CHALMERS

Creating a Lean Value Flow in White Collar Organizations

Improving Quality, Lead Time and Efficiency through Takt and Visualization at Volvo Cars Customer Service

Master of Science in Production Engineering

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Gothenburg, Sweden 2012

MASTER THESIS

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ABSTRACT

This thesis has been conducted at Volvo Car Customer Service with the purpose to enable improved quality, reduced lead time and increased efficiency in Volvo Cars Customer Service (VCCS) white collar organizations through takt based and visual flow. A particular flow has been analyzed in detail of where three departments, Parts Technology, Repair Technology and Standard Times & Campaigns are involved. The analyzed flow produces a spare part structure for new cars, repair methods and standard times for the repairs of the new cars.

The aim of the thesis is to find major current problems that exist in the organization today, develop prerequisites for achieving takt based and visual flow and develop a general model for how VCCS shall work in order to achieve a takt based and visual flow. The aim also includes developing a specific model for how the analyzed flow can work in order to achieve a takt based and visual flow. In order to fulfill the purpose and meet the aim, four research questions have been developed and answered throughout the project. These are:

- What problems exist in the current flow that prevents takt based and visual flow?
- What prerequisites are needed in order for a takt based and visual flow to work at VCCS?
- What important general concepts need to be focused upon in order to create a takt based and visual flow at VCCS?
- What are the potential gains if a takt based and visual flow successfully could be implemented at the analyzed flow?

The problems existing in the current flow mainly concerns flow variation, computer systems, lack of team internal and flow communication together with lack of planning and has been derived from flow mapping, interviews and observations. Three prerequisites have been found, based on the existing problems, by deriving areas of excellence and applying theory. These are; Stable processes, Understanding of the Flow and Balanced Flow.

By raising the level of abstraction of the existing problems to general problems and applying theory, important general concepts that need to be focused upon in order to achieve a takt based and visual flow has been developed. These are; Focus on Flow, Define and Plan, Standardize, Visual Communication and Analyze and Act. These concepts cannot stand alone but have all to be focused upon in order to achieve a takt based and visual flow.

These concepts have been adapted to the analyzed flow of where some of them have been implemented. The potential gains are based on the implementation and concerns improved quality, reduced lead time and increased efficiency. More specific, the potential gains are connected to less waste in the form of rework and waiting, an even system with accurate status visualization, short feedback times and visual problems.

Key words: Lean, Flow, White Collar, Takt, Visualization

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Göteborg, June 2012

Gordon Bindekrans
Marcus Magnusson

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GLOSSARY AND ABBREVIATIONS

Andon	A person that help operators and when problems occur. In that way, problems can be solved and production continued
Blue Collar worker	A person who performs manual labor
JIT	Just In Time
KI/VP	Knowledge Intensive Visual Planning
KPI	Key Performance Indicator, a performance measurement
MSS	Marketing Sales and Customer Service
NEVIS	A program used at VCCS for instance to develop repair and service methods
PRI - team	Project Repair Information team
R&D	Research and Development, which in the case of Volvo is the department that constructs the cars
SPIE	A program used at VCCS for instance to develop repair and service methods
TIE - case	Quality issues coming from workshops around the world
TPS	Toyota Production System
VCC	Volvo Car Corporation
VCCS	Volvo Car Customer Service
VSTG team	Volvo Standard Times Guide team, one of the teams involved in the analyzed flow
White Collar worker	A person that performs professional, managerial or administrative work

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1 Introduction

This chapter will be introduced with a background of why white collar organizations are starting to become interesting from a business excellence perspective, followed by an organizational structure explanation of Volvo Car Corporation (VCC) as well as the purpose of this thesis. The aim will then be presented as together with problem definition and research questions. The research questions will in the forthcoming chapters be answered and thereby fulfilling the aim and purpose of this thesis. The introduction chapter will then be finalized with the delimitations of the thesis.

1.1 Lean Initiative Background

As the world economy becomes more global each day, the competitiveness within all businesses grows with increased actors on the market. New global logistic possibilities and international business agreements are also a contributing factor to the increased competitiveness. An industry that is especially exposed due to these reasons are the automotive industry which is one of the world's most demanding and technology intensive industries, demanding effective organizations delivering what the customer wants, when it is wanted. For more than 100 years the industry has been subjected to research studies regarding quality, lead time and efficiency within manufacturing processes. A number of philosophies, theories and concepts has been developed and tested throughout the century in order to improve manufacturing processes, -technologies and –flows. But even though the development within the manufacturing area has come a long way there are still areas within organizations where the development has hit a standstill, namely the white-collar organizations.

A department that has realized the importance of also improving the white collar organizations is the department Volvo Cars Customer Service (VCCS), a business unit of VCC which handles Customer Service operations. During 2010 a Lean Program was launched at VCCS with the aim to improve quality, reduce lead time and raise efficiency throughout the entire organization. One of the main forces behind the introduction of the Lean Program is due to the cause of the increasing competitiveness from other service actors on the market. During the past years service and repair companies has evolved from being locally owned in private garages to become multinational chains which, apart from brand workshops, can invest their profit back into the organization while VCCS profit is invested in the development of new vehicles. This puts pressure on the brand workshops which now needs to develop their product and processes in other directions in order to find new ways to be profitable.

Another purpose behind the Lean program at VCCS is the new vision of deliver higher customer satisfaction as well as increasing the internal efficiency and employee satisfaction. A more objective viewpoint is to manage a business growth of 25% without hiring and to be able to relocate 60 positions within four years from the program start by identifying and eliminating waste within the existing organization.

The field of major Lean transformations in white collar organizations is relatively undocumented and unexplored due to its complexity and time consuming cultural transformations that has to take place. A lean transformation within a white collar organization is not the same as in manufacturing, the same principles can be applied but there are more degrees of freedom in white collar organizations and it is therefore harder to understand the work progress and the flows.

In manufacturing, where most of the earlier research concerning Lean transformation has been conducted, the takt time is a way to synchronize the rate of production with the rate of demand and thereby connect all activities along the line to the customer demand on a one to one basis. In order to achieve business excellence a coherent state of the organization must be created through a cultural development and adapted to its environmental settings. Therefore this thesis will explore and evaluate the possibility of applying takt based and visual flow principles common in manufacturing to a white collar organization as one of the steps in the cultural transformation.

1.2 Company Background and Organizational Structure

VCC is a car manufacturing company, founded 1927 in Gothenburg, Sweden, by Gustaf Larson and Assar Gabrielsson. The first car rolled out from the factory the same year and since then over 15 million Volvo cars has been produced. VCC was until 1999 a part of the Volvo group when it was acquired by the American owned car company Ford Motor Company. VCC was then acquired yet again in 2010 by the current owners, the Chinese owned company Zhejiang Geely Holding group. The same year a new CEO, Executive Management Team and Board was appointed and new directions and visions for the company were established. Record high sales volumes and profitability targets were set as well as incorporating a new vision of becoming the world´s most progressive and desired luxury car brand. The headquarters is located in Gothenburg, Sweden, and the main production plants is spread over three locations, Uddevalla and Torslanda in Sweden and Gent in Belgium. In Addition to these existing plants a fourth main production plant is scheduled to be opened in Chengdu, China, during 2013.

Marketing, Sales and Customer Service (MSS) is one out of twelve strategic departments within VCC and drives all activities in the market which is done through national sales companies, importers and retail partners. The department is also responsible for the communication and interaction with the customers. MSS in turn is divided into several departments, VCCS being one of them, handling the global logistics, marketing support and operation processes of car accessories and spare parts.

Within VCCS there are yet again several departments, Customer Service Process and Technical Support being one of them, developing workshop and service information for Volvo workshops. The department also develops and present repair requirements to the product development organization and has the responsibility of faulty tracing, repair and upgrading of cars.

Workshop and Owners Information is a department within Customer Service Process and Technical Support that employs about 150 people, of which most are located in Gothenburg. The department acts as a link between product development, manufacturing and Volvo workshops and produces service methods for new car models, standard times for service methods, spare part and accessories catalogue and car related customer information.

The focus of this thesis will be on a production flow consisting of the three departments Parts Technology, Repair Technology and Standard Time & Campaigns (VSTG) within Workshop and Owners Information. The specified flow has been chosen due to two reasons, first being that it is one of the major and most central production flow of the department at Workshop and Owners Information. The second reason is that the flow covers multiple departments which thereby create a complex flow with great improvement potential.

The production flow is initiated by the Parts Technology department that develops a spare part structure. The flow then continues with Repair Technology which develops a repair and service method for the spare parts, used by service technicians all over the world, see Appendix A. The flow is then finalized by Standard Time & Campaigns which sets a time for how long the repair and service operations shall take. This time is then the basis behind how much VCC has to pay for warranty costs and how much the customer is charged for a certain repair or service. An overview of where in the organization the described flow is located hierarchically can be seen in Figure 1.

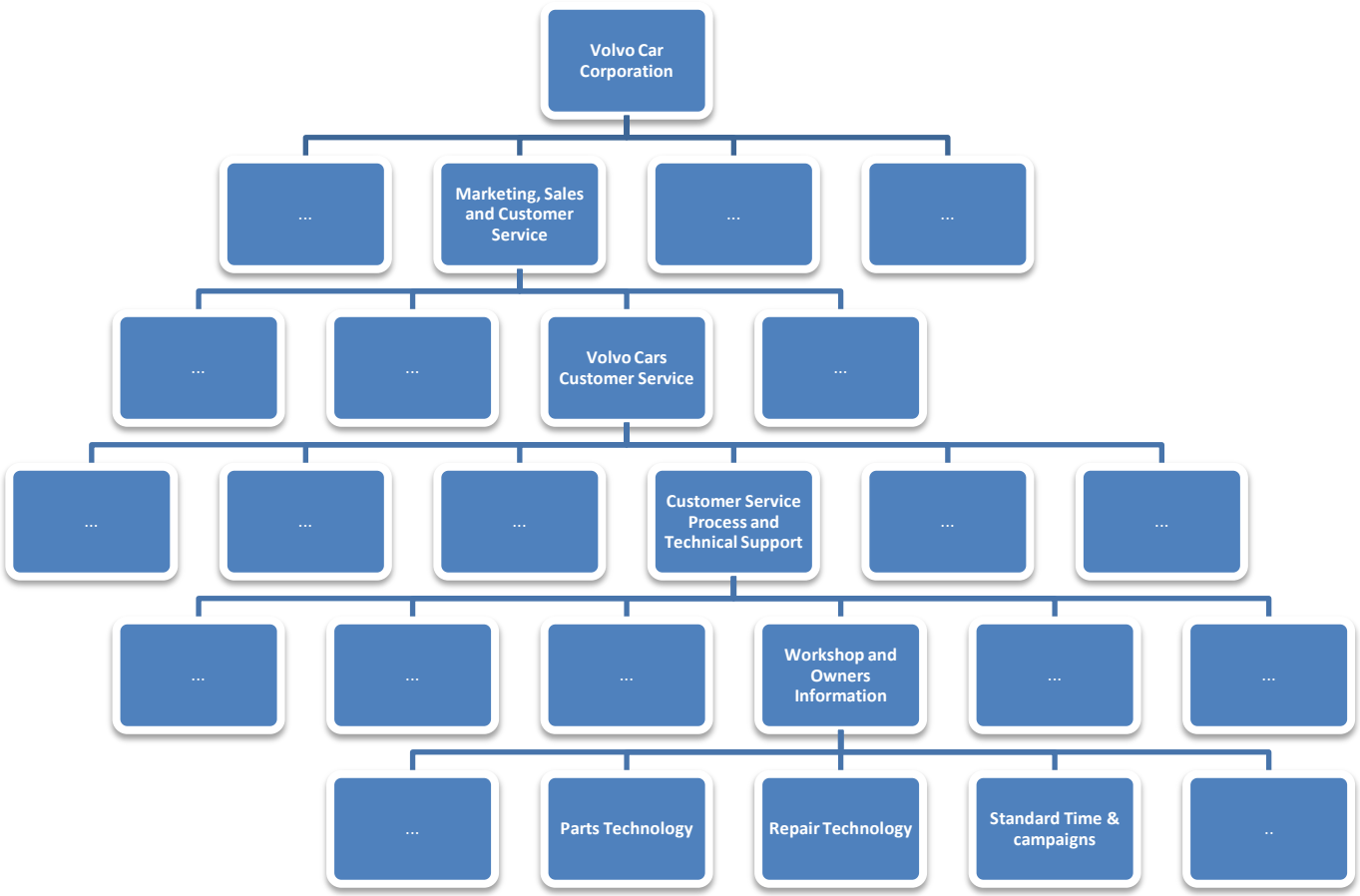


Figure 1, Organisational Structure

1.3 Purpose

The purpose of this thesis is to enable improved quality, reduced lead time and increased efficiency in Volvo Cars Customer Service white collar organization through takt based and visual flow.

1.4 Aim

The aim of this thesis is to find the major current problems that exist in the current organization, develop prerequisites for achieving takt and develop a general and a specific model for how a white collar production flow can use takt and visualization at VCCS.

The general model will be based on a number of developed key factors and form the basic foundation of creating a coherent and customer oriented organization where takt and visualization is enabled at VCCS. This thesis will also give specific recommendations in the form of a specific model with a number of suggestions that can be implemented at the analyzed flow, enabling a takt based

and visual. Both the general and specific model is a combination of philosophy and tool oriented nature since both needs to be present in order to create a coherent organization.

1.5 Problem Definition and Research Questions

As previously mentioned, in order to reach an organizational state close to business excellence the whole organization has to be considered. This especially means focusing on the white collar part of the organization and improving their quality, lead time and efficiency. The field of cultural Lean transformations within major white collar organizations is rare even though vast research has been done on the blue collar side of organizations. This may be rooted in the cause that white collar organizations is a far more complex and changing environment than manufacturing.

The major differences between manufacturing and white collar production can be divided into three groups, namely; physical versus electronic products, small versus large degrees of freedom and relative predictable production system versus a rather unpredictable production system. By having electronic products it is far more difficult to see if anything is out of order than in regular manufacturing where inventory will start to pile up, workers at the line becomes idle or workers cannot keep up. In white collar production there is also far greater degrees of freedom since this system is mostly based on humans who usually work in their own way, in their own pace and for that reason are more unpredictable than machinery. The last group, unpredictable production system, is also a cause of the human interaction since it is impossible to fully standardize so that all workers do exactly the same thing over and over again since the influences of tacit knowledge plays a major role. Therefore, in order to receive a deeper understanding and being able to highlight which issues that currently exist throughout the specified production the following research question (RQ 1) was formulated:

- What problems exist in the current flow that prevents takt based and visual flow?

The analysis of the production flow has been focused on the current existing issues and in order not to overlook important factors that were performed well in the production flow, the second research question (RQ 2) was formulated as:

- What prerequisites are needed in order for a takt based and visual flow to work at VCCS?

Since there is a vast difference between Lean transformation in white collar organizations and manufacturing it becomes vital to adapt the transformation approach to the current environmental settings. This implies that a new set of viewpoints need to be established in order to implement a visual and takt based flow in a white collar organization. Thereby the third research question (RQ 3):

- What important general concepts need to be focused upon in order to create a takt based and visual flow at VCCS?

As described earlier there are huge wastes built in to the white collar organizations if taking the customer value viewpoint. An effect of this is that there are several types of potential gains for an organization if the desired results could be obtained. Therefore the fourth and final research question (RQ 4) has been formulated as:

- What are the potential gains if a takt based and visual flow successfully could be implemented at the analyzed flow?

1.6 Delimitations

The thesis has considered and been conducted on one specific production flow which delivers service and repair methods as well as standard times for these procedures. Only the main departments that concern the specified flow has been considered and functions or other departments that influence the flow in a minor way has been left out. The thesis will only provide recommendations for the different departments through various communication channels such as the report of this thesis and associated presentations.

The authors of this thesis will participate and drive concept implementations to the extent granted by VCCS employees based on certain key recommendations. This has only been performed during the thesis period and since quality, lead time and efficiency needs to be measured and compared over long time periods in order to prove its results these measures has not be included. Since only recommendations and a few pilot implementations was given, this thesis do not focus on in what order the recommendations should be implemented nor taking consideration of financial or organizational means.

2 Methodology

This chapter presents how this thesis has been structured in order to be conducted in a trustworthy way. First an explanation of the research approach will be given, describing the chosen methodology, also visualized in a method mode, giving an overview of how theory and empirical results has been used in different stages of the work process. The different data collection methodologies; literature research, interviews, observations, value flow analysis and field trips will then be presented.

2.1 Work Process

The chosen methodology in this thesis is of qualitative nature which is useful when dealing with new theoretical propositions or management procedures and when the researchers do not have absolute knowledge about the subject (Lee, 1999). The study was performed by interviewing, observing and performing a flow analysis which unveiled specific problems that was categorized into more manageable problem categories. These categories were then raised to a general level in order to be able to apply theory on. Prerequisites were derived by applying theory on things the organization performed well. By applying theory to the general problems, general concepts was developed which were validated through empirical results and theory. If theory and empirical results validated the general concepts, these were included in the general model and acted as a base for the development of specific concepts. The specific concepts were then evaluated through implementations and an attitude survey before they were included in the specific model.

In order to describe the research approach´s four stages, where theory and empirical results enters and what the outcome of each step, a method model has been developed, visually represented in Figure 2. The work process starts in the down left quadrant labeled with a “1” of where specific problems are surfaced. It continues with quadrant labeled with a “2” where theory is applied on general problems, derived from the specific problems. The quadrant labeled “3” shows the general concepts which are the result of the applied theory on the general problems. It is also the quadrant where theory and empirical results validate the general concepts. The last quadrant, labeled “4” shows the specific concepts, derived through theory and empirical results from the general concepts.

Further, the model is divided horizontally where the upper half is on a general level and the lower half is on a specific level. The general level represents a VCCS level and the specific level represents the analyzed flow. The inner circle represents the actions deployed, outer circle symbolizes the transformation of information and the four corners of the model represents the answers to the stated research questions.

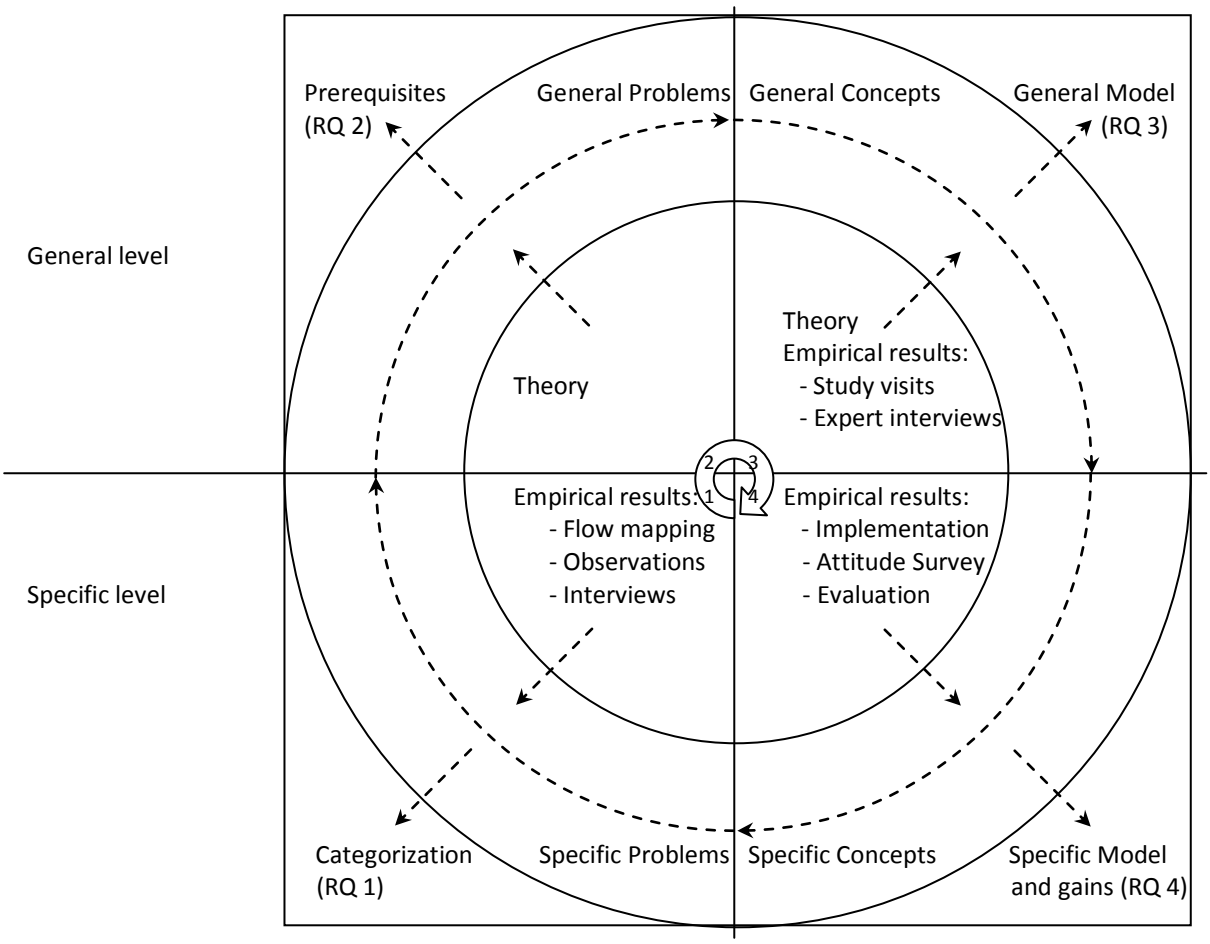


Figure 2, Method Model

The developed research approach makes the study inductive since specific problems derived from interviews, observation and flow mapping is moved to broader generalizations and theories. Some researchers are critical towards inductive studies and means that the theory does not add anything that is not in the empirical material (Popper & Miller, 1983). Though it is only possible to make a limited number of observations, it is not possible to draw complete general conclusions. However, inductive studies have always been used within new areas in which the researchers have no theories (Wallén, 1996). An inductive approach is appropriate for this study since the aim is both to draw general conclusions, in the form of a General Model and to propose specific improvements for Workshop and Owners Information in the form of a Specific Model. Even though the problem areas are based on a limited number of people, they give a reasonable picture of the problems occurring in the organization.

2.1.1 Specific Problems – Quadrant 1

During the initial step of the work process, interviews were held with persons working at Workshop and Owners Information. The purpose with these interviews was to detect specific problems that have to be solved in order to create a visual and takt based flow. Even though interviews are time consuming, they can provide a broad picture and contribute to the researchers understanding of the current operations (Bryman & Bell, 2011). The initial interviews provided the researchers with information about problem areas that were then further investigated. In order to include as wide

areas of aspect as possible, interviews was held with people from different departments and with different types of positions, see Figure 3.

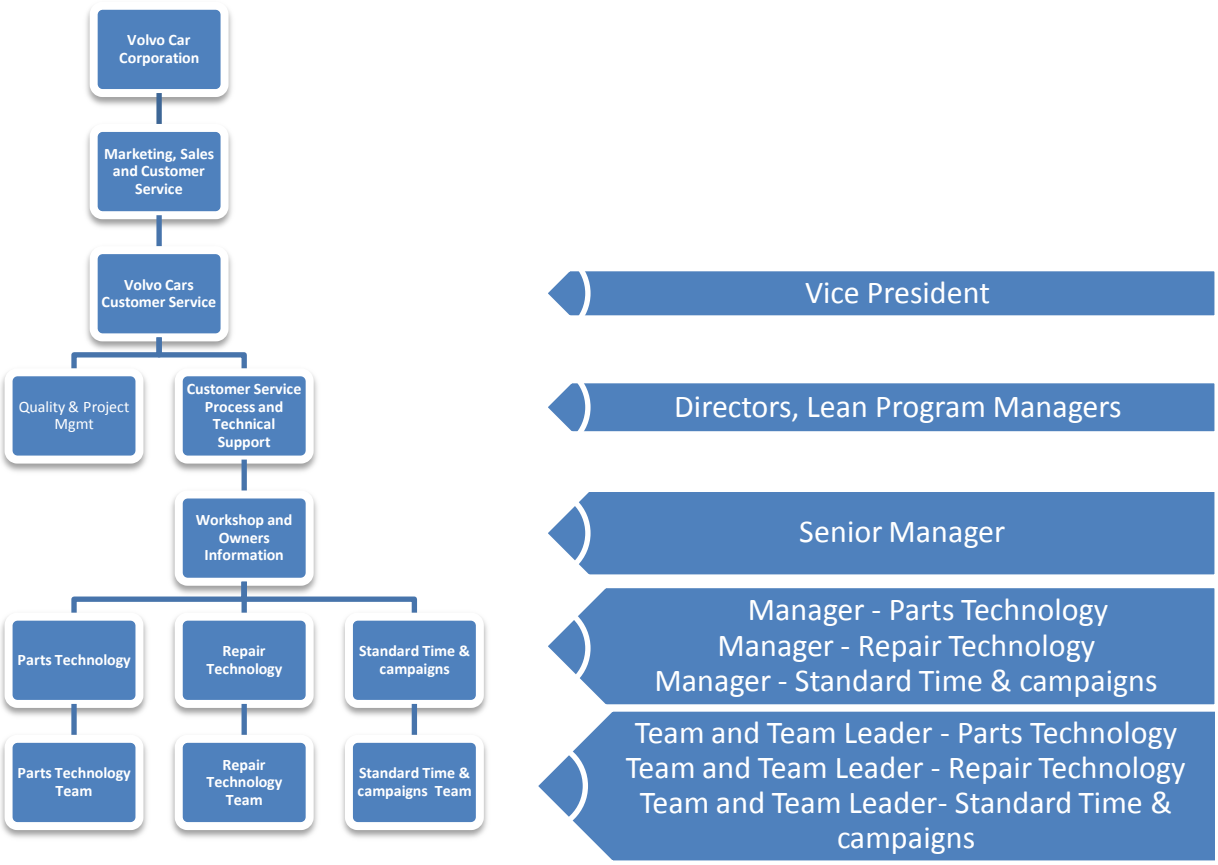


Figure 3, Left: Relevant part of VCC organizational structure, Right: Interviewed functions

Further, the flow of the current operations were mapped and analyzed, to unveil additional problems. In order to fully understand the operations, the researchers also observed persons working at Workshop and Owners Information and studied the basic elements of their work. By doing so, the researchers got a good picture of the current operations and its problems and areas of excellence.

2.1.2 General Problems – Quadrant 2

In order to solve the specific problems found, theoretical knowledge was needed. Theory connected to specific problems at the analyzed department is hard to find and because of that, the specific problems were categorized and generalized. In that way, the specific problems were converted to more general and more abstract problems. The theoretical research was then conducted with the aim to cover the general and more abstract problems in order to develop general concepts, solving the general problems. Because there might be general problems not connected to problems at Workshop and Owners Information occurring at other white-collar organizations, the theoretical research also includes theory regarding areas of excellence at the analyzed operations. That

developed prerequisites for visual and takt based flow which was set in relation to the General Concepts, to see that everything was included and that nothing was contradictory.

When searching for theory to apply on the general problems and on the areas of excellence, data bases were used. In addition, Lean theory in the form of books and articles that the researchers already was familiar to was used, not only as an input but also as a base for search of similar theory. The database of Chalmers University of Technology´s library is one of the databases used, of where Lean, Value flow, Organizational improvements, Visualization and Lean product development are the most common key words. In addition to the Chalmers library database, Education Resources Information Center, Google Scholar and LAI MIT Enabling Enterprise Excellence databases were used.

When choosing among the articles found in the databases, the Lean articles that focused on the mindset were chosen before the ones focusing on tools. Regarding the value flow, visualization and organizational improvement articles, the ones focusing on white collar organizations were chosen before the ones focusing on blue collar organizations. The articles regarding Lean product development were chosen, before others, if the article were based on a case study at a company, not just focusing on common theory.

2.1.3 General Concepts – Quadrant 3

The conducted theoretical research created a theoretical framework which has been based on published material like books by academic writers and articles published in scientific and business magazines found in databases. Based on the theoretical framework, general problems and prerequisites, general concepts that solved the general problems were developed. The general concepts were then used as a base for the empirical data collection where each concept was presented at external interviews and field trips. The purpose with the field trips was to investigate if the visited companies had a specific concept, connected to any of the general concept, which could be used at Workshop and Owners Information. Field trips were made to Thermo Fisher Scientific, SCANIA and RUAG Space which all are individually famous for their Lean efforts in white collar organizations.

External interviews were performed were the general concepts were presented with the aim to discuss specific solutions and adaptations in order to create specific concepts. Thereby each specific concept created was within the scope of the general concept that it was derived from. During the external interviews and field trips, the general concepts themselves were discussed and if found appropriate, included in the general model for visual and takt based flow.

2.1.4 Specific Concepts and Evaluation – Quadrant 4

The specific concepts, created from the general concepts through external interviews, field trips and brainstorming were implemented one by one at the analyzed flow at Workshop and Owners Information. When the implementation of one concept was successful, it was included in the specific model. If the result of the implementation of a concept was not satisfactory, the work process took one more loop in the method model with that concept, once again starting out with the specific problem. By letting each specific concept be within the scope of a general concept, the validity of the general concepts was tested through the implementation of the specific concepts.

