Process improvement

A study of Industrialisation processes at Flextronics

INSTITUTE OF TECHNOLOGY
LINKÖPING UNIVERSITY

Jonna Brandon

Karin Selander

Master Thesis

LiTH-EKI-EX-05/078-SE

Linköping Institute of Technology

Department of Management and Economics

Project, Innovation and Entrepreneurship

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Academic supervisor: Jonas Söderlund

Company supervisor: Tomas Westlund

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Title **Process improvement – a study of Industrialisation processes at Flextronics**

Authors Jonna Brandon & Karin Selander

Summary

Flextronics Industrialization Group (FIG) is an international company specialised in Industrialisation services for the mobile phone industry. Industrialisation services include everything that is done to prepare a product for high-volume manufacturing. This mainly involves developing production processes, production equipment, test processes and test equipment.

This study has been performed at FIG in Linköping, where the work is carried out as projects. In 2004, a new project model called the Product Development Process (PDP) was introduced at Flextronics worldwide. As the name implies, the PDP was originally created to support product development projects, which is why it has been hard to completely utilize the PDP at FIG.

The purpose of this master thesis was to develop an application of the PDP suitable for the Industrialisation projects performed at FIG. During our work internal PDP documentation was studied and interviews with project managers and sub-project managers were performed. Review meetings were held frequently during the entire study and our solutions were revised several times.

Our work has above all resulted in new processes applicable for Industrialisation projects. To make these Industrialisation processes easy to follow we have produced a guideline. This guideline provides a framework for Industrialisation projects at FIG. It includes detailed descriptions of the Industrialisation processes, checklists, decision structure, project organisation and project roles and responsibilities.

We believe that the Industrialisation PDP application will improve the work at FIG. It will be easier to follow a working method that is adapted to the specific business. Using the same working methods will support the project work, improve the way of working and make it more efficient.

Keywords

Industrialisation, processes, process management, working methods, Flextronics

Preface

This report is the result of a master thesis performed at Flextronics Industrialization Group in Linköping. It is the concluding part of our Master of Science degree in Industrial Engineering and Management.

During the work with this thesis several people have helped us with ideas and proof-reading, especially thanks to Johan Brattlöw, Johan Juel and Stina Karlsson. We would also like to thank our academic supervisor Jonas Söderlund and our opponents Anna Nordell and Carina Sjöström.

We would like to thank all people at Flextronics Industrialization Group that have contributed to our work and made this study possible. We would especially like to thank Tomas Westlund, our company supervisor, who has been a great help during the entire study. This has been an interesting and rewarding project, and we hope that you at FIG will find our results useful in future projects.

Linköping, December 2005

Jonna Brandon Karin Selander

Summary

Flextronics Industrialization Group (FIG) is an international company specialised in Industrialisation services for the mobile phone industry. Industrialisation services include everything that is done to prepare a product for high-volume manufacturing. This mainly involves developing production processes, production equipment, test processes and test equipment. The high-volume manufacturing is located in low-cost countries.

This study has been performed at FIG in Linköping, where the work is carried out as projects. In 2004, a new project model called the Product Development Process (PDP) was introduced at Flextronics worldwide. As the name implies, the PDP was originally created to support product development projects, which is why it has been hard to completely utilize the PDP at FIG. The PDP has so far been considered more trouble than support. This has lead to that project managers at FIG are working differently.

The purpose of this master thesis was to develop an application of the PDP suitable for the Industrialisation projects performed at FIG. During our work internal PDP documentation was studied and interviews with project managers and sub-project managers were performed. Review meetings were held frequently during the entire study and our solutions were revised several times.

Our work has above all resulted in new processes applicable for Industrialisation projects. To make these Industrialisation processes easy to follow we have produced a guideline. This guideline provides a framework for Industrialisation projects at FIG and explains the interconnection between the PDP and our new Industrialisation PDP application. It also includes detailed descriptions of the Industrialisation processes, checklists, decision structure, project organisation and project roles and responsibilities. Due to confidentiality reasons, our solutions could not be included in their entirety in this report.

We believe that the Industrialisation PDP application will improve the work at FIG. It will be easier to follow a working method that is adapted to the specific business. Using the same working methods will support the project work, improve the way of working and make it more efficient.

Table of contents

1 Introduction

This chapter provides a background to our work and the purpose of this master thesis. It also includes a disposition of the report.

1.1 Background

Today the product life cycle times for electronics have become shorter and shorter and at the same time the pressure on low costs and fast time-to-market has increased. To reduce the costs for material, production and labour, many companies in the electronics manufacturing segment have moved their production to low-cost countries.

