple (Figure 16, section 2.7). Therefore this study can be useful for other organizations that are to implement lean manufacturing. This generalization of the results is important for a study like this one (Gunnarsson, 2004). The circumstances in the Wacol factory are quite unique since they have just integrated the production of Mack trucks in the same factory as Volvo trucks. The trucks have a totally different design, but what is more important is that the Mack and Volvo organizations are different. A Volvo organization is very standardized and a Mack organization gives more authority to each employee. This makes Volvo’s situation and some of this report’s conclusions unique, but most of the conclusions should be general.
4 Investigation areas

The theory chapter discussed the content of lean manufacturing and its five different parts; elimination of waste, pull instead of push, multifunctional teams, decentralized responsibilities and continuous improvement. In order to make conclusions on how to implement these parts, several areas have to be investigated in the organization. This chapter presents the different areas that were investigated in the empirical study to make conclusions about the implementation.

The areas were formed by grouping together several lean manufacturing aspects that were developed out from the studied theory and with consideration to Volvos ideas about the lean project. Each area has a close connection to the lean concept, and findings from these are supposed to act as a foundation when conclusions are made about the implementation. Attachment D shows a detailed description of each investigation area and how they are connected to the principles in lean manufacturing.

Conditions for implementing lean
This area looks at the current conditions in the organization and its change climate. Things like change mentality, attitudes to lean principles, management support, cooperation between departments and employees’ attitudes are investigated. Findings from the area are supposed to give a general view of the organizations readiness for the implementation of lean manufacturing. If the conditions are good then it will be much easier to implement lean and vice versa.

Managing the lean project
The project’s management and the amount of effort that is put into the project will have a great influence on the project’s outcome. The lean project team’s way of managing the implementation will have a great influence on the success of the project. It is therefore interesting to look at how the project team is put together and who is responsible for what. Since the team had already begun to do some work when this investigation started, it was also possible to investigate the team’s work so far and their future plans.

Production teams
Multifunctional teams are an important part of lean manufacturing and for that reason it is necessary to investigate how the teams in the production work today. Team responsibility, authority, job rotation and team meetings are looked at. Attitudes towards teamwork and increased responsibility among workers are also investigated. The production area is this thesis main focus and in the production area the production teams and the individual workers are the key actors. A functional team organization in the production will help the implementation on its way.

Work procedures at stations
The work at the stations in the factory will to high extent be influenced by the implementation of lean. Some procedures will probably have to be changed and improved, and it is therefore necessary to map the current work at the stations. Standardization, material handling, visualization and environment are investigated in this area.

Material distribution
Reducing inventory and use pull systems instead of push is a big part of lean manufacturing. Therefore the current material delivery system is looked at and also the conditions for
implementing a pull system in the future. Factory layout, types of material and initialization of material deliveries are considered.

**Work with improvements**
Continuous improvements within quality, material handling, work procedures etc. is crucial in order to eliminate waste and achieve a well working lean manufacturing system. Therefore the current work with improvements is investigated. Handling of improvement suggestions, feedback and work with quality are important to look at in this area. The interest to participate in improvement work among B/C workers has also been examined.

All these six areas are important to investigate from a lean perspective. The reason for choosing them is that they cover all the crucial areas that an organization has to work with when implementing lean production. They might also interact with each other. If the investigated organization is good in one area it might help when trying to improve another.
5 Volvo Truck Production Australia

This chapter is supposed to give the reader an introduction to Volvo Truck Australia and create an understanding of the present work situation in the factory. It begins with a general description of Volvo Truck Australia, which is followed by a more detailed description of the work in the factory.

The Wacol factory is the only producer of Volvo and Mack trucks in Australia and produces twelve trucks a day. Volvo currently has a market share in Australia of 10 % and Mack 9 %. Their two biggest competitors in Australia are Kenworth (20 %) and International/Iveco (14 %). Trucks are produced in Australia because it is a unique market with a lot of special parts on the trucks, like extra large tanks and bull bars, together with the long lead time for delivering trucks from overseas.

Volvo is a global company consisting of many different companies; Volvo Trucks, Mack Trucks, Renault Trucks, Volvo Buses, Volvo Construction Equipment, Volvo Penta, Volvo Aero and Volvo Financial Services. Volvo, Mack and Renault trucks are together the world’s second largest producer of heavy trucks, only the Daimler Chrysler Group is larger. Volvo offers solutions for their customers based on the foundation of Safety, Quality and Environment. Volvo Trucks have nine own assembly plants and eight owned by local interests all over the world, of which the Wacol factory is one of their own. Last year Volvo produced 75000 Volvo trucks of which 1300 were produced in the Wacol factory. It also produced 900 Mack trucks, which mean that the Wacol factory has a yearly production of 2200 trucks.

Trucks are produced according to the customers’ demand and not made to stock. The factory normally has an order stock of three months and the customer can change the specification of the truck until three weeks before it goes on line. Since 80% of the suppliers are located in Europe and the USA and have a lead time of 14 weeks most parts are ordered on forecast. These forecasts are based on the current order stock. The production of the truck takes seven days plus another two days for rectification and control. All together the total time from customer order to delivery can differ between three and six months.

The organization consists of six departments that are responsible for the areas; logistics, production, production engineering, quality, finance and human resources. In attachment E there is an organizational chart on all the departments and their major functions. The factory is led by a general manager who is responsible for the factory. The factory’s board group contains the managers of each department together with a manager administrator.

In the beginning of year 2004 the Wacol factory’s board decided to investigate the possibility of improving the productivity and minimizing the needed space for part storage in the production. This decision was made since the parent company in Sweden wanted to invest in a new production line in one of its factories and Wacol was one of the alternatives. There have not been any major productivity investments in the factory the last years since most of the resources have been focused on the integration of Mack and Volvo. This unique integration started in 2001 and was a big challenge for the organization in the factory since the production almost doubled when Mack production was moved into the factory and all the functions within the Mack and Volvo organization were merged together.
The board found the inventory levels and material delivery system as the main problems because of the amount of shortages and the time spent in the production looking for parts. They therefore appointed the logistics manager, Lee Morphew, to be accountable for a lean project. The project was called Wacol’s Material Development Project and its first purpose was to accomplish a pre-study and investigate the possibility of implementing lean production in the factory.

Currently the factory has about 50 different projects going on, some just initiated and some that have been on going for a long time. Therefore the board felt that it is important to show that the whole board are behind Wacol’s Material Development Project. The Wacol organization is used to perform rather small and concrete projects compared to a more comprehensive project like lean production.

The lean project consists of a steering committee that is responsible for the project and a project group that are supposed to ‘do’ the job. To highlight the importance of the project the project’s steering committee contain the logistics manager (steering committee chairman), the general manager (project sponsor), the production engineering manager, the production manager and a material engineer (project group chairman). The steering committee is supposed to make sure that the project is heading in the right direction. They also delegate the necessary financial and human resources to the project group. The project group chairman, Justin Murphy, normally works in the logistic department as a materials engineer, but is now working nearly full time with the project. In his project group he has representatives from different functions in the organization; a production engineering supervisor, a production supervisor and the warehouse supervisor. During the end of 2004 it was only the project group chairman that worked with the project and the others were there to support him and to care of their department’s interests in the project.

From the start of the project in the beginning of 2004 until November 2004 the project group has done visits to factories that already uses lean. In Australia they have visit companies like Holden and Toyota. The steering committee chairman and the project group chairman also went to Volvo’s factory in Brazil because they already had implement lean and the factory is almost the same size as the Wacol factory. The project group has studied some theory about lean production and during the last months they have put together a general budget report on what the costs for the project could be.

At the end of 2004 the parent company in Sweden approved the necessary economic resources and appointed a new general manager for the Wacol factory. The former manager who initiated the lean project resigned at the end of the year. The new general manager came from Volvo’s factory in Brazil where he had been in charge of their successful implementation of lean manufacturing. The project groups will enter a more intensified phase, with distributing information about the lean philosophy throughout the whole organization. Some new project group members from the factory’s organization will also be recruited. The project group will start focusing on the redesign of the workstations, since it is a time consuming process. This will be done by using value stream mapping and introducing kanban deliveries. In order to gain space on the shopfloor they will integrate the current kitting process into a kanban system.

5.1 Factory layout
The Wacol factory was designed for producing ten Volvo trucks per day. When Mack trucks were to be assembled in the same factory they had to enlarge the factory building. When they
did this some of the joint functions like cab and chassis painting remained where they were before Mack came, which resulted in an improper layout of the production area. Despite the enlargement the factory still is small compared to its current production of seven Volvo and five Mack trucks per day together with the amount of material that is handled. The Wacol factory’s facilities consist of a main building with production, offices, a canteen and some storage. Across the yard are the area for finished trucks and the warehouse. Since 80% of the parts come from overseas and are delivered once a week the storage area for inward goods is a problem. The lack of space means that inward goods are placed all over the yard or in the warehouse and often needs several handlings before it can be delivered to the production line.

Figure 19 shows a map of the main building and the production area. The production starts with the punching machines in the upper left corner (1). The rails (frames) are the base of the truck and they are delivered from Europe and the USA. When the rails have received the correct groups of hole in the punching machines they are moved to the start of the chassis line (2). The production on the chassis line is a mix between Volvo and Mack chassis. The cycle time on the chassis line, i.e. the assembly time on each station, is about one hour and fifteen minutes depending on the model that are produced and its length. The chassis line consists of seven following stations with a crossing transportation path in the middle. To assemble seven Volvo and five Mack trucks each day the work on the chassis line has to be carried out during two shifts, one day and one afternoon shift. Along the chassis line the rails are riveted together with cross-members, the axles are docked and some brackets are assembled. At the

Figure 19. Factory layout.
After the chassis paint the Volvo and Mack trucks are separated and assembled on different lines. The Volvo trucks go to the Volvo piping stations (V4) and the Mack trucks to the Mack piping stations (M4). On the piping stations all the electricity, pipes and valves are assembled and it is a labour intensive process, especially for Volvo. The Volvo truck is constructed with more electricity and safety systems which make this process much more extensive than on the Mack truck. The work is performed on parallel stations as there is a big difference in the amount of parts that are needed for each truck.

After the piping stations the trucks are moved to the Volvo main line (V5) respectively the Mack main line (M5). On the main lines the engines and cabs are dropped and assembled onto the chassis. Many other parts are also assembled along the main lines like tyres, fuel tanks, mudguards, exhausters etc. At the end of the main lines the trucks receive lubrication and are filled with fuel before they are started and taken for a test run. The Volvo main line consists of ten following stations with a cycle time of one hour and ten minutes, while the Mack main line has eleven stations and a cycle time of one hour and thirty minutes. Between the main lines and the chassis line there are some sub-assembly stations that pre-assemble parts to make the work along the lines easier. Mack’s sub-assembly stations are located near the line where the parts are needed. Volvo’s on the other hand are not located that close to the line because of the limited space near the Volvo line.

Volvo and Mack have their own trim lines in the factory for cabs (V6 and M6) and engines (V7 and M7). The cabs are delivered to the factory as a welded metal construction that goes directly in to the cab paint station (8). The cabs and all other part that needs painting are being painted there in the colour the costumer wants. After the painting the cab it is moved to its trim line where the parts for the cab are assembled. The Mack cab trim line consists of eight following stations with a cycle time of one hour and thirty minutes, while the Volvo cab trim line has seven stations with a cycle time of one hour and ten minutes. The engine and the gear box are put together at the start of the engine trim lines and after that the engines are complemented with a fan and other part that are needed before it can be assembled onto the chassis. There are two parallel engine lines, one for Volvo and one for Mack, with five stations each. After the cab and engine trim lines the engines and cabs are moved to the main lines for assembling.

The factory has some problems with their suppliers and the transportations into the factory. This results in late deliveries and damaged parts, which means that the parts can not be assembled on the line. Because of these material problems almost every truck needs to be rectified when they leave the main line. At the rectification stations (V9 and M9) missing parts are assembled together with some other adjustments. Some of the trucks have special constructions that can not be assembled on the lines and they are moved to the SVC (special vehicle construction) area, out in the yard, where the trucks are being complemented.

5.2 Production procedures

The production department is responsible for the production and to make sure that the trucks are produced in time and in acceptable quality. The production is divided into seven areas with one production supervisor responsible for each area. Attachment F shows an organizational chart over the production department and their functions.

There are seven production supervisors who are white-collar workers and they are the link between all the other white-collar workers in the office and the blue-collar workers in the
production. A supervisor is responsible for the production and the workers in his area. The supervisor is scheduling the manning levels on his stations and is responsible for the workers’ education and training. In order to increase their skill levels he moves the workers around between the stations and the work tasks. Because of all the material and part problems the supervisors spend most of their day searching for parts in the system instead of their ordinary work tasks. A supervisor’s area of the production is divided into a number of sections depending on how big the area is. Each section has a section leader who is a blue-collar worker that is the link between the supervisor and the workers in the section. A section leader helps the supervisor with daily work tasks.

5.2.1 Order release planning
The master production scheduler in the logistics department is responsible for planning the releases of trucks on the production line and for keeping the schedule updated on the computers. Before letting a truck go on line he makes sure that every vital part for the truck has been delivered to the warehouse. He gets information from the material controllers on what parts that are in storage, are incoming and most important what parts that are running late. All the parts on a truck have a priority from one to three. One means that it is impossible to build a truck on the line without this part, two that it can be done if the production engineer allows it and three that the part easily can be assembled afterwards. In the scheduling process the master production scheduler also cooperates with the production supervisor on the chassis line as his area is the most likely area to be affected if a part is running late. They also consider the trucks length and assemble time on the stations, so they do not put several long or difficult trucks after each other.

The chassis line produces the trucks according to the production plan. On the cab trim lines and the engine lines it is the supervisor’s responsibility to inform what cabs and engines to be produced each day. The supervisor knows the stations cycle time and counts backwards from the stations where the engine or the cab is assembled on the main lines. It is the same procedure on the sub-assembly stations.

5.2.2 Material handling
The warehouse is responsible for inward goods, repackaging, storing and deliveries to the stations in the production. Currently there are about 50 people working in the warehouse, of which two persons work as section leaders on the day shift and one on the afternoon shift. When goods arrive to the factory it is unloaded and checked by quality inspectors. Most of the Volvo parts come in pallets, blue-bins etc, which are easy to handle and store. The Mack parts on the other hand comes in non standardized packages, therefore most of them have to be repacked into packages that are easier to handle and store. All parts that are stored in the warehouse are replenished during the day shift. As most of the parts come from overseas and in large amounts each time, the traffic in the warehouse during the day can be heavy. Because of the heavy traffic and the lack of forklifts during the day, the deliveries to the production stations are performed on the afternoon shift. Parts that can not be stored in the warehouse because of their size (cabs, engines, axels etc) or because they are delivered just-in-time (fuel tanks, tyres etc) are stored outside in the yard.

All the parts that are delivered to the production stations are picked into chassis kits, which mean that each kit contains all the parts that are needed for a specific truck. They are using kits because the storage areas near the production stations are limited and because the stations often need different parts for each truck. The Mack stations have been picking parts into chassis kits for the last three years, since they moved the production to the Wacol factory. The
Volvo stations have recently changed from picking parts into weekly kits to pick them into chassis kits. Information on what parts to be picked is given to the warehouse two days before they are to be delivered to the stations. The chassis kits needed the following day are delivered each afternoon to the stations. The disadvantage with only delivering once a day is that some chassis kits has to be placed high up in the pallet racks because there is not enough space in the lower sections. These kits have to be moved down by forklift drivers before the workers can pick the parts from the pallet. To know what kits to pick and deliver each afternoon one of the warehouse supervisors check the production plan given from the master scheduler. Because there are a lot of late changes in the release of trucks to the line, the plan is not always up to date. Therefore the supervisor has to double check the plan by walking around to each production line and read on a white board what chassis they are to assemble the next day.