If the implementation of a specific concept failed, it could either be due to that the specific concept did not fit the organization or the general concept was not suitable for white collar organizations. It could also be because the specific problem was not converted into a general problem in the right

way. The iterative process of looping the work process when implementation of specific concepts failed assured that the validity of both the general and the specific model was tested. The specific model was then evaluated through a qualitative attitude survey in order to be able to measure the effects of the implemented concepts.

2.2 Data Collection

When collecting data, interviews and observations together with field trips and flow analyses has been used. The interviews were conducted with persons working at different hierarchical levels of the organization, as well as with external experts. When analyzing the current opperations, the VCCS Lean house , later presented in the Empirical results, was used as a base.

Bryman & Bell (2011) claims that research methods are about the techniques used to collect the data. Throughout this thesis, both primary and secondary data has been collected and used. Primary data was gathered through interviews, value flow analysis workshops and observations. The secondary data was gathered through literature research, expert interviews and field trips. In Figure 4 a graphical description of where the different data collection methods have been used is presented. The time axis is based on the work process earlier presented and where primary data collection methods is positioned in the higher half and secondary data collection methods in the lower half.

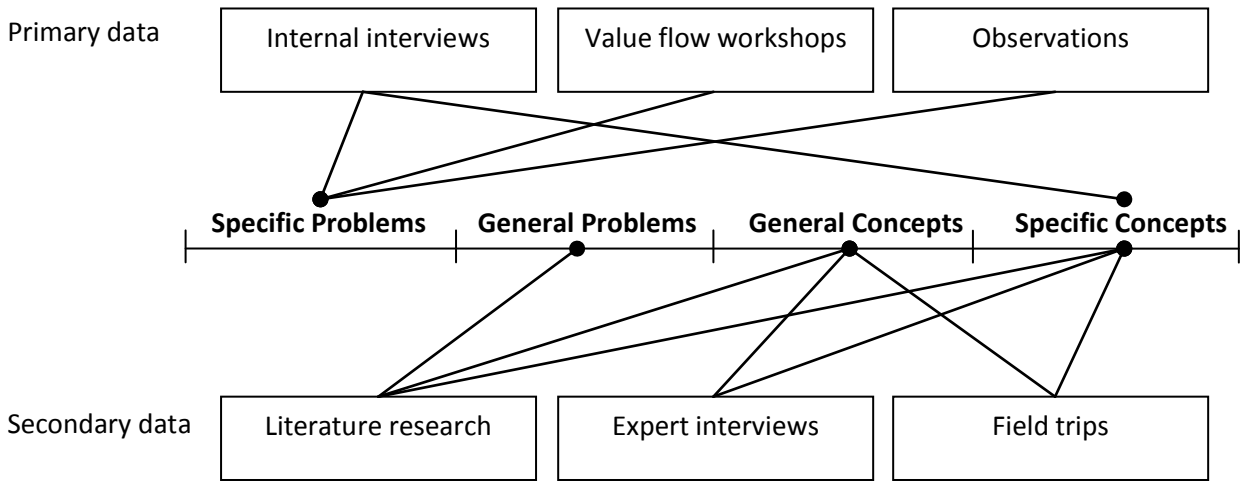


Figure 4, Primary and secondary data collection methods along the time axle

According to (Bryman & Bell, 2011) there are two main criteria for assessing a qualitative research approach, trustworthiness and authenticity. The trustworthiness criteria can be divided into four sub criteria's, credibility, transferability, dependability and confirmability. They will all be explained throughout this chapter.

It is hard to achieve or prove total objectivity in a qualitative research since personal opinions can influence the conduction of the researchers and thereby its findings. However, first hand information has been used to the largest extent possible throughout the entire research, which increases the confirmability (Bryman & Bell, 2011). Further, the collected data has been transcribed and validated before used, which increases the confirmability and the dependability of the research (Bryman & Bell, 2011).

2.2.1 Literature Research

Literature from both internal and external sources was studied. Internal sources in this case are for example VCC presentations and VCC reports. The external sources used were articles published in scientific and business magazines together with books by academic writers. It is important not to begin the literature research before the research questions are defined. One of the main reasons for doing a literature research is to explore what is already known in the area of interest (Bryman & Bell, 2011). In that way the researchers reduce the risk of inventing something that is already invented.

Further reasons for exploring existing literature is to identify what concepts and theories that are relevant to this area, if there are any significant controversies, if there are any inconsistencies in findings related to the area of interest and if there are any unanswered research questions within the area. The areas covered in the literature research were derived from the general problems, prerequisites and enablers for takt based and visual flow. The basis for the areas is within the areas of Lean, Visualization, Organizational improvements and value flows.

2.2.2 Interviews and Observations

For this project, interviews were mostly held in person. When making a quantitative study like this, standard sheets with questions was not used. It is of importance to be able to adapt the questions to the interviewed person and the ability to ask follow up questions are of great importance (Wallén, 1996). Unstructured interviews have the ability to give a lot of inputs but the analysis after the interview can be time-consuming. By choosing semi-structured interviews, the interviewed person will have the chance to talk and explain his or her thoughts and at the same time the predefined structure makes sure that the focus of the interview is not lost (Bryman & Bell, 2011).

The reason for choosing interviews for this research and holding them in person is the advantages of flexibility and the ability to listen to the answers, getting the deeper picture. The ability to ask follow up questions is also an advantage. However there is a risk of bias answers and it can be hard to interpret the answers (Bryman & Bell, 2011).

In order to minimize the impact of bias answers, several interviews with persons at different hierarchical levels of the company has been held. That increases the authenticity of the thesis because it widens the political impact. During the internal interviews, the aim of the research has been presented as in a way to act as incentive to change the circumstances for the employees, which further increases the authenticity (Bryman & Bell, 2011).

In order to further improve the authenticity, the research has helped members to achieve a better understanding of theirs and others social environment by presenting the research findings to them on a regular basis. To make the research as an incentive for change, regular meetings have been conducted with management board members in order to align the research with their overall corporate strategies. Presentations have also been conducted where involved parties had an opportunity to review collected material and findings in order to validate it, which all increases the authenticity (Bryman & Bell, 2011).

In the beginning of the project, the interviews have been focused on learning the organization and its operations and therefore interviews have been held with persons working at the analyzed departments. These initial interviews have been documented by notes by the interviewers which later has been compared with each other and complemented. Problems and issues have been defined by comparing interview answers and categorizing them in order to acquire problem

categories which have been translated into defined problems. The reason for why notes were taken during these initial interviews instead of recording them was due to the risk of not receiving correct and truthful answers due to the delicacy of the questions. Future interviews were recorded if accepted by the interviewees. In order to get a broad and comprehensive understanding of the operations, persons within all levels of the organization has been interviewed, from the technicians creating the methods to the Vice President of VCC.

In order to increase the credibility, the empirical data, based on the interviews, has been sent to all interviewed persons for approval. Further, the credibility has been in focus by triangulation techniques of where several persons have been asked the same questions. One example is that several persons in the organization have been asked regarding existing problems and those answers, together with multiple observations, have been triangulated to improve the credibility of the existing problems. The approval and the triangulation together increase the credibility of the research (Bryman & Bell, 2011).

2.2.3 Value Flow Analysis

In order to understand the operations and surface existing problems, the value flow was analyzed. Each activity performed to create a spare part structure, develop a repair method and setting a standard time was put on a Post-it on a board. The time for each activity and the lead time between the activities were determined together with a classification of whether each activity is value adding or not. The flow analysis was conducted at workshops together with team members and team leaders, which, according to Bryman & Bell (2011), increases the confirmability.

2.2.4 Field Trips

Field trip visits to Thermo Fisher, SCANIA and RUAG Space has been made with the purpose to study if there are other companies using concepts developed for VCCS. The companies was chosen based on their excellence in Lean, especially there usage of Lean in the white collar departments of their organizations. At the field trips, general concepts developed through general problems and theory were presented and discussed. This increased the transferability of the research because the input to the concepts has been showed for persons outside the studied organization (Bryman & Bell, 2011). Before the concepts were incorporated in the model, one of the actions made was this discussion with parties outside VCCS, minimizing the risk of creating a model only based on internal findings and details. Further, rich details regarding the analyzed organization has been presented, which further increases the transferability (Bryman & Bell, 2011).

2.3 Data Analysis

The data analysis chapter describes the categorization of existing specific problems and the attitude survey. The categorization is performed according to the KJ-Shiba Method, described in the subchapter of categorization. Further, the attitude survey, given to the PRI team at the end of the research, is explained.

2.3.1 Categorization

In order to structure the findings from the internal interviews, observations and flow mapping the KJ-Shiba Method was used to create a consensual understanding of the findings. By using the method the specific problem found could be categorized into categorized problems and thereafter raised an abstraction level to general problems. The KJ-Shiba Method is a visual and qualitative method developed to handle large quantities of verbal and observed data and organizing this data into

different groups depending on natural affinity (Scuplin, 1997). The method consists of five stages and totals 19 standardized steps where Post-it notes, A1 paper sheets and a number of different pencils are used. The first stage consists of making the necessary preparations, defining the problem and brainstorming. Second stage consists of clarifying the notes from the brainstorming and the first round of grouping. This stage is then followed by another round of groupings where the previous groupings are raised to a new abstraction level. Fourth stage consists of defining relations where root- and symptom causes are established through cause and effect relationships. The fifth and final stage in the KJ-Shiba Method is evaluation through voting and to draw conclusions related to the problem definition. The output from this method becomes a number of main root cause categories, their relationships and with specific underlying problems included (Scuplin, 1997).

2.3.2 Attitude Survey

An attitude survey was given to all team members at the Project Repair Information team when all short term concepts were implemented. The survey consisted of five questions and the purpose was to give indications of the gains coming from implemented concepts, acting as a base for future implementations of the long term aspects of the Specific Concepts. The survey consists only of questions relevant for the subject and it is only given to people affected by the implemented concepts. This approach reduced the risk for misleading answers (Brace, 2008). There was no need of using exclusion and screening questions in the beginning of the survey because of the small population involved. Further, the questionnaire started out with general questions before more specific questions. In that way the general questions gained trust before the sensitive questions are asked, ensuring correct answers (Brace, 2008). The survey can be seen in Swedish, in Appendix C.

3. Frame of Reference

In this chapter the theoretical framework needed to answer the research questions and to propose a model for takt based and visual flow is presented. Due to the research approach of this thesis, the available literature regarding Lean in white collar organizations is limited. Because of this, the literature study has been aimed towards production and product development literature due to their front edge position within their respective subject. Throughout this chapter the fundamental concept of Lean, different viewpoints as well as literature regarding Lean in white collar organizations will be presented. Further, specific elements within the concept of Lean will be presented which has been identified as fundamental prerequisites and therefore have a strong influence on the development of the model for takt based and visual flow. Quality tools will also be considered due to their strong relation to the current research and work as support in order to justify the prerequisites. In Figure 5 the different literature areas and their usage positions throughout the time axis is shown.

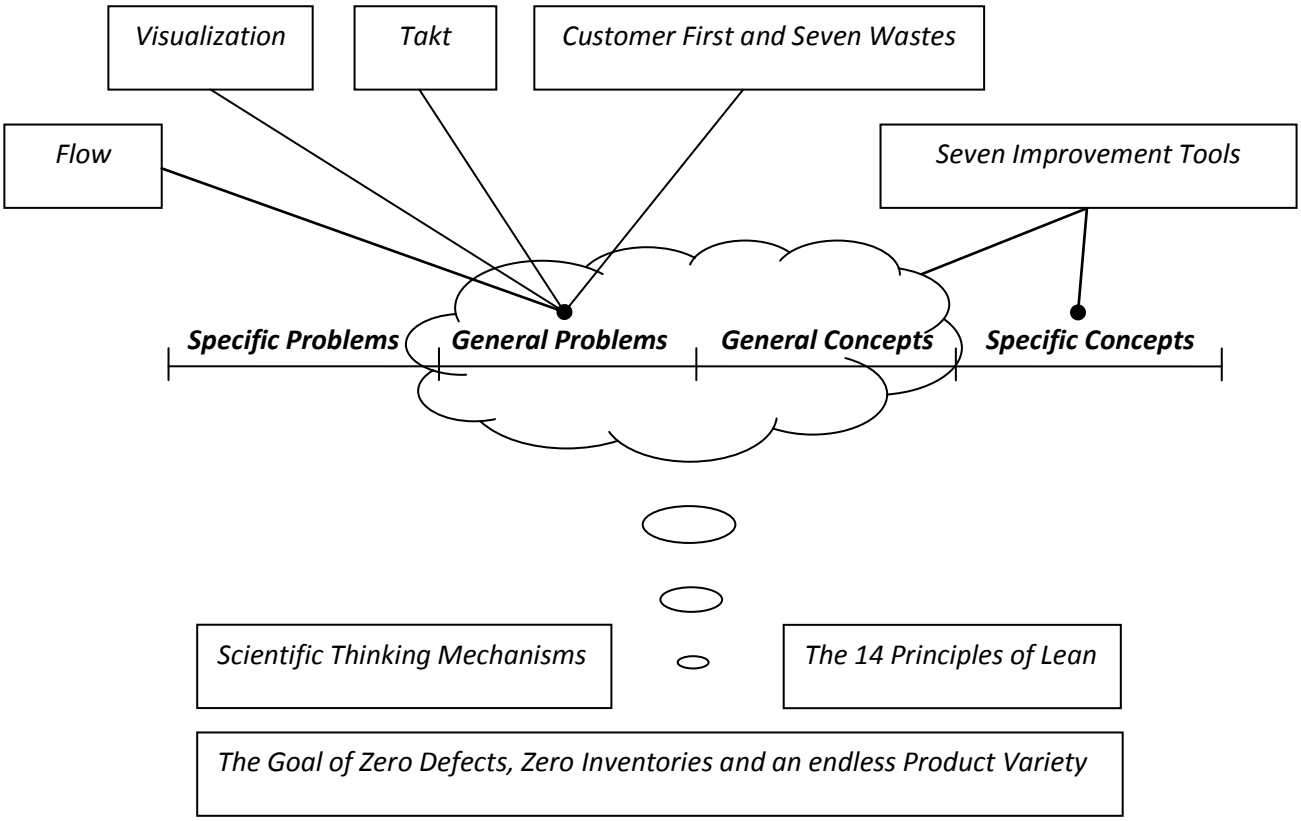


Figure 5, Literature areas of use along the time axis

3.1 The Concept of Lean

There are no straight forward definition of Lean production and no consensus of what Lean really is. Lean production, or Lean as it is often referred to, is today not just used within production but in all parts of business, production as well as white-collar organizations. In the same way as Lean is spread among all areas of business, the definition of Lean is divided from practical definitions, focusing on tools and methods to definitions focusing on philosophy and culture. According to Morgan & Liker (2006), there is a trend towards lean enterprice, not just lean production and the area of Lean product development is becoming the next dominant core competency. Many companies have tried to introduce Lean but few have succeded. The reason is that observed tools and practices in businesses that is successfully working with Lean, is confused with the system itself (Spear & Bowen, 1999).

During this subchapter, three different viewpoints of lean will be presented, The 14 principles of Lean, Scientific Thinking Mechanism and The Goal of Zero Defects, Zero Inventories and an endless Product Variety. These three are chosen because of their major impact on the development of lean, of where The 14 principles of Lean, by many, have been used as the definition of Lean. Scientific Thinking Mechanism has influenced the development of Toyota Production System, something that the 14 principles of Lean try to represent. The goal of zero defects, zero inventories and an endless product variety is the core of a book called The Machine That Changed The World, written by Womack, Jones, and Roos. It is the book that many believe aroused the interest for Lean for researchers and professionals, and therefore made a major impact on the development of Lean. In order to show that there are no unified definition of Lean, these three viewpoints are compared towards the end of this chapter.

3.1.1 The 14 Principles of Lean

The 14 principles of lean are developed by Jeffery Liker, an American professor at the University of Michigan who has spent a lot of time at Toyota. He is an author of several books and numerous articles, which have, to a great extent, influenced the development of Lean. The book with the biggest impact is The Toyota Way – 14 management principles from the world´s greatest manufacturer and mostly concerns how Toyota produces its cars.

The Toyota Way – 14 management principles from the world´s greatest manufacturer, describes fourteen principles which constitute the Toyota way. Those fourteen principles are, according to Liker, the foundation of Toyota Production System, the base for all Toyota manufacturing plants. The principles are divided into four categories, all starting with P, creating Liker´s 4P model of the Toyota way (Liker, 2004) and can be seen in Figure 6.

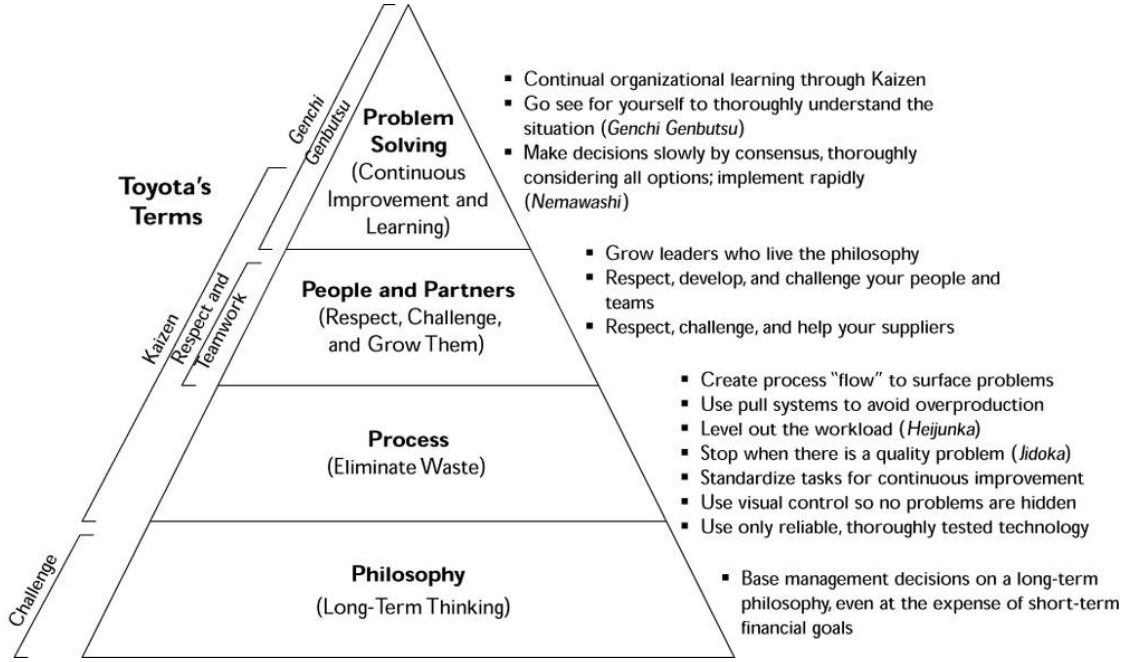


Figure 6, Liker 4P model

Philosophy is the first category and it deals with the long term approach that Toyota has. Liker has incorporated his four categories to Toyotas own Toyota Way that is used internally and the counterpart to philosophy for the internal use is Challenge.

Base management decisions on a long-term philosophy, even at the expense of short term financial goals is the only principle connected to the category of Philosophy. This principle can be viewed as the foundation for all other principles since it explains the importance of doing the right thing for the company, its employees, the customer and the society as a whole. It is also the principle that most companies misses when working with Lean and a common reason for failure (Liker, 2004).

Process and the elimination of waste is the next category and there are no countermeasures at the internal Toyota Way affecting only that category. Instead, Kaizen, or continuous improvements, are connected to process and people as well as partners and there are seven principles connected to process.

Create Continuous Process Flow to bring Problems to the Surface is the first principle connected to the category of process. As Liker (2004) writes "Flow is the heart of the Lean message that shortening the elapsed time from raw material to finished goods (or services) will lead to the best quality, lowest cost, and shortest delivery time". In order to achieve a good flow you have to create processes that can produce the right results and reveal problems. Liker (2004) points out the potential of using one piece flow in order to lower the water level and in that way detect problems and waste in the system. By doing so, there will be an automatic focus on fixing problems and in that way improving the flow (Liker, 2004).

Use Pull Systems to Avoid Overproduction is principle three, also connected to process. The basis of a pull system is that you receive items or information only when you demand it and at Toyota, pull means the ideal state of just in time (JIT). In that way, the customer receives what is wanted, when it is wanted and in the quantity that is wanted. A pull system builds in inventory, which is not the ideal state of lean, but in many cases, inventory is necessary to allow a smooth flow (Liker, 2004).

Level Out the Workload or **Heijunka** is principle number four, also connected to process of where Heijunka is the Japanese word with the same meaning. Liker (2004) quotes Fujio Cho, President, Toyota Motor Corporation, when he explains that the first thing necessary in order to apply Toyota Production System is to even out the level of production. If building strictly to order, piles of inventory and hidden problems will be created, impairing the quality and extending the lead time. This seems to be contradictory to the last principle explained but the secret is to accumulate orders, level the schedule and in that way create a leveled production based on customer demand. The principle does not only consider leveling the volume of the workload, but also the product mix, striving to reduce batch sizes (Liker, 2004).

Build a Culture of Stopping to Fix problems, to get Quality Right the First Time is the fifth principle. At Toyota it is important that operators stop the line when they detect a problem. In that way problems will be solved and operations improved. If reducing inventory, the production will automatically stop shortly after a production problem and quality is built in to the process, something called Jidoka in Japanese. By stopping production when problem occurs, problems can be fixed before the defects continue downstream (Liker, 2004).

Standardized Tasks are the Foundation for Continuous Improvements and Employee Empowerment is the sixth principle and a principle also connected to the category of process. Even at complex work operations, some level of standardization is possible and that is a cornerstone of Toyota Production System. Without standards it is impossible to improve, because you do not know what to improve. Standards shall for that reason be seen as the best practice of today, but which is to be improved tomorrow (Liker, 2004). Another reason for standardizing the work is to build in quality which is made by, when detecting a quality defect, asking if the standardized work was followed or not. If the standard was followed, then the standard needs to be modified.

Use Visual Control So No Problems Are Hidden, principle number seven, is also included in the category of Process. Visual control is a system to reduce the fire-fighting activities that many companies and their managers deal with. When problems are hidden, even the smallest abnormality will grow to a problem of scale until the moment it finally appears. Visual control can be any type of communication used at the work environment that tells how work should be done and whether the work is deviating from the standard or not. It tells at a glance if the work is on track or not. Visual control is connected to the usage of JIT and refers to JIT information to ensure direct and appropriate execution of both processes and operations (Liker, 2004).

Only Reliable, Thoroughly tested Technology That Serves Your People and Processes, principle number eight, is the last principle connected to the category of process. New technology should be introduced only after it has proved its usability in real environment situations. Before adopting new technology, the user has to make sure that it adds value and supports the people working (Liker, 2004).

People and Partners is the next category when moving up in the pyramid. When comparing with the internal version of the Toyota Way, People and Partners has its countermeasure in Kaizen and Respect + Teamwork. The category consists of three principles and the first one is, Grow Leaders Who Thoroughly Understand the Work, Live the Philosophy, and Teach It to Others.

Grow Leaders Who Thoroughly Understand the Work, Live the Philosophy, and Teach It to Others is the ninth principle. According to Liker (2004), leaders shall be grown rather than purchased. In that

way you avoid sudden change of direction and stay away from the roller coaster phenomenon that companies that changes leaders frequently, importing them from other organizations, is dealing with. By understanding how work on the shop floor and in the organization is conducted, a leader is able to understand the way the company is doing business and teach it to others. This ensures that the next leader as well will live the philosophy of the company and grow (Liker, 2004).

Develop Exceptional People and Teams Who Follow Your Company´s Philosophy is the tenth principle, and also a principle belonging to the category of People and Partners. Liker (2004) views team work as essential for a well functioning organization. However, he declares that it is the individual, not the team, who does the value adding work. The team motivates, coordinates the work and act as a channel for spreading competence between its members. Developing people and teams is about challenging and respecting the employees at the same time, trust that an employee will do his or her job and respect the capability of that person (Liker, 2004).

Respect Your extended Network of partners and Suppliers by Challenging Them and Helping Them Improve, the eleventh principle, is the last principle within the category of People and Partners. The principle addresses the importance of finding a solid partner to grow with to gain mutual benefits in the long term. In order to do so, the internal operations have to be evaluated and stable enough to support the extended network. In the same way as individuals within the company shall be challenged and respected, the suppliers also have to be challenged and respected. Having a long term relationship, not changing supplier if another is slightly cheaper, builds trust and a partner relationship beneficial for both parties (Liker, 2004).

Problem Solving is the category in top of Liker's pyramid, focusing on continuous improvements and learning. The corresponding counterpart at the internal Toyota Way is Genchi Genbutsu and the first principle connected is principle number twelve.

Go and See for Yourself to Thoroughly Understand the Situation (Genchi Genbutsu) is principle number twelve and the first principle of the category Problem Solving. In order to understand the business, a manager has to go and see with his own eyes, just looking at reports and hearing what other says is not enough. Looking at reports and numbers, a manager will get a sense of the results that is performed, but it does not show the details and the processes that are followed every day (Liker, 2004).

Make Decisions Slowly by Consensus, Thoroughly Considering All Options; Implement Rapidly is Liker´s Principle number thirteen. According to Liker (2004), it is important to focus on the planning phase of a project, making sure it will work before implementing. Careful and upfront planning is the secret to flawless and successful implementations and a prerequisite for a broad consideration of alternative solutions (Liker, 2004).

Become a Learning organization Through Relentless Reflection (Hansei) and Continuous Improvement (Kaizen) is the last of Liker's principles, Principle number fourteen. In order to do so, Liker explains the importance of identifying the root cause and develop countermeasures. He also elucidates how reflection concerns learning and growth and that it is impossible to improve if you do not reflect over the current situation. Starting to reflect and upon that improve does not make a learning organization by itself, it takes time as creating a learning organization is a long-term journey (Liker, 2004).

3.1.2 Scientific Thinking Mechanisms

The idea of Scientific Thinking Mechanisms is developed by Shigeo Shingo, a Japanese industrial engineer that wrote more than 25 books on manufacturing improvements and worked as consultant for companies like Toyota, Honda and Peugeot (Shingo, 1992). Shingo is cofounder of Toyota Production System and the person behind the Shingo Prize, an award to organizations with a culture where principles of operational excellence are deeply incorporated into the thinking of managers and leaders. Even though Shingo rarely talks about Lean, his work has contributed to the development of lean as a philosophy.

One of Shingo´s main contribution to lean and production improvements is his three-dimensional structure of production which explains the relationship between processes and operations. A mistaken perception is that production equals operations when in reality, production is a network of processes and operations. The network can be described as three-dimensional relationship where processes (Y-axis) and operations (X-axis) change in accordance with time and space (Z-axis) (Shingo, 1992), see Figure 7.

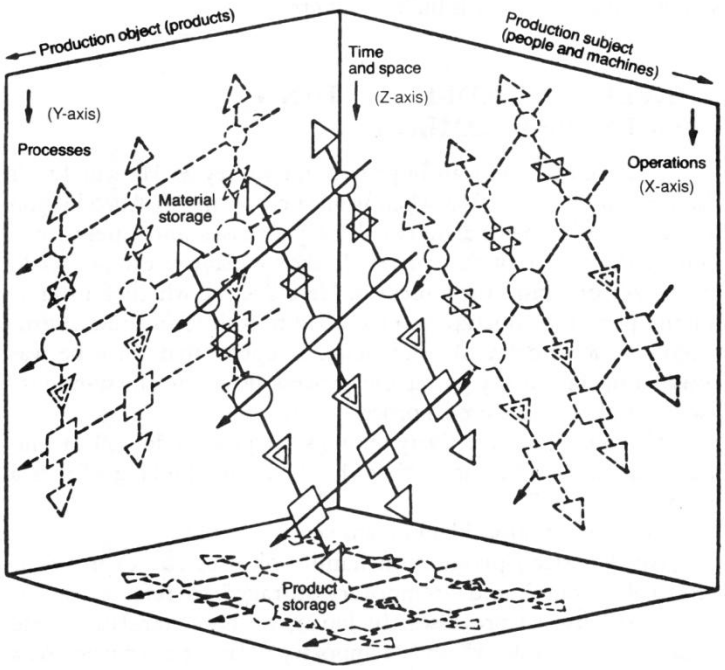


Figure 7, Three-dimensional Structure of Production

Processes is flow transforming raw material into finished products and operations are flow in which people performs work on physical objects. Within operations, people can perform work at each process. According to Shingo (1992), when analyzing the relation of processes and operations, the process sequence is what first has to be established. The sequence of processes is then followed by operational methods to supplement that process sequence. Process improvements have a great impact on operational functions of where specific operations can be eliminated or changed.