The need for project models and common working processes has increased and has almost become a prerequisite for a successful business. Designing processes and implementing new project models requires a thorough knowledge of the business and an understanding for how different tasks are performed. These are important issues; the lack of common working methods makes it hard to keep up a high and even quality, maintain low costs and short lead-times.

Flextronics Industrialization Group (FIG) is an international company specialised in Industrialisation services for the mobile phones industry. FIG is not responsible for product development, i.e. FIG does not develop the mobile phones, but handles the Industrialisation services. Industrialisation services include all activities that are preformed in order to prepare a product for high-volume manufacturing (HVM). This mainly involves developing production processes, production equipment, test processes and test equipment. When selling Industrialisation services it is important to get involved early in the design process to be able to influence and improve the manufacturability.

FIG is part of Flextronics, a leading international electronics manufacturing company. FIG currently has two units; one in Linköping, Sweden and one in Shah Alam, Malaysia. At FIG, project management, production process development, test development and prototyping are performed.

1 Introduction

Most of the work performed at FIG is carried out as projects. There are currently fourteen project managers gathered in the project office in Linköping. The project managers are involved in one or more projects and each project is responsible for the Industrialisation of one mobile phone model. A project manager coordinates the project, mainly by communicating with the customer and with different sub-project managers responsible for various parts of Industrialisation.

In 2004, a new project model was introduced at Flextronics worldwide, including FIG. The purpose was to ensure quality when developing new products and get all different companies and sites within Flextronics to work in a similar way. This model is called the Product Development Process (PDP). The model was developed by a global cross-functional team comprised of representatives from all regions where Flextronics is active. It is a way for Flextronics to be more standardized and act more as one company, even though there are great variations between the different sites. The work to implement the model worldwide is in progress, but the PDP was released before it was fully developed, and there is ongoing work trying to improve the model.

Even though the global decision to implement the PDP at all Flextronics sites was made 2004, over a year ago, this has not been done at FIG in Linköping. As the name implies, the PDP was originally created to support product development, but this is not FIG's responsibility. The structure of a mobile phone project is shown in Figure 1 below; FIG's part is marked with a circle.

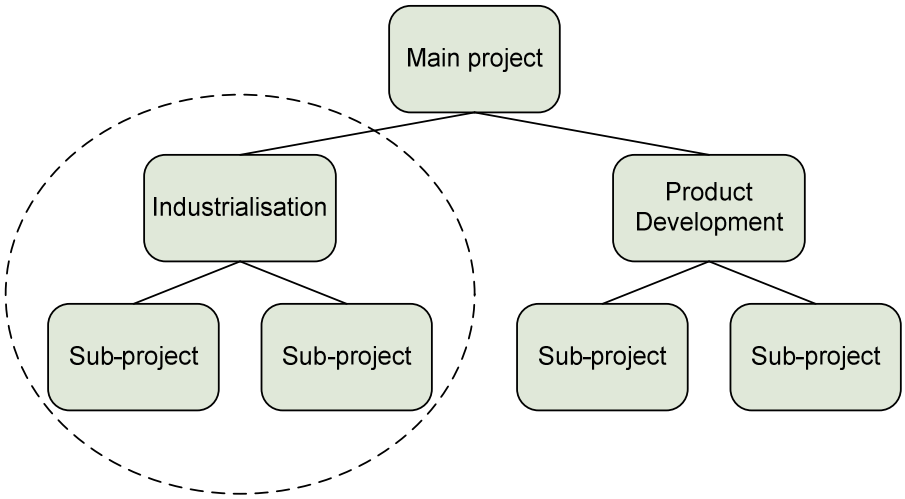


Figure 1: FIG is responsible for the Industrialisation part, which is marked with a circle.

The main project is coordinated by the customer and the Industrialisation project is coordinated by FIG. The work performed at the main project level and at the sub-project level is included in the PDP, but the work performed in the Industrialisation project level is not included. Since documentation is missing for this level it is hard for the project managers at FIG to follow the PDP.

Due to the difficulties when trying to use the PDP in Industrialisation projects, the PDP has been considered more trouble than support. Instead the project managers at FIG work differently, use experience from earlier projects and keep on working as they always have, for example by using their own old templates.

To get the project managers at FIG to use the PDP it must be modified to be applicable for the Industrialisation activities performed at FIG. Using the same working methods will support the project work and make it more efficient. If FIG can improve the way of working, time-to-market and costs can be reduced which will enhance the company's ability to compete on the market.

1.2 Purpose

The purpose of this master thesis is to study the PDP and the project work performed at FIG in Linköping to identify problems with the PDP, modify it and develop an application that is suitable for Industrialisation projects. The expected outcome is a standardized way of working in Industrialisation projects that will secure and improve the quality of the project work and make it more efficient.