Larger parts and just-in-time delivered parts are not delivered in kits. These parts are moved to the stations from the yard when they are needed. This process does not work too well because many of these parts are stored wherever there is space in the factory instead of in the yard. Small parts such as bolts and nuts are stored in the warehouse and are delivered to the stations when they request them. The stations usually stock up a large number of small parts, and put them wherever there is space.

**5.2.3 Procedures at the production stations**

On the Volvo stations each worker can get information from a computer about the truck and what parts to assemble. Since the Mack trucks have more individual constructions and are not that standardized the Mack stations get their information on papers instead of on the computer. Mack has not been focusing on the instructions but there are some future plans on computerizing it. Each section in the production consists of several separate workstations. There is no rotation between the workstations on a daily or weekly basis. It is the supervisor’s responsibility to rotate the workers, but some find the rotation process more important than others. Most of the workers are in fact on the same station every day, despite this they do not have any problems finding people with the right skill when someone is sick or off work.

The worker is supposed to have all parts that are needed for a truck on the station. Some of the parts come from sub-assembly stations within the factory and the worker sometimes has to go and get these parts on his own. To handle the parts they have all necessary equipment and tools and if they are missing some they just contact the maintenance team. The most common problem on the stations is that parts are missing. Sometimes they are not picked in the warehouse even if the note on the pallet indicates that or the parts have gone “missing” during the delivery process. If the worker can not find the part he contacts his section leader or supervisor, who then contacts the material technician (Figure 20). Lately the logistics department created the roll material technicians to get hold of all the missing parts in the factory. Today there are four material technicians who are contacted when a part is missing. They try to trace the part and understand why it is missing. If it is a pick problem they contact a warehouse section leader who then gives feedback to the responsible picker on the afternoon shift.

![Figure 20. Communication procedure when missing parts occur.](image-url)
Shortages are another significant problem for the production. A shortage is a part that has not been delivered to the factory and the factory is aware of it. The worker on the station is being informed about the problem through the note on the pallet, or by his section leader or supervisor. If the worker can not assemble other parts that need the shortage part he places them in a pallet that goes with the truck. All these parts have to be assembled afterwards in the rectification area, which means that the truck has to be stored in the yard until the shortages arrive. When the parts arrive to the factory the workers on the rectification stations walks down the lines to get the shortages that have been delivered to the stations where they were missing.

If the worker finds a defective part on the station he contacts his section leader, who then fills out a reject advice on the computer (Figure 21). The request goes to the warehouse so a new part can be delivered to the station. If it appears to be a common problem the section leader contacts his supervisor and the material technician who then investigates the problem further. If the part has been damaged during the delivery from the supplier or in the warehouse he contacts the quality inspector. All these reporting processes work well. The problem is that all the workers do not feel the responsibility to fix or report all upcoming problems.

5.2.4 Quality controls

The quality department is a small department compared to the others. The quality department is responsible for the control of incoming goods and the quality control of finished trucks. Some of the finished trucks are being controlled and they count the quality audit scores on them. The results from these quality checks are presented to the sections and the responsible workers. During the production process the production department have their own quality rectifiers on the chassis line and the main lines. They make sure that the parts are assembled and make an overall check of the truck. If they find production mistakes they contact the worker that is responsible and document the mistake. If the problem does not have to do with the production they contact the quality department. In addition to this each worker perform its own quality controls before letting the truck move forward to the next station. Each worker signs of its work and that it has been checked. With all these quality controls each truck is checked about 150 times during the production.

5.2.5 Meetings

The production department has regular meetings every second week with all the supervisors and section leaders. There are also meetings on supervisor or section leader level depending on the supervisor’s opinion and the amount of people in the area. These meetings are held every second week if necessary. Each section has about 20 workers and everyone is supposed to attend on the meeting together with the section leader or the supervisor that is holding the meeting. Sometimes the production engineering technician for the area attends the meeting if he or she has something to add.
The meetings are used for distributing information about how the factory is performing according to direct runners and Key Performance Indicators that the quality department measure. In case there is any end customer feedback this can be presented here as well. Some of the supervisors also use the meetings as a discussion forum so the workers can come with suggestions on how to improve their work, but it is far from all supervisors that are using this. If the workers come with suggestions it often concerns safety issues. The last year there has only been a few suggestions in the ‘suggestion box’.
6 Analysis

In this chapter the empirical study is analysed and compared with the theoretical framework. The data from the questionnaire survey was put together in Excel and statistical tests were performed with statistics software.

Some notes that are useful to know when reading the analysis are listed below:

- The answers from the questionnaire are coded from 1 to 5, where 1 corresponds to “very low” and 5 to “very high”.
- Low answers (1-2) and high answers (4-5) are grouped together in some of the diagrams to make them more obvious.
- Averages are put in brackets when they are used in the text, e.g. (3,2).
- Only Mack main line and chassis line have been analysed separately, since there were too few respondents from the other sections, Volvo main line and sub-assemblies, that had market their work section in the questionnaire.
- Correlations between questions have been analysed by using Pearson’s coefficient of correlation at 95% confidence level.
- Differences in answers between white-collars and blue-collars have been analysed with one-way ANOVA at 95% confidence level, which means that there is a difference between the groups with 95% certainty.

A summary of the results from the questionnaire survey is found in attachment G, H and I.

6.1 Sources of waste in the Wacol factory

All activities that do not create value or are necessary for the function of the organizations processes are waste and should be eliminated. The theory chapter described different sources of waste and this section analyses the occurrence of waste at Volvo.

Overproduction is not that common in the factory, since all trucks are made to customer order. A bigger problem is that some of the trucks are not delivered to the customer in time. The delays are often caused by part shortages that have occurred because of supplier and delivery problems. Trucks are sometimes produced when shortages exist and can not be delivered until the missing parts arrive. This means that trucks that are ready, except from the missing parts, must be stored in the yard. In some way this is overproduction, because the trucks are produced before they actually can be delivered. Shortages are also a waste of time, since they result in waiting for parts to build the trucks. When the parts arrive they have to be assembled afterwards in rectification, which is definitely a non value adding activity. Almost every truck has to go through rectification and two days are added to the production lead time as a buffer for rectification.

It is not easy to avoid the problem with shortages, since the production must be running even if some parts are missing. The factors causing shortage problems are often out of Volvo’s control. Many of the parts are delivered from overseas suppliers with long lead times, and the third party logistics does not always work well. The long lead times also means that forecasts sometimes must be used when ordering parts. The forecasts rarely match the actual demand in the factory and the parts that are not needed must be stored in the warehouse. There is a great need for Volvo to improve the interaction with suppliers, but that area is outside the delimitations of this Master’s Thesis.
One area where overproduction exists is between sub-assembly stations and the main line. The empirical study showed that the workers sometimes assembled more parts than the line needed at the moment. Today the products are pushed from the sub-assembly stations to the line, e.g. axels and bumpers. A pull system between the sub-assemblies and the main line would avoid overproduction, and even better is to merge operations together and integrate sub-assemblies into the line. The sub-assembly stations are sometimes far from the line, which means that work in process have to be transported through the factory. Integrating sub-assemblies would avoid the need for transportation and must be considered during the redesign of stations.

The most common waste of motions in the factory is probably caused by the material handling. Since too many parts are stored at the stations, they have to be moved from higher to lower levels on the pallet racks to be reachable. Parts stored at the shopfloor can also be an obstruction for the delivery vehicles, which are hindered to deliver the material in the most efficient way. The factory is not designed to minimize transportation work and the map in section 5.1 shows that there are few straight transportation paths and some stations are hard to access. Fixed stations such as the chassis and cab painting stations are difficult to move, which is an obstacle when trying to improve the transportation layout. Spaghetti mapping is a tool that can be used to analyse the transportation paths when the stations are redesigned. The tool is described in theory section 2.2.3.

It is not surprising that defective products exist in the Wacol factory, since it exists in all kinds of manufacturing industries. The question is rather to what extent and what is done to minimize them. Volvo uses a comprehensive quality control system and is certified by ISO9001. The quality control is extensive, but defects can not be prevented by control. It is therefore important that Volvo develops the quality work at the source of where the defects occur. Those who are building the trucks should be involved in quality problem solving, which also increases the awareness of responsibility for quality. If there are quality defects when the trucks leave the line they must be corrected in rectification, which is a non value adding activity.

Excess inventory exists more or less in the entire factory and was an important reason for starting the lean project. Observations in the factory and the survey showed that the inventory was a great issue, which is discussed further in the next section.

6.2 Decentralized pull systems to reduce inventory

One of the main objectives when changing from push to pull is to reduce inventory. It is therefore important to look at the volition among employees to reduce inventory in the factory before implementing a pull system, since it is easier to motivate and root the implementation if there is an interest. Figure 22 shows that there was a great interest in reducing inventory among white-collars. Correlation analysis showed that white-collars that wanted to reduce inventory also

![Figure 22. Interest in reducing inventory.](image)
wanted to participate in the implementation of lean production\(^1\). The interest among blue-collar workers was also fairly great, but the variation in the answers was bigger. A more detailed analysis of the data showed that blue-collars on the Mack line were less interested in reducing inventory. Average for Mack was 2.5 compared to the others 3.5. This probably depends on the fact that they have had more frequent material deliveries than the other lines, and thus lower inventory levels.

Implementing a pull system means that the station environment has to be changed and improved. It is therefore important that there is a willingness among blue-collar workers to improve the station layout. Figure 23 shows that there was a great interest to improve the workstation environment \((3,7)\) and blue-collars wanted to improve their stations in higher extent than white-collars thought \((3,2)\). The survey also revealed that only 23% of the blue-collars were satisfied with their station environment, but as many as 41% thought it was clear where parts and tools should be stored at the stations. However, observations in the factory indicated that this was not always the case. The difference between the survey and the observations might depend on the fact that the workers have been used to the disorder. It is very important that the workstations are well organised and visualized to make a new pull system run well. Consequently efforts in this area must be included in the implementation of lean.

### 6.2.1 Material distribution in the Wacol factory

According to the theory (section 2.3) different pull systems should be used for different types of parts. The parts that are needed to build a truck can be divided into three main categories; small, bulky, and ordinary parts. Small parts could for example be bolts, nuts and holds. These are often inexpensive and common for all trucks. Bulky parts are the parts that are very heavy and/or take up a lot of space such as tanks, axels and tyres. Ordinary parts are the rest of the parts that are of average size and cost.

The best way to deliver small parts that are common for most of the trucks should be to use a two-bin system, which is described in theory section 2.3.2. According to the theory the two-bin system is suitable for small and inexpensive parts, since it simplifies the handling of parts without significant effect on capital tied up in inventory. The system works best for parts that are common for all trucks, because it is hard to sequence parts that are delivered together with heaps of other similar parts in the same bin. Plastic boxes, such as Volvo blue-bins or smaller, should be used and stored in dedicated two-bin racks. The refill quantity should be set high enough so that the bins do not have to be refilled to often. A guideline could be once a week for bigger parts to once a month for smaller. Since the parts are small and inexpensive they do not take up much space or ties up capital anyway. It is also possible to integrate the two-bin

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\(^1\) Correlation = 0.55 to the question “To what extent are you interested in participating in the implementation of lean production?” (attachment H).
system into a kanban system, if the material handler that transports the kanban trolleys picks up and delivers the two-bins at the same time.

Bulky material is often difficult to handle and integrate in a kanban system, since they are too big to fit into a standard kanban trolley. Standard trolleys are necessary if a kanban loop with material delivery vehicles is used throughout the Wacol factory, and bulky material must therefore be delivered directly to the stations by forklift trucks. Bulky material takes up a lot of space in the factory, and thus it is necessary to clearly mark where the parts should be stored and limit the storage space. Limiting the storage space so that only a specified amount can be stored in the factory is a method to reduce the inventory of bulky parts. Parts that are outside the marked area can also be an obstruction for transportation vehicles and runs the risk of being damaged.

Kanban is suitable for a variety of parts and can be adapted to several production systems. According to the theory kanban has successfully been used by several manufacturing companies, in order to lower inventory and ensure that material and products are pulled through the factory. A kanban system throughout the Wacol factory is probably the best way to deliver ordinary parts, since they are suitable to be stored and moved in kanban trolleys. A detailed description of a kanban system that Volvo can use is given in section 6.2.2.

A majority of the parts are dedicated to a specific truck when they are delivered, which means that the warehouse must have accurate information on what to pick for each truck. If a kanban system is used, the warehouse must know exactly what specific parts to pick on each kanban trolley. The empirical study showed that late changes in the production schedule are common, which means that the information on what to pick on each trolley must be updated continuously to avoid incorrect deliveries. Today late updates are done manually by the section leaders, and the warehouse supervisor has to walk around in the factory to collect the information. The information procedure has to be improved to avoid mistakes and unnecessary work. According to the logistics manager Volvo already has a computerized system that is not yet implemented, and the information distribution should not be any problem when implementing a material delivery system.

A new material delivery system will certainly lead to reduced inventory and increased control over the internal material handling. However shortages will still be common in the factory, since it is rather a supplier and external delivery problem than an internal. This might cause disturbances in a decentralized pull system and routines for handling shortages in the new system must be developed before the implementation. Questions like “How do we treat kits where parts are missing?” and “How do we inform the stations about shortages?”, must be considered. Problems such as missing parts and lack of quality are often exposed when inventory is reduced. It is therefore important to work with continuous improvements and solve the problems, instead of hiding them by increasing the inventory once again. The problems should be used as a starting point for improvements. No problems – no improvements.

6.2.2 Design of a kanban system

This section explains an example of a general kanban system that could be used in the Wacol factory. The purpose is to give some ideas about the design and not to describe a “ready-to-use” system. Theories about kanban are explained in section 2.3.1.
Replenishment loops throughout the factory are adequate in the Wacol factory, where many stations will be supplied by kanban. This means that dedicated material handlers run transportation vehicles, for example a tug train, in a loop through the factory and pick up empty trolleys and leave refilled. The loop then continues to the warehouse where the empty trolleys are left and refilled are picked up. The purpose with a loop is that the vehicles can follow a path in the factory without turning. Several loops should be used in the Wacol factory, which will make the replenishment process run smoother since the vehicles can easier access all stations. One loop for each line could be a possible layout.

Transportation vehicles in the Wacol factory should run continuously through the loop and check for kanbans to pick up. This because of the large number of stations that have to be served. Using continuous reviews also makes it possible to use a single-kanban system instead of a dual-kanban system, which is suitable for periodic reviews. The fact that there is only one supplier station is another reason for using a single system, which holds less inventory than the dual-kanban system. Single- and dual-kanbans are discussed in the theory section 2.3.1. An individual single-kanban loop that could be used in the Wacol factory is illustrated in Figure 24, and a description of each part is given below.

![Figure 24. Kanban loop.](image)

1. **The trolley**
   Several factors must be considered when the kanban trolleys are designed. It is particularly important with flexible trolleys on stations where the parts differ between models. All types of parts must fit in the trolley. In some cases there is also a possibility to use the trolleys as assembly fixtures, which means that the trolleys are not only used for transportation. If a two-bin system is integrated in the kanban loop, there must also be trolleys that are designed to distribute and collect bins. Another important factor is ergonomics. The material must be easy to handle for the workers to avoid injuries. The HR department and safety inspectors should therefore be involved in the design process.