Shingo uses the three-dimensional structure as a base for production improvements and has developed the Scientific Thinking Mechanism for improvements. Scientific Thinking Mechanism for improvements is an extension of Frank Gilberth´s ideas of motion perfection and a four step model for how improvements can be conducted (Shingo, 1992). The first step in the model is Problem Identification, the next step is Basic Conceptual Approaches to Improvement, the third step is Making Plans for Improvement and the last step is Translating Plans into Reality. When working with improvements according to the Scientific Thinking Mechanism, the goals of the improvements is divided into three categories, Focus, Identify multiple goals and Pursue goals systematically. Focus is the idea of revealing goals that are deeper than the obvious ones and Pursue goals systematically refers to the idea of having a broad perspective of the current goals (Shingo, 1992).

3.1.3 The Goal of Zero Defects, Zero Inventories and an endless Product Variety

The goal of Zero Defects, Zero Inventories and an endless Product Variety was presented in the book The Machine that Changed the World by Womack, Jones, & Roos. It illustrates the difference between craft production, mass production and Lean production by explaining that Lean production combines the advantages of craft and mass production. Lean has the advantage of low cost from mass production and flexibility from craft production. Further, the difference between Lean production and mass production is related to the systems ultimate goals. The ultimate goal of mass production is an acceptable number of defects, a maximum acceptable level of inventory and a small range of standardized products. Improving beyond these acceptable limits is simply too costly. On the other hand, the ultimate goal of Lean production is zero defects, zero inventories and an endless product variety (Womack, Jones, & Roos, 2007).

According to Womack, Jones, & Roos (2007), teamwork is an essential part of Lean where workers are grouped into teams with one team leader that fills in for absent workers, coordinates the team and help solving problems. The work of the team is customer driven and team members are invited to react on quality problems by stopping production and in that way solve problems quickly. The customer driven production are based on a build to order system enabled by producing in small batch sizes and providing a wide and flexible product range.

A Lean system has two key organizational features. Tasks and responsibilities are given to the people performing the value adding work and there is a system in place that detects defects and quickly traces the problem to its ultimate cause (Womack, Jones, & Roos, 2007). Lean should be seen as a strategy for achieving value leadership and something that by far exceeds cost savings. Offering over-expanding product variety and fast response to changed customer demand makes Lean exceed mass production on most parameters except pure cost (Womack, Jones, & Roos, 2007)

3.1.4 Lean Viewpoint Comparison

In order to show that there is no unified definition of Lean, the three presented viewpoints are compared. However, when comparing the three different viewpoints of Lean, there is nothing contradictory. The base of their perception of Lean is the same even though their work is focused on different aspects. The level of abstraction is something commonly discussed when comparing different viewpoints of lean but in this case, all of the authors covers the whole spectra, from specific tools to the philosophy underlying the concept of Lean. Even though their work is focused on different aspects, five common elements are present of where their work aligns. These are; Relationships, Flow, Process, teamwork and Problem solving.

Both Liker and Shingo focus on the relationship between elements of Lean, how they support each other and their internal dependency. Liker focuses on the relationship between the different categories of his 4P model, Philosophy, Process, People and Partners and Problem solving. Without having all categories covered, there will be no successful Lean organization and important aspects will be missed (Liker, 2004). Shingo does not focus on these categories, but instead the relationship between Processes and Operations. The three-dimensional relationship states that process improvements have a great impact on operational functions and that an organization is dependent of this relationship working (Shingo, 1992). Womack, Jones and Roos do not, as clearly as Liker and Shingo, focus on relationships but instead the combination of mass and craft production that lean constitutes (Womack, Jones, & Roos, 2007).

Flow is a base of Liker´s definition of Lean and is the heart of principle number two, create process flow to surface problems. Flow is also incorporated in Shingo´s three-dimensional relationship of where process and operation change in accordance with flows of space and time. According to Shingo (1992), both process and operations are different types of flows. Once again, Liker and Shingo have a more unified picture of the importance of flow than either of them has with Womack, Jones and Roos. The importance of flow is not as clear in Womack, Jones and Roos perception of Lean even if they concern the importance of finding problems and solving the root cause, something that Liker strongly connects to the existence of flows.

Process is the third element that the authors have in common. Liker states that process is one of the four categories constituting his 4P model and to which seven of the fourteen principles are connected. Shingo also explains the importance of process by explaining that productivity is a network of process and operations but when comparing the two views of process, Liker has a wider definition, including more aspects of production than Shingo does. Liker includes technology as well as standards and culture in process but Shingo mostly focuses on process as transforming raw material into finished goods. When Womack, Jones and Roos explain the two key features of a Lean system, they explain that task and responsibilities are given to the people performing the value adding work. That value adding work is, according to Shingo (1992), a process and the second key feature, a system that detects defects and traces the problem to its ultimate cause, is included in the category of Process in Liker´s 4P model.

Womack, Jones and Roos value teamwork as an essential part of Lean in the same way as Liker does. According to Womack, Jones and Roos (2007), people shall be grouped into teams with a teamleader that fills in for absent workers and coordinates. Liker share that opinion but develops his thoughts further when explaing the development of the teams and clarifies that it is the individual, not the team, that does the value adding work. Shingo does not focus on the teamwork itself but touches the area when stating the improtance of having leaders focused on devloping and improving.

Problem solving is included in Liker´s 4P model and focuses on improvements and learning in a similar way as Shingo´s Scientific Thinking Mechanism does. The Scientific Thinking Mechanism explains the process of conducting improvements and focus on the understanding of the current situation as well as the planning of an improvement before making it. Liker has the same approach of improvements when he includes the principles of Go and See for Yourself to Thoroughly Understand the Situation and Make Decisions Slowly by Consensus, Thoroughly Considering All Options; Implement Rapidly in the category of problem solving. The area of problem solving is the element that the authors most strongly have the same perception of. Womack, Jones and Roos (2007) focus on problem solving when explaining that a system that detects defects and traces the ultimate cause is one of two key features of a Lean system.

Further, there are some other elements that the authors share but that is not of an extent worth to mention. All authors have a business perspective that goes beyond production even though their focus on tools and enablers for achieving Lean operations varies. All authors emphasize the importance of a customer pull, leveled flow and small bath size but their approach of dealing with those aspects differs. Shingo focus on the enablers like Single Minute Exchange of Die, which to some extent is true for Liker as well and the importance of customer driven processes is shared by Womack, Jones, Roos and Liker. A table clarifying the different viewpoints regarding; relationships, flow, process, teamwork and problem solving is shown in Figure 8.

Figure 8, Lean viewpoint comparison

	The 14 Principles of Lean	Scientific Thinking Mechanisms	The Goal of Zero Defects, Zero Inventories and an endless Product Variety
Relationships	Relationship between the 4 P categories. Elements support each other	Elements support each other. Relationship between process and operations	X
Flow	Flow to surface problems	Process and operations change in accordance with flows of space and time	X
Process	Process is one of four categories	Productivity is a network of process and operations	Task and responsibility
Teamwork	The team is essential, but it is the individual, not the team, that performs the value adding work	Work in teams where the team leader focus on developing and improving	It is essential with teams and team leaders
Problem Solving	Improving and learning	Understand the problem and plan before solving	Use a system that detects and traces defects to its ultimate cause

3.1.5 Lean in White Collar Organizations

As previously mentioned, Lean is transforming from something focusing on manufacturing, to a focus of lean enterprise, also including white collar organizations. Lean product development and Lean service are two examples of researched areas for white collar organizations where studies have been conducted. Even though more research has been conducted on Lean in manufacturing and production, more resources are focused on the entire business of where the white collar organizations constitute a large part. Because of that and the potential gains when improving the entire organization, the area of Lean in white collar organizations is an interesting subject. In white collar organizations, the material that is produced and transported is not physical material as in manufacturing; it is information, customer needs, past product characteristics, competitive product data and principles (Morgan & Liker, 2006). That makes it harder to understand the operations and detect waste, which in turn implies that the potential gains of lean in white collar organizations are great. White collar work can be regarded as production in the same way as pure manufacturing is. The difference is the product but they share the most important aspect, the aspect of delivering

value to the customer. Because of that, the customer values are as important in white collar organizations as they are in manufacturing and something that has to be defined (Liker & Convis, 2012).

Many white collar operations, like product development, can be seen as a repetitive process of steps that are interrupted by waste. It is more complex than manufacturing, have longer cycle time and more variation which places even higher demands on careful planning and synchronization (Morgan & Liker, 2006). Organizations that continue to see their white collar operations as an uncontrollable series of discrete events will get behind and be forced to focus on quick fixes and short term improvements (Liker & Convis, 2012).

In product development, just as in manufacturing, it is important to be able to see and recognize abnormalities. The difference is that it is harder to detect them in white collar organizations because you can´t see inventory, you can´t see if a person is following the work standard and it is hard to know if a project is on schedule. In order to detect abnormalities, visual planning and cross functional communication is helpful, making it possible to frontload the processes and align the organization. By doing so it is possible to have a total value flow perspective and focus on reducing waste instead of reducing value adding activities that otherwise is a common mistake in white collar organizations when trying to reduce lead time and becoming more efficient (Morgan & Liker, 2006). By frontloading work and projects, the opportunity of leveling the workload appears. Leveling the workload is essential for Lean, both in manufacturing but also regarding the white collar organizations. By leveling the workload, variation is reduced, which is a prerequisite for a well functioning Lean organization.

In close connection is also the utilization of standards which in manufacturing can be done to a high extent, but is as important for white collar work as well. In Lean product development there are, according to Morgan & Liker (2006), three different types of standardization, namely; design, process and skill-set standardization. Design standardisation is about standardising the design of components and creating a standardised architecture. Process standardisation deals with the standardisation of tasks, work instructions and sequence of tasks. The last type of standardization that Morgan & Liker (2006) mentions, Skill-Set, is about standardising skills across employees and teams. Just as checklists can be used in manufacturing, they can be used for white collar operations. One example is air pilots that uses checklists to make sure the plane is working propertly before take off. It is important to make sure that the persons supposed to use the checklists are the ones responsible for maintaining and using them (Morgan & Liker, 2006).

3.2 Specific Elements of Lean

In addition to the different viewpoints of Lean, there are other aspects, not enough explained by the viewpoints to cover the whole area of Lean, from tools to philosophy. For that reason, important elements of lean will be explained in this chapter. The chosen ones, due to their importance for a takt based and visual flow, is the concept of flow, Customer first and the Seven Waste of Lean Production, Visualization, Takt and the Seven Improvement Tools.

3.2.1 The Concept of Flow

The relation between how much value is added to a unit through a system and the total throughput time of the unit through the system is called the flow efficiency measurement. High flow efficiency will result in lower throughput times as well as decreased work in progress (Modig & Åhlström,

2011). A flow is built up by processes which are tightly coupled so problems in one process will have an almost immediate effect on other processes in the chain (Liker & Morgan, 2011). The processes contain materials, information or humans where value in some way is added to the units along its way through the system. As both Liker & Morgan (2011) and Modig & Åhlström (2011) explain, it is between these process steps where the greater waste is hidden in a flow. By reducing this waste, it is far more likely that the waste elimination will have a greater impact than eliminating waste within single processes.

After high flow efficiency is achieved the next step in order to create a good flow in the organization is to increase resource efficiency which is a measure on how utilized the system resources are. Majority of companies only focus on utilizing the resources and thereby forgets the important of flow efficiency which instead results in longer lead times, decreased quality and increased costs. Low flow efficiency also hides problems and ties up capital in the form of attention, time, space and other overhead costs. Further the work in progress increases and the overview of the system degrades due to difficulties in managing several units simultaneously (Modig & Åhlström, 2011). In connection is the common focus on rules and responsibilities together with system and tools, which, according to Westberg (2011), reduces the focus on deliveries. Instead, Westberg (2011) emphasizes the importance of focusing on deliveries before focusing on system and tools together with rules and responsibilities.

When defining and analyzing a value stream flow the ordinary approach is to define it from when it arrives from the supplier until it is delivered to the customer, the door-to-door principle (Rother & John, 1999). A widespread conception among many companies and organizations today is, according to Modig & Åhlström (2011), that local functional improvements will be enough in order to improve the whole system. This phenomenon results instead in the creation of isolated functional islands, which within themselves may be better, but not in a holositc perspective. The reason for this phenomenon is according to Rother & John (1999) that no one is responsible for the entire flow due to the organisational layout in functional departments. Further they explain that “it is very rare to visit a facility and find one person who knows the entire material and information flow for a product” which in turns makes it difficult to understand and thereby almost impossible to improve. Rother & John (1999) and Liker & Convis (2012) also emphasizes the importance of having a responsible person for the entire flow as well as for the quality and delivery of the product to the customer.

3.2.2 Customer First and The Seven Wastes

‘It is the customer that pays the wages’ Henry Ford (1922). The signification of this famous quote from the founder of Ford Motor Company has later become one of the fundamental principles of manufacturing. To be able to sell products to a customer one must satisfy the customer demands in the best possible way. In order to be able to satisfy these demands the first step is to define the customer values (Morgan & Liker, 2006). Morgan & Liker (2006) as well as Womack and Jones (2005) further describe the importance of deeply understand what adds value to your customers, identifying the value stream they participate in as well as eliminate waste in and between the processes. All in order to make the flow as efficient as possible so the system delivers what the customer wants without any delays, this is by Womack and Jones (2005) called “lean consumption”.

Another exemplary analogy behind the importance of customer focus has been said by Shigeo Shingo, one of the co-developers of Toyota Production System through the quote: 'When you buy bananas all you want is the fruit not the skin, but you have to pay for the skin also. It is a waste. And you the customer should not have to pay for the waste.'

One of the key steps in Lean is to identify which steps that creates value for the customer and which do not. By classifying all activities into these two categories it is possible to improve the value adding and eliminate the non value adding steps. According to (Emiliani, Stec, Grasso, & Stodder, 2007) there are three traditional broad types of wastes, namely: Muri, Mura and Muda and can be seen in Figure 10.

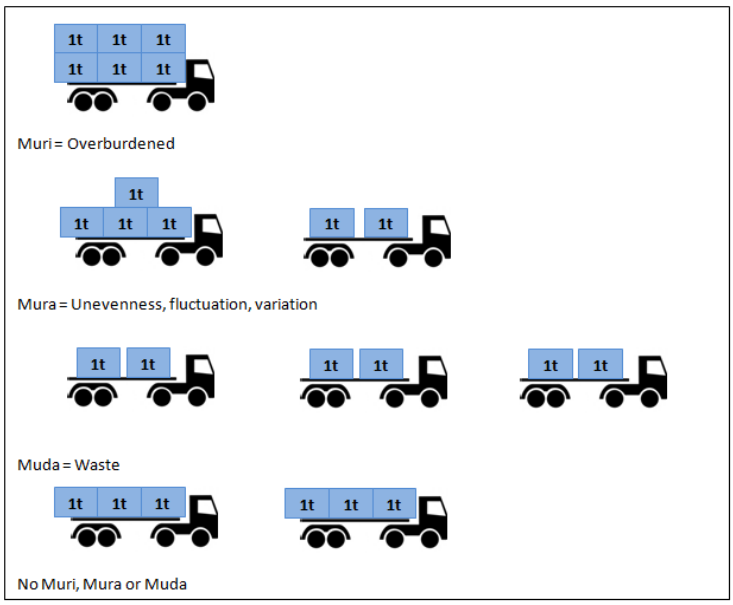


Figure 10, The three traditional broad types of wastes

The first waste, Muri, represents the waste of continuously overloading processes which eventually will lead to exhaustion and fatigue. The second, Mura, is the waste of variations which creates an uneven and unpredicted system. The final type of waste, Muda, is a representation of all activities that does not add any value to the customer.

Figure 9, The Seven plus One Wastes

- Transportation
- Inventory
- Excess Motion
- Waiting
- Over-Processing
- Over Production
- Defects

- Creativity

Taiichi Ohno, Toyotas´s Chief Engineer identified that Muda consisted of seven different wastes that were commonly present, namely: Transportation, Inventory, Excess motion, Waiting, Over-processing, Over-production and Defects. The first one, transportation, refers to all unnecessary movements that are done within the system, for example moving products from one storage place to another. The second waste is unnecessary inventory such as Work in Progress (WIP) which adds cost, hides problems and increase lead time, for example having unnecessary buffers between process steps. Third waste, excess motion is strongly connected to ergonomics and contains for example lifting, reaching and bending. Whenever a product is not moving or being processed it is exposed to the fourth waste, waiting. This waste normally constitutes the majority of a products total time in any production system and is especially seen in batch-and-queue manufacturing. The fifth waste refers to processing things more or using a more expensive machine than necessary, an often cited term connected to this waste is the expression: "using a sledgehammer to crack a nut". When producing something that is not actually required and that cannot be immediately sold or shipped is called over-production, the sixth out of the seven wastes. The seventh and final waste is according to Taiichi Ohno's classification the waste of quality defects which results in rework or scraping of material and products. Effects from these quality issues

often results in high cost for organizations due to direct costs such as quarantining and scraping material/products as well as indirect cost due to rescheduling, capacity losses, re inspections etc.

In later days an eight waste has been added in addition to Taiichi Ohno´s original seven wastes by Womack & Jones (2003), namely the waste of under utilizing peoples creativity that can eventually eliminate the other seven wastes as well as improve their own working performance, seen in Figure 9 is a compilation of the seven plus one wastes.

3.2.3 Visualization

Information sharing is a fundamental qualification in order for all companies and organization to work properly. Information gaps are a common problem in most companies and organizations, resulting in that important information does not reach the user it was intended for. By making information visible it will be easily accessed, favor discussions, valued more or the management of it will be facilitated (Sparrow, 1998). Eppler & Burkhard (2007) have in their reserach identified five perspectives that is important to consider when visualising information which can be answered through five key questions. The first perspective regard what type of information that is visualized, i.e. the content. Second question to consider refers to the purpose of visualizing the information, what is strived for through this visualization. Third and fourth regard for whom it is visualized for and in which context. The fifth and final key question refers to how the information can be represented, i.e. in what format is it easily accessed, understood and managed.

According to Liker (2004) a working visual control system is any communication device used to instantly get an overview of current working status and whether or not it is deviating from the schedule. A working system helps for example emplyees to see and communicate the status of how they are doing as well as what and how much they are doing at the current time. In order to make use of the control system in the right way the information that is visualized should be as clear as traffic signals and signage, they should not require to be studied in order to understand them. The fundamental aspects of visualization can briefly be summarized as to support the employees through visual control so that they have the best possible opportunity to performe a good job. (Liker, 2004)

The visual control system can be set up in many different forms, a common application within industry today is the Knowledge Innovation / Visible Planning (KI/VP) which has been developed by JMAC (Hines, Francis, & Found, 2006). The tool is mainly used for project planning, monitoring and execution and the essence of it is to “allow everyone in the team to see what their tasks is, what everyone else is doing and where the interactions and handovers are”(Hines, Francis, & Found, 2006). KI/VP is a people-centered approach where the focus is on the people within the process and consists mainly of a board where members is responsible for writing down activities, deliverables, issues, absence and inputs on Post-it notes and place them on the board. The layout of the board consist of a gridline with one row for each team member and where the columns represents a timeline (Lindlöf & Söderberg, , 2011). The board is used as the main communication tool at a short meeting, often daily and about 15 minutes long. The team manager often start the meeting by addressing important issues or information and then each team member has a time slot to go through his or her row. Team members have during this time slot the opportunity to address issues that has arise, will proboably arise as well as his or her current status of activities and deliverables. (Lindlöf & Söderberg, 2011)

The KI/VP tool provides, according to Hines, Francis & Found (2006), a “nexus for motivation, identifies problems and seeks resolution to problems”. Other benefits of visual planning is the increase of communication efficiency through the short and frequent meetings as well as increased coordination capabilities between resources (Lindlöf & Söderberg, 2011).

Questions and concerns that often arise when implementing visual planning and visualization of information often regard the extra work that may come along. The analoge format of the board and printing sheets of information and putting them on the walls are also common concerns related to the extra work. Conclusion can be drawn that everything does not fit everywhere. For example if the team consist of people with many different speciality competences the handovers can become problematic (Lindlöf & Söderberg, 2011). “it doesen´t give me that much to tell others what I do, because no one can help me anyway…” is according to Lindlöf & Söderberg (2011) a common expression in some companies. Other aspects where visual planning and visualisation of information does not fit is in global teams since the board and the Post-it notes are analog. Another issue is due to the previous one, since the notes are physical artefacts they are not saved and easily accessed but rather thrown in the bin or placed in a reflection book. Third issue regards that it is difficult to see linkages between activities and deliverables as well as how they affect each other if a Post-it note is moved. (Lindlöf & Söderberg , 2011)

3.2.4 Takt

The basic concept of takt time is to synchronize the processes in a flow so that performance variation is reduced and thereby getting a predicable output rate (Liker, 2004). It is used to set the pace of the production and thereby alerting workers if they are ahead or behind the planned production schedule. It also clarifies for everybody involved what is expected by them and that there will be consequences for the flow if the takt is not followed (David & Zokaei, 2005).

There are numerous benefits with a well functioning takt time system. It will provide a rhythm in which the system can operate, production is smoothly planned which implies that operations is carried out without interruptions (David & Zokaei, 2005). It synchronizes the production system with customer requirements, pull scheduling is facilitated which also brings that no over production is created. The system can confidently operate in one pace and countermeasures can be deployed in early stages so that no rush hours are needed just before deadlines. The flow will be clearer and facilitate understanding of the flow which will reveal work in progress and other problems interrupting the flow which is the foundation of the continuous improvement work. Other benefits of takt time are the one piece flow that is created which, to mention a few, builds in quality, creates real flexibility, creates higher productivity and improves work morale (Liker, 2004).

3.3 Seven Improvement Tools

In order to conduct improvement work, data are required together with an analysis of this data. For this reason, a toolbox called The Seven Improvement Tools can be used. The purpose of the tools is to be effective for improvement works but yet simple, making it possible for everyone to use them (Bergman & Klevsjö, 2010). The toolbox consists of seven improvement tools but only Data Collection, Histogram, Pareto Chart, Cause-and-effect diagram and Control Charts will be presented and thereby leaving out stratification and Scatter plots since they are not relevant for the intended environment.

Data Collection is the first tool, and one of the most important steps when working with quality improvements. It is essential that correct data is collected and for that reason, the purpose of the data collection has to be clearly communicated among all interested parties. Before starting to collect data, two questions, what is the quality problem and what facts are required to elucidate the problem, has to be answered. Check sheets are a common way of collecting data where new facts can be marked with a stroke or a cross; see Figure 11 (Bergman & Klevsjö, 2010). There is no uniform design of check sheets but the underlying idea is to collect all relevant information relative to abnormalities so that process or product improvement can be facilitated (Ryan, 2011).

Check Sheet	
PROBLEM CATEGORY	FREQUENCY
Problem 1	II
Problem 2	IIIII IIII
Problem 3	IIIII I
Problem 4	IIIII IIIII III
Problem 5	I

Figure 11, Check Sheet

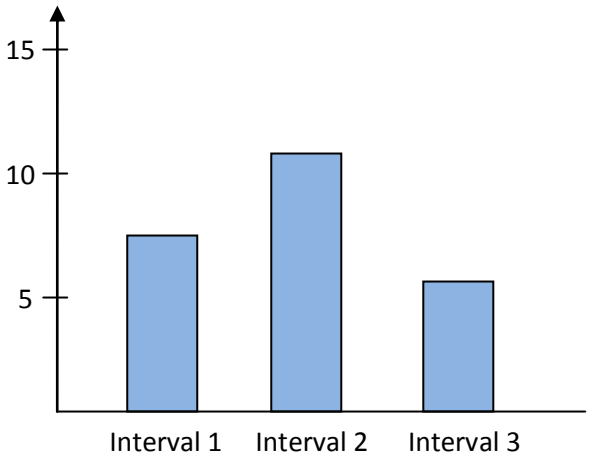


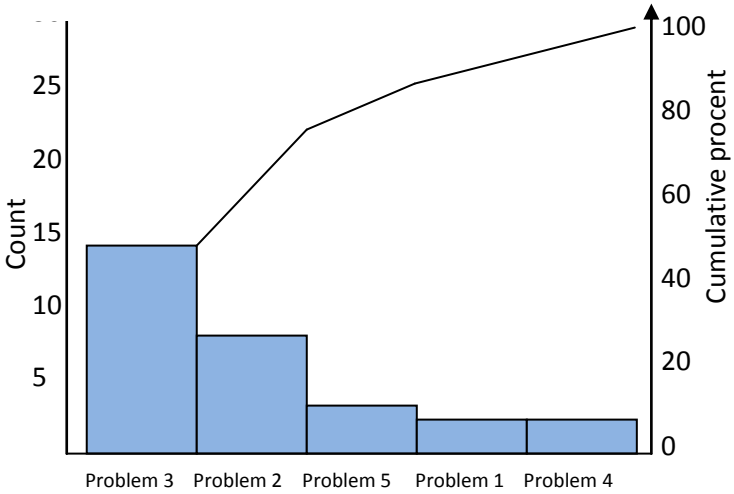
Figure 12, Histogram

Histogram is a tool that can illustrate data where measurements are divided into classes and the value in each class is represented by a rectangle having the ability to illustrate data in a proper way. The area of the rectangle is proportional to the fraction of observations in that class. Histograms are often used to illustrate how process or product characteristics vary and can be obtained using a frequency table as a basis. Histogram enables an overview of patterns that is hard to see in tables of numbers, see **Fel! Hittar inte referenskälla.** (Juran & De Feo, 2010).

Pareto charts provides a clear picture of the frequency of different error types, where each error type is represented by a rectangle whose height equals its number of defects (Deming & Walton, 1986). It is a proper tool to use when problems are visualized, but it still is hard to decide in which order the problems should be addressed. The order of the different types of defects is arranged in a way that the one with the largest frequency is placed leftmost and the one with the smallest frequency is placed rightmost, see Figure 13.

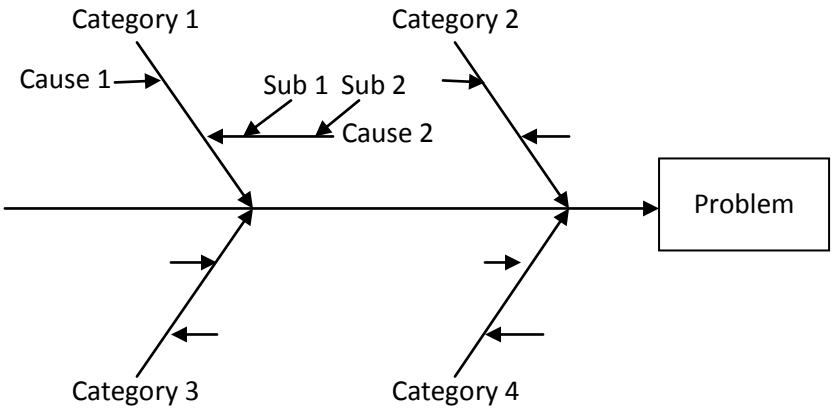
The Pareto chart can also be based on experienced consequence cost of the different types of defects. It is possible to draw a line illustrating the accumulative number of defects on the right hand scale in the chart, something that is not present in all Pareto charts and something of that the purpose can be questioned (Bergman & Klevsjö, 2010).

Figure 13, Pareto Chart



Cause-and-effect diagrams can be used when a specific problem is addressed and its rote cause is to be found. The diagram is also known as fishbone diagram or Ishikawa diagram, see Figure 14 (Ishikawa, 1976). The diagram roughly describes the types of causes that can possibly produce the observed quality problem. Each roughly described cause is then further investigated and divided into causes that can produce the rough cause. One specific problem or cause is analyzed at a time and the aim is to get a complete picture of all causes affecting the observed problem (Bergman & Klevsjö, 2010).

Figure 14, Cause and Effect Diagram



Control charts can be used to make processes predictable by analyzing if assignable causes of variation exist and continually track random samples from the process at regular pre-planned intervals (Urdhwareshe, 2011). Information from the process is gathered at regular intervals, process quality indicators are developed and, based on the indicators, the process performance is checked if suitable or not. In this way, the process variation as a function of time is illustrated together with indicators of process change. As long as the process lies within the quality indicators, the control limits, the process is considered as stable; see Figure 15 (Bergman & Klevsjö, 2010).

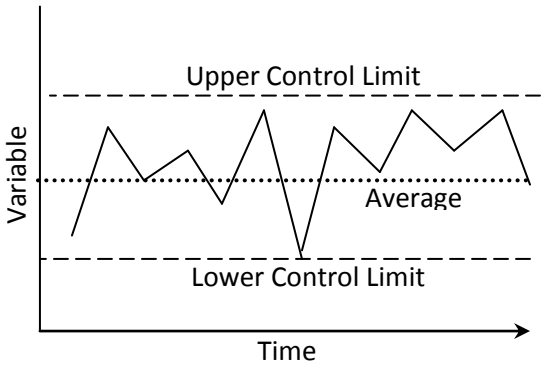


Figure 15, Control Charts

4. Empirical Results – Current State and Model Conditions

This chapter is based on the research questions and divided into internal and external empirical results. It starts with research question number one, focusing on the existing problems in the organization and further includes research question number three. The current operations and the flow mapping are described in order to present the existing problems and will be further analyzed in chapter 4.1.4. The current operation is described based on the VCCS lean house, see Figure 17*, and for that reason, the house itself is also described. The external empirical data is used to validate the general concepts and to create specific concept. In that way, the external empirical data is used to answer research question number three.*

4.1 Internal Empirical Result

The value flow that this Master thesis analysis consists of three functional groups, Parts Technology, Repair Technology and Standard times and Campaigns. Within each group there are several teams, but not all of the teams are connected to the flow that this thesis concerns. Parts Technology consists of three teams that all contributes to the analyzed flow and the main work for those teams is to create a spare part structure for upcoming cars. Even though they are different teams they perform the same work, however for different parts of the car. Because of that and the fact that they all work in a similar way they will, in this thesis, be referred to as one team, the Parts Technology team (PT team).