The application of the PDP should only concern the work at an overall Industrialisation project level and not include details concerning different sub-projects, since that would require a much deeper technical insight in, for instance, production process development and test development.

1.3 Disposition of the thesis

This disposition outlines each chapter in the thesis. A glossary, references and an appendix are found at the end of the report.

1 Introduction
This chapter provides a background to our work and the purpose of this master thesis. It also includes a disposition of the report.

2 Company description
The purpose of this chapter is to provide a description of Flextronics, both FIG in Linköping where this thesis has been performed, and Flextronics as a global company. This chapter is based on internal Flextronics information.

3 Methods of research
This chapter describes the work procedure during this thesis, different approaches to research and how they have been applied to our study. It also includes criticism of the chosen method.

4 Description of the Product Development Process
This chapter contains the first part of the empirical findings and describes the PDP to provide background and concepts for the remaining report.

5 Problem areas
This chapter contains the second part of the empirical findings. It describes the different problem areas relevant to our study that have been identified.

6 Frame of reference
This chapter constitutes the theoretical frame of reference for the thesis, and consists of theories on basic project management, process management and roles and responsibilities.

7 Analysis
This chapter specifies and breaks down the assignment into smaller and more manageable parts. It also describes how we have arrived at our solutions.

8 Solutions and recommendations
This chapter presents our proposed solutions to the identified problem areas. It also includes further recommendations on how to proceed when implementing the solutions.

2 Company description

The purpose of this chapter is to provide a description of Flextronics, both FIG in Linköping where this thesis has been performed, and Flextronics as a global company. This chapter is based on internal Flextronics information.

2.1 Flextronics worldwide

Flextronics is an international electronics manufacturing company that provides complete design, engineering and manufacturing services to technology companies. Within the electronics manufacturing industry Flextronics is ranked number one in the world (www.emsnow.com, 2005-11-15). The biggest competitors are Hon Hai, Sanmina-SCI and Solectron. Flextronics is active in over 30 countries on five continents and is involved in various product and industry segments. The four main product groups are mobile communication, printing and imaging, infrastructure and consumer electronics/medical. The mobile communication segment accounts for 33 per cent of Flextronics' total revenue. Some of the industry leading customers are Casio Computer Corporation, Dell Computer Corporation, Ericsson Telecom, Hewlett-Packard, Microsoft Corporation, Motorola, Sony-Ericsson and Xerox Corporation. Headquarter for Flextronics is officially in Singapore but CEO Michael Marks is situated in San José, USA.

2.2 Flextronics Industrialization Group

The core business for FIG is Industrialisation services for the mobile phone industry. The concept Industrialisation will be explained later in this chapter. The projects at FIG vary from involving activities during the whole product life-cycle to taking on a much smaller role, like only developing prototypes or test fixtures, depending on what the customer wants. As shown in Figure 2, FIG has two divisions; one in Linköping, Sweden and one in Shah Alam, Malaysia. The sites in Linköping and Shah Alam both offer all services within Industrialisation. HVM is mostly performed at production sites in Malaysia, China, Mexico and Brazil.

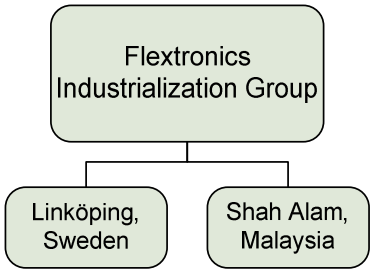


Figure 2: FIG has divisions in Sweden and Malaysia.

Sony Ericsson Mobile Communications (SEMC) and Ericsson Mobile Platform are the largest customers and represent the main part of FIG's business. Some other customers are Sagem, Texas Instruments, Sharp and Siemens.

2.2.1 Industrialisation

Industrialisation services are the core business at FIG. When performing an Industrialisation project, FIG does everything that is necessary to prepare a developed product for HVM. This mainly involves development and validation of production processes, production equipment, tests and test equipment. A lot of Industrialisation work is done to secure the ability to test, produce and distribute the product effectively. Prototyping is also an important part of Industrialisation. Building prototypes is a way to validate both the product, i.e. the mobile phone, and the production and test processes. The equipment used for producing and testing the mobile phones are called assembly fixtures and test fixtures. Assembling the mobile phones is mainly done manually. Sometimes simple mechanical assembly fixtures are used to simplify the assembly and make it more standardized to be able to keep a high and even quality. The test process is automated and the test fixtures consist of both mechanical and electrical parts. A description of the production and test line is included in section *2.2.5 Typical production and test flow*. Numerous fixtures are developed and duplicated in Linköping and then transferred to the HVM sites; during one year more than 1500 fixtures are sent from Linköping to the HVM sites in Asia.