2. **The kanban card**
The cards can easily be made with ordinary paper that is plastic laminated, and should contain information about number of parts authorized, trolley capacity, station number, card number etc.
3. The station
There must be clearly marked areas where the kanban trolleys should be stored, so that the material handler knows exactly where to deliver them. An idea is to paint a square on the floor with the station number in the middle. There must also be storage racks for two-bins if this is included in the system.

When the assembly worker picks the last part from a trolley he puts the corresponding card in a collection box, which must be easy to find and access for the material handler. There must also be a collection box for empty two-bins.

4. Drop off area
The material handler drops off the empty trolleys and puts the collected kanban cards on a schedule board. The cards must be scheduled according to some priority rule. The best option in Wacol’s case should be to use FIFO (first-in-first-out), since it minimizes both lead time variability and maximum lead time. It is important that the arrival of new cards is relatively smooth in order to avoid long replenishment time.

5. Replenishment
The warehouse worker picks up the kanban card that is first in the que on the schedule board and the corresponding trolley. He then enters the station number written on the card on the computer and receives information on what to pick into the trolley.

The possibility to pick parts into kits should be considered, since there are a plenty of different parts that has to be delivered to each workstation. According to the theory kits in kanban systems can reduce the number of trolleys at the stations and create space in the factory. It also reduces the assembly time, since the workers do not have to pick parts from several different pallets. However kitting requires more work in the warehouse and causes extra material handling. Because of that the warehouse probably needs additional workers.

The kits must be designed so that the production workers easily can find the right part. Putting too many small parts together makes it hard to distinguish between the parts. To avoid this, small parts can be separated by grouping similar parts together and put them in plastic bags. Consideration must also be taken to assembly sequence, so that those parts that are assembled first easily can be picked first. Furthermore it must be clear to what truck each kit is dedicated.

6. Pick up area
When the warehouse worker has refilled the trolley he puts it at the pick up area with the card attached. The material handler picks it up and delivers it to the right station together with all the other trolleys that are ready to be delivered.

6.2.3 Specifying kanban parameters
The first parameter to be specified is the number of units authorized by each kanban card. The theory chapter (section 2.3.1) suggested that it should be set to the quantity that fits into a trolley or a multiple of trolleys, since the inventory levels was rather influenced by the lead time for replenishment. However this is not completely correct in Volvo’s case. Here the replenishment time is relatively short compared to the time it takes to empty a trolley at the production station, which means that the number of units per card will have a greater influence on the inventory levels. Consideration should therefore also be taken to inventory levels when specifying number of units per card and not only the quantity that naturally fits
into a trolley. The advantage with this for Volvo is that the inventory levels can easily be gradually reduced by lower the number authorized by each card. This would not have the same effect on inventory levels in the case where replenishment time is long compared to the consumption time.

Consideration must also be taken to the number of kanban cards when specifying the quantity for each card. These two parameters must be analysed together since they are interacting according to the formula presented in theory section 2.3.1. An example on how Volvo can use the formula for analyzing the number of kanban cards and quantity per card is given below.

The formula must be slightly adjusted before it can be used in Volvos case, since the formula assumes that all the parts authorized by one card are used instantly when they arrives at the workstation. The usage rate (demand) for Volvo is incremental, which means that the trolleys are emptied according to the takt time of the line. One additional card is therefore ‘tied up’ at the station compared to the original formula. Because of that the formula is changed to:

\[ k \geq \frac{t \cdot D \cdot (1 + s)}{n} + 1 \]

A calculation example for Volvo main line is given below:

- **D = 6 trucks/day** (demand on the line)
- **n = 2, 4, 6, 8** (quantity per card)
- **s = 0.2** (20% safety stock)
- **0.1 < t < 1 days** (replenishment time analyzed)

\[ k = \text{number of kanban cards} \]

Figure 25 shows the number of kanban cards needed for different replenishment lead times and quantities per card. What can be seen is that for many values on \( n \) and \( t \) the number of kanban cards needed is less than 2. Using only 2 cards is very simple in practice and is possible in some cases for \( n \) and \( t \). The possibility to reduce the number of cards when the system has been implemented is limited when using only 2, but as has been discussed earlier the best way for Volvo to reduce inventory after the implementation is to reduce the quantity per card. However there is often a difference between theory and reality. If practical tests reveal that 2 cards are too few, an additional card can simply be added to the system.
The procedure for Volvo when specifying parameters could be:

1. Plot a diagram for quantities per card \( n \) between 2 and 10 by using the formula.
2. Choose a quantity per kanban card that naturally fits into a trolley (or a multiple of a trolley), but is below 3 kanban cards.
3. Try to reduce the quantity per card when the system has been in use for a while.

The project team has already decided that the implementation of a new material delivery system will be accomplished station by station when they are redesigned. It is important to map the current state at the station concerning inventory, layout, types of parts etc. in order to identify improvement areas and chose the appropriate combination of material delivery systems. Value stream mapping, which is described in theory section 2.2.6, is a useful tool in this phase. Most of the stations both have small parts, bulky parts and ordinary parts, which mean that the combination of delivery systems must be carefully chosen for each individual station.

6.3 Create multifunctional teams in the production

According to the studied literature the creation of multifunctional teams is crucial for lean manufacturing. Interviews made with managers and supervisors shows that they believe that they are already working with multifunctional teams in the production today. The problem is that the work force in the production area is organised in teams but all the teams do not work in the way that a multifunctional team is supposed to do.

The members in a team are supposed to solve problems together and help each other. The culture in Australia and especially in Volvo’s factory is that the blue-collar workers are there to assemble trucks and the white-collar workers are supposed to support them and solve all their upcoming problems. This philosophy does not match the Volvo group’s own goals and meaning of an efficient organization. In “The Volvo way”, a book where all Volvo’s goals are gathered, you can read that Volvo has a decentralized organization because they want to get closer to the end costumers and get a local responsibility for the results in the company. This gap between blue-collars and white-collars is the root cause to many problems in the Wacol organization. The gap will be a big obstacle to overcome for the organization. The communication climate must be stimulated and improved if the team organization is to be developed. The communication between the teams must be increased as the communication between blue-collars and white-collars. In the future everyone in the organization must feel like a part of the organization and be responsible for the whole organizations results towards the customers.

The theory chapter shows that a lean organization needs demanding and intelligent workers that want to change the current production philosophy. Therefore the implementation of lean manufacturing will be easier if all the production teams would work as independent units along the production line, with motivated workers that want to achieve something better. Today’s organization with teams that are divided according to the production flow seems correct. To make the teamwork easier and more effective the managers and the lean project group should take a look at the current team sizes and which structure and behaviour they want the team to have. The problem is that the teams contains of 20 to 30 workers and one section leader each, which is to many if you want to have a well working team organization.

The questionnaire survey showed that both white-collar (4,2) and blue-collar (4,2) workers want to increase teamwork in the production. The results from similar questions like how they
found the importance of teamwork (4,1 and 4,3) and if they want to develop and increase the teamwork (4,0 and 4,0) were comparable. Cooperation between workers in the production is necessary in order to achieve a good work according to the theory. ‘The Volvo way’ is to work in teams because the teams total ability is higher than the sum of the individual’s abilities.

Both blue-collars (4,0) and white-collars (4,1) believe that increased cooperation in the production will help the workers in their job. They also think that the blue-collar workers want to increase the cooperation (3,3 and 3,3). There is a will in the organization to increase the teamwork in the production but there are few solutions on how to do it.

The responsible team educator has an important role in the creation of teams. The theory describes the significance of having a supportive and well educated teacher. One of the biggest problems for Volvo in this phase will be to explain and motivate why some of the work standards that have been used for the last ten years has to be updated. An Australian study showed the difficulties with attitudes and behaviours among the workers. The responsible manager has to be determined in his actions when he explains these changes for the organization, otherwise they might fail from the beginning.

6.3.1 Team meetings – standardized and on regular basis

The questionnaire survey together with the performed interviews showed that there are very few team meetings among the production teams. It is up to the supervisor to decide if his teams need to have a team meeting or not. Far from all supervisors have them on regular basis and those who have them just use them for information distribution. The empirical study did not find any major differences in the answers between blue-collars and white-collars in the survey’s three questions about team meetings. The questions were about the ability of discussing problems at team meetings, if the blue-collar workers find them important, and if the workers are interested in discussing problems at the meetings. The average score was about 3 on all three questions, but the blue-collars had a standard deviation of 1,2 compared to the white-collars deviation of 0,9 (attachment G and H).

When the results from the blue-collars were analysed a difference appeared when looking at the production areas answers. Figure 26 shows that the chassis line has the best team meeting consider the ability of discussing problems at them. The workers on the Mack line want to increase discussions about problems at meetings. The results from the empirical study together with the interviews made with the supervisors on the chassis line and the Mack line emphasize the differences in the production when it comes to team meetings. The problem is that not every supervisor sees the potential of team meetings and its importance for the daily

![Figure 26. Questions from the empirical study about team meetings.](image)
development. To get better and more efficient team meetings all the different production teams must have the same amount of meetings, on regular basis and performed according to a fixed and standardized structure. The theory chapter discusses the potential of team meetings and its importance for a lean organization. The Wacol organization can use the meetings for distributing information about lean and for motivating the workers to be a part of the change. The project group has to involve the blue-collar workers in the implementation and the team meetings could be a good channel to discuss and inform about the implementation’s progress. To get a functional and standardized team meeting culture in the factory should be one of the board’s first priorities, if they want to implement lean.

Some of the teams already have good team meetings (chassis line), but others will have to go through some introduction steps. The theory chapter describes what to do in the first meetings. As the team members learn how and what to do they can discuss more production specific problems at the meetings.

6.3.2 Team leader – a crucial position

Each team has a section leader that is responsible for the daily work. Above him in the hierarchy is a supervisor that is responsible for one part of the production (attachment F). The theory emphasizes the importance of having the right person on the leader position. In Sweden and Europe many organizations want to have a rotational leadership among the production teams. The interviews with managers and supervisors in the factory show that this is not that common in Australia. Australia prefers the British military organization that is more hierarchical. The supervisor on the Mack line for example does what he wants in his area. Therefore the cooperation between the supervisors in the factory is limited. They do not evaluate their work in order to set a ‘best standard’ as the theory recommends. The supervisor and section leader position is very important in the implementation of lean manufacturing, as they are the ‘bridge’ between blue-collars and white-collars.

Figure 27 shows the differences between the production areas on the question if they think that the factory is managed in a proper way. The workers in the factory do not have that much contact with the managers in the factory. Therefore this question relates more to their contact with their own supervisor than with the rest of the managers and supervisors. The chassis line feels that they get the best support from their supervisor which is visualized in Figure 28.
It is the supervisor’s responsibility to make sure that his teams has the right combination of knowledge within the team. Lean manufacturing advocates job rotation and work extension in order to become lean. The Wacol organization has the same problems with job rotation as with team meetings, there are only a few teams using it. Observations and interviews has given a picture of the work force that some of them do not want to rotate between jobs or extend their work tasks. As discussed in the theory there will always be workers that have done one task for the last years and now they do not want to change. The empirical study on the other side shows that most of the workers want to increase job rotation (3,3) and variation in their work tasks (3,7). Figure 29 shows the differences between the production areas in using job rotation today. As with other team issues the chassis line has the best result from a lean perspective.

Supervisors and the managers in the factory understand the advantages with job rotation. The overall knowledge and understanding for how a truck is produced will be better and the work satisfaction will increase as the workers learn more tasks. Figure 14 in the theory, ‘The flow channel’ visualizes the importance of giving the workers challenge and skill. Observations and interviews indicate that the workers have a high skill compared to a low challenge level, as they do the same rather complicated job every day. According to Csikszentmihaly’s model this should lead to boredom. Some of the supervisors say that it takes to long time to learn a new balance, up to several months, and some are not interested in having job rotation in their area at all. Job rotation exists in the organization today, which means that it will be easy to intensify. As with team meetings job rotation should have a high priority on the project groups list of improvements.

The theory and Volvo Truck in Sweden recommend the use of ‘flexi-matrixes’, which is a matrix where all the team members skills are mapped. This way of visualizing the team’s knowledge and daily work tasks will help the leader to organize, but it will also create a feeling of group belonging among the workers. The flexi-matrix should be put on the team’s
information board (ANDON-boards). Today Volvo already uses a matrix over the workers knowledge in order to give them the right salary and encourage them to learn more. A visualization of this matrix and use in the daily work is an easy step to take towards becoming lean. The flexi-matrix is discussed further in theory section 2.4.1.

Today the workers get a higher salary the more assembly balances they know. This is one step towards a lean salary system. The next step is to introduce some kind of group bonus system, in order to bring the team members closer together. The advantage with a group bonus system according to the theory is that the workers are likely to watch one other’s contributions.

6.3.3 Team communication

In chapter 5, Volvo Truck Production Australia, some information and communication examples are explained; missing parts and defect parts. In these situations there are no clear and effective communication channels. There are many people involved and therefore some of the information and suggestions are gone missing. Many of the workers feel that if they come with a question or improvement suggestion it takes too long time to get an answer if they ever get one. The solution to this problem is to shorten the communication channel and give the teams more responsibility. Today there are white-collar workers in the departments that are supposed to solve the problems without disturbing the production workers. This leads to bad solutions and involvement of unnecessary people. The whole communication climate within the production and between the production teams and the other departments must be improved. As described in the theory the project group should use process mapping when they are evaluating the communication within a process. To achieve this change it will help if the managers lead the way by changing their own communication behaviour, which will show the rest of the organization how it should be. This will be discussed further in the analysis of continuous improvements (section 2.6).

When the project group is trying to level the Wacol organization by eliminating unnecessary job positions, there will be a problem. In the theory there is a section about problems that will occur when someone has to give away some of his work tasks. The ‘donor’ might find it hard to give away some of his power and position within the organization, if a blue-collar workers is to perform some of his tasks. To prevent this problem the managers has to be aware of it and inform everyone about the problem. If the communication between the ‘donor’ and the workers is good it will be much easier.

The creation of multifunctional teams is a first step towards lean production. When the teams are well organized and educated the decentralization process and the work with production problems can start. Field studies shows that lean production organizations are using more teams in problem solving, the workers performed a higher variety of tasks and the proportion of implemented suggestions are higher than in non-lean companies according to Forza (1996).

6.4 Decentralize responsibilities to the production workers

Decentralizing responsibilities is about solving problems closer to where they appear. Today many production problems are solved in departments by white-collar workers and the involvement of blue-collars is limited. The work with production teams and cross-functional teams is therefore limited in Volvo’s organization. Like with other similar problems one of the root causes is the existing gap between white and blue-collar workers. The theory describes the inefficiency with having managers and supervisors performing tasks that the production worker or his team can perform. Australia’s union culture with a big difference between office workers and production workers in the factory has to be considered and
probably changed. To achieve this, the organization has to improve its vertical information system in order to achieve sustainable effects in the organization and to bring blue-collars and white-collars closer together. The creation of cross-functional teams could be a good start, when trying to limit the gap.

6.4.1 Increase the production teams’ responsibility

The teams in the production feel responsible for the work on their stations (4,1)\(^2\). The only thing that the blue-collar workers are responsible for today, except from building trucks, is their own quality checks. After they have assembled their parts they check them before sending the truck to the next station. Interviews and observations showed that the workers feel ownership for their part of the production, which is good, but their feeling of ownership for the whole production is limited. The managers’ opinion is that the teams just blame each other or the departments when something is wrong instead of solving the problem. As Figure 30 indicates both blue-collars and white-collars think it is important to increase the blue-collar workers responsibility and authority (3,7 and 3,6). The next question shows that blue-collar workers want to have more responsibility than the white-collar workers think they do (3,1 and 2,6). On both these questions the worker’s location in the factory, years at the company or age does not matter.