Within Repair Technology there is one team, Project repair information team (PRI team), working with the analyzed flow, creating service and repair manuals for new cars. Within that team there are seven persons connected to the analyzed value flow and six persons not connected. Regarding Standard times and campaigns there is one team, Volvo standard times guide team (VSTG team), connected to the analyzed flow. Their mission is to set standard times based on the repair and service manuals, which can be used in the workshop to determine the customer price. In that team there are four team members working with tasks connected to the analyzed flow and four members having other work tasks.

4.1.1 The Flow

In order to understand the operations and the process of producing a spare part structure, a repair method and a standard time, this section will describe that specific value flow. The flow and the activities in it will not be explained in detail, see Appendix B. The important steps performed in order to create a spare part structure, develop a repair method and determine a standard time will though be clarified.

The PT team is, within VCCS, the first team in the flow, seen in Figure 16, that receives inputs in the form of construction drawings from research and development. The team creates a spare part structure, controls drawings and registers the articles in the software Nevis. Based on the spare part structure, PRI team performs a method assessment in order to plan the method production. The method assessment consist of several activities but the main steps is to analyze drawings, visit pre-production, determine which repairs that needs new methods and which that can be performed with old methods. Further, the assessment also consists of ordering new tools and applying for new phrases to use in the methods.

When the method assessment is completed, the development of methods can begin. The main steps of the method production is creation of pictures, consolidation of pictures, the addition of text and links to other methods, physical verification and sending the method to the VSTG team.

The VSTG team then takes over and the first activity in that part of the flow is to determine whether the method is new or already exist in the system. When that is determined, the next activity is to discuss details regarding the method with a team member of the PRI team before setting the time itself. At last, the time is sent back to project repair information team that closes the order. Throughout the flow, it is the team members that creates the spare part structure, develops the method and sets the time while the team leader has a supportive and coordinating function. However, sometimes the team leader helps in the process, acting like an Andon person.

Figure 16, Schematic illustration of the analyzed flow

4.1.2 The Lean House

An important aspect of VCCS lean initiative is the developed lean house, see Figure 17. It is communicated through the organization and is the base for how VCCS operates. This section will first explain the house itself and the house will then be used to describe the current operations at the analyzed flow. Just as a regular house, it is built from the ground and up meaning that the blocks in the upper part of the house are depending on the lower ones.

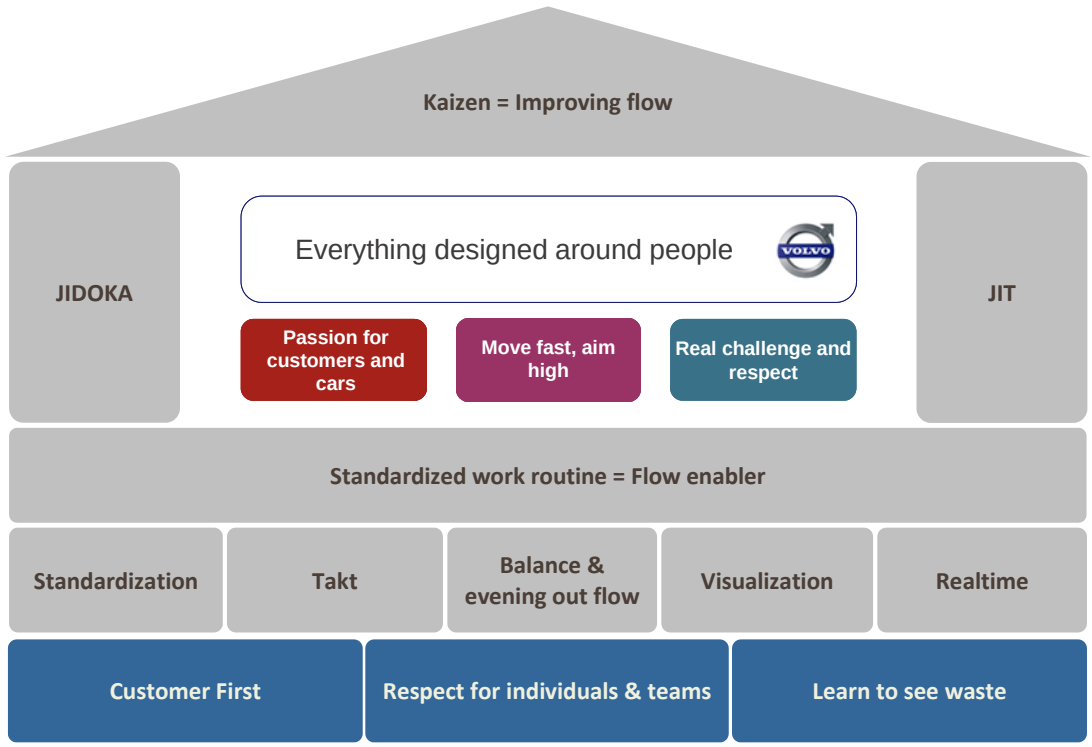


Figure 17, VCCS Lean House

Starting from the bottom is customer first which means that the most important actor is the customer and that all activities shall be performed with the customer in mind. Respect for individuals and teams means respecting all persons working and making it able for each individual to influence their own situation. Learn to see waste is an important aspect of focusing on the customer by being able to identify what activities that do not add value to the customer (Westberg, 2010).

Standardization refers to the standardization of activities to reduce variation and Takt is a crucial factor in the white collar sectors of VCCS just as it is in the blue collar sectors of VCCS. Balance & evening out flow means creating a flow that does vary and provide a stable situation among individuals and teams. KI/VP is an important aspect of visualization but visualization includes visualization of takt, project status and issues etc. Real time means that the current status is visualized and issues are dealt with right when they appear. It also includes working with up to date information and having close connection between activities that facilitates direct feedback (Westberg, 2010).

Standardized work routine = flow enabler differs from standardization by focusing on standardizing the flow instead of standardizing the activities. JIDOKA can be translated into automation with a human touch and means that production is stopped when abnormal conditions appears. That prevents production of defect products and builds in quality in the process. The next important factor is JIT. It means that products shall just be produced when they are needed and in the quantity that is needed. Kaizen is the roof of the house and means continuous improvement. When it comes to this Lean house, kaizen is focused on improving the flow by constantly improving in small steps (Westberg, 2010).

4.1.3 Current Operations

In order to explain the current operations, the VCCS Lean house is used. The house consists of important factors needed to be able to achieve a takt based and visual flow and upon that improve the operations. For that reason, all blocks that represent the house are covered in the explanation of the current operations and are described as they were when this thesis started.

4.1.3.1 Customer First

Customer first is connected to how the organization deals with feedback from the market, called Tie-cases. Employees at workshops around the world reports when they detect errors in the spare part catalogue, issues with the repair methods or if they think that the standard time does not correspond to the actual time it takes to perform the repair. When doing so the workshop decided to whom they shall give the feedback, the PT team, the PRI team or the VSTG team. That team is then responsible for analyzing the case and providing a solution for the customer and the workshop. This work was not performed in accordance to any standard. Sometimes the team leader delegated the cases to team members and sometimes the team members received the case without the intermediate team leader. It was then up to the individual team member to take care of the case and respond to the workshop. None of the teams had a systematic way of finding the root cause of the problem and solve that issue. Instead the consequence of the problem was solved and there were hardly any information sharing among team members or teams, preventing similar problems from occurring again.

4.1.3.2 Respect for Individuals and Teams

The usage of KI/VP is essential when talking about Respect for individuals and teams and by using the board to plan every persons work, each team member is respected and their time valued. Neither of the teams planned all their work on the board, which indicates improvement possibilities for all of the teams. However, all team members in all analyzed teams explained, to some extent, what they should carry through that day, which is connected to Respect for the individual.

The usage of the KISP-VP boards is also essential when it comes to respect for the team. By visualizing issues and closely follow up the work progress, problems are surfaced early and the team leader is able to escalate problems to the next level in the hierarchy. In that way the team receives help and it is easy for the team to show that external factors affects the work, making sure they will not be blamed for something that is beyond their ability to affect. The PRI team gathered information about external issues affecting the work but they did not visualize them. Upcoming issues at the PT team and at the VSTG team did sometimes make its way to the issue box on the KI/VP board but the usage of the issue box did, in reality, not contribute to increased respect for the team. Further, when mapping the flow and creating the element sheets, most of the work has been performed by the team members themselves. That is another activity connected to respect for individuals and teams.

4.1.3.3 Learn to see Waste

Learn to see waste consist of learning to see all the seven waste, something that neither of the teams worked with in a systematic way. However, defects are a waste that all the teams worked with systematically by measuring the number of quality issues from the market and the time to respond on those cases. Waiting is a waste that in this case often was an effect of problems with either hardware or software, stopping or slowing the work. At the PT team, when issues are surfaced, either the team leader or one of the team members gets responsible for solving the issue. At the PRI team the team leader made a note on a Post-it each time there was a system failure or something else that stopped or slowed down the work, and put the Post-it in a book. Regarding the VSTG team, the team leader made a not in a book and raised the issue to management if the issue was serious or repetitive.

It is obvious that waiting in this value flow also occurred as an effect of multiple handovers, lack of planning and insufficient communication within and between the teams. Neither of the teams worked with the process of learning to see this type of waste. On the daily meetings, team members mentioned if they could not work because they waited for information or inputs from another team but it was never visualized or progressed in a way to learn to see that type of waste.

4.1.3.4 Standardization

All of the studied teams worked in some way with standardization and used element sheets for specific parts of the work. The usage of element sheets and standardized work tasks varied among the teams but neither of the teams used the sheets in their daily work, securing that the work followed the standard. The PRI team divided their work into blocks, with element sheets for each block, making it possible to keep track of the progress of the work, but as for the other teams, the detailed standard instructions were not followed. The VSTG team used the element sheets and the standardized work tasks more like instruction manuals for new employees than as a way to reduce the variation between the team members.

4.1.3.5 Takt

Both the PT team and PRI team had introduced the term Takt. The PT team had developed a takt for the work before a specific gate and for the updating job before new releases. The PRI team was the team that had made the most out of takt and used it in their main production. In that case, the takt was based on how many methods the group should develop each week and was calculated based on total amount of methods to develop during the current project divided by the number of weeks for that project. Because of that, the takt did not correspond to the definition of takt, which are a unit of time and not a unit of numbers. The takt at the PRI team was defined not only on finished methods but also on started, if the actual method was created and if it was verified. The VSTG team did not work with takt at all, but measured how much the team produces.

4.1.3.6 Balance and Evening out Flow

There were big variation in the flow and neither of the teams worked with balancing and evening of the flow in a structured way. There was no balancing or evening of the flow between the different teams and there was no structured way to balance the workload within the team. The inputs from R&D varied a lot, which affected the workload for the PT team and escalated through the flow, giving the VSTG team a workload that varied and were neither balanced nor even. Within the teams, as mentioned, there was no structured way of balancing the work but it happened that persons during the morning meetings decided to help each other out because it was clear that one or more persons had more work than the others.

4.1.3.7 Visualization

Visualization is something that all the teams worked actively with. The usage of KI/VP boards were something that all three teams worked with every day but the way of working with the boards varied. The PT team was the team with the least progress in usage of visualization and KI/VP boards, just gathering around the board every morning without actually using it. There were just a few Post-its on the board and it was hard to follow the work progress. However, there were diagrams showing how well the met their deadlines and how well they responded on TIE-cases. Regarding the PRI team, the usage of the KI/VP board was insufficient but there were still some Post-it´s showing deliveries and activities. The progress of the current week was visualized through a paper where each team member draws a line for each step in the progress of developing a method. The takt itself was also visualized which made it possible to understand the status of the week, but there were nothing visualizing the overall status of the different projects. The VSTG team used the KI/VP to the same extent as the PRI team did but lacked the visualization of the status of the current week that the later had.

4.1.3.8 Real time

Real time is something that all of the teams had a hard time to understand and because of that there were no focus of working according to a real time system. Since all of the teams lacked experience of working with the KI/VP boards, the real time aspects of the boards were missed. Neither of the teams used Post-it´s to plan their actions and tasks and in that way they all got a hard time getting real time feedback on their progress. There was some sense of real time connection between the PRI team and the VSTG team because the lead times between the two teams are fairly short. In the cases when the PRI team delivered in small batches the goal of achieving real time was met, but when batching the work, there was not much of a real time system. The absence of real time in the connection between the PT team and the PRI team was obvious because of the long lead time between the two teams. In many cases, information made by the PT team could wait in the system

for a year before the PRI team actually started to work with it. In that way the feedback was far from direct and the absence of real time was obvious.

4.1.3.9 Standardized Work Routine = Flow Enabler

When looking at the aspect of enabling the flow through a standardized flow, all teams can be viewed as one unit, working together throughout the flow. Since the flow, from the PT team, through the PRI team to the VSTG team, is not defined, it is not standardized. The sequence of performing tasks and who shall perform them are not standardized and there is no focus on the entire flow, just on specific isolated parts of the flow.

4.1.3.10 JIDOKA

The wide term of JIDOKA includes some of the other blocks in the house like standardization and visualization but also aspects like Poka-Yoke and Andon. As earlier mentioned, all teams have standards but the usage of the standards varies. Poka-Yoke are more or less absent but verifying the methods on a real car before handing them over to the next instance can be viewed as one type of JIDOKA that the PRI team had. The VSTG team had no quality assurance and when it came to the PT team, the closest thing to JIDOKA was the incorporation of team members from PRI team when creating the spare part structure.

4.1.3.11 JIT

Looking at the entire flow, from creating the spare part structure to setting the standard times, there are a few activities that can be categorized as JIT. There are no indications of a JIT system between the PT team and PRI team though the information often sits idle for a year before the later instance starts working on it. The connection between the PRI team and the VSTG team can sometimes be considered JIT. That is when the methods are delivered one by one and not in batches that sometimes is the case. When delivered one by one in a one piece flow and team members at the receiving instance can start setting the standard time directly, the system can be viewed as JIT and the PRI team gets direct feedback on the work. Often more methods are produced then the person at VSTG team can handle and sometimes team members at the VSTG team do not receive enough methods to continue working, which indicates that the system are far from JIT. So with a total flow perspective, there is not a JIT system but when looking into specific parts, JIT is sometimes used.

4.1.3.12 KAIZEN

All teams work with improvements and try to eliminate waste in the system and in their part of the flow. However, since there is no standard followed, the improvements are not conducted in a structured way and cannot be considered as Kaizen. When working with flow mapping, the PRI team has started to consider changing their standards and element sheets which is continuous improvements through kaizen.

4.1.4 Existing Problems

By mapping the flow and analyzing the current operations through observations and interviews, several problems preventing takt based and visual flow have been identified. The identified problems are problems that can be connected to takt, flow or visualization though that is the scope of the thesis.

Through observations and by attending daily and weekly meetings, problems with information from previous steps in the process have been identified. 3D drawings were late several times, especially on the panel board. Another problem experienced are that models in the software Visualizer often got lost and made it impossible to continue working on specific methods for the PRI team. Further, there were several more problems with the used software and persons working in the teams often told that SPIE and NEVIS was slow, making the workers spend a lot of their time waiting. PRI team complained that they could not open the RCE and it was observed several times that VIDA-draft did not work at all.

- *3D drawings late to panel board*
- *Lack of visualizer models*
- *SPIE and NEVIS is slow*
- *PRI team could not open RCE*
- *VIDA draft do not work*

By attending the daily meetings and talking to team members and team leaders it become obvious that the number of methods produced at PRI team did not correspond to the actual work produced. Number of methods left to do in the project did not tell how much work that was left. The team members also had a hard time knowing how many methods the group had to do in each project and it was even harder to know how many methods each team member had to do in each project. In close connection was the difficulty to follow the progress for each project and each person. That complicated the work of the team leader to define project status with facts and not only on feeling.

- *Number of methods left do not correlate with how much work is left*
- *Hard to see how many methods the groups has left*
- *Hard to see how many methods each individual has left*
- *Hard to follow each person´s progress*
- *Hard to demonstrate status through fact and not subjectively*

When focusing on the approach for dealing with TIE-cases and attending daily meetings for all of the teams it was observed that the VSTG team solved TIE-cases that actually were meant for the PRI team got no information about those TIE-cases at all. By attending daily meetings at all teams the flow of products and information could be followed, surfacing the problem of the VSTG team having nothing to do while project repair information team was overloaded. Connected to that were also the problem that the VSTG team did not know when they would receive information and methods so they could continue working. When mapping the flow it became clear that there are several activities that are performed by more than one team throughout the flow. Comparison of methods and verification are two examples of activities that were performed by both the PRI team and VSTG team.

- *VSTG solves effects of TIE cases where the cause is due to wrong methods*
- *PRI team do not receive information regarding TIE cases that concerns them*
- *VSTG team members are waiting for work*
- *VSTG do operations that already has been done by the PRI team*
- *VSTG do not know when they will receive methods to work with*

- *Unclear when one should verify, before or after production*
- *Unclear when tool orders shall be made in the method assessment*
- *Unclear regarding how handovers shall be done*
- *Late change orders*
- *The work content vary heavily between different projects for the PT team, the PRI team and the VSTG team*

Further, mapping the flow surfaced the problem of inconsistency among team members regarding when in the sequence of activities to verify the products produced. When to order tools were not defined either and the hand over's between teams were not defined, resulting in missed information and long lead times.

Interviewing team members on what they currently worked on and how much work they had surfaced the problem of variation of quantity of work. Connected is the absence of measures when the work did not progress according to plan and late changes in construction changing the job scope for projects and making rework necessary.

As earlier mentioned, when to verify the work was not defined and that made it even harder to plan for test vehicles, which resulted in a lack of test vehicles when they were needed. Another problem observed is the lack of consensus regarding deadlines. It was obvious, several times, that team members did not know when the deadlines were and what the deadlines accounted for. Because of the ever changing method estimation the job scope of the projects changed throughout the project, making the takt at project repair information team useless. Further, the daily meetings showed a lack of understanding of what deliveries each team and each person should deliver and when it was due.

- *Missing test vehicle for verification of methods and times*
- *Confusion regarding when project deadlines is due and what the deadlines is accounted for*
- *Methods assessment is changed during production phase*
- *Unclear guidelines when the method assessment shall be completed*
- *Unclear which deadlines the group and individuals has*

- *Do not plan the work at the KI/VP board*
- *Lack of involvement from team members at the KI/VP meetings*
- *KI/VP feels like an extra work load*
- *The Post-it system does not add anything*
- *The board structure is hard to follow*
- *No actions taken when the takt is not followed*

The KI/VP boards were not used as indented and team members did not plan their activities and deliveries. It was seldom a problem focus on the meetings and during interviews team members told they saw the Post-it´s like an extra burden. They did not see what the KI/VP board brought to them and they had a hard time understanding all the information on the board.

When looking at the received TIE-cases, images and links were often missing. Another common problem was that the method did not represent the intended car model and the time for performing the job did not match the actual time performing it.

- TIE cases is received on that pictures is missing in the methods
- TIE cases is received on that the time for reparation is wrong
- TIE cases is received on that links is missing
- TIE cases is received on that methods is not accurate according to the car

4.2 External Interviews and Field Trips

During this Master thesis several interviews, with experts within the area of Lean and operational development, was conducted. The interviews were conducted in order to receive empirical data used to validate the general concepts developed and to facilitate turning general concepts in to specific concepts. In order to expand the empirical research and to gain hands on information and inputs, three field trips to different companies was conducted. The field trips made it possible to examine if there are companies using any of the developed general concepts and if they thought the concepts would work in their organization. The visited companies are Thermo Fisher Scientific, a company located in Uppsala, Sweden, mainly working with systems for allergy diagnostics, SCANIA CV AB, a company within the automotive industry with its base in Södertälje, Sweden and RUAG Space AB, a company in the space industry with its Swedish head office in Gothenburg. During the interviews and the field trips, the general concepts were presented and discussed.

The expert interviews and companies together formed the empirical results, seen in Figure 18, which by the feedback from the interviewees could be categorized into the following aspects, Visualization, Flow and Takt. Many of the persons interviewed and the persons met at the studied companies emphasized these particular aspects and explained their importance for a well functioning organization. This subchapter will present these principles and why they are of importance according to the interviewees.

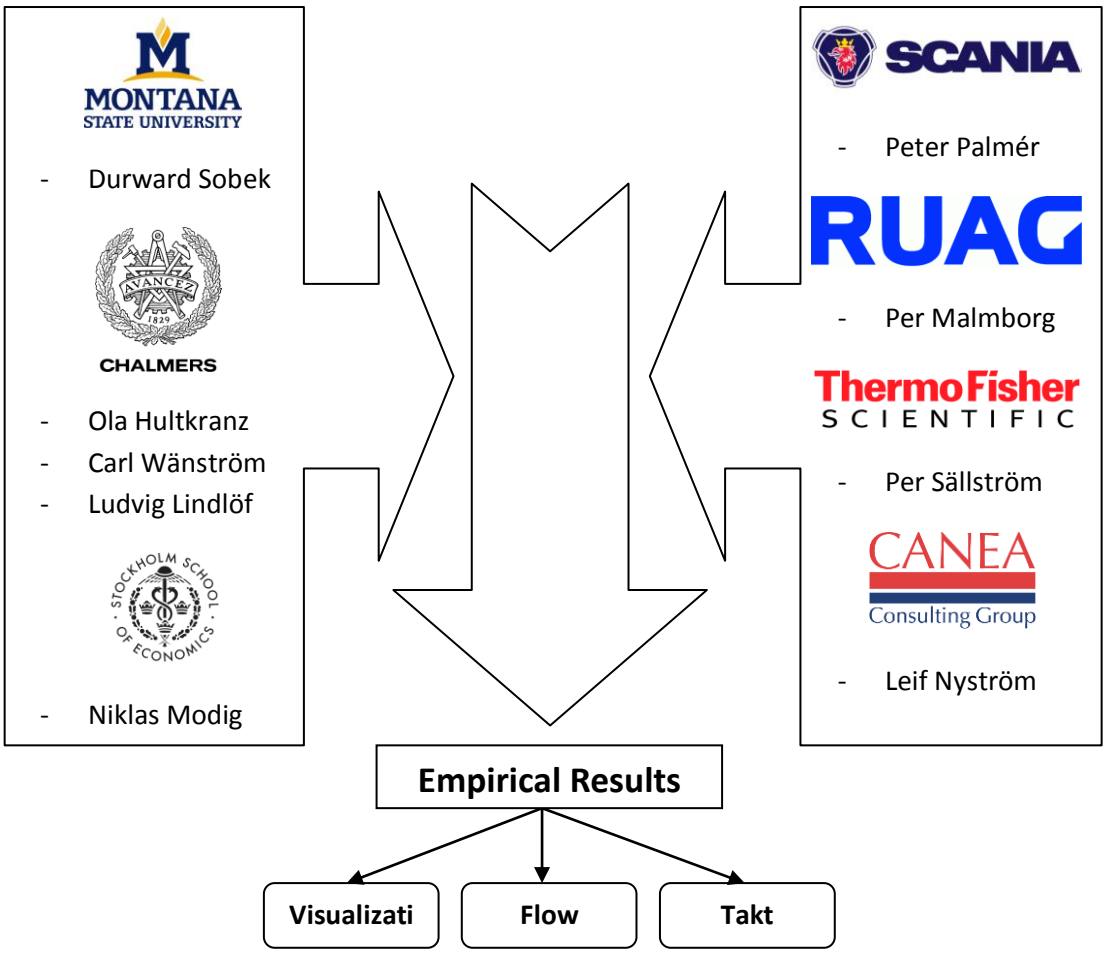


Figure 18, Expert interviews and Companies forming the Empirical Results

4.2.1 Visualization

According to Palmer (2012), visuall planning is the first step when talking in the terms of a takt based flow and visualization is not only to facilitate planing, it is a communication site where knowledge is spread among team members. The primarily use for visualization and in particular visual planning is to facilitate interteam communication and to break a project into smaller parts (Sobek, 2012). Further, the most important things to visualize is, according to Sobek (2012), limits and goals. In relation to that is visualization of knowledge gaps and what issues that complicates the production. Nyström (2012) shares that opinion when he emphazises the importance of visualizing when information or products get stuck. Sällström (2012) emphazises that one of the primarly uses for visual planning is that the team starts to reflect over the current operations and starts to measure. When working with visuall planning, Palmér (2012) emphasizes the importance of focusing on problems and not on information sharing and for that reason, all problems has to be visualized.

In order to get the full use of visualization, it has to be actively worked with and updated. In order to achieve a culture of actively working with the visualization and updating the visual planning, it is of importance that the persons working with it has an internal need of coordination and communication(Lindlöf, PhD-Student, 2012). Lindlöf (2012) also points out the importance of the leader that has to show commitment to visualization and make an effort to proceed with the work. Palmér (2012) shares that opinion and adds that team members that feel that they contributes to the development of the visualization gets more insprired to use visualization in their daily work.

Sobek (2012) means that KI/VP boards might not be the ulimate solution to visulize takt but emphazises the the ability of Post-it´s to visualize wether the takt is followed or not, by signalating red or green. The takt itsels can instead be visualized with a burn down graph showing the progress of the work. By the usage of a burndown graph it is possible to determine the resources needed to the next deadline (Sobek, 2012). When using a burn down graph it is important to determine the allowed margin of error and decide when to escalate problems and whitin which margin which person is responsible (Hultkrantz, 2012).

Wether the takt is followed or not is in connection to the status of work or project, something that ThermoFisher visualizes. ThermoFisher uses a rule, the 1:3:9-rule, where it shall take one second to determine wether the project is in phase of not, three seconds to understand what the problem is and nine seconds to understand the what is made to solve the problem. Visulazition is the key to follow this rule and ThermoFisher uses the principles of KI/VP in a structured way to achieve this. Further, Lindlöf (2012) means that all teams using visualization do not have to do it in the exact way, but elements has to be the same. That aligns with ThermoFishers 1:3:9-rule that is dependent of that the person viewing the board recognize themselves. Palmér (2012) agrees when explaining that standardization is finding key points, not copying a whole system.

4.2.2 Flow

According to Modig, (2012), flow is what all organizations has to focus on before starting to improve the organization in any other way. It is more important to focus on the flow efficiency than it is to focus on resource efficeny and because of that, the whole flow has to be included when improving operations. In order to do so, all functions involved in developing a product has to be responsible for the product and understand the flow that is creating value for the customer(Modig, PhD student, 2012). Further, Modig (2012) emphazises the importance of creating a standard for the entire flow and not just specific parts of it. That is a prerequisite for the incorporation of shared responsebility for the end product.

Modig (2012) explains the alternative of using pull when it is impossible to create a continouos flow. In an ideal world that would mean that products are only produced when a customer needs it but in reality, pull is often created in the pacemaker process, which is the process in the flow that determines the pace. Hultkrantz (2012) also explains the concept of pull but clarifies that a pull system has drawbacks like the creation of bufferts. Therefore it is important to keep track of the inventory in the system, work in progress and the buffers. Hultkrantz (2012) emphasize, just as Modig (2012) ,the improtance of understanding the flow and based on that measure and analyse inventory in the system to detect waste. Nyström (2012) shares that opinion when explaining the importance of having a manageable number of flows and stopping the production when the system is overloaded. A Kanban system can be used in the purpose of making sure the system is not overloaded and is a way to create pull.

A prerequsite for achieving a system with a paced and smooth flow is, according to Nyström (2012), to have small variation and that requires an understanding of the flow and a standardization of the flow. Sobek (2012) has the opinion that an organization should flow everywere it can, and pull where it must. In order to do so, the capacity has to be known. There is allways some natural vairation which, with a high capacity utualization, has to be minimized (Sobek, 2012). Modig (2012) is of the opinion that in order to achieve a good flow efficiency, the recusoure utulization has to be sacrified in the beginning. It is more important to focus on the flow than the recources when improving, even though both the flow and the resource utuization is of improtance when creating a well functioning organization. Sobek (2012) explains the phenomenon as a trade off between buffering with capacity or buffering with lead time.

A prerequisite for good flow is that employees can perform more than one task and is able to work both up stream and down stream in the flow (Nyström, 2012). Palmér (2012) shares that opinion and explains that it is common that factory workers, when they are able to perform their own work tasks correctly, starts working on down stream tasks. When these task also are performed in a correct way, the worker moves back to its original work before moving even further up stream. That creates a good understanding of the flow and creates a flexible system where emoloyees can fill in for eachother. This also give insights in the situation for adjacent process, something that increases the comunication and the coordination throughout the flow and facilitates both planning and execution (Sobek, 2012).