Industrialisation activities also include defining material supply chains and processes. This involves securing suppliers and finding alternate suppliers for different components. Logistics processes such as transportation, warehousing and delivery are also parts of Industrialisation.

At FIG two types of projects are performed; Original Equipment Manufacturing (OEM) and Original Design Manufacturing (ODM). In an OEM project an external customer, e.g. SEMC, develops the mobile phone and in an ODM project it is Flextronics that develops the mobile phone. In either case, FIG solely provides the Industrialisation services. FIG mostly performs OEM projects. In an ODM project there are no external customers involved from the beginning. When the phone is ready, it is bought by one or several customers that put their own brand or logo on it and sell the phone as their own.

2.2.2 Line organisation

FIG in Linköping is divided into different divisions with altogether approximately 200 employees. The biggest division is Production Test Development, where half of the employees work. Figure 3 shows the line organisation at FIG in Linköping. These divisions are described below.

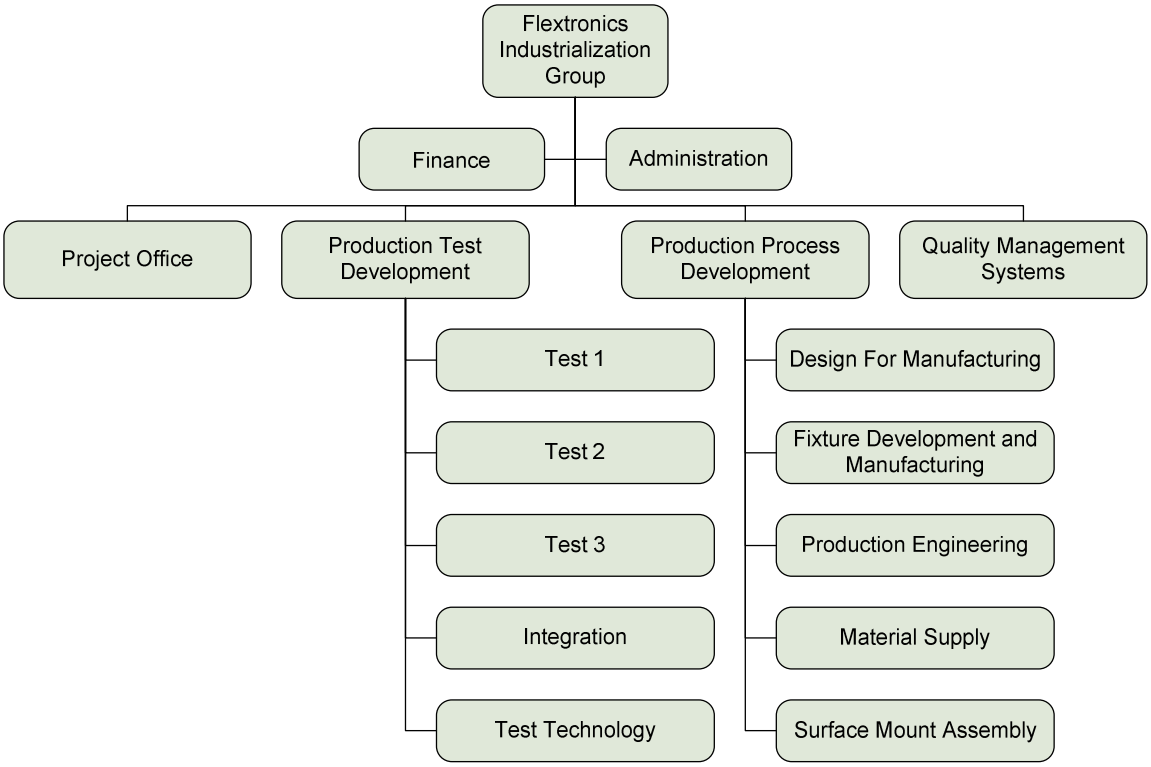


Figure 3: Line organisation at FIG in Linköping.

Project Office

Most of the work performed at FIG in Linköping is carried out as projects. The project managers are gathered in a division called the Project Office. The project managers often work in international projects, which can involve team members from several countries. For example, development of production processes and prototyping can be performed in Linköping, and then knowledge and equipment are transferred to Asia for the HVM.