![Figure 30. Questions about the blue-collar’s responsibility and authority.](image)

The blue-collar workers’ answers on the question if they want to have increased responsibility (3,1), correlates with if they want to have increased variation in their work tasks (3,7). On the question if the blue-collar team had appropriate responsibility and authority there was a big difference between the blue-collars (3,1) and the white-collars (2,3) answers. These examples show that the white-collar workers and especially the blue-collar workers feel that the production teams should have more responsibility and authority.

Interviews with managers and supervisors showed that there are few who want to increase the production teams’ responsibility. There were few ideas among them of what could be decentralized. Hopefully this implementation of lean and its redesign of the workstations can be a good start on the decentralization process. All the members in the project group think that the workers should have increased influence and responsibility during the redesign of their workstation.

In the long run it is important that the decentralization of responsibility not is a temporary thing just during the implementation, but that it will be a permanent change. In the beginning everyone does not want to have more responsibility but as more and more tasks are being decentralized the resisting group will decrease. As both the theory and the managers suggest it is important to find they who want to have more responsibility in the beginning to get it

\(^2\) “To what degree do you feel responsible for your work tasks today?” (Attachment G).
started. This decentralization of responsibility and authority is supposed to end up in less production stops and quicker solutions.

6.4.2 Hierarchy levels – an organizational obstacle

The theory about lean says that the goal is to eliminate one hierarchical level, often the supervisor level. This should be done in order to get a smaller and more efficient communication and information climate. The Wacol organization’s problem is that they never remove any positions, just create new ones. There has been a culture of creating a job if there is a problem. The solution has always been to involve a new part in the communication process. This culture has to stop. Instead of reacting when there is a problem they should try to trace the problem before it occurs and prevent it. The interviews with the managers indicated that they are aware of the importance of this.

During the implementation supervisors and section leaders will have an important role. Therefore it is important to use them all in the beginning to get it started and as time goes by some of them could be reorganized to another job. The theory chapter deals with the problem of degrading a supervisor. When the project group have time they should map the process that goes on between the production and the departments in order to evaluate the organization. As this is done they will find a lot of unnecessary job positions.

6.4.3 Evaluate the information system

If the production teams are to get more responsibility it is important that they get the correct information in time. Observations in the production indicated that the existing ANDON-boards were inaccurate. Each team should have one board and it should only be used for information like quality audit scores and flexi-matrixes. It is important that the information boards are updated continuously otherwise it will not work. This is an easy and visual change that should be done in the beginning of the implementation. In the theory there are some examples of field studies performed in Australia and Europe that shows what a good tool ANDON-boards could be.

There is a discussion in the theory about written and verbal communication. In the Wacol factory there is a communication problem both between the departments, within the production and between production and departments. The problem is that the exchange of information is too rare and much of the information does not reach the receiver in time. It is important that every worker understands the importance of the information he or she has and how it can affect others. When the project group look at a station they should also take a look at the station’s communication and exchange with other areas. It could be how they communicate when there is a missing part, how they get their quality scores etc. The conclusion is that a good communication system within an organization will help all the other implementation areas as information and communication is a big part of every process.

According to some of the managers and the theory it is crucial to increase the workers’ understanding of the whole organization. Observations and questionnaires showed that the blue-collar workers have a lack in the understanding of the whole factory and its processes (2,9 and 2,6). When a problem occurs in the production one department gets involved, often the production engineering department. Instead of communicating with the workers in the production and some of the workers in the other departments many solutions are optimal for just one department and not the whole factory. The cooperation between the departments and

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3 How would you grade the blue collar workers understanding of the whole production process? (Attachment I)
the exchange of knowledge is limited in these cases. 63% of the white-collar workers think that the cooperation between the departments today is bad, but as many as 97% wants to improve the cooperation.

The theory recommends the managers to walk around in the factory on a daily or weekly basis. Observations in the factory show that many of the workers are dissatisfied with the managers’ commitment. Walking around in the factory and talking to the workers will bring the organization closer together and hopefully improve the overall understanding for the factory. The managers think that they do walk around and do not understand why the workers are not satisfied. Maybe it is a cultural thing, as with the union, managers should not talk to the workers in the same way as workers do between themselves. The organization has a hierarchy and power problem.

6.4.4 What can be decentralized?

A good start in the decentralization of responsibility to the production teams is to increase the workers assembly knowledge. Increasing job rotation and work enlargement can do this. After this the workers and the teams should get better feedback on their work and be given some of the responsibility for improvements. Other areas that the workers could work with are missing parts, quality problems, scheduling manning levels and improving the work environment. These are work tasks that the Wacol organization has problems with and the solution is increasing the blue-collar workers’ responsibility.

The hard part will be to get it started. Therefore the implementation of lean will be a good start but the project group and the workers managers have to be prepared for the next step. The decentralization process must not stop when the station has been redesigned. Thus a lot of trust and commitment are needed to keep the implementation process running.

When the workers are to be responsible for new tasks they need to be educated on them. In the theory section 2.4.4 about teams the ‘flow channel’ is presented. The figure shows what might happen if the workers are given too much responsibility without the proper education. Therefore, the supervisor that is responsible for the workers training has to focus on this as well. He might have to enlarge his education program and include some former supervisor and manager tasks.

6.5 Continuous improvements – crucial for lean success

The quality control system that is used in the Wacol factory is extensive, and seems to be working well. Defects that are discovered are corrected and reported to the quality department, which compiles the information. However there is a difference between quality control and quality improvements. The information that is received from the controls should be used as an input for improvements, by identifying the most frequent and severe problems. Concerned teams in the production must receive feedback on discovered problems, not only general audit scores, but detailed information directed to the team. The questionnaire survey showed that only 17% of the blue-collar workers thought they received enough feedback and as many as 82% wanted more feedback on their work. Interviews also indicated that the feedback concerning quality and other performance indicators should be improved, and that there is no systematic way of giving feedback.
Feedback is an important starting-point when working with continuous improvements. The feedback should be discussed and treated in cross-functional improvement groups consisting of blue-collar workers and representatives from the different departments. Blue-collars often have good knowledge of the manufacturing process and Figure 31 shows that there is a great interest in giving suggestions on improvements. In fact blue-collars are more interested than white-collars think they are. The survey also confirmed that a majority of the blue-collars thought that changes are positive for their work situation (3,4), and that they wanted to work with improvements together with white-collars (3,4).

Currently when blue-collar workers have suggestions they often talk to their section leader or supervisor, who forwards the suggestion to the concerned department. There is also a suggestion box, but the number of suggestions has been very low (less than five during 2004). Figure 32 shows that blue-collars do not think white-collars pay attention to their suggestion. A reason for that could be that the process time for investigating the suggestions is too long, which came up in the interviews. Lean manufacturing emphasises the importance of working continuously with improvements in groups, and the traditional suggestion box have less importance.

Improvement work in the production often affects several departments, such as production engineering, logistics, quality and construction. It is therefore important that the cooperation between the departments works well. The survey revealed that only 3% of the white-collars thought that the cooperation between the departments worked to high or very high extent, and as many as 97% wanted to increase the cooperation. Working with cross-functional improvement groups is a way to develop the cooperation between departments, since they have to cooperate in problem solving and improvement work.

According to the analysis a methodical way to work with continuous improvements is needed. Improvement work can be carried out in many ways, but one way is to form cross-functional improvement groups consisting of five to eight people. There could for example be one group...
connected to each production team (start of chassis line, end of chassis line, start of Volvo main line etc.), consisting of one representative from each department and four to five workers from the production team. Some departments are quite small and the same person might have to participate in several cross-functional groups. This should not be any problem since the white-collars are supposed to principally have a supportive role in the group. It is important to choose representatives from the production team that are interested in participating and come up with suggestions. It does not have to be the section leaders that are chosen for the improvement group. The other workers that are not involved in the improvement group must also be encouraged to come up with suggestions, which can be discussed during team meetings and in the cross-functional group.

Meetings where problems and improvement projects are discussed could be held for example once a week or every other week. A suitable project to start with is 5S, since it is easy to understand and often contributes with significant improvements. 5S is described in theory section 2.6.2. It is important that the participants in the group report to their department or production team after each meeting. Every production team should have an information board where ongoing improvement activities and results from accomplished projects are posted. It is important to evaluate the results of each project and make the solutions to a new standard in order to prevent future problems.

### 6.6 Achieve stability – creating best practice standards

Observations in the factory revealed that similar processes were performed in different ways depending on what area that was looked at. The questionnaire survey also indicated that there were differences, and Figure 33 and Figure 34 shows a comparison between chassis line and Mack line in four different areas (the number of answers were to low to analyse Volvo line). Chassis line uses work rotation in higher extent than Mack line and the workers also have better knowledge about other stations. The team meetings and amount of feedback is different as well. One reason for the difference between chassis and Mack might be that Mack was integrated into the factory only a few years ago. The participants in the questionnaire from Mack line were older and had worked at Mack/Volvo for longer time than those from chassis line, which could be another reason for the differences. The interviews revealed that the supervisors’ view of team meetings, feedback, work rotation etc. had a conclusive influence on the way the team worked.

The survey showed that the use of standards also have to be improved. 70% of the blue-collar workers (3,7) and 83% of the white-collars (4,0) thought that more standardized work should improve the production process. Only 18% of the blue-collars thought they had enough instruction to perform their work tasks, which indicates that there is a need to improve the documentation of work procedures. A computerized system with building instructions that everyone can access is used for Volvo trucks, but Mack on the

![Averages for Chassis & Mack](image)

Figure 33. Comparison between Cassis and Mack line.
other hand uses paper based instructions. Instructions for Volvo are therefore updated more frequently and are more comprehensive than for Mack.

The theory chapter emphasized the importance of having standardized work procedures to achieve stability in the organization’s processes. The currently best known way of building a truck or handling material should be used and standards and instructions must be continuously improved and communicated to all concerned employees, which is illustrated in Figure 17 section 2.7. This works quite well for Volvo trucks, and the need for improvements seems to be greater for Mack.

6.7 Managing the lean project

The analysis is based on studies carried out during the end of 2004, and does not consider the lean project efforts that have been done after that. The project started in the beginning of 2004 and the steering committee and project group was formed. Regular meetings were held, benchmarking visits to other factories were accomplished and a pilot project in the factory was carried out. After the enthusiastic start of the project the activities began to decline during the latter part of 2004. Only the chairman of the project group has been working full-time with the project and the meeting frequency has been low. A reason for that is that they have been waiting for approval from the parent company for the required budget. The interviews indicated that the project team members felt unsure about what was happening in the project, which might have been a consequence of the lack of meetings and continuous information.

The implementation of lean manufacturing is a comprehensive and complex project, which concerns every department, function and employee in the organization. The Wacol factory is not used to carry out large improvement projects, their former projects have rather been smaller and more delimited. Implementing lean manufacturing means a change in the organization's way of thinking, handling and acting and a lot of knowledge and experience is therefore required to accomplish the project. Involvement of professional consultants during the planning and implementation should therefore be considered. It is important the consultants merely have a supportive role and not take care of the entire project. The organization itself must still be the owner of the project. The consultants can for example evaluate the project team’s work on regular basis, they do not have to work fulltime with the project.

6.7.1 Project vision and objective

The board’s main purpose with implementing lean production was to get control of all the parts and material in the factory and reduce inventory levels. The project was therefore called “Wacol’s Material Development Project” and the choice of responsible department, the logistics department, was no surprise. Nevertheless the interviews with steering committee and project group members showed that there were different opinions on what the vision and objective of the project should be. Some members thought of it as a logistics project and
others as a business project involving several departments and areas. Even though some departments wanted to run the project as a business project, their interest in participating was limited.

Theories about implementation of lean production emphasises the importance of a clear vision that the entire senior management support. Commitment from everyone in the top team is necessary to show the organization the importance of the project (section 2.8.2). It is therefore vital that unity is achieved among managers and in the steering committee. Managers from all the concerned departments must be involved in the early stages of planning and show their interest in participating in order to achieve unity. It is critical to get the entire organization motivated to join the project. If they fail to motivate the workers the project team will find it hard to accomplish a successful implementation. All the managers and the members of the project group should be educated in the lean philosophy, otherwise they will not be able to motivate and persuade their employees.

The empirical survey revealed that there is a need to improve several areas within the organization. Some examples are:

- Both blue-collar (52%) and white-collar workers (86%) think it is important to reduce inventory at the stations.
- 91% of the blue-collar workers want to increase and develop the teamwork.
- Both blue-collar (64%) and white-collar workers (76%) think that blue-collars should have increased responsibility and authority.
- 70% of the blue-collar workers want to give suggestions on how to improve their work, but only 9% think that white-collars pay attention to their suggestions.

The survey highlights that there is a need to not only focus on material and logistic issues, but also areas like teamwork, decentralized responsibilities and improvement work. All these areas are interdependent and all of them must be considered to success in any of them. The lean project should therefore be carried out as a business project to achieve a sustainable change in the organization’s way of thinking and acting.

6.7.2 Involvement of employees

The project team has planned to involve the supervisor, the section leader and some of the workers on the concerned station during the redesign. The amount of involvement of the workers and the trust that the project members give them might have a great influence on the project’s outcome. It is essential to choose workers for the redesign group that are really interested in participating in the change. If the right persons are involved they can act as ‘ambassadors’ for the project in their production team, and motivate other team members to join the new way of thinking. The questionnaire survey showed that most of the blue-collar workers thought changes in the production area are positive for their work situation (3,4), but when they were asked if they wanted to participate in the change the answers were more negative (3,0). This further highlights the importance of finding those who are interested in participating.

Training and education in lean manufacturing tools and words should be given in smaller groups in connection to the redesign process. A general training could for example be given to everyone at the station that is going to be redesigned and more profound education to those workers that will be involved in the redesign group. The pilot project that has already been accomplished can be used as a classroom example in the education, because many people tend to easier understand things when they look at a tangible example. The theory also emphasises
the importance of creating a common language that all involved employees can understand, since there are many expressions that might not be familiar to everyone. Training must not only include how, but also why. There have to be an understanding of why lean tools are used, otherwise it will be hard to motivate and root the implementation.

The redesign of workstations will probably result in great improvements, which is a good start for the work with continuous incremental improvements. Improvement work with the involvement of production workers must take place after the redesign to achieve sustainable effects. The work with continuous improvements must be supported and one way to do this is to work with improvement groups, which are discussed in section 2.6.2.

6.7.3 Information during the implementation

Information about lean manufacturing and the project status is an important part of the implementation, and is needed to avoid confusion and create motivation. The project members have to some extent different thoughts about the amount of information that will be needed and how to distribute it. Some members think that it will be enough with a short presentation just before the redesign process and others think that massive and frequent information is needed. The theory supports the latter version as lean is about changing the organizations mentality and way of thinking and acting (section 2.8). General information to the entire workforce must be held before the implementation starts, in order to introduce the project to the organization. The focus should be on the benefits and results that lean can provide in order to create motivation. The name of the project must be powerful and express enthusiasm, and the provisional name “Wacol’s Material Development Project” might not be an accurate name when the implementation starts. Mack and Volvo’s factory in America uses the name “Race to excellence” for their major improvement project and maybe the already established expression “Team Wacol” could be used in the name of the project.

The organization must continuously be informed about the project’s status. General information on present activities, results and future plans could for example be communicated in a newsletter that is distributed in the entire factory and/or on team meetings.