That aligns with the aspects of aligning the organization according to the flow and not according to specific functions that Lindlöv (2012) emphazises when he explains the importance of the need for communication and coordination among team members within a team. When team members are interrelated the insentives for actively plan activeiys and helping eachother throughout the flow

increases (Lindlöf, PhD-Student, 2012). Modig (2012) shares that opinion, that there are greats benefits when creating work teams based on the flows, but mentiones the drawbacks aswell. The drawbacks are, according to Modig (2012), the reduced knowledge transfer that can occur when using a flow organization instead of a functional organization. The functional organization has the advantage of gatherig expertice knowledge and make person good at what they are doing. Sobek (2012) agrees upon that and includes the risk with not having persons working with similar tasks located at the same place in on office environment. Advices and tricks will be kept to each individual and competence will not be spread in the same way as with a functional organization. However, Sobek (2012), explains that on possible solution to that is to work according to the flow but physicaly sit together with persons within the same area of expertise.

The concept of frontloading projects, processes and flows, is something that Modig (2012) emphasizes. Frontloading by planning the progress will turn internal processes to external process and the lead time for receiving informtaion will not effect the lead time for producing the products. Further, frontloading the projects gives a consensus for the projects that is important for the the progress and the flow of the project (Sällström, 2012). An advantage with fronloading is the ability to plan towards the real recources(Malmborg, 2012). Frontloading and planning towards the real resources is in connection to single tasking, which, according to Malmborg (2012), reduces the leadtime for projects and reduces the risk of more than one project missing the deadline. A graphical presentation of the phenomenon of project single tasking is presented in Figure 19 where the upper graph illustrates three projects in parallel and the lower three projects in sequence. Palmér (2012) states the same and explains that it takes longer time to perform work in many projects than it takes to perform work in a few projects. The flows gets more direct and pure when the number of projects are reduced and the insentives for batching work is reduced.

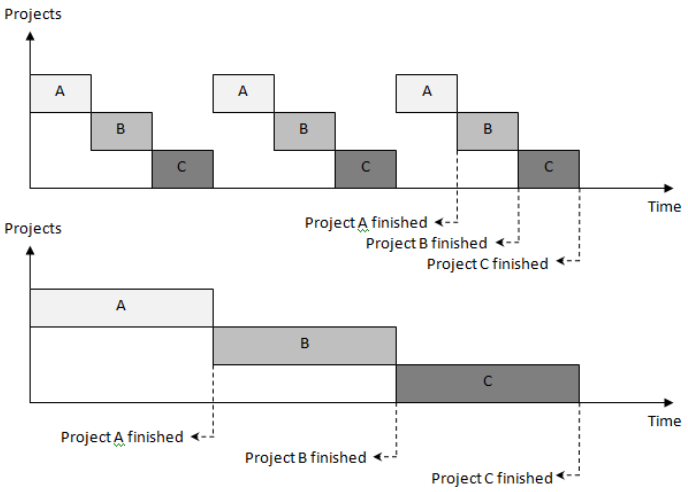


Figure 19, Project single tasking

4.2.3 Takt

When having a takt, it is important to develop a takt that is based on the customer demand and that is able to follow up. The definition of takt is net available time to work, divided by customer demand (Sobek, 2012). However, when using the term takt in white collar organizations, it is often more convenient to use the inverse of takt. That is defining how much units that shall be produced per time period instead of much time for each unit (Sobek, 2012). Further, Sobek (2012) explains that a common problem in white collar organizations is that the cycle time can vary a lot between different tasks. That makes it hard to utilize the takt because the number of performed task does not correspond to the actual work performed. It is natural to start with the easy work tasks and show fast progress, submitting false sense of correct project status, ending up missing the deadline because of hard and time consuming work tasks towards the end of the project. Because of that, both Sobek (2012) and Modig (2012) think a classification of work tasks is a way to reduce the error

of margin between the takt and the reality. The takt can therefore be based on the classification of work tasks instead on the number of work tasks. In order to be able to do so Modig (2012) emphasizes the importance of frontloading the projects and allowing time for resource and time planning.

As earlier mentioned, Palmer (2012) explains that the first thing to do when moving towards a takt system is visual planning and in order to do so, the work tasks has to be broken down to smaller parts and defined. By doing so, it is possible to follow the progress for each individual product and detect exactly where in the process that problems occurs (Modig, PhD student, 2012). That also prevents batching and in that way reduces the feedback lead time. To make use of the takt, the needs of the system has to be defined, the activities standardized and the sequence of the activities set. The proportion and the content of each activity also has to be defined (Modig, PhD student, 2012). When that is defined, it is clear that giving more work to an organization will not result in more output (Sobek, 2012). The capacity has to be known and using 100% capacity will only increase the lead time and reduce the quality.

Sobek (2012) further explains that over producing in one department often results in over utilizing the next instance and increasing the lead time for the total system. A visual system with Post-it´s can be used to quantifying how much that is produced and how much each person or team has in work in progress. The takt can be based on those Post-it´s which also creates visual inventory surfacing problems. Hultkrantz (2012) supports the idé of visualizing work in progress to surface problems and set a limit to prevent overproducion.

5. Analysis – Problem Generalization and Prerequisites

In this chapter the analysis will be presented according to the method model earlier presented and it is based on the theoretical framework and empirical results. The objective of this analysis is to answer the first three earlier stated research questions. The chapter is introduced by answering the first research question regarding what problems that currently exist in the organization that prevent takt based and visual flow to work successfully.

Through the applied theory, prerequisites for takt based and visual flow was established and hence answers research question number two, namely what prerequisites are needed in order for a paced and visual flow to work at VCCS. The third research question refers to which important general concepts that needs to be focused upon in order to create a paced and visual flow at VCCS and has been derived from the general problems, prerequisites and the theory. Finally the general and specific concepts will be presented in a combined manner and thereby denoted general and specific models.

5.1 Categorized and Generalized Problems

From the interviews, observations and flow mapping, a number of issues was discovered that prevent the foundation of paced and visual flow to work. These issues has through the KJ Shiba method been categorized, these categorizations has then been raised an abstraction level in order to create general problems.

5.1.1 Influences that Interfere the Flow

As explained in the empirical results, promised 3D drawings was in many cases late and parts of visualizer models was lacking or even missing. These specific issues has been categorized to that there are availability and quality issues regarding the 3D models since them both regard the 3D models. Related problems that was discovered was also that systems like SPIE and NEVIS sometimes was slow, the PRI team could not open RCE and that VIDA Draft sometimes did not work. These issues was categorized to that the system reliability is low since they are all IT systems that is hard to change and therefore heavily affect the work. These two categories has then been raised an abstraction level and thereby generalized to “influences that interfere the flow”, see Figure 20.

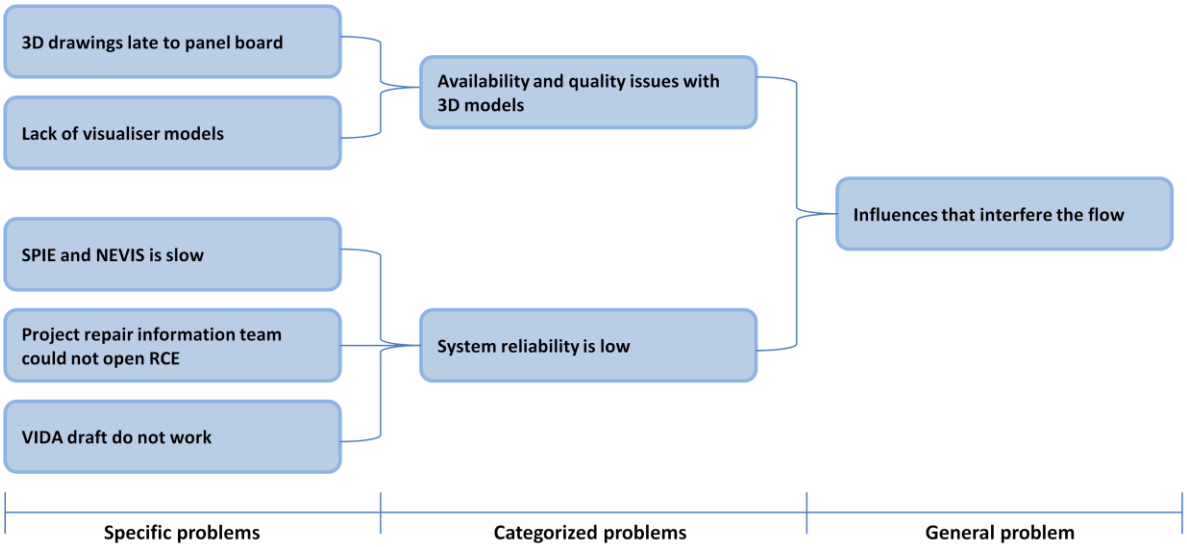


Figure 20, Categories and General Problem connected to "Influences that interfere the flow "

5.1.2 Difficult to Determine Project Status

It has been found that the amount of methods left do not correlate with how much work is left, this in combination with that it is hard to see how much work each group and individual has left makes it hard to demonstrate a status through facts. This also contributes to the difficulty of following a person's progress and being able to deploy help measures proactively. These issues has all been categorized to that current production progress toward deadlines is hard to know since all issues has the common factor of communication. The increased abstraction level of the categorized problem that current production progress toward deadline is hard to know has led to that it is "difficult to determine project status", see Figure 21.

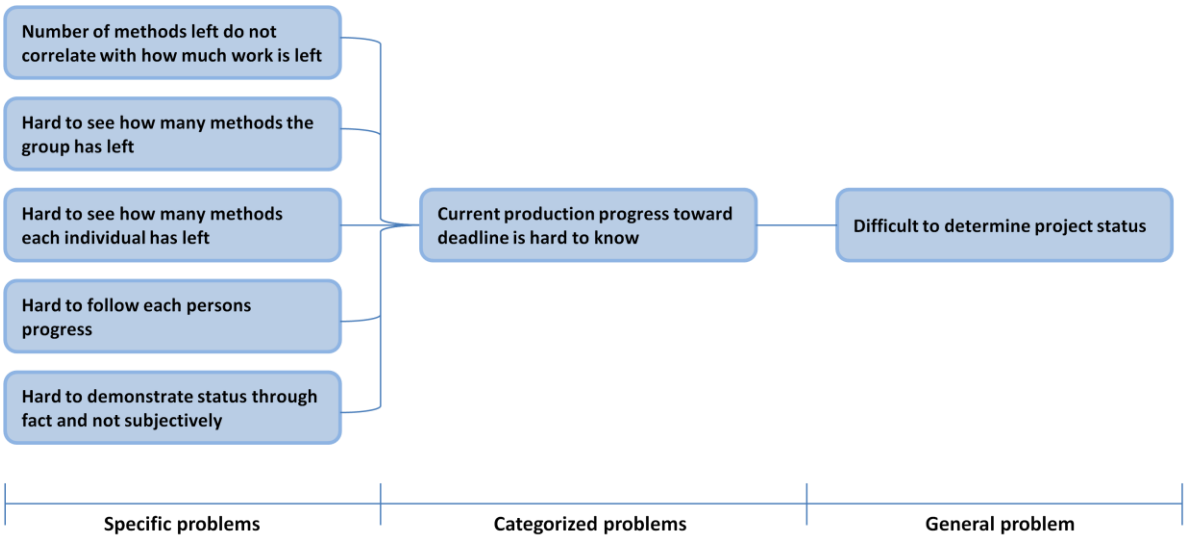


Figure 21, Categories and General Problem connected to "Difficult to determine project status"

5.1.3 Lack of External Communication and Coordination

When attending meetings along the flow issues regarding that VSTG solve TIE cases by changing the times when in fact it is actually the method that is wrong and thereby also the time. It also became obvious that the PRI-team did not receive information regarding TIE cases that actually concerns them. Through observations it also became clear that sometimes the VSTG-team is at a standstill due

to that they are waiting for work from previous departments and that they do not really know when they will receive it. From the flow mapping it also became clear that activities in the flow are made several times by different departments. These issues has been categorized to that the different departments do not communicate with each other regarding planned deliveries, workloads and issues since they all depend on efficient communication. The categorized problem was then raised an abstraction level to “lack of external communication and coordination”, see Figure 22 .

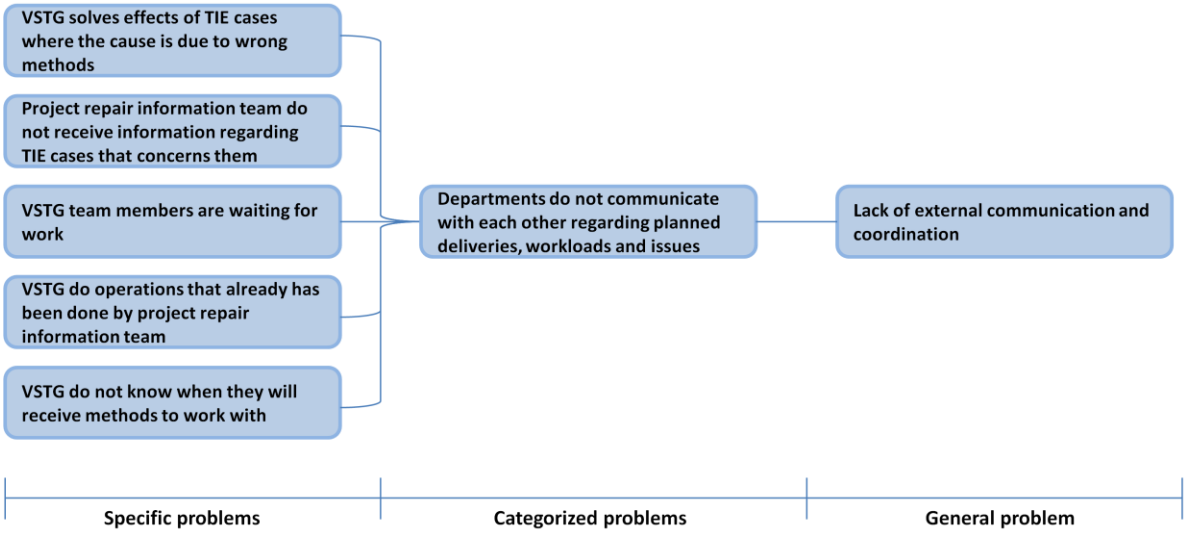


Figure 22, Categories and General Problem connected to "Lack of external communication and coordination"

5.1.4 Flow Variations

From the flow mapping it was also revealed that uncertainties could be found when one should verify a method or a standard time. Unclearness was also found regarding when tool orders shall be made as well as how handovers shall be performed between departments. These issues has been categorized to that there exist confusions regarding sub operations and its sequences.

Interviews revealed that late change orders were common and that the work content differed heavily between different projects both for each resource and between departments. These issues have been categorized to fluctuation and uncertain work input since they both have the common factor that they interfere with achieving a leveled and predefined workload. These categories has then been generalized to the common issues of “Flow variations”, see Figure 23.

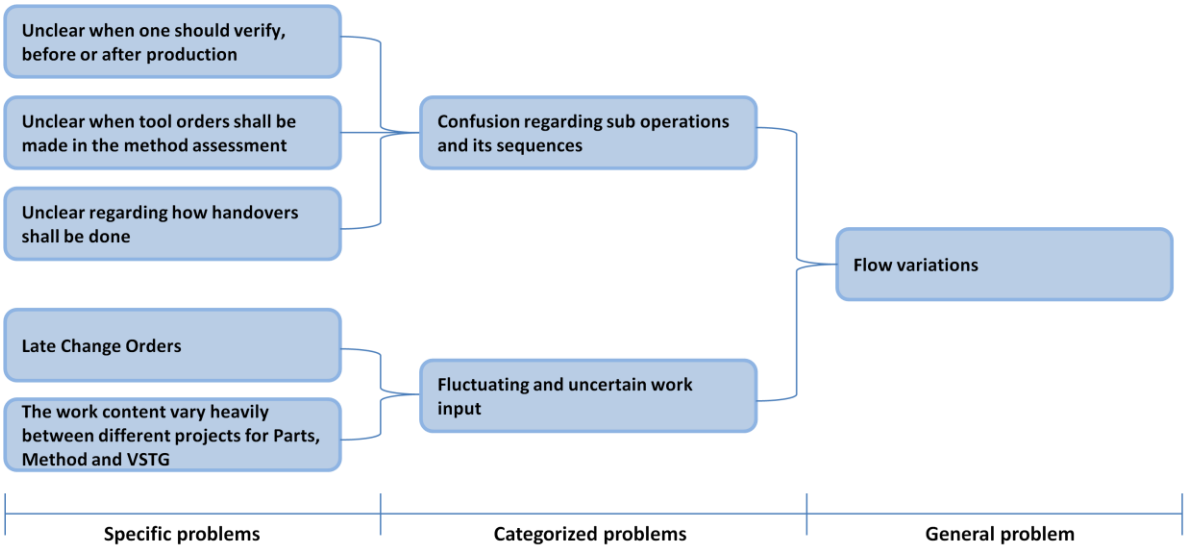


Figure 23, Categories and General Problem connected to "Flow variations"

5.1.5 Lack of Planning

Missing test vehicles for verification of methods and times, confusion regarding when project deadlines is due and what they stand for is some of the issues that surfaced then performing interviews and observations. It was also revealed that the method assessment is changed during the projects production phase which combined with the previous two problems can be categorized to that there exist a lack of insight in project contents.

It was also found that there existed confusion regarding when the method assessment shall be finished and which deadlines both the group and individuals has to stick to. These issues has due to their lack of insight in the projects been categorized to that there exist confusions regarding what and when things shall be done in different projects. These two categories has then been generalized to that there exist a “Lack of planning” since they both are effects of inadequate planning, see Figure 24.

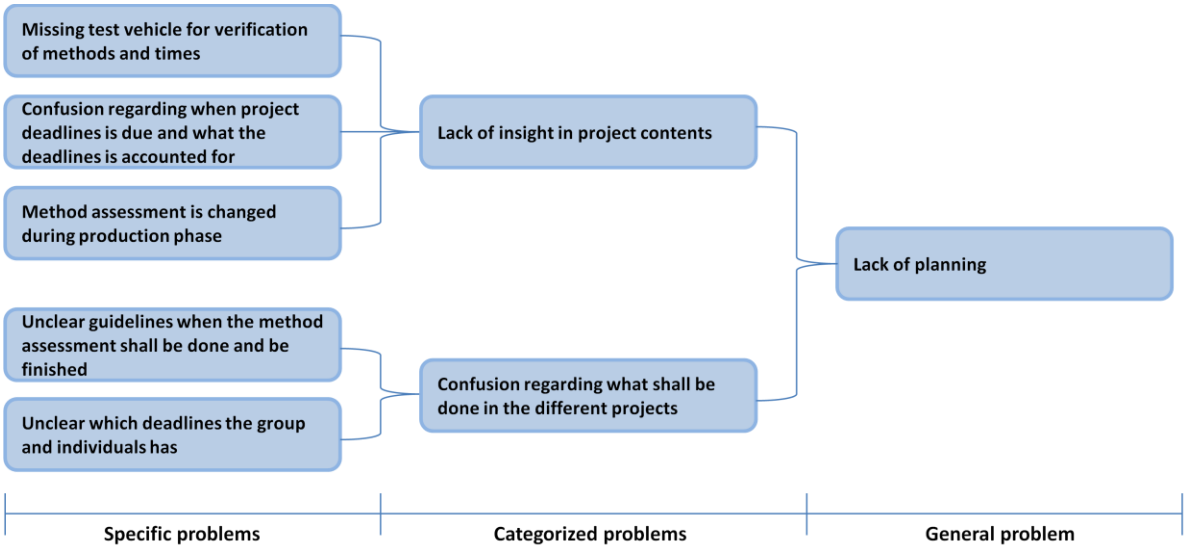


Figure 24, Categories and General Problem connected to "Lack of planning"

5.1.6 Inefficient Internal Communication

From observations at the daily meetings it became obvious that they do not plan the work at the KI/VP board, there also exist a lack of involvement from team members and that the KI/VP meetings therefore feels like an extra work load. Further it has surfaced comments like that the Post-it system does not add anything and that the board structure is hard to follow. Observed was also that to specific actions on individual level was taken when the group takt was not followed. These issues have been categorized to lack of structure and usage of the KI/VP meetings since their common factor is that they are all rooted in communication. A generalization of this categorized problem is a widespread lack in internal communication and denoted “inefficient internal communication”, see Figure 25.

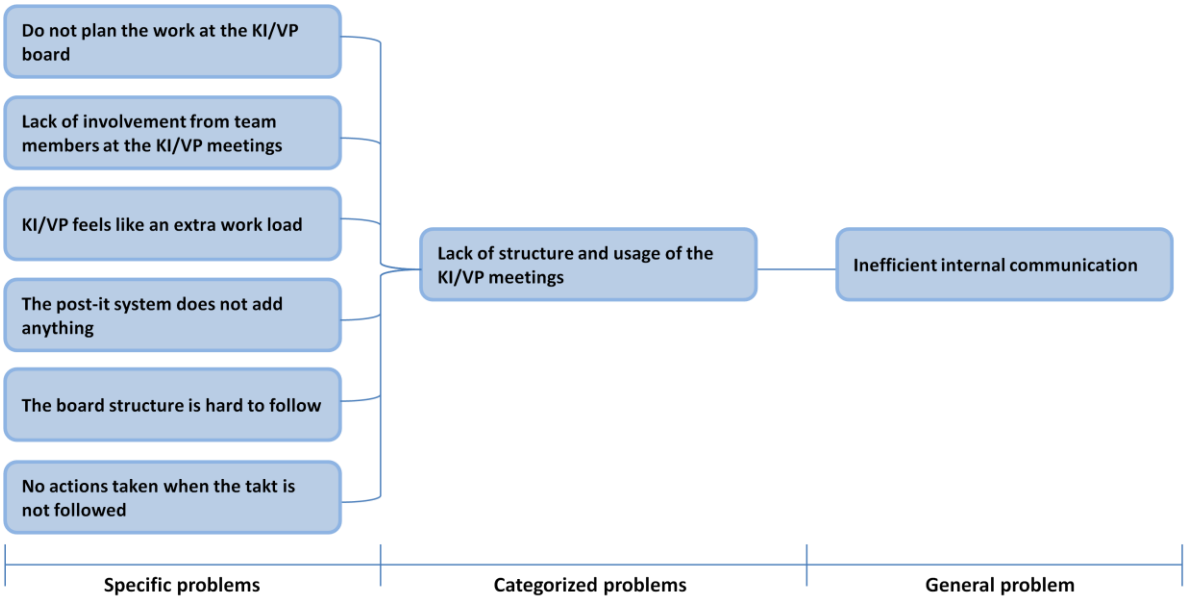


Figure 25, Categories and General Problem connected to "Inefficient internal communication"

5.1.7 Quality Issue

A great amount of time is spent on dealing with TIE-cases which is received by a number of reasons. The most common causes is that pictures are missing, standard times is set wrong, links are missing and that the methods do not correspond to actual car in mind. These issues has been categorized to incorrect methods and standard times and generalized to “Quality issues” since all of them are a cause of lack of quality, see Figure 26.

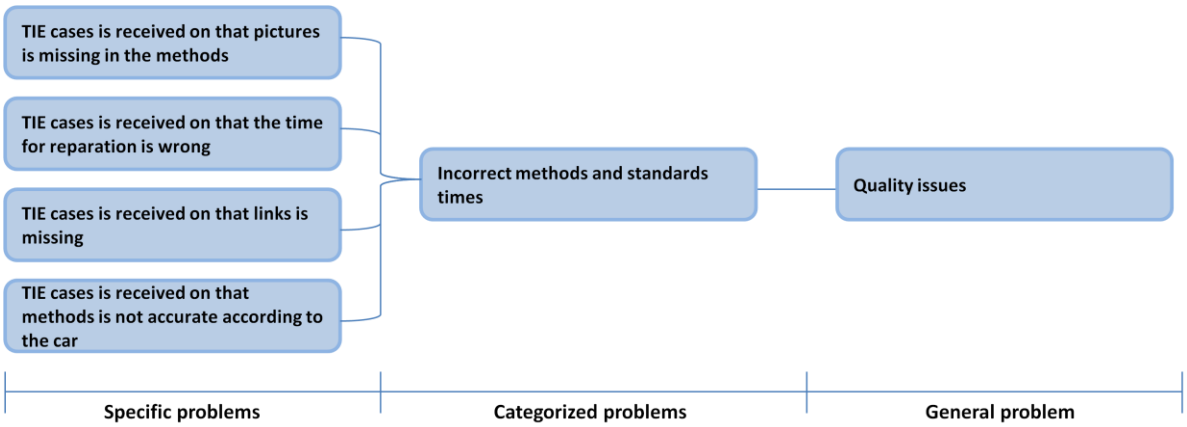


Figure 26, Categories and General Problem connected to "Quality issues"

5.1.8 Categorized Problems

Research question number one concerns what issues exist in the current organization of the analyzed flow, which is the problems described in the previous sections. However, in order not to be too specific and focus too much on details, it is better to answer research question number one at the level of categorized problems. Therefore, the answer to research question number one, What problems exist in the current organization that prevents visual and takt based flow, is the presented categorized problems and can be seen in Figure 27.

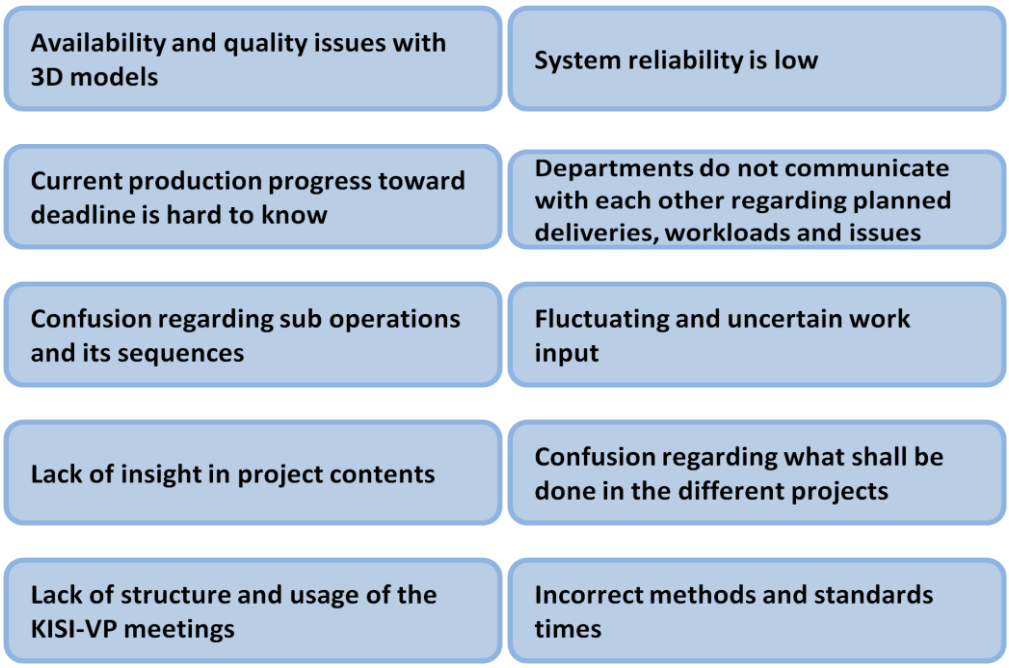


Figure 27, Problem categories derived from specific problems

5.2 Prerequisites

Prerequisites for a paced and visual flow at VCCS have been developed in the purpose of not overlooking important factors that the analyzed organization performs well, not having issues with. The general problems derived from specific and categorized problems have been used as a base for identifying important aspects for paced and visual flow that the organization fulfills. Theory has then been applied on those aspects to develop prerequisites that will be explained throughout this chapter. The prerequisites are also the answer to research question number two, What prerequisites are needed in order for a visual and takt time based flow to work at VCCS?

5.2.1 Stable Processes

One thing that worked well in the organization was the competence deployment among team members. That is, according to Liker (2004), important when it comes to performing work that produces products with the right quality and reviles problems in the process. Great competence gives team members the possibility to identify problems in the process and in that way stop production to get quality right the first time, which is one of Liker´s 14 principles. Morgan and Liker (2006) also empathizes the importance of seeing and recognize abnormalities in order to create stable processes and in that way achieve a takt based flow. Shingo (1992) states that processes is flow transforming raw material in to finished goods and Liker (2004) explains the importance of standards in order to achieve a good flow, something that the teams has started to work with. Without the processes a flow cannot be achieved and in order to reach a paced flow, the processes have to be stable.

Stable processes are also important when it comes to visualization and the reason is that visualization of results from unstable processes is likely to show inconsistent information (Liker, 2004). All teams had clearly defined and visual vision, mission, goals and KPI´s which is, especially the KPI´s, important for the visualization of the flow (Eppler & Burkhard, 2007). Further, stable processes are a prerequisite for proper handovers which, according to (Hines, Francis, & Found, 2006) shall be visualized in order to achieve a takt based flow.

5.2.2 Understanding the Flow

When mapping the flow, it has been the team members themselves together with the team leader that has performed the mapping. That makes the team understand the flow and in detail get the whole picture of how the products are produced. Hines, Francis, & Found (2006) emphasizes the importance of visualizing the flow so that all team members can see what their tasks is, what everyone else is doing and where handovers are performed. That gives the desired understanding of the flow and how activities are linked.