The project managers are involved in one or more projects and each project is responsible for the Industrialisation of one mobile phone model. A project manager coordinates the project, mainly by communicating with the customer and different sub-project managers responsible for various parts of Industrialisation. Besides coordinating the project, the project managers draw up budgets, time plans and manages all invoicing. There are also project managers working with other activities such as repair, capacity planning or transfer. Transfer means moving all the production and test lines to the HVM sites.

Production Test Development

Production Test Development develops and manufactures complete test systems for mobile phones. This includes developing test processes, software, fixtures and measuring devices. The subdivisions Test1, Test2 and Test3 develop the tests and the subdivision Integration transfers the processes and equipment to the HVM site and initiates the production. Test Technology is a subdivision that supplies support and service to the entire Production Test Development division. This involves administrating all work documents, e.g. documentation that describes every test station, installation and adaptation of developing tools and maintenance of old and new production control systems.

Production Process Development

Production Process Development consists of five subdivisions; Design For Manufacturing, Fixture Development and Manufacturing, Production Engineering, Material Supply and Surface Mount Assembly. The subdivision Design for Manufacturing makes sure that the circuit boards and the products, i.e. the mobile phones, are manufacturable and adjusts the product and the processes to make them compatible. The subdivision Fixture Development and Manufacturing designs the assembly fixtures and the mechanical part of the test

fixtures. This subdivision is also responsible for assembling all the test fixtures. Production Engineering is a subdivision responsible for the whole production process and designs the production line. Material Supply purchases and distributes all the material needed for building fixtures and prototypes. Surface Mount Assembly is responsible for mounting all the components on the circuit boards.

Quality Management System
This division focuses on the customer. A lot of effort is spent on finding out how to please the customer. This is for example done by letting the customers fill out surveys and then having face-to-face interviews to find out what can be improved. Improvement work is an on-going activity to secure quality at FIG.

2.2.3 Project organisation

When a new project has been initiated, a project manager at the Project Office is appointed. The project manager communicates with the line managers, i.e. the resource owners, at the concerned divisions and requests resources for the project. When a project has been finished, the involved people go back to being resources in the line organisation.

The project organisation consists of representatives from the different divisions described in section *2.2.2 Line Organisation*. Sub-projects are formed and for each sub-project there is a sub-project manager assigned. All sub-project managers report to the project manager, that coordinates the entire project. The project organisation is shown in Figure 4 below.

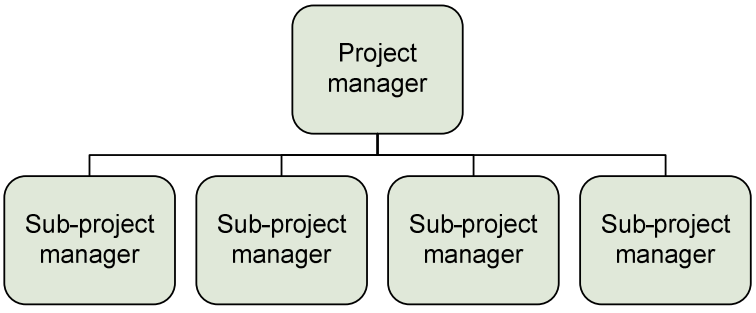


Figure 4: Project organisation at FIG in Linköping.

2.2.4 From product development to high-volume manufacturing

Some time after the product development of a new mobile phone has been initiated the Industrialisation project starts. When selling Industrialisation services it is important to get involved early in the design process to be able to influence and improve the manufacturability. During an Industrialisation project, several prototypes are built, which is shown in Figure 5. The number of prototypes built varies from project to project, depending on what the customer wants.