6.7.4 Project management

As the project is in a critical stage and the former founder of the project has resigned it is important to clarify who is going to support and lead the project. A complex project of this extent will need different kind of leadership in different stages. The theory describes to different leaders, the supportive one and the decisive one. In Volvo’s factory every manager wants to give his opinion when something is discussed, but no one wants to be accountable. Since a lean project is a complex and soft process, that needs support and commitment, the project needs both a decisive and a supportive leader. This project needs a committed and responsible project and steering group that have a good communication climate. Without this it will be hard to control and lead a lean project.

In the beginning it is important to have a decisive leader who can steer the project in the right direction. As the project involves many people and activities the project’s plan will be affected of the project’s environment and unforeseen factors. Therefore the project will need a supportive steering group that is able to cooperate. As the project proceeds the leadership should be more and more supportive as more issues can be delegated.

The steering committee should do a priority list over the projects different areas. The project group’s main focuses should be to create a time schedule and point out when things has to be
The creation of the project plan as a time schedule is important according to former lean implementations. As the Wacol organization has pressure from the parent company to accomplish this implementation as soon as possible a time plan should help. A plan will help the management group to delegate tasks and get a good view of the situation. As the organization is not prepared in the way lean people advocates the project will get even more complex and in need of a good plan. Remember that a project plan is a living document that is supposed to be updated and developed. The creation of a project plan is also discussed in section 2.8.5.

The project group has done some benchmarking at other factories. The theory recommends that all these projects are evaluated, both the good and bad ones. Volvo’s implementation in Brazil was a success. What went well and what were the circumstances before the implementation started, compared to the Wacol factory? These are questions that are very important to ask oneself. Brazil might be a better culture for these kinds of projects.

As this project plan is created the project group, the managers and all the other involved people have to start to communicate with each other. The theory highlights four obstacles for a successive implementation. During the Wacol factory’s first year with the lean project most of these obstacles still exist. The amount of meetings has been too few, but worse is that no one knows what the other team members are doing. To inform and communicate is the key to a successful implementation of lean production. Volvo’s future problems will be what to do when they have redesigned each station and maybe introduced tools like 5S. Lean production is more than that. It is a continuous process that never ends, according to Womack & Jones (2003).
7 Conclusions

The report’s conclusions are based on the studied theories about lean manufacturing and the analysis of Volvo’s current situation. Volvo is in a critical stage where many decisions have to be made. Decisions that are made in these early stages are crucial for the project’s outcome, since large improvement projects like lean are hard to redirect once they are running. Therefore Volvo needs a skilled and committed leader that is able to steer the project in the right direction. The lean project group’s lack of meetings and absence of sharing information has to be enhanced, so that the knowledge of the project increases and the vision is spread throughout the organization. In addition to this the factory’s board and the lean project group have to be motivated and committed as well. A united and strong management team is crucial in order to motivate and root the project in the organization. All concerned employees must be involved in the project. This might be difficult since the gap between blue-collars and white-collars is significant. If the project only is supported by white-collars and not blue-collars it will have a small chance to succeed.

- Skilled and committed leader
- United management team
- Reduced gap between B/C and W/C

A major area that has to be taken care of before the implementation is the differences in the way of working in the factory. All the production teams should work in the same best known way regarding team meetings, job rotation, assembly instructions, missing parts, ordering parts etc. The development of standardized work procedures is mainly the production department’s responsibility, but the other departments must also contribute with their special skills in order to get an efficient production. When standardized work and stability in the production processes has been achieved, the ‘real’ implementation of lean manufacturing with material distribution, pull systems, decentralized responsibilities and continuous improvements can start. As soon as the work in the production teams has been developed, the most important task will be to organize a functional continuous improvement system in order to preserve the changes towards lean.

- Standardize the work in the production teams
- Implement a continuous improvement system
- Start the implementation of lean when stability has been achieved

7.1 The project team

The project team has to take its responsibility if this project is to be a success. To get motivated employees that want to participate in the implementation process the information about lean must be massive and frequent. Weekly newsletters and team meetings are two effective information channels. The project’s current name “Wacol’s material development project” is not that encouraging. A more inspiring and motivating name should be used, like “Race to excellence”. The lean temple emphasises the importance of working with several lean areas to achieve a ‘lean’ production. The analysis revealed that Volvo has to work with all the lean areas, not only the distribution of material. The project should therefore be carried out as a large business project that involves everyone in the factory. As a business project concerns many different areas in the Wacol organization, the project group can not be responsible for all changes. Therefore each department should take responsibility for their part of the lean project. It might be necessary to involve outside consultants that can evaluate and
support the project, since the knowledge of lean manufacturing is limited within the organization.

Before the project proceeds to the next phase, the implementation phase, the project group has to create a detailed project plan. The plan should contain intermediate goals, milestones and all other important activities. A good plan will help the project group to work in a structural way and show the rest of the organization in what direction the project is heading. Intermediate goals and milestones are important if the project is to be accomplished in time and with a satisfying result. As the project’s environment will change during the project the plan has to be updated continuously. In addition to the plan all the departments has to standardize and improve their work procedures, which will make the implementation easier.

When the implementation starts with the redesign of workstations the project group should try to work in parallel teams, i.e. several stations at the same time. Otherwise it will take too long time to finish all stations. In this phase the project leadership should change from decisive to supportive. It is important to start with stations that have a great chance to success and where clear improvements can be achieved, in order to create a positive attitude towards the project. The education during the redesign phase should be accomplished in small groups and not only focus on how but also why. At the same time as the stations are redesigned the work with teams and continuous improvements should be prioritised. The project group should be accountable for all the additional areas, but the changes must be accomplished by the concerned department since the human resources in the project group will not be enough.

- **Massive and frequent information**
- **See it as a large business project**
- **Improve the project plan**

All the above presented conclusions can be taken care of immediately and they do not depend on other measures. They are all ‘project management’ issues that have to be improved in order to get a functional project. In the coming conclusion chapters more specific actions for each department will be presented.

### 7.2 Managers

The factory’s managers should concentrate on the gap between blue-collars and white-collars. They must create a ‘Team Wacol’ spirit and convince the employees that everyone’s work is important and contributes to the factory’s result. A good start would be if each manager performed some ‘management by walking around’, in order to level the gap. Except from the overall spirit the board should try and increase the cooperation between the departments and between blue-collars and white-collars by using cross-functional groups. These teams could start to work with organisation of workstations by using 5S or standardization of work procedures. Each procedure should be performed according to ‘best practise’. The work with cross-functional groups should take over when the stations have been redesigned, in order to preserve the change and improve the work even further.

- **Create cross-functional teams**

### 7.3 Production department

The production department will have a crucial role in the early stages of the implementation as the production work must be more standardized. If the implementation of lean starts in the factory area without common and standard work procedures among the workers the implementation might not work. Therefore it is important that each team have a proper
amount of members, are logically organized and work in the same way as the other teams. Each team should have an ANDON-board, use job rotation, use flexi-matrixes and have team meetings. The meetings should be held on regular basis, in a structural way and all teams should have similar meetings. Except from ordinary meetings each team should have an improvement group consisting of some of the team members. To achieve all these changes the supervisors and section leaders will have a central role. If some of them do not want to achieve all these changes it will have a bad influence on the whole lean implementation. All these changes are part of the foundation and preparation for lean, therefore they have to be taken care of immediately.

- **ANDON-boards, Flexi-matrixes**
- **Job rotation**
- **Standardized team meetings**

### 7.4 Production engineering department

The production engineering department should focus on work standards and continuous improvement groups. The work standards should be set according to the whole organization’s best interest and not only the production engineering department’s interest. The work with improvement suggestions should be performed in cross-functional improvement groups throughout the factory. These groups should cooperate and be supported by the production engineering technicians. This work with continuous improvement is one of the most important parts to take care of, since the present continuous improvement work hardly exists.

- **Develop a functional continuous improvement work in the factory**

### 7.5 Logistics department

The logistics department will be involved in the redesign of workstations and the warehouse. Except from these implementation issues the department should concentrate on the interaction with suppliers, since many shortages appear because of supplier problems. The procedures when parts are missing also have to be developed by the logistic department. It should be decentralized to the production teams if possible, since all upcoming problems are to be solved close to where they appear.

- **Start to focus on missing parts**
- **Later the logistic department will have a big part in the implementation**

### 7.6 Quality department

The quality department must be more involved in the implementation than they are now. They should be responsible for the work with continuous improvements regarding quality issues. Each production team must get quick and correct feedback on their work in order to improve their work standards. Quality scores should be highlighted on the production teams’ ANDON-boards. Therefore this work can be taken care of immediately. In order to get a methodical way of working with improvements each improvement group should work according to the PDCA-cycle.

- **Focus on continuous improvement regarding quality**
- **Make sure that quality is considered during each implementation step**

Volvo’s view of the implementation is that it will start with the redesign of work stations. In this conclusion chapter we have tried to show each part of the organization what they can improve before the ‘implementation’ starts. If these areas, or at least some of them, are not
improved before the redesign of work stations starts the changes of the stations might just be for the moment. If Volvo wants to achieve a change in the long run and especially a change in behaviours the foundation of the ‘lean temple’ has to be improved. The above suggested areas will be a good start.

Volvo’s investment in a lean production system in the Wacol organization should be seen as a great opportunity to improve the factory’s status in the Volvo group. It will take time to achieve this implementation, up to three years, since the organization also has to work on the foundation of the lean temple. With the right people in the right positions and with the support of the production workers, hopefully it will result in a satisfying result. The start on a lean journey never ends according to James Womack and the lean enterprise institute. There are always functions and procedures that can be improved.
8 Discussion of the results

The conclusions and the results are unique for the present situation in Volvo’s factory in Brisbane. But, most of the theories are common lean production theories and can therefore be useful for any production organization. When the work with this Master’s Thesis started the focus was on giving the Wacol organization a chronological plan over the coming implementation. The more we learned about the organization the more we understood that their first problem was not in what order to implement lean, but in what preparations that had to be done. A stable foundation for the implementation had to be created. Therefore the conclusions are more focused on the ‘bottom’ of the lean temple instead of the pillars and the roof.

As this thesis project proceeded, the managers and the project group in Wacol realized what we were after. Some of these problems were not new to them but it is always easier to convince other people when you have proof. When we presented the results from our questionnaire survey the managers realized what a problem it could be. If we were to do this again we would have tried to be more ‘hands on’. Instead of talking about team meetings and improvement teams it would have been better to work close with a production team and practised our recommendations.
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Lean production questionnaire

This questionnaire has been carried out as a part of a pre-study for the implementation of lean production in the factory. The pre-study is an independent student project accomplished in cooperation with Volvo’s Wacol factory. The pre-study will act as a help for Volvo’s Lean Production Team when they start to look at the implementation of lean at the beginning of next year.

The questionnaire will be handed out to about 20% of the blue collar workers, and is supposed to show your opinion on some critical implementation issues. Your opinion is really important to us when we are developing the pre-study, since changes in production have a great impact on blue collar workers. This is not only a good opportunity for you to influence the pre-study, but also the whole implementation of lean production.

Before you start to fill out the questionnaire, we want to emphasize some important matters:

- Your individual answers will be treated confidentially and will only be handled by us. The questionnaire will be destroyed after use.
- The results will be presented to Volvo as the blue collar group’s opinion and not the individual’s opinion.
- There are no right or wrong answers, we just want your opinion.
- Try to answer all questions, even if the alternatives do not always suit your opinion.

The questionnaire contains 49 questions. You answer the questions by marking with an ‘X’ to what extent you agree with the question, from ‘very low’ to ‘very high’. Do not stop too long at each question, it is your spontaneous opinion we want!

Thank you for participating!

Andreas Berg & Fredrik Ohlsson

1. **To what extent do you think it is important to reduce inventory/parts on the stations?**
   - [ ] Very low extent
   - [ ] Low extent
   - [ ] Neither / nor
   - [ ] High extent
   - [ ] Very high extent

2. **To what amount do you think it is important to increase responsibility and authority for the blue collar workers?**
   - [ ] Very low amount
   - [ ] Low amount
   - [ ] Neither / nor
   - [ ] High amount
   - [ ] Very high amount

3. **To what extent do you think it is important to increase teamwork among blue collar workers?**
   - [ ] Very low extent
   - [ ] Low extent
   - [ ] Neither / nor
   - [ ] High extent
   - [ ] Very high extent

4. **To what extent do you feel that your work contributes to the whole production process?**
   - [ ] Very low extent
   - [ ] Low extent
   - [ ] Neither / nor
   - [ ] High extent
   - [ ] Very high extent

5. **To what degree do you feel that you have knowledge about the other stations in your section?**
   - [ ] Very low degree
   - [ ] Low degree
   - [ ] Neither / nor
   - [ ] High degree
   - [ ] Very high degree

6. **How would you grade the blue collar workers understanding of the whole production process?**
   - [ ] Very low
   - [ ] Low
   - [ ] Neither / nor
   - [ ] High
   - [ ] Very high

7. **To what extent do you think changes in the production area are positive for your work situation?**
   - [ ] Very low extent
   - [ ] Low extent
   - [ ] Neither / nor
   - [ ] High extent
   - [ ] Very high extent
8. To what degree do you think blue collar workers are interested in participating in a change?

- [ ] Very low degree
- [ ] Low degree
- [ ] Neither/nor
- [ ] High degree
- [ ] Very high degree

9. To what extent do you feel that the organisation is ready for a change?

- [ ] Very low extent
- [ ] Low extent
- [ ] Neither/nor
- [ ] High extent
- [ ] Very high extent

10. To what extent do you feel that blue collar workers are satisfied with their work?

- [ ] Very low extent
- [ ] Low extent
- [ ] Neither/nor
- [ ] High extent
- [ ] Very high extent

11. To what degree would you like to change your present workplace at Volvo/Mack because of work dissatisfaction?

- [ ] Very low degree
- [ ] Low degree
- [ ] Neither/nor
- [ ] High degree
- [ ] Very high degree

12. To what extent do you feel that your salary is adequate in relation to your work?

- [ ] Very low extent
- [ ] Low extent
- [ ] Neither/nor
- [ ] High extent
- [ ] Very high extent

13. To what extent do you think that the Wacol factory is managed in a proper way?

- [ ] Very low extent
- [ ] Low extent
- [ ] Neither/nor
- [ ] High extent
- [ ] Very high extent

14. To what degree do you feel that the top management at the factory is concerned about the blue collar’s work situation?

- [ ] Very low degree
- [ ] Low degree
- [ ] Neither/nor
- [ ] High degree
- [ ] Very high degree

15. To what extent do you think that blue collar workers have sufficient instructions for their work tasks?

- [ ] Very low extent
- [ ] Low extent
- [ ] Neither/nor
- [ ] High extent
- [ ] Very high extent

16. To what extent do you think that blue collar workers need more training in their work tasks?

- [ ] Very low extent
- [ ] Low extent
- [ ] Neither/nor
- [ ] High extent
- [ ] Very high extent

17. To what degree do you believe that more standardized work could improve the production process?

- [ ] Very low extent
- [ ] Low extent
- [ ] Neither/nor
- [ ] High extent
- [ ] Very high extent

18. To what amount do you think that blue collar workers want to participate in the development of work standards/procedures?