The teams visualization of vision, mission, goals and KPI´s previously mentioned are, according to Eppler & Burkhard (2007), important for the understanding and communication of the flow. All team leaders are involved in the work and have a great knowledge in the details of the performance. Team leaders sometimes help team members perform the tasks and by doing so, Liker (2004) explains that the leader's of the business gets an understanding the operations and the flow. That is concluded in the principle of "Go and Wee for Yourself to Thoroughly Understand the Situation (Genchi Genbutsu)". Womack, Jones, & Roos (2007) have the same opinion and explains that a team leader shall fill in for absent workers, coordinates the team and helps solving problems. That makes the team able to work in a customer driven flow, solving problems quickly and understand the activities in the flow.

According to Morgan & Liker (2006), understanding the flow is as important in white collar organizations as it is in manufacturing. The absence of visual products makes it even more important to focus on understanding the flow and in that way detect waste, increasing the value for the customer. According to (Morgan & Liker, 2006) it is vital to, in order to create a takt based and visual value flow, to understand the flow and in that way get rid of the perception of the operations as an uncontrollable series of discrete events. By visualizing the flow and how processes interacts the interdependence of activities are shown and understood by all team members, making it possible to create a takt and visualize the progress (Modig & Åhlström, 2011). Rother & Johan (1999) explains that it is important to understand the flow in order to be able get a paced flow and improve the flow. Visualizing the flow, in order for team members, team leader and managers to understand the flow is critical for the system to run smooth in a paced flow (Liker, 2004).

5.2.3 Balanced Flow

At the PRI team the team members sometimes told the team at the morning meeting what methods they were working on and how they progressed. By doing so, it was possible for the team leader to realize when persons became overloaded and based on that balance the flow. That balancing only affected the internal balancing between team members and not balances over time and along with the flow. The takt introduced at the PRI team surfaced problems with the internal resource utilization and facilitated in that way the internal balancing for the team.

Liker (2004) has included the principle of a balanced flow through leveling the workload. Liker (2004) does not only focus on the internal balance between resources but on leveling the workload over time and the product mix. Without a balanced flow, inventory is created and problems hidden, resulting in a system that is far from visual and impossible to smooth through a pace set by the customer (Liker, 2004). Shingo (1992) explain that in order to improve operational functions, the sequence of processes has to be established, also important for the flow and connected to both the visualization of the flow and the takt of the flow. Womack, Jones, & Roos (2007) emphasizes the importance of having a customer driven production and Liker (2004) agrees but adds the importance of balancing the flow by accumulating orders, synergizing the advantages from a build to order system and a balanced flow to support a takt based and visual flow. The syncronization that is connected to balancing the flow is something that Morgan & Liker (2006) emphasizes when dealing with variation in the flow, preventing the full advantages of a paced flow. Further, Morgan & Liker (2006) states that leveling the flow is essential in order to reduce variation, a prerequsite for a takt and visual flow.

Leveling can be done through frontloading of projects and by frontloading, it is possible to have a total value flow perspective and focus on reducing waste instead of reducing value adding activities which is common in white collar organizations (Morgan & Liker, 2006). The balanced flow is also a prerequisite for the usage of takt because variation in the flow makes the takt go up and down, building waste in to the system. In order to be able to cope with the peaks in the flow, a lot of resources will be allocated to the flow, resulting in a lot of waiting in periods with low demand. Alternativly, there will not be enough resources when the demand is high leading to the waste of Muri, overloading processes (Emiliani, Stec, Grasso & Stodder, 2007).

6. Model Generation and Evaluation

This chapter explains the generation of a general and specific model through the development of general and specific concepts. First, the General Concepts are explained, followed by an explanation of the General Model. Further, the Specific Concepts, the Specific Model and an evaluation are presented in order.

6.1 General Concepts

In this subchapter the frame of reference is applied to the previously developed general problems and form General Concepts. These General Concepts is then validated through theory and the empirical results from the case study as well as from the expert interviews and field trips. The general concepts regard operations at a VCCS level, not detailed enough to be put in any part of the organization without doing adjustments or raise the level of details. However, they are not general enough to be used in any organization without first raising their level of abstraction.

6.1.1 Focus on Flow

Lack of external communication and coordination is a general problem that permeates the entire organization, leading to a functional system that builds in waste in the system. Instead of focusing on the flow, the organization focuses on increasing the resource utilization which increases the lead time, decrease quality and increase cost (Modig & Åhlström, 2011). Further, Modig & Åhlström (2011) states that by focusing on the resources, isolated functional islands are created which are internally improved but lack the power of improving the total value flow, due to insufficient communication. By instead focusing on the flow, the barriers between functional islands are reduced which enables communication throughout the entire flow. When focusing on the flow, Rother & John (1999) emphasizes the importance of having one person responsible for the entire flow, creating the role of a flow manager instead of a functional manager. Rother & John (1999) further explains that without having a leader that understands the entire flow it cannot be communicated and coordinated, showing the importance of having a leader understanding the flow in order to achieve a takt based and visual flow.

Within the flow which is built up by coupled processes, most of the waste is hidden between the processes (Morgan & Liker, 2006). That is connected to the general problem of lack of coordination, which by reducing the handovers between processes facilitates the coordination and decreases the waste to an extent greater than trying to improve just within the processes and the isolated functions. Therefore, in order to increase the coordination, the organizational structure has to follow what is previously stated with the flow managers, creating a flow structure where each flow manager is responsible not only for a flow but also for people working cross functionally throughout the flow. That increases flow efficiency, surface problems and reduces inventory, facilitating for communication and coordination, enabling a paced and visual flow (Morgan & Liker, 2006).

In order to be able to work cross functionally at the analyzed organization, the people performing the work needs the ability to perform more tasks than when working functionally focusing on specific parts of the flow. Because of that, with a focus on expanding the knowledge from a flow perspective, communication and coordination will be improved. When having the ability to perform activities across the flow, the ability to balance resources throughout the flow appears, facilitating for a takt based and visual flow. That is supported by Shingo (1992) that explains that processes is flow transforming raw material into finished products and operations are flow in which people perform work. Within the operation people can perform work at each process (Shingo 1992), indicating that

the more processes each individual can perform, the more raw materials can be transformed into finished products in the flow. Further, by focusing on the flow instead of the systems and the rules, the customer gets in the focus and value is added (Spear & Bowen, 1999). Because of that, the number of system throughout the flow shall be minimized, only using systems to support the operations instead of controlling it.

Liker (2004) states that by focusing on the flow instead on the resources to create a continuous process flow, problems are brought to the surface and the general problem of quality issues, flow variations and influences that interfere the flow is reduced. That is achieved, according to Liker (2004), by striving for a one-piece-flow system to lower the water level and detect problems and waste in the system. For that reason, producing in batches shall be avoided, striving for small continuous deliveries. One way to avoid batches and over production is to use a pull system (Liker, 2004). By using a pull system, the customer receives just what is wanted and even though a small amount of inventory is built into the system, it enables a smooth and takt based flow.

In close connection to the leveling and balancing from a flow perspective is the idea of working in only a few parallel projects, which, according to Morgan & Liker (2006), can solve the general problem of that it is difficult to determine project status. It is based in their statement that it is harder to detect and recognize abnormalities in white collar organization than it is in manufacturing, because of invisible inventory and the difficulty of determine project status. With parallel projects, there are even more to keep track of, making it even harder to detect abnormalities and understand the flow, something necessary for a takt based and visual flow. Further Morgan & Liker (2006) states that in order to have a total value flow perspective and focus on reducing waste, cross functional communication and coordination is a necessity.

When aiming for incorporating takt into the flow it is important to keep the definition of takt in mind. Takt is net available time to work divided by customer demand and because of that, the customer demand has to be defined. In order to do so, the customer values has to be established and it is important to understand what adds value to the customer. That is achieved through focus on the value stream by focusing on the communication and coordination throughout the flow, not just within departments. Lack of external communication and coordination prevents focus on the entire value flow but by developing a takt based on the customer demand and creating the takt from flow perspective, the customer gets the focus, enabling an efficient flow delivering value to the customer (Womack & Jones, 2005). That means, instead of creating a takt for a specific functional department with the purpose of utilizing the resources to a maximum, the takt shall be created based on customer demand and incorporated throughout the entire value flow.

The two general problems, Influences that interfere the flow and Variation in the flow also get affected by a takt created with a flow perspective. That is because it couples the activities tighter, makes problems surface and stop the flow more rapidly than with an isolated takt for each department (Liker, 2004).

Focus on Flow

- *Flow Teams and Flow Managers*
- *Takt from a flow perspective*
- *Fewer systems along the flow*
- *Extended work competence throughout the flow*
- *Small continuous deliveries*

This means that Focusing on the Flow, by having flow managers and an organization based on flow teams and flow groups the communication and coordination throughout the flow will be improved. Developing a takt from a flow perspective and not with the aim to utilize resources, the customers will be in focus, enabling a balanced flow surfacing problems and facilitating both communication and coordination as well as preventing quality issues by the focus on problem solving. Further, the flow focus is a necessity for small continually deliveries in few parallel projects, facilitating the determination of project status and creating an understanding of the flow, making it possible to communicate throughout the flow. The number of systems and their impact on the flow shall be reduced, creating a system of where the operations and the flow are in focus. At last, flow focus includes widen the competence through the flow and having a leader that understands the flow and its importance for the customer.

Modig (2012) supports the idéa of focusing on the flow and not the resources and further explains the importance of focusing on the entire flow when improving, not just islolated parts. Sobek (2012) is of the same opinion and explains the phenomenom as a trade off between buffering with capacity by not focusing on the resources and buffering with lead time by not focusing on the flow. Lindlöv (2012) also supports the idea of having a flow oriented organization with flow teams which increases the flow communication and coordination within the teams. Modig (2012) is of the same opinion but mentions also the drawbacks of having only a flow orientation, like reduced knowledge transfer and Sobek (2012) adds the risk of loosing the communication of advices and tricks between people working with similar work tasks. Because of that Sobek (2012) suggests that people working with similar tasks shall be placed physically together, enabling communication and knowledge transfer.

The importance of having the customer in focus when creating the takt is supported by Modig (2012) that explains the concept of pull when a continuous flow is impossible. The quest for small continuous deliveris and few paralell projects is supported by Nyström (2012) who explains the importance of having a manageble number of flows and stopping production when the flows gets overloaded. Nystöm (2012) explains that a pull system and canban can be used to prevent overproduction. Palmér (2012) is of the same opinion and explains that it takes longer time to perform work in many projects than in few because it makes the flows more direct and reduces the insentives for batching, heading for one-piece flow. Malmborg (2012) further exlains that single tasking reduces the lead time and reduces the risk of more than one project missing the deadline.

The widening of competence through the flow and having a leader that understands the flow is supported by Nyström (2012) who emphazises the importance of developing employees so that they can work both up streams and down streams in the flow. By explaining the positve aspects like good understanding and flexibility within the system of letting factory workers learn work tasks up stream and down stream in the flow, Palmér (2012) is of the same opinion. Further, Sobek (2012) explains that this increases the flow communication and coordination and facilitates both planning and execution.

6.1.2 Define and Plan

The second concept that has been derived in order to solve the general problems of lack of planning is to Define and Plan. Frontloading a project regarding work content, deliveries and sequences will according to Liker (2004) bring a number of benefits including less downtime, less waiting and increased leveling capabilities. Liker (2004) further explains that it is important to focus on the planning phase of the projects to secure flawless and successful imlementation or production, a prerequisite for paced and visual flow. That in conjunction to frontloading makes it is favourable to adapt the work flow to the next process in the value chain flow so that a pull system is achieved. Especially if the different tasks is connected to each other and needs to be waited upon in order to proceed. The pull system is a way to avoid overproduction, otherwise a common problem when there is lack of planning (Liker, 2004).

In order to be able to show project statuses it is important that a certain standardization regarding what is visualized exist (Liker & Morgan, 2011). In order not to only visualize a subjective interpretation of a project status the workload has to be defined in a unified way. Thereafter an objective project status can be determined based on the relation of workload and available time to deadline. This solves the general problem of that it is difficult to determine project status, which also is connected to the principle of frontloading.

Due to the nature of a white collar organization it is impossible to exactly determine how long time a certain task will take (Morgan & Liker, 2006). Therefore it is vital to create a workload categorization for the tasks. These categories will then be connected to a specified time interval which addresses units to the categorization. In that way, different tasks gets different units, based on the predicted time the task is supposed to take. That can be made by measuring the times for different tasks and using a Histogram to illustrate how the measurements are divided (Juran & De Feo, 2010).

Basing the takt on these categories and units is an essential part in order to create a takt based and visual flow in white collar organizations since it needs to be done in an objective and structured way in order to receive the desired impact. The categorization is also a way to facilitate the leveling within the team by dividing the tasks and the units between team members. Of the two aspects of leveling, within the team and over time in the flow, the first can be solved by leveling work tasks between team members and when leveling the total workload, it is essential to accumulate orders to create a leveled production based on customer demand (Liker J. K., The Toyota Way - 14 management principles from the worlds greatest manufacturer, 2004). This also affects the general problem of flow variations, which without leveling can make it hard to achieve a takt based and visual flow.

By frontloading a project in this way an opportunity is given to level the workload and thereby reducing variation and enabling unified communication and coordination between team members as well as between team leaders (Liker J. K., The Toyota Way - 14 management principles from the worlds greatest manufacturer, 2004). This is one way to reduce the general problems of flow variations and lack of communication and coordination. By knowing the workload and statuses for different resources and projects it is possible to decrease the number of projects that is active simultaneously for each resource by dividing it among the other resources. This will, according to Modig & Åhlström (2011) and Liker & Morgan (2011), make the system easier to overview and manage since

Define and Plan

- *Frontloading*
- *Pull*
- *Workload Classification*
- *Few parallel projects*

the system does not degrade due to difficulties in managing several units simultaneously.

When planning the projects and the work, KI/VP is a tool that facilitates both the planning, monitoring and execution of the work (Hines, Francis, & Found, 2006). It can also be used to show where handovers are and in that way solve the general problem of both lack of external communication and coordination and inneficient internal communication. Activities and deliveries visualized through KI/VP helps solving the general problem of lack of planning, facilitating for a takt based and visual flow (Lindlöf & Söderberg, 2011).

This means that the concept of Define and Plan includes frontloading and a focus on the planning phase of the project. By having a pull system based on customer demand and level the schedule through accumulation it is possible to avoid overproduction and a steady flow is achieved. Within the team, classification of different tasks is the base for leveling and reduces variations in the flow. Project progress, handovers and time to deadline has to be visualized in order to determine project status and by reducing the number of active projects, the determination of project status is further facilitated.At last, the usage of KI/VP is an essential part of Define and Plan though it visualized several important aspects of the operations.

Sobek (2012) supports the idea of using visual planning to plan and define the work and Modig (2012) explains the advantages with a pull system by mentioning the reduced risk of overproduction . He also includes the importance of a pacemaker process, setting the pace. Sobek (2012) is of the same opinion and explains that an organization shall flow where it can and pull where it must and in order to do so, the capacity has to be known, something that is aligned with defining the work and planning the execution. Modig (2012) emphazises the importance of frontloading because it turns internal processes to external processes, reducing the lead time.

Further, Sällström (2012) explains that fronloading creates consensus for the projects which is important for a paced and visual flow. Another advantage with frontloading is, according to Malmborg (2012), the ability to plan towards the real resources. That is connected to single tasking which facilitates the determination of project status. It also reduces the leadtime and reduces the risk for more than one project mising the deadline. This is supported by Plamér (2012) who explains that it takes longer time to perform tasks in many projects than it takes to perform tasks in few projects. Both Sobek (2012) and Modig (2012) supports the idea of using classification of work tasks and explains that it reduces the margin of error between the belived project progress and reality. When using classification, Modig (2012) further emphazises the importance of fronloading to allow time for recource planning.

6.1.3 Standardization

As earlier mentioned, influences that interfere the flow are a general problem that affects the organization and when analyzing the root cause of the problem, variation is the key. A low variation is a prerequisite for a well functioning organization which can be achieved by standardization (Morgan & Liker, 2006). The problem of influences that interfere the flow is affected by the input of the system. When there is low quality information entering the system, there will be a hard time processing that information throughout the flow. Because of that, Skill–Set standardization can be used to make sure all information needed is present before starting a project (Morgan & Liker, 2006). By using checklists as quality assurance for the information entering the system, the influences that interfere the flow will be reduced and the quality improved(Morgan & Liker, 2006).

Visual Communication

- *Projects*
- *Project Status*
- *Project Progress*
- *Project Workloads*
- *Production Issues*
- *Quality Issues*
- *Flow Delays*

When dealing with influences that interfere the flow it is important to collect data regarding what the influences are and communicate them to all interested parties in the organization. A standardized data collection method based on a check sheet needs therefore to be established. Further, the progress of reporting and dealing with the issues has to be standardized in order to assure that all issues are dealt with (Bergman & Klevsjö, 2010), (Juran & De Feo, 2010).

Another general problem is flow variations, which is connected to the previously described problem of influences that interfere the flow, but focuses more on the internal variations. Morgan and Liker (2006) explain that process standardization is the standardization of tasks, work instructions and sequence of tasks which can be used to reduce process and flow variations. By standardizing the accomplishment of tasks and standardizing the sequence of tasks, variation is reduced and the possibility to improve appears (Liker 2004).

Further, by using standardized work tasks, quality is built in to the process, solving the general problem of quality issues. Morgan and Liker (2006) support the concept of using standards as a way to build in quality by standardizing the design. By standardizing the design, components and architecture, the quality level will align and act as a base for further improvements. The standards have to be clear and visualized because it is hard, especially in white collar organizations, to see if a person is following the standards or not (Morgan & Liker, 2006).

The standards cannot be at the same detailed level as in manufacturing but the activities and the sequence of activities can be standardized. The same is true for the process of dealing with issues, which, by using process standardization will be reduced. The standardized process of dealing with issues has to be based on the concept of first asking whether the standard was followed or not when a quality issue is discovered. If the standard was followed, the standard has to be reviewed and questioned but if the standard was not followed, the way of using the standard must be improved, ensuring that everyone always uses the standard (Morgan & Liker, 2006). Further, there must be a way to follow up quality issues to make sure the root cause is found and solved. That can be achieved by using a standardized Cause-and-Effect diagram and analyze all possible causes separately to get the complete picture of all causes (Bergman &

Standardization

- *Input*
- *Work Instructions*
- *Data Collection*
- *Tasks and Sequence*
- *Product Design*
- *Issue Handling*
- *Flow*

Klevsjö, 2010).

One activity that all producing units have to define and standardize is the verification of the product produced. The activity of verification has to be included in the standard work process and the place of the activity in the sequence has to be standardized as well. The reason is the quality aspect and can be compared with the checklists that air pilot's uses before takeoff. The checklist itself is standardized and the sequence in the preparation process is standardized as well.

That means that a General Concept named Standardization is developed and includes verification of information and products entering the system, standardize the data collection regarding issues, standardize work instruction, tasks and sequence together with product design and the process of dealing with issues is important when it comes achieving a takt based and visual flow. That is supported by Modig (2012) that emphasizes the importance of standardizing the entire flow with activities and the sequence of activities. Nyström (2012) is of the same opinion and explains that a small variation is a prerequisite for achieving a paced and visual flow which only can be accomplished by standardization of tasks and sequences. By stating that standards are about finding key points, Palmér (2012) indicates that checklists where key points are checked is a way to build in quality in the processes and the flow, enabling a paced and visual flow.

6.1.4 Visual Communication

From the application of theory on the seven general problems it has been evident that visualization is a widely common factor which can decrease the impacts or completely solve the effects from the general problems. When regarding the first general problem that was developed through the case study, Influences that interfere the flow, it can be seen that visualization could be part of the solution. But according to Eppler & Buckhard (2007), this is more a question regarding how and which information that is right for the intended receiver.

Due to the implications from interferences, visualization and communication can be a means of creating a common understanding and being able to base decisions on facts. By using data collection tools and visualizing the results of how much interference a certain work process has due to for example IT-systems, a unified comprehension of the interferences can be achieved (Bergman & Klevsjö, 2010). The collected data can then be used as a foundation to build business cases in order to escalade problems to higher instances to solve the root causes that usually mean larger investments to change IT-systems or to drive reorganizations.

The second general problem that was found regarded that it was hard to determine the current status of projects. According to Liker (2004), a successful visual control system shall be as clear as traffic signals which imply that the visualization of project status must be done by a straightforward and unified communication system. It is also important to visualize the progress of the projects and signal if the intended progress is not followed. The supplementary question in order to start visualizing a project status is to work out what to visualize based on facts instead of on a subjective perception, further discussed in chapter Define and Plan 6.1.2.

Lack of external communication and coordination is the third general problem that was found. Both Liker (2004), Sparrow (1998) and Eppler & Burkhard (2007) agree that visualization is a tool to be able to enhance communication and coordination. Thereby visualization is the natural and trivial answer to external communication and coordination problems. By visually communicating workloads

and statuses for different resources to other department functions the possibility is given to be able to work proactively with balances of work contents and resources.

General problem number four, Flow variations, seems at a first glance to be closely related to general problem number one, Influences that interfere the flow, but there exist a major difference. The first one regards external influences which is hard to affect on a short term basis while Flow variations concerns the internal work flows. By defining and visualizing relevant information such as the flow and the different project workloads for departments and resources it is possible to create a unified understanding of the flow and its content variations (Sparrow, 1998).

The fifth general problem is connected to a lack of planning, which also can be improved through visualization by the use of visual planning, KI/VP (Hines, Francis, & Found, 2006). By utilizing the method the coordination planning and leveling of workloads is facilitated and instantly communicated to both the team leader and other members of the team. In addition to the external communication and coordination issues, a general problem revealed is inefficient internal communication. As mentioned before, KI/VP is a visual planning tool specially developed to increase communication as well as coordination and is therefore the natural solution here as well.

Visualization can also be applied in order to decrease the effects of the seventh general problem, Quality issues, by communicating which quality issues that has been detected, their root causes and which counter measures that have been deployed in order to solve them. By for example visualizing the root causes of the quality issues in a Pareto chart a clear picture of the frequency of different root causes can be shared among team members (Deming & Walton, 1986).

This means that the concept of Visual Communication includes visualizing the different projects, their status, progress and workload. It also includes visualizing issues that interfere the flow and quality issues together with their root cause in order to be able to base decisions on facts. This is supported by Palmér (2012) who is of the opinion that visual planning is the first step when talking in terms of a takt based and visual flow. Palmér (2012) also supports the earlier mentioned statement that visualization facilitates communication and coordination and has the ability to break projects into smaller parts. The importance of visualizing issues that interfere the flow together with quality issues is explained by Sobek (2012) together with Nyström (2012) who adds the importance of visualizing information or products that get stuck. Palmér (2012) is of the same opinion when explaining that all problems have to be visualized in order to ensure a focus on actively working with problems. Sobek (2012) supports the idea of using KI/VP to plan activities and deliveries but has the opinion that it might not be the ultimate solution to visualize takt. However, the usage of visual signals to show whether the takt is followed or not is something that Sobek (2012) supports.

6.1.5 Analyze and Act

Analyze and Act is the fifth and last concept and its content can be connected to many of the general problems. The reasons are that the concepts deals with the importance of finding problems and solve them as fast as possible. The first aspect of Analyze and Act is to analyze the operation in order to surface problems. That is derived from the general problem of influences that interfere the flow and the aspect of first understanding that there are influences that interfere the flow, before moving on and finding the specific influences. Liker (2004) describes this with principle number two, create continuous process flow to bring problems to the surface. Because of that, the aspect of finding the right influences is connected to the flow, the base of principle number three.

Further, Liker (2004) emphasizes the importance of building a culture of stopping to fix problems, to get quality right the first time. Here, the aspect of act enters the picture by the stopping the production. This is connected to Jidoka and builds in quality by fixing problems before the defects continues downstream (Liker, 2004). This is also supported by Womack, Jones, & Roos (2007) who states that it is essential that team members react on quality problems by stopping production and in that way solve problems quickly.

The usage of visual control so no problems are hidden, principle number seven, prevents small problems to grow to a problem of scale until the moment when it finally appears (Liker, 2004). That affects the general problem of influences that interfere the flow but also flow variation and quality issues. Liker (2004) has named one of the four categories of TPS problem solving, which includes both Analyze and Act and there are several principles within problem solving connected to the concept of Analyze and Act.

By having principle number fourteen in mind, become a learning organization Through relentless Reflection and Continuous Improvements, when dealing with flow variations, quality issues and influences that interfere the flow, many aspects of Analyze and Act is covered. Analyze and Act includes finding the root cause, which also is included in principle fourteen, which can be achieved in several ways. One way is to use a cause-and-effect diagram and analyze each problem and cause to get a complete picture of the problem. Further, project status and work progress has to be reflected upon and analyzed, before actions are taken in order to get back on track if the status is not sufficient or the progress is to slow (Morgan & Liker, 2006).

The general problem of flow variations is also connected to root cause analysis through cause-and-effect diagrams, surface problems by focusing on the flow and reflect to improve. However, in order to reduce flow variations, the flow has to be defined. A defined flow does not only mean the sequence of activities, it includes cycle time for the activities and possible error activities. There must be a system in place that detects defects and traces the problem to its ultimate cause, where of the later can be achieved by cause-and-effect diagrams but the previous has to be achieved by the people performing the work (Womack, Jones, & Roos, 2007). Because of that, the people performing the work has to define the theoretical time for each activity and put that in perspective to both the value adding time and the time it actually takes to perform the task. By doing so, waste in the system will surface and there can be a focus on fixing problems instead of trying to deal with uncontrollable series of discrete events (Morgan & Liker, 2006).

Analyze and Act

- *Focus on Issues before they escalate*
- *Theoretical cycle time versus real cycle time*
- *Root cause analysis*
- *Take action by countermeasures*
- *Monitor WIP and queues*

The focus on problems has to be present at meetings as well in order to reduce flow variations and cope with quality issues. Because of that, team members shall take the opportunity at the daily meetings to address issues that has arise and issues that probably will arise so that resolutions can be seeked (Lindlöf & Söderberg, 2011). Emiliani, Stec, Grasso, & Stodder (2007) is of the same opinion and explains that one of the key factors of lean is to identify steps that creates value for the customer and which do not. All three types of waste, Muri, Mura och Muda has to be considered and the classification gives a picture of where to start the process of improving.

When dealing with issues, variation and problems it is important to base the progress towards a solution on correct input data. It is also important to really make a change and not stop the work when a solution is found, it has to be implemented. According to Shingo (1992), the first step in conducting improvements is to identify the problem. That can be done by using the tool of data collection through check sheets. The idea is to collect all relevant data and information relative to the observed abnormalities and based on that identify and define the problem (Ryan, 2011). The next step is to create basic conceptual approaches to improvements, followed by making plans for the improvements and at last translating the plans into reality (Shingo, 1992). Within this process, Histograms can be used to illustrate how data are divided into classes and Pareto charts can be used to facilitate in the process of deciding in which order to address the problems (Bergman & Klevsjö, 2010). That means that information regarding flow variations, quality issues and influences that interfere the flow shall be collected, divided into classes and addressed in the appropriate order through improvement tools and careful planning. However, it is not to forget the importance of translating the plans into reality.

This means that the concept of Analyze and Act includes a focus on problems, through focusing on the flow and by aiming on detecting and acting upon problems before they grow bigger. The theoretical time it takes to perform a task has to be set in relation to the time it actually takes to perform and what the value adding time is. Further, when a problem is surfaced, its root cause has to be found and the status of projects has to be reflected upon, before taking action through effective countermeasures.

Sobek (2012) and Nyström (2012) supports the idea of focusing on the problems and emphasizes the importance of visualizing issues and problems that complicates the production. Hultkrantz (2012) further explains that one of the main ideas of visualizing work in progress is to surface problems and in that way facilitate the organizational focus on problems. The importance of reflect upon status and flow is supported by Sällström (2012) who believe that the primarily use for visual planning is to reflect over current operations. Further, Palmér (2012) explains that it is important to focus on problems in the daily work and for that reason all problems has to be visualized.

6.2 General Model

The general concepts, derived from the general problems and theory, is set in relation with the prerequisites in order to determine if there is anything contradictory between them and that all aspects of the prerequisites are covered in the concepts. It was found that the General Concepts have nothing contradictory with the three prerequisites, stable processes, understanding the flow and balanced flow. Further, the content of the prerequisites are covered in the General Concepts of where stable processes are connected to Flow Focus, Define and Plan, Standardize, Visual Communication and Analyze and Act. Understanding the flow is connected to Flow Focus, Visual Communication and Analyze and Act. Balanced flow is connected to Flow Focus, Define and Plan and Visual Communication.

In this way, the prerequisites can be used as the bridge between the concepts and paced flow through takt and visualization. For example, it might be hard to understand how Standardization contributes to a takt based flow, but the connection between standardization and stable processes together with the connection between stable processes and takt based flow are easier to understand. This strengthens the utilization of the prerequisites and makes the prerequisites work as a link between the concepts and what is to be achieved.