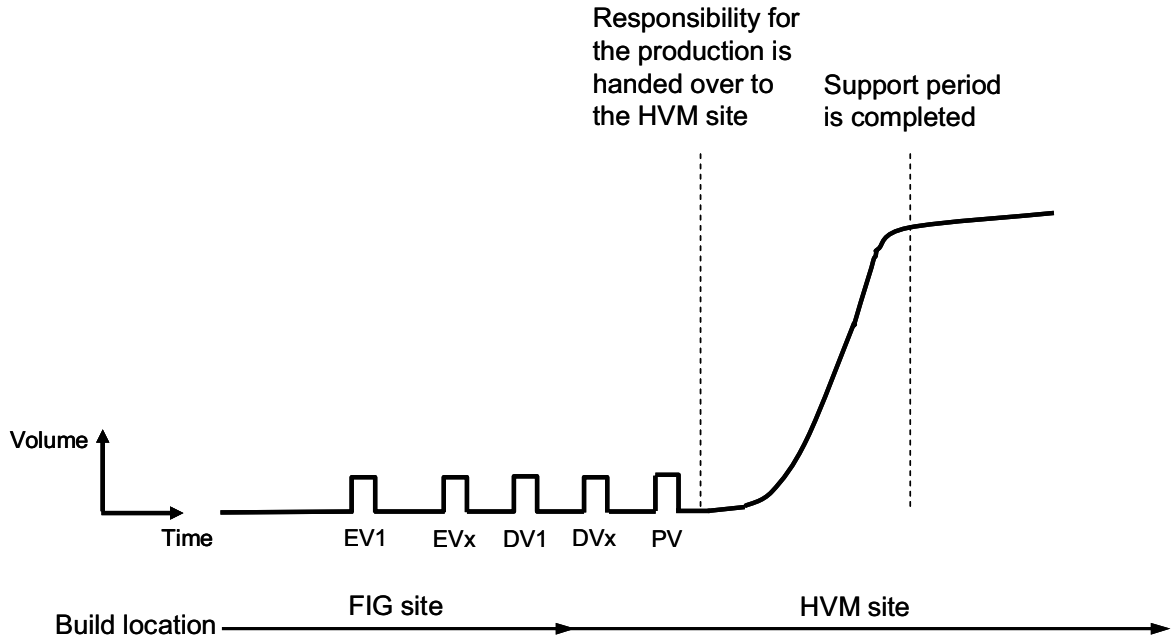


Figure 5: The process from product development to HVM.

The first prototypes that are built are called Engineering Verification (EV) and these are made to complete the design. Sometimes an EV involves only the circuit board, and not the entire phone. Next are Design Validation (DV) prototypes and at this stage the correct processes are used when building the phone. DV prototypes are used to verify the production process. The first DV prototype is often built at FIG and then the process is transferred to the HVM site. The remaining prototypes are called Process Validation (PV) and these are built at the HVM site. The purpose is to verify that the production process is working correctly at each HVM site. After the process has been transferred, the training of the sustaining line organisation at the HVM site is initiated. When the PV prototypes are approved and the training of the sustaining line organisation

is sufficient FIG hands over the responsibility for the production to the HVM site. After that, FIG is only responsible for supporting the production. FIG releases many of their project resources at this point since fewer people are needed for the support phase, which normally lasts for three months. When the support period is completed, the project is finalized and all resources are released. This is where the project ends for FIG.

2.2.5 Typical production and test flow

When manufacturing mobile phones in high volumes, a typical production and test line looks like the one shown in Figure 6. Circuit boards without any components enter the line, and the finished phones that are ready to be delivered to the end user come out on the other side.

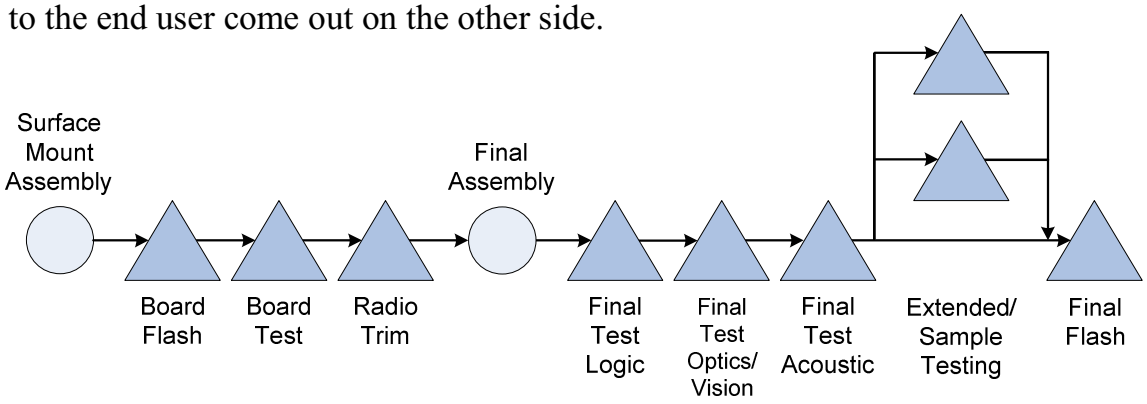


Figure 6: Typical production and test flow.

The stations in the line are shortly described below:

- **Surface Mount Assembly.** All components are mounted on an empty circuit board.
- **Board Flash.** Test software is downloaded into the circuit board and some base band tests are conducted.
- **Board Test.** The GSM radio is tested and base band measurements requiring instruments are conducted.
- **Radio Trim.** The GSM radio is trimmed and the radio is tested and calibrated.
- **Final Assembly.** The phone is assembled without being customized.
- **Final Test Logic.** Keypad, display, vibrator and camera are tested manually. Microphone, earphone and loudspeaker can also be tested manually if this is cost efficient.