- [ ] Very low amount
- [ ] Low amount
- [ ] Neither/nor
- [ ] High amount
- [ ] Very high amount

19. To what degree do you think that blue collar workers are satisfied with their work station environment?

- [ ] Very low degree
- [ ] Low degree
- [ ] Neither/nor
- [ ] High degree
- [ ] Very high degree

20. To what extent do you think that it is clearly defined where parts and tools should be stored at the stations?

- [ ] Very low extent
- [ ] Low extent
- [ ] Neither/nor
- [ ] High extent
- [ ] Very high extent

21. To what extent do you feel that blue collar workers want to improve their work station environment?

- [ ] Very low extent
- [ ] Low extent
- [ ] Neither/nor
- [ ] High extent
- [ ] Very high extent
22. How would you grade the importance of teamwork within the production team?
   - Very low
   - Low
   - Neither/nor
   - High
   - Very high

23. To what extent do you think blue collar workers are comfortable with work in teams?
   - Very low extent
   - Low extent
   - Neither/nor
   - High extent
   - Very high extent

24. To what degree would you like to develop and increase the teamwork in production?
   - Very low degree
   - Low degree
   - Neither/nor
   - High degree
   - Very high degree

25. To what extent do you think blue collar workers are satisfied with their cooperation with the supervisors?
   - Very low extent
   - Low extent
   - Neither/nor
   - High extent
   - Very high extent

26. To what degree do you feel that the supervisor supports blue collar's work?
   - Very low degree
   - Low degree
   - Neither/nor
   - High degree
   - Very high degree

27. To what extent do blue collar workers rotate between different work stations today?
   - Very low extent
   - Low extent
   - Neither/nor
   - High extent
   - Very high extent

28. To what amount do you want to increase the variation in your work tasks?
   - Very low amount
   - Low amount
   - Neither/nor
   - High amount
   - Very high amount

29. To what degree do you feel responsible for your work tasks today?
   - Very low degree
   - Low degree
   - Neither/nor
   - High degree
   - Very high degree

30. To what degree do you think blue collar workers want to increase the rotation between stations?
   - Very low degree
   - Low degree
   - Neither/nor
   - High degree
   - Very high degree

31. To what degree do you feel that your current team has appropriate responsibility and authority?
   - Very low degree
   - Low degree
   - Neither/nor
   - High degree
   - Very high degree

32. To what grade do you think that blue collar workers want to have more responsibility and authority delegated to the team?
   - Very low grade
   - Low grade
   - Neither/nor
   - High grade
   - Very high grade

33. To what extent do you feel that blue collar workers can bring up and discuss problems at the team meetings?
   - Very low extent
   - Low extent
   - Neither/nor
   - High extent
   - Very high extent

34. To what extent do you think blue collar workers want to have increased responsibility and authority?
   - Very low extent
   - Low extent
   - Neither/nor
   - High extent
   - Very high extent

35. To what degree do you think that the blue collar workers find the team meetings important?
   - Very low degree
   - Low degree
   - Neither/nor
   - High degree
   - Very high degree
36. To what extent do you think that the blue collar workers are interested in discussing improvement suggestions at the team meetings?

37. To what amount do you think that blue collar workers like to cooperate with their team members?

38. To what degree do you think that increased cooperation among blue collar workers could help them in their job?

39. To what amount do you believe that blue collar workers want to give suggestions on how to improve their work?

40. To what extent do you believe that white collar workers pay attention to suggestions from blue collar workers?

41. To what extent do you think that blue collar workers can influence their work?

42. To what amount do you think that blue collar workers want to have increased influence over their work?

43. To what extent do you think blue collar workers receive feedback on their work?

44. To what extent do you believe that blue collar workers want to participate in production improvements?

45. To what degree do you believe that blue collar workers want to receive more feedback on their work?

46. To what degree do you think that blue collar workers want to work with improvements together with white collar workers?

47. What is your age?

48. For how many years have you worked at Volvo/Mack?

49. In what section are you working?
Lean production questionnaire

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This questionnaire will be handed out to white collar workers that will be directly or indirectly involved in the implementation of lean production. Your opinion is really important to us when we are developing the pre-study, since you will participate in the implementation process. A similar questionnaire will be handed out to about 20% of the blue collar workers, and is supposed to show their opinion on some critical implementation issues.

Before you start to fill out the questionnaire, we want to emphasize some important matters:

- Your individual answers will be treated confidentially and will only be handled by us. The questionnaire will be destroyed after use.
- The results will be presented to Volvo as the white collar group’s opinion and not the individual’s opinion.
- There are no right or wrong answers, we just want your opinion.
- Try to answer all questions, even if the alternatives do not always suit your opinion.

The questionnaire contains 46 questions. You answer the questions by marking with a ‘X’ to what extent you agree with the question, from ‘very low’ to ‘very high’. Do not stop too long at each question, it is your spontaneous opinion we want!

Thank you for participating!

Andreas Berg & Fredrik Ohlsson

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   - Very high extent

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   - Neither / nor
   - High amount
   - Very high amount

3. To what extent do you think it is important to increase teamwork among blue collar workers?
   - Very low extent
   - Low extent
   - Neither / nor
   - High extent
   - Very high extent

4. To what degree do you feel that blue collar workers have knowledge about the other stations in their section?
   - Very low degree
   - Low degree
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   - High degree
   - Very high degree

5. How would you grade the blue collar workers’ understanding of the whole production process?
   - Very low
   - Low
   - Neither / nor
   - High
   - Very high

6. To what extent do you think changes in the production area are positive for the blue collar’s work situation?
   - Very low extent
   - Low extent
   - Neither / nor
   - High extent
   - Very high extent

7. To what degree do you think blue collar workers are interested in participating in a change?
   - Very low degree
   - Low degree
   - Neither / nor
   - High degree
   - Very high degree
8. To what extent do you feel that the organisation is ready for a change?

<table>
<thead>
<tr>
<th>Very low extent</th>
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9. To what extent do you feel that blue collar workers are satisfied with their work?

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<th>Very low extent</th>
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<th>Neither / nor</th>
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</thead>
</table>

10. To what extent do you think that the Wacol factory is managed in a proper way?

<table>
<thead>
<tr>
<th>Very low extent</th>
<th>Low extent</th>
<th>Neither / nor</th>
<th>High extent</th>
<th>Very high extent</th>
</tr>
</thead>
</table>

11. To what degree do you feel that the top management at the factory is concerned about the blue collar’s work situation?

<table>
<thead>
<tr>
<th>Very low degree</th>
<th>Low degree</th>
<th>Neither / nor</th>
<th>High degree</th>
<th>Very high degree</th>
</tr>
</thead>
</table>

12. To what extent do you think that blue collar workers have sufficient instructions for their work tasks?

<table>
<thead>
<tr>
<th>Very low extent</th>
<th>Low extent</th>
<th>Neither / nor</th>
<th>High extent</th>
<th>Very high extent</th>
</tr>
</thead>
</table>

13. To what extent do you think that blue collar workers need more training in their work tasks?

<table>
<thead>
<tr>
<th>Very low extent</th>
<th>Low extent</th>
<th>Neither / nor</th>
<th>High extent</th>
<th>Very high extent</th>
</tr>
</thead>
</table>

14. To what degree do you believe that more standardized work could improve the production process?

<table>
<thead>
<tr>
<th>Very low degree</th>
<th>Low degree</th>
<th>Neither / nor</th>
<th>High degree</th>
<th>Very high degree</th>
</tr>
</thead>
</table>

15. To what amount do you think that blue collar workers want to participate in the development of work standards/procedures?

<table>
<thead>
<tr>
<th>Very low amount</th>
<th>Low amount</th>
<th>Neither / nor</th>
<th>High amount</th>
<th>Very high amount</th>
</tr>
</thead>
</table>

16. To what degree do you think that blue collar workers are satisfied with their work station environment?

<table>
<thead>
<tr>
<th>Very low degree</th>
<th>Low degree</th>
<th>Neither / nor</th>
<th>High degree</th>
<th>Very high degree</th>
</tr>
</thead>
</table>

17. To what extent do you think that it is clearly defined where parts and tools should be stored at the stations?

<table>
<thead>
<tr>
<th>Very low extent</th>
<th>Low extent</th>
<th>Neither / nor</th>
<th>High extent</th>
<th>Very high extent</th>
</tr>
</thead>
</table>

18. To what extent do you think that blue collar workers want to improve their work station environment?

<table>
<thead>
<tr>
<th>Very low extent</th>
<th>Low extent</th>
<th>Neither / nor</th>
<th>High extent</th>
<th>Very high extent</th>
</tr>
</thead>
</table>

19. How would you grade the importance of teamwork within the production team?

<table>
<thead>
<tr>
<th>Very low</th>
<th>Low</th>
<th>Neither / nor</th>
<th>High</th>
<th>Very high</th>
</tr>
</thead>
</table>

20. To what extent do you think blue collar workers are comfortable with work in teams?

<table>
<thead>
<tr>
<th>Very low extent</th>
<th>Low extent</th>
<th>Neither / nor</th>
<th>High extent</th>
<th>Very high extent</th>
</tr>
</thead>
</table>

21. To what degree would you like to develop and increase the teamwork in production?

| Very low degree | Low degree | Neither / nor | High degree | Very high degree |
22. To what extent do you think blue collar workers are satisfied with their cooperation with the supervisors?

23. To what degree do you feel that the supervisor supports blue collar's work?

24. To what degree do you think blue collar workers want to increase the rotation between stations?

25. To what degree do you feel that the blue collar work teams have appropriate responsibility and authority?

26. To what grade do you think that blue collar workers want to have more responsibility and authority delegated to the team?

27. To what extent do you feel that blue collar workers can bring up and discuss problems at the team meetings?

28. To what extent do you think blue collar workers want to have increased responsibility and authority?

29. To what degree do you think that the blue collar workers find the team meetings important?

30. To what extent do you think that the blue collar workers are interested in discussing improvement suggestions at the team meetings?

31. To what amount do you think that blue collar workers like to cooperate with their team members?

32. To what degree do you think that increased cooperation among blue collar workers could help them in their job?

33. To what amount do you believe that blue collar workers want to give suggestions on how to improve their work?

34. To what extent do you believe that white collar workers pay attention to suggestions from blue collar workers?

35. To what extent do you think that blue collar workers can influence their work?
36. To what amount do you think that blue collar workers want to have increased influence over their work?

- Very low amount
- Low amount
- Neither / nor
- High amount
- Very high amount

37. To what extent do you think blue collar workers receive feedback on their work?

- Very low extent
- Low extent
- Neither / nor
- High extent
- Very high extent

38. To what extent do you believe that blue collar workers want to participate in production improvements?

- Very low extent
- Low extent
- Neither / nor
- High extent
- Very high extent

39. To what degree do you believe that blue collar workers want to receive more feedback on their work?

- Very low degree
- Low degree
- Neither / nor
- High degree
- Very high degree

40. To what degree do you think that blue collar workers want to work with improvements together with white collar workers?

- Very low degree
- Low degree
- Neither / nor
- High degree
- Very high degree

41. To what extent do you think that an implementation of lean production can lead to a better work situation among the white collar workers?

- Very low extent
- Low extent
- Neither / nor
- High extent
- Very high extent

42. To what degree do you think that the cooperation between the different departments works?

- Very low degree
- Low degree
- Neither / nor
- High degree
- Very high degree

43. To what amount would you like to increase the cooperation between the departments?

- Very low amount
- Low amount
- Neither / nor
- High amount
- Very high amount

44. To what grade would you like to work in cross functional teams consisting of people from different departments together with blue collar workers?

- Very low grade
- Low grade
- Neither / nor
- High grade
- Very high grade

45. To what extent are you interested in participating in the implementation of lean production?

- Very low extent
- Low extent
- Neither / nor
- High extent
- Very high extent

46. For how many years have you worked at Volvo/Mack?

- 0 - 1
- 1 - 3
- 3 - 10
- Over 10
<table>
<thead>
<tr>
<th></th>
<th>Interviews</th>
<th>Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lean project team</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Steering committee:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lee Morphew</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Justin Murphy</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lars Farnskog</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Wayne Dixon</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Peter Heit</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><strong>Project group:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cathy Lewis</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Terry Roebig</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Adam Carne</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Logistic department:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Justin Murhpy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adam Carne</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Material technicians x 3</td>
<td></td>
<td>x*</td>
</tr>
<tr>
<td>Emma</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Production engineering department:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lars Farnskog</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Cathy Lewis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nirosh Matai</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Paul Blake</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Wayne Westwood</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Kevin Dinsdale</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Garry Paskins</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quality department:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shane Zoch</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Pat Robertson (quality supervisor)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Tony Ingeldew (SQA)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Quality inspectors x 3</td>
<td></td>
<td>x*</td>
</tr>
<tr>
<td><strong>Production department</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peter Heit</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Andrew Ford</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Andrew Barker</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Bob McSkimming</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Mick Floyd</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Terry Roebig</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Pedro Miranda</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Garrin Miranda</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