Further, all general concepts are supported by the empirical results and have for that reason been incorporated in to the general model. The model consist for that reason of the general Concepts and is the answer to research question number three, What important general concepts need to be focused upon in order to create a visual and takt time based flow at VCCS?

The general model is illustrated by a wheel to a Volvo S60 R-design or a Volvo V60 R-design named Ixion 8x18. Each concept is represented by a spoke of the wheel, creating the total general model. Each revolution of the wheel is one takt which creates a takt based flow and the ability to see the rotation of the wheel illustrates the visualized flow. Thus, the rotating wheel illustrates paced flow through takt and visualization of where each spoke is necessary to achieve the paced flow. Missing one of the concepts, one of the spokes, makes the wheel unable to achieve a pace flow, losing its takt which instantly gets visual.

In addition, all wheels on a car have to rotate in the same speed and pace in order to synchronize the tires, making the ride smooth. In the same way, all parts of an organization have to be synchronized. Therefore, in order to achieve a paced and visual flow, the concepts are necessary aspects of creating this synchronization.

Figure 28, Graphical representation of general model

6.3 Specific Concepts

In this chapter the specific concepts, based on the general concepts, will be presented. They are derived from the general concepts through the application of theory together with empirical results and constitute the Specific Model. The Specific Concepts regard operations at the level of the analyzed flow, the PT team, the PRI team and the VSTG team and are developed to improve that specific flow.

6.3.1 Specific Concept of Focus on Flow

One of the main suggestions included in the general concept of Focus on Flow is to arrange the teams according to the flow. That increases coordination and communication and is achieved in the analyzed organization by having the seven persons in the PRI team working on new car projects together with the four persons in VSTG team working with new car projects. That means these eleven persons form one team, responsible for developing all methods and setting all standard times. The team shares the same KI/VP board and has one team leader responsible for the entire flow, from method assessment to the determination of a standard time.

This reduces handovers between teams, increases communication and coordination as well as increasing the understanding for the flow for both the team members and the team leader (Rother & John, 1999). Moving up in the hierarchy, it is important that this flow organization is followed, creating the role of a flow manager instead of a department manager (Liker & Convis, 2012). In that way, the flow manager gets the full responsibility for the end product together with full responsibility for all involved employees. However, in order to keep the communication and knowledge transfer between people with similar work tasks, all persons developing methods, both for projects and running shall sit together (Sobek, 2012). The same is valid for the persons setting the times of where all persons setting times shall be located at the same place in the office.

Further, when implementing takt in the flow, it is more appropriate to base it on number of orders per week instead of how long time each order shall take, which would be the case if the definition of takt was strictly followed (Sobek, 2012). Though the customer demand is of importance when creating the takt, it has to be communicated through the entire value flow. Because of that, the flow, from the creation of a spare part structure through method assessment and method production to the creation of a standard time, has to be in focus when developing the takt. Takt cannot just be used in an isolated part of the flow with the purpose of utilizing the resources to a maximum, it has to be developed throughout the entire flow with the last process, the VSTG team, determine the pace. In that way, all functions gets synchronized and the merge of the PRI team and the VSTG team further facilitates the synchronization of the flow through takt with a flow perspective.(Modig, PhD student, 2012)

The merge of the PRI team and the VSTG team is close connected to widening the competence throughout the flow, something suggested in the general concept of Focus on the Flow. In this case, it means that the person's developing the methods shall learn to set the times as well and the person setting the times shall learn develop the methods. That increases the understanding of the flow and creates a flexible system of where people can fill in for each other (Palmer 2012).

It also opens up the opportunity to remove the separated functions of developing the method and setting the time. That means that the person developing the method also sets the time, which reduces handovers and increases the flow focus. Further, it is of importance that the persons in the

merged PRI-VSTG team gain insight to the work of the PT team, increasing the understanding of the flow and reducing the waste of looking for information that already is known by team members of the PT team. The same is true for the team leader and the flow manager that has to be able to understand the flow and have knowledge of activities connected to the flow, performed outside VCCS (Hultkrantz, 2012).

When producing, it is important to focus on the flow, not on the production itself (Modig & Åhlström, 2011). By producing methods with small continuous deliveries, work in progress and queues between persons are reduced (Liker, 2004). That, in turn, reduces the lead time for developing methods and standard times, making it possible to postpone all processes making it feasible to work with better updated information and status on test vehicles. That reduces the waste in terms of rework but working with small continuous deliveries also balances the flow, making it more stable and easier to takt. It also reduces inventory in the system, surfacing problems faster making the feedback time descend, creating a system that has the ability to react faster on changed demands and conditions (Nyström, 2012).

Further, flow focus includes a reduced focus on system and rules. In this case it means working in Nevis directly, not in Spie and creating a flow that is not controlled by embedded rules but instead supported by the system. Many of the activities in the flow, connected to systems, does not add any value and be eliminating activities like the ABC classification, the waste within the system is reduced, facilitating for takt and visualization. It also decreases the lead time, which in turn, accelerates the feedback, enabling better quality and efficiency.

Focus on Flow

- ✓ *PRI team and VSTG team working together in the same team*
- ✓ *Persons within the same function sit together*
- ✓ *Work competence widening between PRI and VSTG members*
- ✓ *Small continuous deliveries of methods and times*
- ✓ *Takt for a flow from creating the spare part structure to setting the time*
- ✓ *Less focus on systems like SPEI and system activities*

6.3.2 Specific Concept of Define and Plan

Frontloading is an important aspect of the general concept Define and Plan which makes it included in the Specific Model as well. In the case of the analyzed organization, frontloading is about putting a lot of effort into the method assessment, the phase of where the method production is planned. Without a correct output from the assessment, it is impossible to plan the production of methods, leading to either over capacity or over utilization of resources. That goes hand in hand with the focus on the planning phase that is suggested in the general model and supported by both Sällström (2012) and Malmborg (2012).

The focus on the method assessment is also important when it comes to work in few projects at the same time, another thing suggested in the General Concept of Define and Plan. The reason is that by focusing on the assessment and completing it before starting to produce methods, there are fewer parallel tasks at the same time, reducing the actual number of projects active at the same time. Because of that, the specific concept of Define and Plan includes a separation of the assessment phase and the production phase with a defined deadline for the assessment.

In order to further reduce the number of project each person is working in, all persons shall not work in all projects. Most of the time, a car project mainly concerns a few functional areas, but there are some methods and time to develop for all functional areas. That means that all people work in all projects, but there are only a few that focus their work on each project. By dividing the projects so that the persons that have a lot do in one projects gets all methods and times, they can focus on that projects and do not have to bother about other projects of where they might only have a few methods or times to produce.

The focus on the assessment also includes a categorization of methods and standard times based on the time they are planned to take to perform. The categorization shall be based on the time the method engineers and the standard time technicians think the method or standard time will take to perform and a histogram can be used to help doing the categorization (Juran & De Feo, 2010). In the case of the PRI-team, it was derived through interviews and histograms, and three different categories are to be used, see Figure 29. The first category is methods that take between zero and four hours, the second is methods that take four to eight hours and the third is methods that take more than eight hours. Methods in the first category is worth one takt units, the methods in the second category is worth two takt units and methods in the third category is worth three takt units. This means that the takt shall be based on those takt units instead of number of methods or standard times, reducing the gap between the real progress and believed progress Modig (2012).

Fast	0 – 4 h	|
Medium	4 – 8 h	||
Long	8 –> h	|||

Figure 29, Categorization of methods and standard times

When using takt on an individual level instead of on a team level, the takt units can be used as a base for balancing and leveling of the flow, surfacing who actually has a lot to do and who actually has less to do. For that reason, an individual takt shall be used instead of a takt on a team level. Further, the classification and the takt units facilitates the planning though it makes it possible to plan closer to reality and to the real resources compared to just working with numbers of methods or standard times (Malmborg ,2012).

When the work is defined through the categorization in the assessment phase, it is time to plan the daily work. That is performed through the KI/VP board where each person developing the methods, for the upcoming days, put a delivery Post-it on the day that each method is to be completed. In the same way, each person setting the standard time puts a delivery Post-it on the day the time is to be completed. A blue delivery Post-it for the person developing the method becomes a green input Post-it for the person setting the time for that method. In that way, it is easy to follow the progress and early detect where capacity problems will occur. The methods and the times that are to be performed in the upcoming weeks do not have to be detailed planned on an individual method or time level. Instead it is enough to use

Define and Plan

- ✓ *Accurate method assessment before project start*
- ✓ *Planning deliveries of methods and times on the KI/VP board*
- ✓ *Divide projects among team members to reduce the number of parallel projects*
- ✓ *Base takt on a work categorization*
- ✓ *Takt on individual level*

Post-it´s for subsystem as deliverables for the upcoming weeks. Important activities like physical verification shall also be put on a yellow Post-it on the board. By doing so, other persons that also needs to do a physical verification can join, reducing the amount of rework.

6.3.3 Specific Concept of Standardization

The general concept of Standardization includes standardized work instructions which in the case of the analyzed organization can be accomplished through element sheets. The element sheets shall include the activities to perform, important aspects to keep in mind and why this activity is important. The sequence of activities also has to be standardized so that rework is minimized. Because of that, the whole value flow has to be defined, including in what order to perform the activities, who is responsible for each activity and who to consult if a problem occur. That means that all activities and their sequence to create a spare part structure, create a repair method and set a standard time has to be defined. That standard will align the work and the quality of the product, at the same time as it act as a base for improvements (Modig, PhD student, 2012).

The general concept of Standardization deals also, among others, with input to the system. In the case of the analyzed flow the input is product information from research and development, often in the form of drawings. The first person in the analyzed flow, a team member of the PT team, checks if 2D drawings on all parts are delivered. That person also checks the quality of the drawing but does not consider whether there are any 3D models of the parts or not. The PRI team is in need of 3D models to create the methods and by including an activity of checking the existence and quality of 3D models early in the flow, quality issues are surfaced earlier, enabling time to solve the problem before the critical point of use. Because of that, the specific concept of Standardization includes checklists that ensure that the right information with the appropriate quality entering the system.

When dealing with quality issues, there has to be a standardized way to collect data of the issues and also a standardized way to deal with those issues (Bergman & Klevsjö, 2010),(Juran & De Feo, 2010). Standardized data collection sheets shall for that reason be used and the issues must be visualized in order to follow the progress of obtaining the solution. When solving issues, Cause-and effect diagrams shall be used in the purpose of finding the root cause of the problem, not aiming for the impact of the issue, spending time fire fighting critical issues (Bergman & Klevsjö, 2010). This will further be described in the section of Visual communication.

Further, the design of the methods has to be standardized. In that way, the quality will align and there will be a possibility to improve. The technician using the method when repairing a customer's car will recognize the outline and fast be able to utilize the information. It also increases the ability to reuse parts of old methods and introduce new employees to the procedure of creating repair methods.

Standardization

- ✓ *Work instructions*
- ✓ *Sequence of activities*
- ✓ *Flow of methods and times*
- ✓ *Input control of drawings*
- ✓ *TIE cases and production problems*
- ✓ *Data collection*

6.3.4 Specific Concept of Visual Communication

The specific concept of visual communication is based on the important aspects of Visualization. It covers the areas of visualizing projects, project status, project progress, project workload, production issues, quality issues and the visualization of where in the flow information get stuck.

To begin, visualizing progress and takt of the projects can be accomplished by a burn down graph for each person. This is supported by Sobek (2012) and Hultkrantz (2012) that explains that it also is important to include the allowed margin of error and decide when to escalate problems and who is responsible for the issue at each margin of error. In the case of the PRI team the allowed margin of error has been set, in corporation with the team leader, to ten percent. The burn down graph shall be based on the takt units presented in the specific concept of Define and Plan, in order to show a progress as close to reality as possible. The burn down graph is incorporated in the KI/VP board in order to put focus on the production. The burn down graph is illustrated in Figure 30 and the newly designed KI/VP board with the burn down graph illustrated in Figure 31.

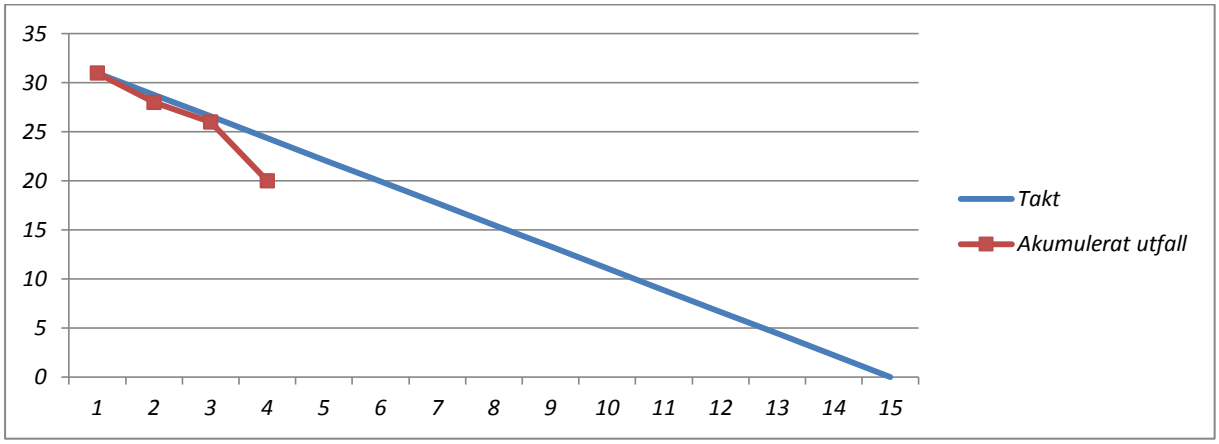


Figure 30, Burn down graph

	Takt	Status	Queue	WIP	Action	Mon	Tue	Wed	...
Person 1			11	5					...
Person 2			1	2					...
Person 3			7	10					...
...	...	...	...	...	...	...	...	...	...

Figure 31, Further developed KI/VP board

Each row in the KI/VP board represents one person, which is the same as on a regular KI/VP board. However, between the column with the names and the columns with the dates, five columns have been added. The first added column shows the burn down graph visualizing the takt. The next column clarifies whether the takt is followed or not by a red or a green Post-it. To the right of that column there is a column visualizing the queue in the inbox for each person, followed by a column showing the work in progress of where one unit equals one takt unit for the methods or standard

times that is started. The purpose of the last column is to visualize the action or the countermeasure taken in order to get back on track when the takt is not followed.

Working proactively by visualizing and analyzing work in progress, issues that later will result in the takt not being followed, is surfaced earlier. When work in progress increases there is something preventing the production of methods or standard times to be completed. In that way, an increased work in progress will result in too few orders being sent to the next instance to follow the takt. All parts of the flow do not have a queue that can be defined but where it is possible to visualize a queue, it is an indicator of whether the flow is in balance or not. A person with a large queue does not have the same pace as the person delivering, surfacing a problem and maybe a need for rebalancing the workload of the team.

When visualizing projects, project workloads and projects status, Post-it´s can be used. That is supported by Sobek (2012) who means that Post-it´s has the ability to visualize whether the takt is followed or not. Because of that, a project board has been developed that shows all active projects, their workload and the status of the project, everything on an individual level. The board is presented in Figure 32.

	Project 1 Deadline Test Vehicle ... C - Disc			**Project 2** Deadline Vehicle ... D - Disc			**Project 3** Deadline Vehicle ... D - Disc			**Project 4** Deadline Vehicle ... A - Disc			**Project 5** Deadline Vehicle ... A - Disc			**Project 6** Deadline Vehicle ... B - Disc		
	Number of takt units	Method Assessment	Project Deadline	Number of takt units	Method Assessment	Project Deadline	Number of takt units	Method Assessment	Project Deadline	Number of takt units	Method Assessment	Project Deadline	Number of takt units	Method Assessment	Project Deadline	Number of takt units	Method Assessment	Project Deadline
Person 1	3			32			19			6			0			17		
Person 2	56			23			10			24			5			6		
Person 3	0			6			0			19			0			0		
Person 4	0			3			0			0			10			0		
Person 5	13			7			23			17						5		
Person 6	0			42			0			35			0			2		
Person 7	0			29			50			32			0			0		
Person 8	12			17			12			23			52			12		
Person 9	5			0			15			31			51			23		
Person 10	0			4			41			8			13			0		
Person 11	35			25			13			0			29			26		

Figure 32, Project board

Each major column represents one projects and each row represents one person. In the top of each column, deadlines, handovers, number of methods or standard times translated to takt units, time interval for test vehicles present, what release each project belongs to and team arrangements are stated in order to reduce misunderstandings. For each person and project, the number of methods or standard times translated into takt units is visualized together with a Post-it showing green if the method assessment is completed or red if the assessment is not completed.

Further, there is a Post-it showing whether each person will meet the deadline or not for each project without help from management. A red Post-it tells management that assistance is needed and a green Post-it tells management that the person, together with the team will meet the deadline. This signal to management is an extension of a board located in the management room where each team at the section visualizes which projects are on track and which are not. This makes it possible for management to look at the board showing all projects and all teams, detecting that the PRI team signals red on Project 1. Management can go to the board belonging to the PRI team and see who signals red on that project and assist that person, escalating the problem to a higher level of hierarchy with the power to help.

The combination of the developed project board and the further developed KI/VP board gives a complete picture of the production. The KI/VP board is, when set in relation to the project board and the management board, the board on the lowest level, showing the details of the production. It can be viewed as the input to the project board which is the input to the management board, see Figure 33. Production problems at the KI/VP board, if they cannot be solved within the team generate a red Post-it on the project board for that person in that project. That Post-it, in turn, generates a red Post-it on the management board. This means that if the takt is not followed for one person, but there is an internal action within the team planned that will get the takt and the status of the progress back on track, there shall still be a green Post-it on the project board. If the burn down graph gets out of scope for the team to handle and the team does not have a solution themselves, the red Post-it on the KI/VP board generates a red Post-it on the project board, generating a red Post-it on the management board.

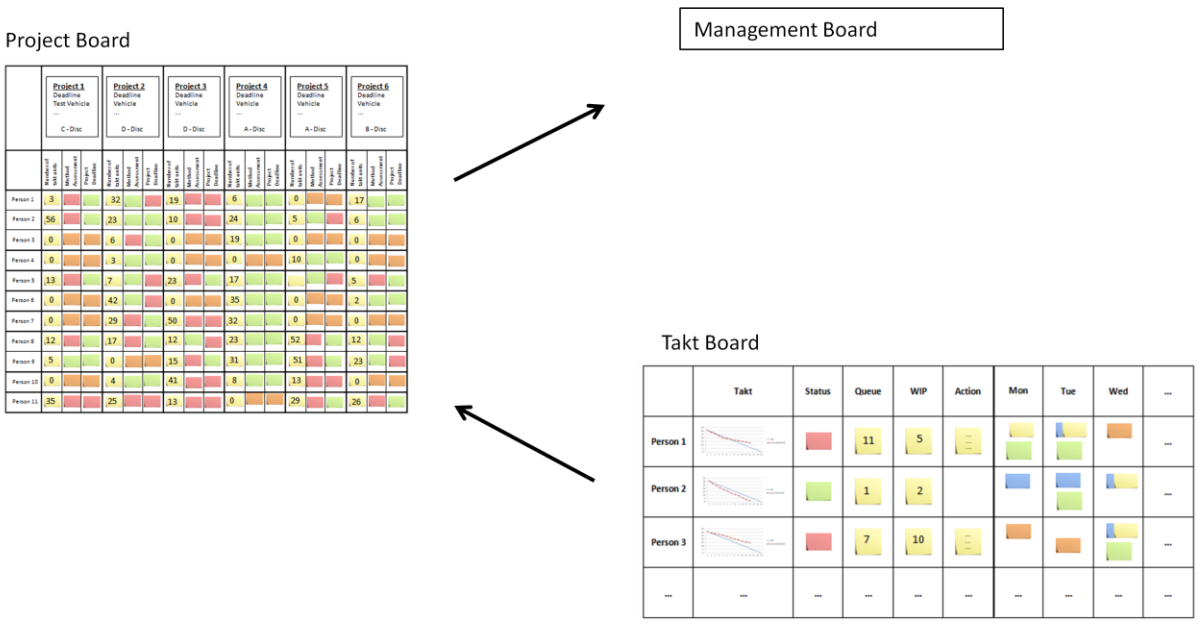


Figure 33, Board Hierarchy between Takt Board, Project Board and Management Board

Nyström (2012) emphasizes the importance of visualizing where information and products gets stuck and in order to do that in the analyzed organization, the value flow can be used. Each order for each project is for that reason visualized for the important steps in creating the method or setting the time. In the case of developing the method, the steps are, generated from the value flow, started, verified, sent to VSTG and closed. Each step for each method is marked with a dot which makes it possible to detect where in the flow order get stuck. Figure 34 shows the visualization of methods to develop.

Project 1

Method name	VCC ID	Takt units	Real takt unit	Started	Verified	Sent to VSTG	Finished	Comments
Engine body - B4164T, B6 // B4164T3, B6	…	1		X	X	X	X	OK
Cylinder Head - B4164T3 // B4164T	…	2		X	X			
Engine, removal - B4164T, MPS6	…	2		X				
Engine, removal - B4164T, B6 // B4164T3, B6	…	3						
Engine, fitting - B4164T, B6 // B4164T3, B6	…	3						
Engine - 526*, B4164T // 525*, B4164T	…	1		X	X	X	X	OK
Engine body, fitting details - B4164T, B6 // B4164T3, B6	…	1		X				

Figure 34, Method list

In addition to the visualization of methods and the steps is a box for each person and week where the person developing methods marks with a line the number of takt units sent to the person setting the time. The person setting the time also draws a line for the number of takt units that is closed. That acts as the input to the burn down graph and makes it possible to follow the takt on a daily basis instead of just looking on the burn down graph which is updated once a week on the weekly meeting.

Further, the specific concepts include visualization of production and quality issues mentioned in the general concept of Visual Communication. Regarding production issues, issues like lack

	New	*Error Reported*	*Plan Exist*	*To Manager /SPL*	*Deviation*	*Archive*
SPIE / NEVIS						
VIDA Draft						
Tools						
Software script						
3D Models						
Other						

Figure 35, System issue collection board

of drawings and slow computer systems is visualized on Post-it´s and the Post-it is moved according to what status the issue is in. This visualization only concerns computer related issues and is illustrated in Figure 35.

The rows are different categories of production issues that are external, i.e. different types of computer problems. When a new issue is surfaced, it is put, on a Post-it, in the first column, named new. When the issue is reported it is put in the next column and when there is a plan in place to cope with the issue, the Post-it is moved one column further to the right. If the issue is escalated to management, the Post-it is placed in the column named Management. Further, the last two columns are deviation and archive where the Post-it is put when the issue is solved.

When there are other types of production issues like incomplete information or lack of test vehicles, the KI/VP board shall be used. When that type of issues is surfaced it shall be noted on a pink Post-it and put on the KI/VP board with a deadline and responsible person. In that way, all issues are visualized together with their progress. If the issue has to be raised to management, the team leader makes a new Post-it on the management KI/VP board and a green input Post-it on the team board.

Regarding quality issues which in this case are TIE-cases, they all have to be visualized (Palmér, 2012). The Tie-cases creates variations in the flow and needs for that reason to be minimized in order to create a takt based and visual flow. The issue board shall for that reason include quality issues of where all incoming issues are put in the inbox, checked at every daily meeting and given to one of the persons working in the team. That person than makes a blue delivery Post-it and put it on the KI/VP board in order to make sure the case is solved. Further, the KI/VP board shall be used to visualize what methods that is to be developed in the near future, with a blue delivery Post-it for each method. Se Figure 31.

The same is valid for the person setting the standard time who makes one blue delivery Post-it for each standard time that is to be created. A blue Post-it at the person developing a method has to be complemented with a green input Post-it at the person setting the time for that method, see Figure 31. In that way the communication and coordination throughout the flow is improved.

Visual Communication

- ✓ *Project board*
- ✓ *Individual status reporting through burn down graphs*
- ✓ *Flow delays*
- ✓ *Value flow sequence*
- ✓ *System issue collection board*
- ✓ *Displaying TIE cases*

6.3.5 Specific Concept of Analyze and Act

The specific concepts, just as the general concept, of Analyze and Act, are in close relation to the concept of Visual Communication. It is also connected to the concept of Focus on the Flow. The general concept of Analyze and Act includes the idea of focus on problems, which in the specific variant of the concept is expressed by focus on production and quality issues at the daily team meetings. That is something necessary at all teams and is achieved by making sure all team members explains the project situation, tells the production progress since the last meeting and informs about both production and quality issues surfaced. The problems has to be collected in a standardized way, which is described in the specific concept of Standardization and visualized, described in the specific concept of Visual Communication. The root cause of the problems has to be found in a standardized

way, which can be achieved through cause-and-effect diagrams, further described in the specific concept of Standardization.

In order to surface problems before they grow big, it is important to focus on indicators of upcoming problems. In the analyzed flow, high work in progress for the PT team and the PRI team is an indicator of that something is wrong in the flow and that it is a production problem that, if no countermeasures are taken, will result in missed deadlines and poor quality. The same is true for the VSTG team with the addition of measuring the inbox, their queue. A large queue for a person setting the standard times indicates that the person upstream in the flow are working to fast and the absence of a queue indicates that the person setting the standard times spends time waiting. For that reason, the work in progress for the person developing the time and the queue together with work in progress for the person setting the standard time is visualized in the KI/VP board, further explained at the specific concept of Visual Communication.

Another way to surface waste in the system that is mentioned in the general concept of Analyze and Act is to define the flow, which in this case is done by defining the activities and the sequence for creating a spare part structure, developing a repair method and setting a standard time. All activities then have to be analyzed in order to understand the theoretical cycle time of conducting them. By setting that time in correlation to the actual time it takes to perform the activity and the amount of the time that is value adding, waste is surfaced and the first step of reaching a better flow is taken. That can be accomplished by using the workload classification, setting the actual time in relation to the time represented by the takt unit from the method assessment. In that way, a learning system is created. Further, it is important to start from the customer's perspective, the one that needed the car repaired with a spare part changed based on a repair method and charged based on the standard time. That means that it is important to have the big picture in mind when analyzing the activities, not only focusing on waste within activities but also on activities that is waste themselves.

When waste is surfaced and there is a solution to the root cause of production and quality issues, it is of importance to take action, implement the solutions and take countermeasures in order to get rid of the waste. When the issues are solved, it is important to sustain the new operation and that is one of the reasons for standardization, further described in the specific concept of Standardization.

Analyze and Act

- ✓ *Focus on surfacing problems*
- ✓ *Define cycle time actively measure against real time through work categorization*
- ✓ *Root cause analysis of issues*
- ✓ *Monitor WIP and queues of methods and times*
- ✓ *Reflect on statuses and deploy countermeasures*

6.4 Specific Mode

This chapter presents the Specific Model which consists of the Specific Concepts. By making sure each Specific Concept is within the scope of the associated General Concept, the Specific Model is within the scope of the General Model. The model is represented by the same wheel as the General Model and the name for each spoke, concept, is the same. However, the content of each concept, illustrated by a spoke, is adapted to the analyzed flow and suggestions made are of a more detailed and precise nature. In the same way as for the General Model, all spokes, concepts, of the wheel of the Specific Model has to be thought of in order to create a paced flow based on takt and visualization at the analyzed flow.

Focus on Flow

- ✓ *PRI team and VSTG team working together in the same team*
- ✓ *Persons within the same function sit together*
- ✓ *Work competence widening between PRI and VSTG members*
- ✓ *Small continuous deliveries of methods and times*
- ✓ *Takt for a flow from creating the spare part structure to setting the time*
- ✓ *Less focus on systems like SPEI and system activities*

Define and Plan

- ✓ *Accurate method assessment before project start*
- ✓ *Planning deliveries of methods and times on the KI/VP board*
- ✓ *Divide projects among team members to reduce the number of parallel projects*
- ✓ *Base takt on a work categorization*
- ✓ *Takt on individual level*

Standardization

- ✓ *Work instructions*
- ✓ *Sequence of activities*
- ✓ *Flow of methods and times*
- ✓ *Input control of drawings*
- ✓ *TIE cases and production problems*
- ✓ *Data collection*

Visual Communication

- ✓ *Project board*
- ✓ *Individual status reporting through burn down graphs*
- ✓ *Flow delays*
- ✓ *Value flow sequence*
- ✓ *System issue collection board*
- ✓ *Displaying TIE cases*

Analyze and Act

- ✓ *Focus on surfacing problems*
- ✓ *Define cycle time actively measure against real time through work categorization*
- ✓ *Root cause analysis of issues*
- ✓ *Monitor WIP and queues of methods and times*
- ✓ *Reflect on statuses and deploy countermeasures*

Some of the Specific Concepts have been implemented in the organization. The implementation has mainly been focused at the PRI team, because of their central part of the flow. In order to achieve a paced and visual flow, all concepts have to be implemented throughout the entire flow. However everything cannot be done at the same time. This first implementation shall be seen as a pilot of where the effects validate the models which I a first step towards a takt based and visual flow. Some aspects of the concepts have been implemented right away when others are of a long term nature.