- **Final Test Optics/Vision.** The display background light is calibrated and the display is being checked for dust and failing pixels.
- **Final Test Acoustic.** The microphone and speaker are trimmed and tested.
- **Extended/Sample Testing.** Extended test are performed on sample basis (one phone out of a thousand is often recommended). This can involve testing how the radio responds to high and low temperature, how well the phone works when the battery level is low and if there is any distortion of acoustics.
- **Customization.** Customization can for example involve putting on a customer logo, changing the colour of the cover or enclosing specific accessories along with the phone. This station is often before Final Flash. The later the better for FIG, since the phone may be sold to more than one customer.
- **Final Flash.** Customer software is loaded into the circuit board, and the mobile phone is now ready to use. After this station the phone gets packed and shipped.

3 Methods of research

This chapter describes the work procedure during this thesis, different approaches to research and how they have been applied to our study. It also includes criticism of the chosen method.

3.1 General description of the work procedure

For this thesis we have been inspired by a work procedure described by Scott (2004), which was modified to better suit the needs of our project. We believe that this work procedure was appropriate because of the logic order of the phases and also because the work can be seen as an iterative process. When entering a new phase the previous ones can be reviewed and revised. The chosen work procedure is depicted in Figure 7. The work performed in the different phases is described in the sections below.

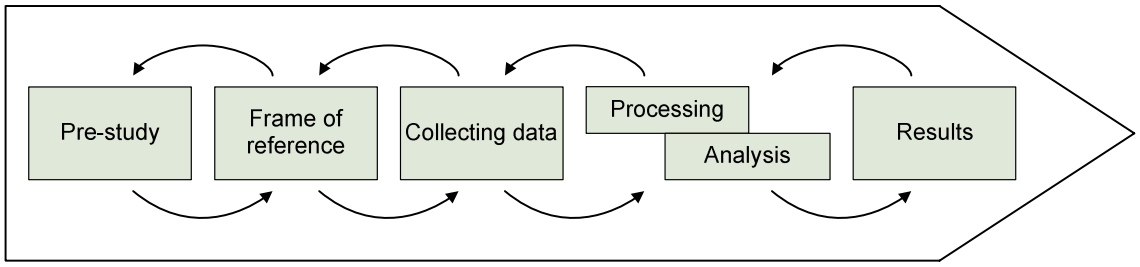


Figure 7: Work procedure for this master thesis.

3.2 Pre-study

During the pre-study phase we received information about the company and were introduced to the employees at the Project Office. We had several meetings with our company supervisor in order to better understand the assignment and to get an overview of FIG's business. Our company supervisor works as a project manager and is also responsible for PDP implementation and improvement work at FIG in Linköping. Meetings with our academic supervisor were held to make sure that the assignment was appropriate for a thesis. A meeting with both the company and academic supervisors was also held to discuss the assignment and to plan an appropriate work procedure.

The pre-study was performed in order to understand the assignment and the problems further. We studied internal PDP documentation and conducted several interviews. The interviews were held with project managers at the Project Office and sub-project managers working at the divisions Production Process Development, Production Test Development and Quality Management System. In the beginning of our study we decided in collaboration with our company supervisor who to interview. Later, as our knowledge increased, we selected additional people to interview by ourselves. The goal with the interviews was to get an understanding of how different people use the PDP and what their opinions about it are. The interviews were also held to provide an understanding of the work performed at the different divisions. After the pre-study we chose, in collaboration with our company supervisor, what problem areas to focus on.

The pre-study phase resulted in a project plan for the continuous work and the chapters *2 Company description* and *4 Description of the Product Development Process*.

3.3 Frame of reference

To form a theoretical base and to be able to further develop the problem discussion, appropriate project literature was studied. Literature concerning different types of research and research strategies was also studied to be able to choose appropriate research methods for our study. We searched the university library database and read other master theses to find relevant references. After reading and analysing literature we were able to find relevant theories for the problem areas. We also decided what research methods to use in our study.

This phase resulted in the chapters *3 Methods of research* and *6 Frame of reference*, which later have been revised several times after learning more about the assignment.

3.4 Collecting data

Collecting data can be performed in many ways. Different types of research and research strategies can be used depending on the character of the problem.

3.4.1 Types of research

Lekvall & Wahlbin (2001) classify research into three different categories depending on the knowledge that is obtained through the study. These categories are *exploratory*, *descriptive* and *explanatory* research. Depending on the character of the problem, Patel & Tebelius (1987) divide research into *quantitative* and *qualitative*. These five different types of research are described below.