*Question 41 excluded

14 29
<table>
<thead>
<tr>
<th>INVESTIGATION AREA</th>
<th>WHY IS IT INVESTIGATED?</th>
<th>CONNECTION TO LEAN PRINCIPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Elimination of waste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pull instead of Multifunctional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>teams</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decentralized responsibilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous improvement</td>
</tr>
<tr>
<td>CONDITIONS FOR IMPLEMENTING LEAN</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Altitudes towards lean principles</td>
<td>Affects the implementation of all lean manufacturing principles.</td>
<td>X</td>
</tr>
<tr>
<td>Change mentality</td>
<td>An important factor for the whole implementation process.</td>
<td>X</td>
</tr>
<tr>
<td>Comprehensive view of the manufacturing process</td>
<td>A way of measure the B/C's interest and understanding of the factory.</td>
<td>X</td>
</tr>
<tr>
<td>Perception of importance of work</td>
<td>Understanding the importance of the individuals contribution to the whole is important for the implementation.</td>
<td>X</td>
</tr>
<tr>
<td>Work satisfaction</td>
<td>Low satisfaction can lead to willingness to change production procedures.</td>
<td>X</td>
</tr>
<tr>
<td>Management support</td>
<td>The experienced management can influence the change.</td>
<td>X</td>
</tr>
<tr>
<td>Cooperation between departments</td>
<td>The lean project will affect several departments. Cooperation between departments is therefore important.</td>
<td>X</td>
</tr>
<tr>
<td>MANAGING THE LEAN PROJECT</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Responsibilities in the lean project team</td>
<td>Must be investigated in order to see how the project is managed.</td>
<td>X</td>
</tr>
<tr>
<td>Project teams current work and future plans</td>
<td>Some things has already been done and future plans has been developed. Shows how the project is managed today.</td>
<td>X</td>
</tr>
<tr>
<td>Information to the organization about the project</td>
<td>To see how the lean team plans to inform the organization and root the project.</td>
<td>X</td>
</tr>
<tr>
<td>Involvement of B/C in the project</td>
<td>The implementation of lean production will affect many of the workers in the factory. Their involvement is therefore important.</td>
<td>X</td>
</tr>
<tr>
<td>PRODUCTION TEAMS</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Willingness to work in teams/groups</td>
<td>Influence the formation and development of teams and groups.</td>
<td>X</td>
</tr>
<tr>
<td>Responsibility and authority</td>
<td>If the operators have any present responsibility or authority it will make it easier to give them more.</td>
<td>X</td>
</tr>
<tr>
<td>Team meetings</td>
<td>The present group meetings and how they work will have an influence on the implementation of new meeting procedures.</td>
<td>X</td>
</tr>
<tr>
<td>Education and training</td>
<td>The workers current education process and how they want to be educated will influence the education that is needed.</td>
<td>X</td>
</tr>
<tr>
<td>Work satisfaction</td>
<td>Low satisfaction can lead to willingness to change production procedures.</td>
<td>X</td>
</tr>
<tr>
<td>Management support</td>
<td>The experienced management can influence the change.</td>
<td>X</td>
</tr>
<tr>
<td>Cooperation</td>
<td>If there are any cooperation along the line today it will help in the implementation of teams.</td>
<td>X</td>
</tr>
<tr>
<td>WORK PROCEDURES AT STATIONS</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Standardization of work</td>
<td>The present use of standards and if they want more standardized work will influence the use of new ones.</td>
<td>X</td>
</tr>
<tr>
<td>Material handling at stations</td>
<td>The way they work with materials at the stations today is interesting when implementing pull systems.</td>
<td>X</td>
</tr>
<tr>
<td>Missing parts</td>
<td>Their work with missing parts is interesting for pull, improvements and waste.</td>
<td>X</td>
</tr>
<tr>
<td>Defective parts</td>
<td>Same as for missing parts.</td>
<td>X</td>
</tr>
<tr>
<td>Visualization of workstations</td>
<td>Current visualization workstations and areas will help when implementing many of the lean principles.</td>
<td>X</td>
</tr>
<tr>
<td>Workstation environment</td>
<td>If the workers are not satisfied with their environment they might be interested in changing it.</td>
<td>X</td>
</tr>
<tr>
<td>MATERIAL DISTRIBUTION</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>General factory layout</td>
<td>To achieve knowledge about flows and distribution paths in order to eliminate waste and designing pull system.</td>
<td>X</td>
</tr>
<tr>
<td>Delivery frequency</td>
<td>It is interesting to know how often material can be delivered when implementing pull.</td>
<td>X</td>
</tr>
<tr>
<td>Types of material</td>
<td>What can be kitced, pulled, two bin delivered etc.</td>
<td>X</td>
</tr>
<tr>
<td>Initialization of material delivery</td>
<td>What kind of system are the workers used to? Important for pull and decentralized responsibility.</td>
<td>X</td>
</tr>
<tr>
<td>Order release planning</td>
<td>Do they consider shortages and the amount of work on every truck when planning the production sequence?</td>
<td>X</td>
</tr>
<tr>
<td>Integration of workstations</td>
<td>When creating teams and implementing pull it is good if work stations can be integrated for example sub-assemblies.</td>
<td>X</td>
</tr>
<tr>
<td>WORK WITH IMPROVEMENTS</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Improvement suggestions</td>
<td>Are there many improvement suggestions today and how are they handled?</td>
<td>X</td>
</tr>
<tr>
<td>B/C possibility to influence their work</td>
<td>If they can and want to it is a good start for more responsibilities and involvement in improvement work.</td>
<td>X</td>
</tr>
<tr>
<td>Objective oriented work</td>
<td>If they work with objectives today it will help when developing the improvement work.</td>
<td>X</td>
</tr>
<tr>
<td>Information and feedback to B/C</td>
<td>The current communication must be studied before giving them new directions.</td>
<td>X</td>
</tr>
<tr>
<td>Willingness to participate in improvement work</td>
<td>If they want to participate it is an advantage.</td>
<td>X</td>
</tr>
<tr>
<td>Scheduled time for improvement work</td>
<td>If it exists among the workers and if they want it, it will help when introducing improvement work.</td>
<td>X</td>
</tr>
<tr>
<td>Feedback from end customer</td>
<td>If they receive it today it is good for the improvement work.</td>
<td>X</td>
</tr>
<tr>
<td>Quality control</td>
<td>What quality controls do they have and do they lead to improvements. If the workers are involved today it is an advantage.</td>
<td>X</td>
</tr>
<tr>
<td>Measuring of quality indicators</td>
<td>Who does it and how is the figures communicated. Important to know for the improvement work.</td>
<td>X</td>
</tr>
<tr>
<td>Amount of rectifications needed</td>
<td>If there are many rectifications caused by lack of quality today, a new improvement system should be easier to motivate.</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Production department
organizational chart
## B/C questionnaire results

### ATTITUDES

<table>
<thead>
<tr>
<th>Statement</th>
<th>Average</th>
<th>Low</th>
<th>Neither</th>
<th>High</th>
<th>Std dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehensive view of the manufacturing process</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. To what extent do you feel that your work contributes to the whole production process?</td>
<td>3.9</td>
<td>8%</td>
<td>11%</td>
<td>82%</td>
<td>0.8</td>
</tr>
<tr>
<td>5. To what degree do you feel that you have knowledge about the other stations in your section?</td>
<td>3.5</td>
<td>23%</td>
<td>18%</td>
<td>59%</td>
<td>1.1</td>
</tr>
<tr>
<td>6. How would you grade the blue collar workers understanding of the whole production process?</td>
<td>2.9</td>
<td>39%</td>
<td>24%</td>
<td>36%</td>
<td>1.0</td>
</tr>
<tr>
<td>Change mentality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. To what extent do you think changes in the production area are positive for your work situation?</td>
<td>3.4</td>
<td>12%</td>
<td>36%</td>
<td>52%</td>
<td>0.8</td>
</tr>
<tr>
<td>8. To what degree do you think blue collar workers are interested in participating in a change?</td>
<td>3.0</td>
<td>32%</td>
<td>32%</td>
<td>36%</td>
<td>0.9</td>
</tr>
<tr>
<td>9. To what extent do you feel that the organisation is ready for a change?</td>
<td>3.4</td>
<td>17%</td>
<td>31%</td>
<td>52%</td>
<td>1.0</td>
</tr>
<tr>
<td>Work satisfaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. To what extent do you feel that blue collar workers are satisfied with their work?</td>
<td>2.9</td>
<td>32%</td>
<td>38%</td>
<td>30%</td>
<td>0.9</td>
</tr>
<tr>
<td>11. To what degree would you like to change your present workplace at Volvo/Mack because of work dissatisfaction?</td>
<td>3.3</td>
<td>21%</td>
<td>30%</td>
<td>48%</td>
<td>1.0</td>
</tr>
<tr>
<td>12. To what extent do you feel that your salary is adequate in relation to your work?</td>
<td>2.6</td>
<td>52%</td>
<td>27%</td>
<td>21%</td>
<td>1.1</td>
</tr>
<tr>
<td>Management support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. To what extent do you think that the Wacol factory is managed in a proper way?</td>
<td>2.8</td>
<td>39%</td>
<td>35%</td>
<td>26%</td>
<td>1.1</td>
</tr>
<tr>
<td>14. To what degree do you feel that the top management at the factory is concerned about the blue collar’s work situation?</td>
<td>2.4</td>
<td>58%</td>
<td>24%</td>
<td>18%</td>
<td>1.1</td>
</tr>
</tbody>
</table>

### WORK PROCEDURES AT STATIONS

<table>
<thead>
<tr>
<th>Statement</th>
<th>Average</th>
<th>Low</th>
<th>Neither</th>
<th>High</th>
<th>Std dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardization of work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. To what extent do you think blue collar workers have sufficient instructions for their work tasks?</td>
<td>2.4</td>
<td>62%</td>
<td>20%</td>
<td>18%</td>
<td>1.0</td>
</tr>
<tr>
<td>17. To what extent do you think that more standardized work could improve the production process?</td>
<td>3.7</td>
<td>8%</td>
<td>23%</td>
<td>70%</td>
<td>0.8</td>
</tr>
<tr>
<td>18. To what amount do you think that blue collar workers want to participate in the development of work standards/procedures?</td>
<td>3.1</td>
<td>28%</td>
<td>32%</td>
<td>40%</td>
<td>0.9</td>
</tr>
<tr>
<td>Visualization of workstations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. To what extent do you think it is important to reduce inventory/parts on the stations?</td>
<td>3.3</td>
<td>30%</td>
<td>18%</td>
<td>52%</td>
<td>1.2</td>
</tr>
<tr>
<td>20. To what extent do you think that it is clearly defined where parts and tools should be stored at the stations?</td>
<td>3.1</td>
<td>36%</td>
<td>23%</td>
<td>41%</td>
<td>1.1</td>
</tr>
<tr>
<td>Work station environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. To what degree do you think that blue collar workers are satisfied with their work station environment?</td>
<td>2.9</td>
<td>35%</td>
<td>42%</td>
<td>23%</td>
<td>0.8</td>
</tr>
<tr>
<td>21. To what extent do you feel that blue collar workers want to improve their work station environment?</td>
<td>3.7</td>
<td>14%</td>
<td>17%</td>
<td>70%</td>
<td>0.8</td>
</tr>
</tbody>
</table>

### SHOPFLOOR DESIGN

<table>
<thead>
<tr>
<th>Statement</th>
<th>Average</th>
<th>Low</th>
<th>Neither</th>
<th>High</th>
<th>Std dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness to work in teams</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. How would you grade the importance of teamwork within the production team?</td>
<td>4.1</td>
<td>11%</td>
<td>9%</td>
<td>80%</td>
<td>1.0</td>
</tr>
<tr>
<td>23. To what extent do you think blue collar workers are comfortable with work in teams?</td>
<td>3.2</td>
<td>23%</td>
<td>36%</td>
<td>41%</td>
<td>0.8</td>
</tr>
<tr>
<td>24. To what degree would you like to develop and increase the teamwork in production?</td>
<td>4.0</td>
<td>3%</td>
<td>15%</td>
<td>82%</td>
<td>0.8</td>
</tr>
<tr>
<td>25. To what extent do you think blue collar workers are satisfied with their cooperation with the supervisors?</td>
<td>3.1</td>
<td>26%</td>
<td>38%</td>
<td>36%</td>
<td>0.9</td>
</tr>
<tr>
<td>26. To what degree do you feel that the supervisor supports blue collar’s work?</td>
<td>3.2</td>
<td>23%</td>
<td>30%</td>
<td>47%</td>
<td>1.0</td>
</tr>
</tbody>
</table>
### Job rotation and work extension

<table>
<thead>
<tr>
<th>Question</th>
<th>2,2</th>
<th>65%</th>
<th>17%</th>
<th>18%</th>
<th>1,1</th>
</tr>
</thead>
<tbody>
<tr>
<td>27. To what extent do blue collar workers rotate between different work stations today?</td>
<td>3,7</td>
<td>12%</td>
<td>15%</td>
<td>73%</td>
<td>0,9</td>
</tr>
<tr>
<td>28. To what amount do you want to increase the variation in your work tasks?</td>
<td>3,3</td>
<td>23%</td>
<td>26%</td>
<td>52%</td>
<td>1,0</td>
</tr>
<tr>
<td>30. To what degree do you think blue collar workers want to increase the rotation between stations?</td>
<td>3,1</td>
<td>23%</td>
<td>41%</td>
<td>36%</td>
<td>0,9</td>
</tr>
</tbody>
</table>

### Responsibility and authority

<table>
<thead>
<tr>
<th>Question</th>
<th>4,1</th>
<th>8%</th>
<th>2%</th>
<th>91%</th>
<th>0,9</th>
</tr>
</thead>
<tbody>
<tr>
<td>29. To what degree do you feel responsible for your work tasks today?</td>
<td>3,1</td>
<td>30%</td>
<td>33%</td>
<td>36%</td>
<td>1,1</td>
</tr>
<tr>
<td>31. To what degree do you feel that your current team has appropriate responsibility and authority?</td>
<td>3,2</td>
<td>23%</td>
<td>35%</td>
<td>42%</td>
<td>0,8</td>
</tr>
<tr>
<td>32. To what grade do you think that blue collar workers want to have more responsibility and authority delegated to the team?</td>
<td>3,1</td>
<td>23%</td>
<td>41%</td>
<td>36%</td>
<td>0,9</td>
</tr>
<tr>
<td>34. To what extent do you think blue collar workers want to have increased responsibility and authority?</td>
<td>3,7</td>
<td>9%</td>
<td>27%</td>
<td>64%</td>
<td>0,8</td>
</tr>
<tr>
<td>2. To what amount do you think it is important to increase responsibility and authority for the blue collar workers?</td>
<td>3,0</td>
<td>32%</td>
<td>20%</td>
<td>48%</td>
<td>1,2</td>
</tr>
</tbody>
</table>

### Team meetings

<table>
<thead>
<tr>
<th>Question</th>
<th>3,0</th>
<th>32%</th>
<th>20%</th>
<th>48%</th>
<th>1,2</th>
</tr>
</thead>
<tbody>
<tr>
<td>33. To what extent do you feel that blue collar workers can bring up and discuss problems at the team meetings?</td>
<td>2,9</td>
<td>39%</td>
<td>21%</td>
<td>39%</td>
<td>1,2</td>
</tr>
<tr>
<td>35. To what degree do you think that the blue collar workers find the team meetings important?</td>
<td>3,3</td>
<td>21%</td>
<td>26%</td>
<td>53%</td>
<td>1,0</td>
</tr>
<tr>
<td>36. To what extent do you think that the blue collar workers are interested in discussing improvement suggestions at the team meetings?</td>
<td>3,3</td>
<td>21%</td>
<td>26%</td>
<td>53%</td>
<td>1,0</td>
</tr>
</tbody>
</table>

### Cooperation

<table>
<thead>
<tr>
<th>Question</th>
<th>3,3</th>
<th>26%</th>
<th>20%</th>
<th>55%</th>
<th>1,0</th>
</tr>
</thead>
<tbody>
<tr>
<td>37. To what amount do you think that blue collar workers like to cooperate with their team members?</td>
<td>4,0</td>
<td>2%</td>
<td>18%</td>
<td>80%</td>
<td>0,7</td>
</tr>
<tr>
<td>38. To what degree do you think that increased cooperation among blue collar workers could help them in their job?</td>
<td>3,7</td>
<td>13%</td>
<td>19%</td>
<td>68%</td>
<td>0,9</td>
</tr>
</tbody>
</table>

### Education and training

<table>
<thead>
<tr>
<th>Question</th>
<th>3,7</th>
<th>13%</th>
<th>19%</th>
<th>68%</th>
<th>0,9</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. To what extent do you think that blue collar workers need more training in their work tasks?</td>
<td>3,7</td>
<td>13%</td>
<td>19%</td>
<td>68%</td>
<td>0,9</td>
</tr>
</tbody>
</table>

### WORK WITH IMPROVEMENTS

### Improvement suggestions

<table>
<thead>
<tr>
<th>Question</th>
<th>3,7</th>
<th>12%</th>
<th>18%</th>
<th>70%</th>
<th>0,9</th>
</tr>
</thead>
<tbody>
<tr>
<td>39. To what amount do you believe that blue collar workers want to give suggestions on how to improve their work?</td>
<td>2,2</td>
<td>65%</td>
<td>26%</td>
<td>9%</td>
<td>1,0</td>
</tr>
<tr>
<td>40. To what extent do you believe that blue collar workers pay attention to suggestions from blue collar workers?</td>
<td>2,9</td>
<td>44%</td>
<td>18%</td>
<td>38%</td>
<td>1,1</td>
</tr>
</tbody>
</table>

### B/C possibility to influence work

<table>
<thead>
<tr>
<th>Question</th>
<th>3,7</th>
<th>11%</th>
<th>20%</th>
<th>70%</th>
<th>0,8</th>
</tr>
</thead>
<tbody>
<tr>
<td>41. To what extent do you think that blue collar workers can influence their work?</td>
<td>2,9</td>
<td>44%</td>
<td>18%</td>
<td>38%</td>
<td>1,1</td>
</tr>
<tr>
<td>42. To what amount do you think that blue collar workers want to have increased influence over their work?</td>
<td>3,7</td>
<td>11%</td>
<td>20%</td>
<td>70%</td>
<td>0,8</td>
</tr>
</tbody>
</table>