The first Specific Concept, Focus on Flow, has not been implemented due to the organizational changes needed. To implement flow teams and flow managers, the entire hierarchical organization of Workshop and Owners Information has to be changed. That requires an understanding of all flows within the section, how they affect each other and what activities that are performed by whom and when. That knowledge is not present at the moment but the recent work of starting to map all flows will eventually make that possible. The rest of the suggestions for that concept, like small continuous deliveries and takt from a flow perspective, also require significant changes, making it better to implement the entire concept at one time, when all flows within the organization is understood. However, putting the PRI team and the VSTG team at the same KI/VP board can be done instantly.

Two important aspects of Define and Plan, classification of work and individual takt, are implemented. Instead of looking at the total number of methods the PRI-team has to develop, the takt for each individual is now followed. The takt is based on the classification of methods so that each person now has a specific number of takt units to perform each week instead of the group developing a specific number of methods. The other aspects of Define and Plan, like frontloading and fewer parallel projects, are not implemented yet but is planned by the team leader of the PRI team to be implemented in the future.

Standardization was, to some extent, implemented throughout the entire flow before this thesis started, in the form of element sheets. However, the concept of Standardization includes more than element sheets and has a total value flow perspective, something that is soon to be accomplished. The work of standardizing the flow through the PT team, the PRI team and the VSTG team is started, defining the flow as it is today with all activities and the sequence. The next step will be to create and implement a future state, standardizing the activities and the sequence. The standardization of work instructions goes hand in hand with the standardization of the flow and the standardization of data collection, product design and checklists are implementations on a long term perspective.

The concept of Visual Communication is the concept where most suggestions have been implemented. At the PRI team, burn down graphs showing the takt for each team member is implemented together with the visualization of status, work in progress, queues and appropriate action. The suggested usage of the KI/VP board was already implemented when the thesis started but the suggestion of handling all methods developed at the PRI team as deliveries on the board is something that has been implemented through the project. Further, the visualization of computer related issues like absence of 3D drawings and slow systems have been implemented. The project board has been presented for the PRI team and will be implemented when the individual takt and visualization of progress with the burn down graphs are rooted in the organization.

Regarding the concept of Analyze and Act it is partly implemented through the implemented Visual Communication and Standardization. Visualization of problems and progress makes the problems come in focus, making it possible to act. Further, root cause analysis is now used to find the root

cause of the issues instead of just firefighting existing problems. In connection to the flow mapping performed, value adding and non value adding activities and times has been defined. This is the first step of setting the activities in connection to the value adding time and by that improve the flow.

6.5 Evaluation

After the implementation, an attitude survey, found in Appendix C, where given to all seven persons in the PRI team working with methods for new cars. Most of those team members are positive to the implementation of individual takt, burn down graphs, work classification, problem visualization and visualization of projects, deadlines and project status. The first question regards how visualization would affect the work and all but one answered it would affect the work in a good way. The last person answered that it would affect the work in a very good way.

Regarding the second question, how an increased communication between the PRI team and the VSTG team would affect the total production, two persons answered it would have a moderate affect, four persons answered it would have a good affect and two persons answered it would have a very good affect. The third question, regarding how well problems have become a focus area since the implementation of the system issue collection board was also answered of all seven team members asked. Two answered it had become a focus in at moderate level, three answered at a good level and one answered at a very good level.

When it comes to the fourth question, how the team members thought takt on an individual level would work, only one person answered it would work in a moderate way. Five answered it would work in a good way and one person answered it would work in a very good way. The last question, regarding how takt based on takt units would contribute to an increased understanding of the individual project status, was answered by all seven persons. Two persons answered it would contribute in a moderate way and five persons answered it would contribute in a good way.

The attitude survey indicates that the implemented concepts are a step in the right direction. Since most of the team members are positive to the implemented concepts, indicating a positive attitude to future implementations. Further, though the attitude survey indicates the specific concepts can work, it also indicates that the specific model together with the general concepts and the general model can work.

7. Discussion

This chapter presents a discussion and reflection of the chosen methodology, the General and the Specific Model, recommendations for future work and the implementation. Further, the fourth and last Research Question, What are the potential gains if a paced and visual flow successfully could be implemented at VCCS, will be answered in this chapter.

The chosen methodology, based on the method model, provided the ability to work on two different abstraction levels, a prerequisite for this thesis. By following the model, both existing problems and existing areas of excellence are included in the analysis of the current operations. Theory and empirical results are applied in a structured way on the appropriate level of abstraction regarding problems and concepts which makes the model appropriate for this type of study. The fact that the Specific Model and its concepts is within the scope of the General Model and its concepts makes the General Model valid through the implementation of the concepts belonging to the Specific Model. That validation is further strengthened through the iterative nature of the model, making it possible to re lop the progress and start out by analyzing the existing problems once again.

Though the study has been conducted in close cooperation with the team members and team leaders in the analyzed flow, the daily operations have been studied from an internal perspective. The researchers have had the opportunity to be a part of the PRI team and got to know the operations from the inside. This gives validity to the developed models and the research questions because they are dependent on the existing issues and areas of excellence in the organization.

Without this inside perspective, the method model can be questioned, indicating that the model is not suited for research studies that have its base in theory and not in empirical results. However, the method model is possible to use in research studies with its base in empirical results and are not locked to research studies regarding operation improvements. It is a useful tool when trying to apply theory on problems and areas of advance in a structured way and has the ability to combine theory and empirical results, developing solutions on different levels of abstraction. Finally, the model is self correcting through its iterative nature and validates both the specific and general model through the implementation of the specific concepts.

The focus of the observations has been on the PRI team which might have affected the results in the form of deceptive specific problems. However, several KI/VP-meetings have been attended at the VSTG team and the PT team, together with real work observations at all the teams. The least focus has been on the PT team and the reason is that the PT team constitutes the least of the total flow. The fact that interviews have been conducted at all levels at VCCS gives validity to the results in the form of obtaining both the broad long term perspective and the operational detailed perspective. That reduces the impact of the unequal distribution of focus regarding observations throughout the flow.

The theory used is mainly based on lean philosophy which might have narrowed the scope of the developed models. However, since the theory was chosen based on the general problems, there is nothing indicating that inappropriate theory was used. Further, the theory used includes a wide range of published lean philosophies making the developed models span from specific tools to philosophies and mind set, presenting a complete picture of paced flow through takt and visualization. At a first glance, it can be questioned why the fourteen principles of Lean or Liker´s description of the Toyota Product Development System were not used as the model for paced flow.

However, the fourteen principles focus too much on manufacturing to be used in white collar organizations and Toyota Product Development System, even though the operations are similar to VCCS white collar operations, focus on another degree of complexity. Therefore, existing concepts of Lean and operations management have not been used straight away, but instead applied on the general problems, in order to create a customized model for this organization.

Regarding the general model, it is hard to determine the generality. The purpose of the model is to be suitable at all white collar operations at VCCS and its concepts is discussed with all managers at Workshop and Owners Information, receiving positive feedback. It has also been presented for a team at Workshop and Owners Information working in a totally different flow. The feedback and the conclusions from that presentation tells that all general concepts are important in their operations as well. However, some the general concepts, derived from problems existing in the analyzed flow, already existed in their operation and flow, only giving validity to the general model.

Further, it is important to mention that the general model shows that the ground of the VCCS Lean house is of great importance in order for a takt based and visual flow. Takt, the core of the general model, is one of the stones in the VCCS Lean house, but in order to be able to have a takt, many of the other stones has to be present. The house includes concepts like standardization and visualization, which is also used in the general model in the purpose of achieving takt based and visual flow. That shows that all concepts are depending on each other and that neither the Lean house or the developed General and Specific Model will work without all concepts in place.

The fourth research question, what are the potential gains if a paced and visual flow successfully could be implemented at the flow of producing a spare part structure, repair method and setting a standard time, will further be discussed in this chapter, concept for concept. The first concept, Focus on Flow will, when having the persons producing the repair method and the persons setting the standard time in the same team, increase the communication and coordination throughout the flow and in that way reduce waste. The waste of waiting is the waste that probably will be reduced the most, especially in a future state when the same person is responsible for both developing the method and setting the time. Further, the waste of rework will be reduced when information is easier communicated throughout the flow and information does not have to be gathered more than one time.

In addition, rework in the form of performing verification is reduced when only one person has to verify and in the initial stage, when both persons can verify at the same time, only demounting and mounting the car one time. By increasing the communication and produce in small continuous deliveries, the buffer between the person developing the method and the person setting the time will decrease, reducing the lead time. Further, having the flow in mind when creating the takt will coordinate the flow, leading to reduced lead time, higher quality and less waste.

By utilizing the concept of Define and Plan, frontload the projects and put more effort in to the method assessment, there will be a steady pace from the first produced method and time to the last one produced before the deadline. That reduced unevenness in the system, reducing the waste and making it possible to plan towards real capacity, not building waste in to the system or utilizing the resources through Muri, overburden. The frontloading of projects, separating assessment from production reduces the number of parallel work tasks making it possible to focus on what is important at the moment. The production gets less messy and it will be easier to keep track of the

progress. Fewer parallel projects will also be achieved by dividing the projects among the team members, refine the production and focus on the important tasks.

Further, the specific concept of Define and Plan includes a categorization of methods and standard times, making it possible to base the takt on progress closer to the real progress than before. The leveling of the workload is in that way facilitated and a smooth production rate from start to finish of a project will be achieved. That reduces the waste of overburden in the later part of projects and reduces the need for paying overtime to the team members in order to meet the deadline.

The third specific concepts, standardization will reduce the waste of rework by having a standard for the total value flow, including activities and sequence. By having a standardized checklist for the information entering the flow, problems will be surfaced earlier, enabling the team to solve them before the point of use, increasing the possibility to meet the deadline. By standardizing the problem solving process and include root cause analysis, the factor underlying issues and problems will be solved, reducing the need for firefighting activities and making it possible for both team members and team leaders to focus on value adding activities. The last potential gain of incorporating standard in the flow is aligned design and quality of methods and standard times. That will make it possible to improve the product, raising the value for the customer.

The potential gains of the fourth concepts, Visual Communication, is, regarding the burn down graph the fact that the individual progress and total status is visualized, facilitating rebalancing and actions to help. The project board, together with the burn down graph at the KI/VP board gives a complete picture of the production and give management the opportunity to see exactly where problems occurs. In that way, management has the ability to set in direct help and resources to the instance that needs it, enabling a takt based flow. The project board further puts a focus on the assessment phase, increasing the incentives to meet the deadline for the assessment, enabling a takt based and leveled production. The visualization of issues and problems makes it impossible to shut one´s eyes for the problems, increasing the possibility to solve the root cause and pave the way for future production. Further, by visualizing deliveries and inputs in the form of methods and standard times at the KI/VP board, waste in the form of waiting will be reduced, enabling a more efficient flow.

By focus on the indicators of upcoming problems, like queues and work in progress, actual problems and issues will be reduced, making it possible to focus on production, reducing the lead time and increasing the quality. In that way, efficiency will be increased. Further, the specific concept of Analyze and Act does, by setting actual time in relation to theoretical time and value adding time, surface waste in the flow, making it possible to eliminate it. The elimination of waste and solution of issues and problems through appropriate actions and countermeasures reduces disruptions in the flow, enabling for a paced flow based on takt and visualization.

The potential gains are supported by the attitude survey, found in Appendix C, where most of the team members are positive to the implementation of individual takt, burn down graphs, work classification, problem visualization and visualization of projects, deadlines and project status. All persons answered that the project board would affect their work good or very good. The average answer to how well problem solving had become a focus area and how well takt on individual level would work was good. Regarding how well an increased communication between the PRI team and the VSTG team would improve the production, most persons asked answered good or very good and

two persons answered medium. Regarding the last question, all but two answered that a takt based on takt units contributed to an increased understanding of status towards deadline in a good way.

Based on the potential gains, several recommendations for further work have been developed. One of the main recommendations is to continue with the flow mapping throughout the entire organization. That will create an understanding for the operations and the flow, making it possible to improve in the future. It is also a prerequisite for the implementation of a flow organization which is strongly recommended. The change from a functional organization to a flow organization is something that involves the whole section and requires a lot of time and effort, but it is necessary for a paced flow based on takt and visualization, has strong potential gains and is for that reason strongly recommended. It is further recommended to incorporate this model in other parts of the flow, outside VCCS. As earlier mentioned, a total flow perspective is of great importance and by including Research and Development in the flow, benefits of scale will be achieved, taking the takt based flow to a new level.

However, when going for a flow organization, it is of importance to remember that it can be drawbacks as well. Merging the PRI team and the VSTG team and letting one person both develop the method and setting the time puts new demands on the engineers. There might be a hard time in the beginning, learning the new tasks, but since the technical knowledge is about the same, the added requirements mostly refers systems which over time is assumed to be a minor issue. Another drawback is that when one person does all the work in the flow, including quality assurance through verification of the end product, the quality can be decreased since there is not somebody else verifying the job. However, increased responsibility for the end product is assumed to exceed any possible quality drawbacks.

In order to validate the general and the specific model, the method model that this thesis is based on has to be used from the start more times. By starting out by analyzing the operations once again, new specific problems will probably appear, leading to new general problems which might affect the general and the specific concepts developed. In order to further validate the concepts and the models, the method model shall be used at other departments, to see if the general concepts still are suitable or if new ones are developed.

While analyzing the operations and creating models for how to achieve a takt based and visual flow, areas of improvements outside the scope of this thesis has been found. The main potential improvement, not connected to the core of the thesis, is increased usage of virtual tools. By working virtually, with better product information, earlier in the projects, the total lead time for developing a new car, develop service and repair information and start selling it can be reduced. The reason is that much of the work can be done in parallel with research and development so that only verification is left when the first physical cars are built. However, there are no possibility of doing this today when models and product information is of low quality until the end of the development process.

8. Conclusions

The purpose of this thesis was to give recommendations in order to improve quality, reduce lead times and increase efficiency in white-collar organizations through takt based and visual flow. This has been accomplished through a work progress, illustrated by the method model, based on existing problems in the analyzed flow, surfaced through internal empirical data. The existing problems was categorized and transformed into general problems by raising the level of abstraction. Theory has been applied on the general problems to develop solutions, named general concepts. External empirical results and extended theory was then used to transform the general concepts into specific concepts, solving the existing problems at the analyzed flow.

The work process, based on the four quadrants in the method model, has also answered the four research questions of where the first one regards current problems existing in the organization, preventing visual and takt based flow. From the method model, it can be derived that the answer to that question is the categorized problems. These are; Availability and quality issues with 3D models, System reliability is low, Current production progress towards deadline is hard to know, Departments do not communicate with each other regarding planned deliveries, workloads and issues, Confusion regarding sub operations and its sequence, Fluctuating and uncertain input, lack of insight in project contents, confusion regarding what shall be done in the different projects, Lack of structure and usage of the KI/VP meeting and incorrect methods and standard times.

The second research question is also found in the method model and concerns prerequisites for visual and takt base flow at VCCS. The prerequisites were found through studying the problems in the current operation and based on them find areas of excellence. Theory regarding Lean and organizational improvements has been applied on those areas of excellence, developing the following prerequisites; Stable Processes, Understanding of the Flow and Balanced Flow.

The third research question regards which important factors that need to be considered and focused upon in order to create visual and takt based flow at VCCS and is also derived from the method model. Five concepts have been found through the application of theory on the general problems. The first concept is Focus on Flow of where flow teams ad flow managers shall be used with takt from a flow perspective. Further, there must be a focus on small continuous deliveries and widening of work competence. Define and plan is the second concept, focusing on frontloading, workload classification and few parallel projects. Third is the concept of standardization including data collection, issue handling and flow with activities and its sequence. The fourth concept is Visual Communication of where project progress, project status and issues shall be visualized. The last concept is Analyze and Act, including setting theoretical cycle time in relation to real cycle time, root cause analysis and taking action through countermeasures.

The potential gains of a visualized and takt based flow implemented at the analyzed flow, the fourth and last research question, is also derived from the method model. Increased communication and coordination, leading to less waste in the system, is two gains related to the concepts of Focus on Flow. Define and Plan will give the benefit of a leveled flow, reducing the waste of waiting and overburden and the concept of Standardize will surface problems earlier and give the possibility to improve. Understanding status and progress, enabling help from management together with surfaced waste are two gains coming from the concept of Visual Communication. Further, the gain of Analyze and Act is to be able to solve upcoming issues before the production gets affected, reducing the waste in the system.

Those gains, coming from the concepts, will improve quality of the repair methods and standard times, reduce lead time for the entire flow, from the creation of a spare part structure to a determined standard time. It will also increase efficiency, mainly through the elimination of waste and reduced issues, making it possible to focus on the production of repair methods and standard times. The quality will improve because the system will start operating at a common and even pace which results in met project deadlines without scarifying quality and decreased stress level enabling quality assurance like repair method verification. Lead time will be reduced since work in progress of methods and times will decrease which in turn will surface problems, improving quality. The efficiency will be increased because the takt creates pace in the flow, aligning the PT team, the PRI team and the VSTG team, decreasing the interruptions and reducing the waste in the flow.

References

Bergman, B., & Klevsjö, B. (2010). *Quality - from Customer Needs to Customer Satisfaction.* Lund: Studentlitteratur AB.

Brace, I. (2008). *Questionnaire Design : How to Plan, Structure and Write Survey Material for Efective Market Research, 2 edition.* London: Kogan Page Limited.

Bryman, A., & Bell, E. (2011). *Business Research Methods.* New York: Oxford University Press Inc.

David, S., & Zokaei, K. (2005). Application of lean paradigm in red meat processing. *British Food Journal, Vol. 107 Iss: 4* , pp. 192 - 211.

Deming, E., & Walton, M. (1986). *The Deming Management Method.* New York: The Berkly Publishing Group.

Emiliani, B., Stec, D., Grasso, L., & Stodder, J. (2007). *Better thinking, better results: case study and analysis of an enterprise-wide lean transformation (2nd ed.).* Kensington: Conn: Center for Lean Business Management.

Hines, P., Francis, M., & Found, P. (2006). Towards lean product life cysle management. *Journal of Manufacturing Technology Management* , Vol. 17 No.7 pp. 866-887.

Hultkrantz, O. (2012). Program Director at Chalmers . (G. Bindekrans, & M. Magnusson, Interviewers)

Ishikawa, K. (1976). *Guide to quality control.* Tokyo: Asian Productivity Organization.

Juran, J. M., & De Feo, J. A. (2010). *Juran´s Quality Handbook.* United States of America: McGraw-Hill Professional Publishing.

Lee, T. (1999). *Using qualitative methods in organizational research.* Sage publications inc.

Liker, J. K. (2004). *The Toyota Way - 14 management principles from the worlds greatest manufacturer.* New York: McGraw-Hill.

Liker, J. K., & Convis, a. L. (2012). *The Toyota Way to Lean Leadership.* New York: The McGrow-Hill.

Liker, J. K., & Morgan, J. (2011). Lean Product Development as a System: A Case Study of Body and Stamping Development at Ford. *Engineering Manageent Journal* , 16-28.

Lindlöf, L. (2012). PhD-Student. (G. Bindekrans, & M. Magnusson, Interviewers)

Lindlöf, L., & Söderberg, B. (2011). Pros and cons of lean visual planning: experiences from four product development organisations. *Int. J. Technology Intelligence and Planning* , Vol. 7. No.3 pp.269-279.

Malmborg, P. (2012). Operations development and Lean Manager at RUAG Space AB. (G. Bindekrans, & M. Magnusson, Interviewers)

Modig, N. (2012). PhD student. (G. Bindekrans, & M. Magnusson, Interviewers)

Modig, N., & Åhlström, P. (2011). *Vad är Lean?* Stockholm.

Morgan, J. M., & Liker, J. K. (2006). *The Toyota product developmet system.* New York: Productivity Press.

Nyström, l. (2012). Business Area Manager and Partner at CANEA Consulting Group . (G. Bindekrans, & M. magnusson, Interviewers)

Palmer, P. (2012). Senior Manager Process Support R&D at Scania. (G. M. Bindekrans, Interviewer)

Popper, K. R., & Miller, D. W. (1983). A proof of the impossibility of inductive probability. *Nature 302* , p. 687-688.

Rother, M., & John, S. (1999). *Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA.* Cambridge: The Lean Enterprise Institute.

Ryan, T. P. (2011). *Statistical Methods for Quality Improvements.* New Jersey: John Wiley & Sons, Inc.

Scuplin, R. (1997). The KJ Method. A technique for Analyzing data derived from japanese ethnology. *Human Organizations* .

Seddon, J. (2010). *Bort från styrning och kontroll - omvärdering av Lean service.* Lund: Studentliteratur AB.

Shingo, S. (1992). *The Shingo Production management System : Improviong Process functions.* Portland: Productivity Press.

Sobek, D. (2012). Ph.D. (G. Bindekrans, & M. Magnusson, Interviewers)

Sparrow, J. (1998). *Knowledge in Organizations: Access to Thinking at Work.* Thousand Oaks, CA: Sage Publications.

Spear, S., & Bowen, H. K. (1999, September). Decoding the DNA of the Toyota Production System. *Harward Business Review* , pp. 96-106.

Sällström, P. (2012). Lean Coordinator & Project Management at Thermo Fisher Scientific. (G. Bindekrans, & M. Magnusson, Interviewers)

Urdhwareshe, H. (2011). *Six Sigma for Business Excellence: Approach, Tools and Applications.* India: Dorling Kindersley Pvt. Ltd.

Wallén, G. (1996). *Vetenskapsteori och forskningsmetodik.* Studentlitteratur.

Westberg, P. (2010). *Program Plan - VCCS Lean Program.* Göteborg: VCCS Lean team.

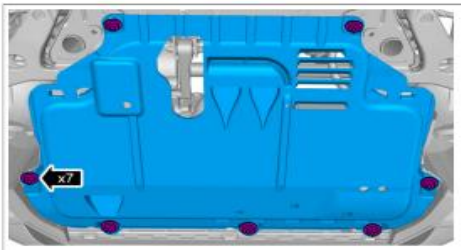
Womack, J. P., & Jones, D. T. (2003). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation.* New York: Free Press.

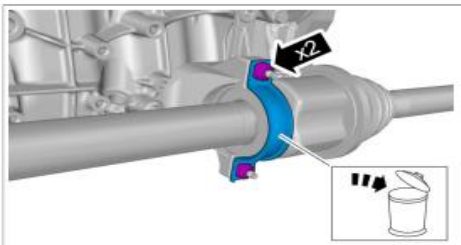
Womack, J. P., Jones, D. T., & Roos, D. (2007). *The Machine That Changed The World.* New York: Free Press.

Womack, J., & Jones, D. (2005). *Lean Solutions: How Companies and Customers can Create Value and Wealth Together.* New York: Free Press.

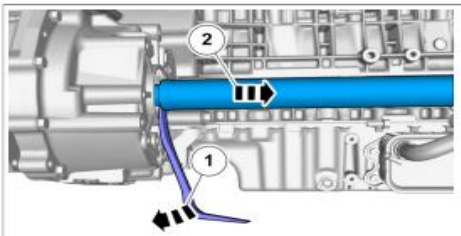
Appendices

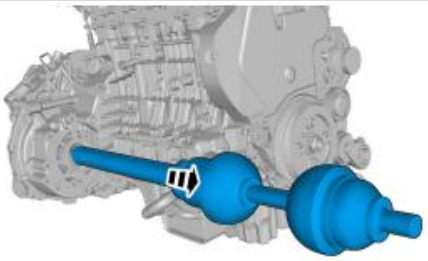
Appendix A: VCC Service and Repair Method





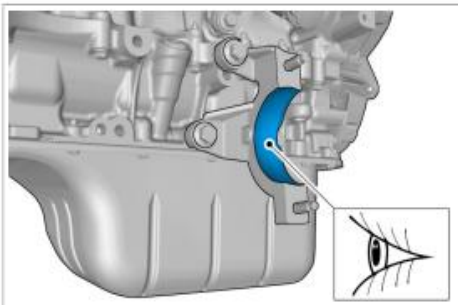
Obs! Säkerställ att en ny komponent används.





Viktigt! Säkerställ att inre drivaxelknuten inte delar sig.

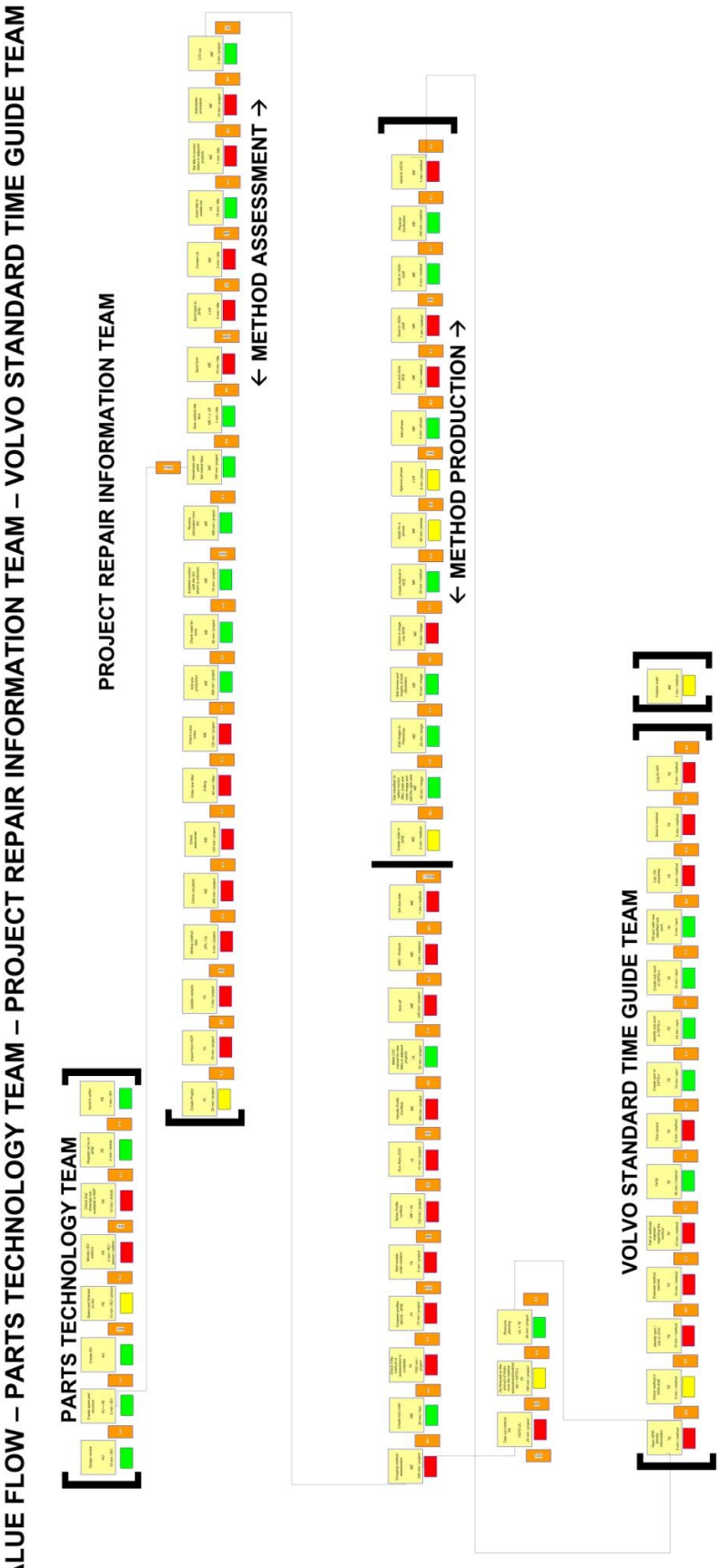
Ditsättning



Viktigt! Säkerställ att ytan är ren och fri från främmande material.

Sätt dit i omvänd ordning.

Appendix B: Analyzed Value Flow



Appendix C: Attitude Survey

Frågeformulär angående arbetet med ett taktat och visuellt flöde.

Vänligen ta några minuter och fyll i denna undersökning gällande vad du tycker om nedanstående områden. Syftet med denna undersökning är att ta fram data för hur arbetet med taktat och visuellt flöde upplevs av personer som arbetar inom sektionen. Markera med ett kryss i den cirkel som du tycker bäst passar ihop med texten. Alla svar behandlas konfidentiellt.

Tack för din medverkan!

Hur skulle en tydlig visualisering av projektomfång, deadlines och projektstatus påverka ditt arbete?

○	○	○	○	○
Dåligt	Ej tillfredsställande	Medel	Bra	Mycket Bra

Hur tror du en ökad kommunikation med VSTG skulle påverka den totala produktionen?

○	○	○	○	○
Dåligt	Ej tillfredsställande	Medel	Bra	Mycket Bra

Hur väl anser du problemlösning kommit i fokus i och med visualisering av systemproblem?

○	○	○	○	○
Dåligt	Ej tillfredsställande	Medel	Bra	Mycket Bra

Hur tror du takt på individnivå kommer fungera?

○	○	○	○	○
Dåligt	Ej tillfredsställande	Medel	Bra	Mycket Bra

Hur tycker du takt baserad på taktenheter bidrar till en förståelse för hur du ligger till gentemot deadline?

○	○	○	○	○
Dåligt	Ej tillfredsställande	Medel	Bra	Mycket Bra