### Information and feedback to B/C

<table>
<thead>
<tr>
<th>Question</th>
<th>3,4</th>
<th>18%</th>
<th>24%</th>
<th>58%</th>
<th>0,9</th>
</tr>
</thead>
<tbody>
<tr>
<td>43. To what extent do you think blue collar workers receive feedback on their work?</td>
<td>3,4</td>
<td>21%</td>
<td>20%</td>
<td>59%</td>
<td>1,0</td>
</tr>
<tr>
<td>44. To what degree do you believe that blue collar workers want to receive more feedback on their work?</td>
<td>3,7</td>
<td>39%</td>
<td>18%</td>
<td>42%</td>
<td>0,7</td>
</tr>
</tbody>
</table>

### Willingness to participate in improvement work

<table>
<thead>
<tr>
<th>Question</th>
<th>3,4</th>
<th>18%</th>
<th>24%</th>
<th>58%</th>
<th>0,9</th>
</tr>
</thead>
<tbody>
<tr>
<td>45. To what degree do you believe that blue collar workers want to participate in production improvements?</td>
<td>3,4</td>
<td>21%</td>
<td>20%</td>
<td>59%</td>
<td>1,0</td>
</tr>
<tr>
<td>46. To what degree do you think that blue collar workers want to work with improvements together with white collar workers?</td>
<td>3,4</td>
<td>21%</td>
<td>20%</td>
<td>59%</td>
<td>1,0</td>
</tr>
</tbody>
</table>

### DEMOGRAPHIC DATA

<table>
<thead>
<tr>
<th>Question</th>
<th>47</th>
<th>39%</th>
<th>35%</th>
<th>26%</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>47. What is your age?</td>
<td>48</td>
<td>30%</td>
<td>18%</td>
<td>52%</td>
<td>1,0</td>
</tr>
<tr>
<td>48. For how many years have you worked at Volvo/Mack?</td>
<td>49</td>
<td>30%</td>
<td>27%</td>
<td>42%</td>
<td>1,0</td>
</tr>
</tbody>
</table>
## WC questionnaire results

<table>
<thead>
<tr>
<th>ATITUDES</th>
<th>Average</th>
<th>Low</th>
<th>Neither</th>
<th>High</th>
<th>Std dev</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comprehensive view of the manufacturing process</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. To what degree do you feel that blue collar workers have knowledge about the other stations in their section?</td>
<td>3.1</td>
<td>31%</td>
<td>34%</td>
<td>34%</td>
<td>0.9</td>
</tr>
<tr>
<td>5. How would you grade the blue collar workers understanding of the whole production process?</td>
<td>2.6</td>
<td>59%</td>
<td>21%</td>
<td>21%</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Change mentality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. To what extent do you think changes in the production area are positive for the blue collar’s work situation?</td>
<td>3.7</td>
<td>14%</td>
<td>10%</td>
<td>76%</td>
<td>0.9</td>
</tr>
<tr>
<td>7. To what degree do you think blue collar workers are interested in participating in a change?</td>
<td>2.8</td>
<td>45%</td>
<td>31%</td>
<td>24%</td>
<td>0.9</td>
</tr>
<tr>
<td>8. To what extent do you feel that the organisation is ready for a change?</td>
<td>3.1</td>
<td>34%</td>
<td>21%</td>
<td>45%</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Work satisfaction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. To what extent do you feel that blue collar workers are satisfied with their work?</td>
<td>2.4</td>
<td>52%</td>
<td>41%</td>
<td>7%</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Management support</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. To what extent do you think that the Waco! factory is managed in a proper way?</td>
<td>2.8</td>
<td>38%</td>
<td>38%</td>
<td>24%</td>
<td>1.0</td>
</tr>
<tr>
<td>11. To what extent do you feel that the top management at the factory is concerned about the blue collar’s work situation?</td>
<td>3.1</td>
<td>28%</td>
<td>31%</td>
<td>41%</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Cooperation between departments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. To what extent do you think that the cooperation between the different departments works?</td>
<td>2.3</td>
<td>62%</td>
<td>34%</td>
<td>3%</td>
<td>0.7</td>
</tr>
<tr>
<td>13. To what amount would you like to increase the cooperation between the departments?</td>
<td>4.6</td>
<td>0%</td>
<td>3%</td>
<td>97%</td>
<td>0.6</td>
</tr>
<tr>
<td>14. To what degree do you think that blue collar workers want to participate in cross functional teams consisting of people from different departments together with blue collar workers?</td>
<td>3.9</td>
<td>7%</td>
<td>7%</td>
<td>86%</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Work PROCEDURES AT STATIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. To what extent do you think that blue collar workers have sufficient instructions for their work tasks?</td>
<td>2.8</td>
<td>41%</td>
<td>31%</td>
<td>28%</td>
<td>0.9</td>
</tr>
<tr>
<td>16. To what extent do you think that more standardized work could improve the production process?</td>
<td>4.0</td>
<td>0%</td>
<td>17%</td>
<td>83%</td>
<td>0.6</td>
</tr>
<tr>
<td>17. To what extent do you think that blue collar workers want to participate in the development of work standards/procedures?</td>
<td>2.9</td>
<td>41%</td>
<td>21%</td>
<td>38%</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Visualization of workstations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. To what extent do you think it is important to reduce inventory/parts on the stations?</td>
<td>4.2</td>
<td>3%</td>
<td>10%</td>
<td>86%</td>
<td>0.8</td>
</tr>
<tr>
<td>19. To what extent do you think that it is clearly defined where parts and tools should be stored at the stations?</td>
<td>2.8</td>
<td>41%</td>
<td>28%</td>
<td>31%</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Work station environment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. To what extent do you think that blue collar workers are satisfied with their work station environment?</td>
<td>2.8</td>
<td>31%</td>
<td>55%</td>
<td>14%</td>
<td>0.8</td>
</tr>
<tr>
<td>21. To what extent do you feel that blue collar workers want to improve their work station environment?</td>
<td>3.2</td>
<td>28%</td>
<td>14%</td>
<td>59%</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>SHOPFLOOR DESIGN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. How would you grade the importance of teamwork within the production team?</td>
<td>4.3</td>
<td>3%</td>
<td>3%</td>
<td>93%</td>
<td>0.7</td>
</tr>
<tr>
<td>23. To what extent do you think blue collar workers are comfortable with work in teams?</td>
<td>3.1</td>
<td>31%</td>
<td>34%</td>
<td>34%</td>
<td>0.9</td>
</tr>
<tr>
<td>24. To what extent do you think it is important to increase teamwork among blue collar workers?</td>
<td>4.2</td>
<td>3%</td>
<td>3%</td>
<td>93%</td>
<td>0.7</td>
</tr>
<tr>
<td>Shopfloor management behaviour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>22. To what extent do you think blue collar workers are satisfied with their cooperation with the supervisors?</td>
<td>3.0</td>
<td>28%</td>
<td>52%</td>
<td>21%</td>
<td>0.8</td>
</tr>
<tr>
<td>23. To what degree do you feel that the supervisor supports blue collar’s work?</td>
<td>3.1</td>
<td>21%</td>
<td>52%</td>
<td>28%</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Job rotation and work extension**

| 24. To what degree do you think blue collar workers want to increase the rotation between stations? | 3.1 | 21% | 45% | 34% | 0.7 |

**Responsibility and authority**

| 25. To what degree do you think that the blue collar work teams have appropriate responsibility and authority? | 2.3 | 69% | 17% | 14% | 0.9 |
| 26. To what grade do you think that blue collar workers want to have more responsibility and authority delegated to the team? | 2.7 | 48% | 31% | 21% | 0.8 |
| 28. To what extent do you think blue collar workers want to have increased responsibility and authority? | 2.6 | 48% | 31% | 21% | 1.0 |
| 2. To what amount do you think it is important to increase responsibility and authority for the blue collar workers? | 3.6 | 17% | 7% | 76% | 0.9 |

**Team meetings**

| 27. To what extent do you feel that blue collar workers can bring up and discuss problems at the team meetings? | 3.3 | 21% | 28% | 52% | 1.0 |
| 29. To what degree do you think that the blue collar workers find the team meetings important? | 2.8 | 41% | 31% | 28% | 0.9 |
| 30. To what extent do you think that the blue collar workers are interested in discussing improvement suggestions at the team meetings? | 3.2 | 17% | 41% | 41% | 0.9 |

**Cooperation**

| 31. To what amount do you think that blue collar workers like to cooperate with their team members? | 3.3 | 17% | 28% | 55% | 0.9 |
| 32. To what degree do you think that increased cooperation among blue collar workers could help them in their job? | 4.1 | 0% | 10% | 90% | 0.6 |

**Education and training**

| 13. To what extent do you think that blue collar workers need more training in their work tasks? | 3.6 | 10% | 28% | 62% | 0.8 |

**WORK WITH IMPROVEMENTS**

**Improvement suggestions**

| 33. To what amount do you believe that blue collar workers want to give suggestions on how to improve their work? | 3.2 | 24% | 31% | 45% | 0.9 |
| 34. To what extent do you believe that white collar workers pay attention to suggestions from blue collar workers? | 2.7 | 48% | 21% | 31% | 1.0 |

**B/C possibility to influence work**

| 35. To what extent do you think that blue collar workers can influence their work? | 3.2 | 21% | 41% | 38% | 0.9 |
| 36. To what amount do you think that blue collar workers want to have increased influence over their work? | 3.1 | 31% | 24% | 45% | 0.9 |

**Information and feedback to B/C**

| 37. To what extent do you think blue collar workers receive feedback on their work? | 2.6 | 52% | 24% | 24% | 1.1 |
| 39. To what degree do you believe that blue collar workers want to receive more feedback on their work? | 3.6 | 7% | 24% | 69% | 0.8 |

**Willingness to participate in improvement work**

| 38. To what extent do you believe that blue collar workers want to participate in production improvements? | 3.0 | 28% | 41% | 31% | 0.9 |
| 40. To what degree do you think that blue collar workers want to work with improvements together with white collar workers? | 3.0 | 31% | 31% | 38% | 0.9 |

**MANAGING THE LEAN PROJECT**

| 41. To what extent do you think that an implementation of lean production can lead to a better work situation among the white collar workers? | 3.5 | 21% | 21% | 58% | 1.1 |
| 45. To what extent are you interested in participating in the implementation of lean production? | 4.0 | 11% | 7% | 82% | 1.0 |

<p>| 46. For how many years have you worked at Volvo/Mack? | 24% | 17% | 59% |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Average BC</th>
<th>Average WC</th>
<th>Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To what extent do you think it is important to reduce inventory/parts on the stations?</td>
<td>3.3</td>
<td>4.2</td>
<td>-1.0</td>
<td>X</td>
</tr>
<tr>
<td>2. To what amount do you think it is important to increase responsibility and authority for the blue collar workers?</td>
<td>3.7</td>
<td>3.6</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>3. To what extent do you think it is important to increase teamwork among blue collar workers?</td>
<td>4.2</td>
<td>4.2</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>5. To what degree do you feel that you have knowledge about the other stations in your section?</td>
<td>3.5</td>
<td>3.1</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>6. How would you grade the blue collar workers understanding of the whole production process?</td>
<td>2.9</td>
<td>2.6</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>7. To what extent do you think changes in the production area are positive for your work situation?</td>
<td>3.4</td>
<td>3.7</td>
<td>-0.3</td>
<td></td>
</tr>
<tr>
<td>8. To what degree do you think blue collar workers are interested in participating in a change?</td>
<td>3.0</td>
<td>2.8</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>9. To what extent do you think the organisation is ready for a change?</td>
<td>3.4</td>
<td>3.1</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>10. To what extent do you think that blue collar workers are satisfied with their work?</td>
<td>2.9</td>
<td>2.4</td>
<td>0.5</td>
<td>X</td>
</tr>
<tr>
<td>11. To what extent do you think that the Wacoil factory is managed in a proper way?</td>
<td>2.8</td>
<td>2.8</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>12. To what extent do you think that the top management at the factory is concerned about the blue collar’s work situation?</td>
<td>2.4</td>
<td>3.1</td>
<td>-0.7</td>
<td>X</td>
</tr>
<tr>
<td>13. To what extent do you think that blue collar workers have sufficient instructions for their work tasks?</td>
<td>2.4</td>
<td>2.8</td>
<td>-0.6</td>
<td></td>
</tr>
<tr>
<td>14. To what extent do you think that blue collar workers need more training in their work tasks?</td>
<td>3.7</td>
<td>3.6</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>15. To what extent do you think that more standardized work could improve the production process?</td>
<td>3.7</td>
<td>4.0</td>
<td>-0.3</td>
<td></td>
</tr>
<tr>
<td>16. To what extent do you think that blue collar workers are satisfied with their work station environment?</td>
<td>3.1</td>
<td>2.9</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>17. To what extent do you think that blue collar workers are satisfied with their work station environment?</td>
<td>2.9</td>
<td>2.8</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>18. How would you grade the importance of teamwork within the production team?</td>
<td>4.1</td>
<td>4.3</td>
<td>-0.2</td>
<td></td>
</tr>
<tr>
<td>19. To what extent do you think blue collar workers are comfortable with work in teams?</td>
<td>3.2</td>
<td>3.1</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>20. To what extent do you think that blue collar workers have sufficient instructions for their work tasks?</td>
<td>3.1</td>
<td>2.8</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>21. To what extent do you feel that blue collar workers want to improve their work station environment?</td>
<td>3.7</td>
<td>3.2</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>22. To what extent do you think blue collar workers are satisfied with their cooperation with the supervisors?</td>
<td>3.1</td>
<td>3.0</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>23. To what extent do you feel that the supervisor supports blue collar’s work?</td>
<td>3.2</td>
<td>3.1</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>24. To what extent do you think that your current team has appropriate responsibility and authority?</td>
<td>3.1</td>
<td>3.1</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>25. To what extent do you think that blue collar workers have more responsibility and authority delegated to the team?</td>
<td>3.2</td>
<td>2.7</td>
<td>0.5</td>
<td>X</td>
</tr>
<tr>
<td>26. To what extent do you think that blue collar workers can bring up and discuss problems at the team meetings?</td>
<td>3.0</td>
<td>3.3</td>
<td>-0.3</td>
<td></td>
</tr>
<tr>
<td>27. To what extent do you think blue collar workers have increased cooperation among blue collar workers?</td>
<td>3.1</td>
<td>2.8</td>
<td>0.3</td>
<td>X</td>
</tr>
<tr>
<td>28. To what extent do you think blue collar workers can bring up and discuss problems at the team meetings?</td>
<td>2.9</td>
<td>2.8</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>29. To what extent do you think that blue collar workers find the team meetings important?</td>
<td>3.3</td>
<td>3.2</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>30. To what amount do you think that blue collar workers like to cooperate with their team members?</td>
<td>3.3</td>
<td>3.3</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>31. To what extent do you think that blue collar workers have increased cooperation among blue collar workers?</td>
<td>4.0</td>
<td>4.1</td>
<td>-0.1</td>
<td></td>
</tr>
<tr>
<td>32. To what extent do you think blue collar workers can influence their work?</td>
<td>3.7</td>
<td>3.1</td>
<td>0.6</td>
<td>X</td>
</tr>
<tr>
<td>33. To what extent do you think blue collar workers receive feedback on their work?</td>
<td>2.4</td>
<td>2.6</td>
<td>-0.2</td>
<td></td>
</tr>
<tr>
<td>34. To what extent do you think that blue collar workers want to participate in production improvements?</td>
<td>3.4</td>
<td>3.0</td>
<td>0.5</td>
<td>X</td>
</tr>
<tr>
<td>35. To what extent do you think that blue collar workers want to receive more feedback on their work?</td>
<td>3.9</td>
<td>3.6</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>36. To what extent do you think that blue collar workers want to work with improvements together with white collar workers?</td>
<td>3.4</td>
<td>3.0</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>

X = 95% confidence level one-way ANOVA