Exploratory

Lekvall & Wahlbin (2001) recommend using this type of study when conducting a pre-study or when the knowledge within a certain area is insufficient to be able to make any decisions. It is done to obtain fundamental knowledge and understanding. After conducting the exploratory study, it is possible to go on and perform the analysis or decide in what areas further studies are needed. According to Patel & Tebelius (1987) the strategies that are mostly used within exploratory research are interviews and participant observations, when performing a pre-study, and case studies when performing a main study.

Descriptive

The purpose of a descriptive study is, according to Lekvall & Wahlbin (2001), to map out the facts and describe, without explaining why, a certain situation or issue. The description can for example concern people or situations, and it can be matters that already have occurred or something in present time. Patel & Tebelius (1987) point out that different strategies may be used to collect data for the descriptive study, for example surveys, observations and interviews.

Explanatory

This type of study is done to explain the relations between different matters and tries to elucidate the connection between cause and effect. Sometimes it can be hard to see the difference between descriptive and explanatory research. (Lekvall & Wahlbin, 2001)

Quantitative

According to Bell (2000) quantitative researchers collect data that they analyse and try to find connections between. They perform measurements and use scientific techniques to find quantifiable and if possible general conclusions. Patel & Tebelius (1987) emphasize the importance of the researcher trying to neutralize all subjective elements and collect data objectively. A quantitative research should give the same result when being performed repeatedly.

Qualitative

Qualitative researchers are, according to Bell (2000), more interested in studying how people interact with their surroundings. They want to gain insight into how people interpret different situations. Patel & Tebelius (1987) mean that the researcher's life experience and values play an important role when interpreting the information collected from the interviewed persons.

3.4.2 Research strategies

When conducting research, there are many different strategies to choose from. Patel & Tebelius (1987) recommend classifying the strategies according to how they are performed. Lantz (1993) points out that both surveys and interviews can consist of questions that enable qualitative or quantitative analysis or a combination of these. The contents of the questions do not dictate the choice of research strategy, but it affects the design of the options the subject is given as possible responses. Two commonly used strategies are surveys and case studies and these are described more below.

Surveys

When the research group is large, interviews can be very time-consuming and expensive. Therefore, Patel & Tebelius (1987) recommend surveys when conducting a study of large groups of individuals concerning a delimited quantity of variables. This strategy mostly involves questionnaires. Since surveys have not been used in this study it will not be described any further.

Case studies

Case studies are suitable when conducting a study of a smaller group concerning a larger quantity of variables. The study is in most cases performed in the individuals' natural environment and tries to cover the whole perspective.

Several different techniques can be used, such as interviews, observations and studying documents. Case studies are often exploratory and constitute the foundation for future descriptive studies. (Patel & Tebelius, 1987)

3.4.3 Action research

One approach to research is action research. Bell (2005, p.8) defines action research as *an approach which is appropriate in any context when specific knowledge is required for a specific problem in a specific situation, or when a new approach is to be grafted on to an existing system.* When performing action research, the goal is to achieve recommendations for good practice that will enhance the performance of the studied organisation. This is done by making changes to the organisation's rules and procedures. In action research reviews and revisions are an important part. When the investigation is finished, and the results have been considered by all participants, the job is still not finished. The participants continue to review, evaluate and improve the results. This can be seen as a feedback loop.

Gummesson (2000) advocates that all those affected by a study should be involved and contribute to the outcome. Being action researchers imply that the researchers assume the role of so called change agents of the processes they are simultaneously studying. The action researcher is deeply involved and can be a person who is both an academic researcher and either an employee or an external management consultant. Action researchers are expected to produce not only knowledge but usable knowledge that can be applied and validated in action. The researchers also interact closely with the people and the environment they are studying. Those that are involved, i.e. the researchers and the people working in the studied organisation, solve problems in collaboration and learn from each other. It is important for the action researcher to focus on the totality of a problem, but still make it simple enough to engage those involved. Qualitative, informal, in-depth interviews and observation and participation are important parts of action science. Quantitative survey methods such as questionnaires or structured interviews may also be useful.

3.4.4 Interviews

According to Bell (2000), different information can be obtained depending on how the interview is outlined. It is important to be aware of the fact that interviews are time-consuming; they need to be planned, conducted and processed. It is easier to arrange and quantify the results if the interviews are standardized.

Degrees of structure

Different kinds of interviews yield different kinds of data. Therefore, it is important to decide what type of knowledge that is of value before preparing the actual interview. A structured interview is advisable when there are many respondents. When the respondents are few an unstructured interview is recommended, since the data processing is limited anyway. (Lantz, 1993)

When wanting to find out the important areas or to get ideas for further studies an unstructured interview is suitable. A disadvantage is that more knowledge and experience is needed than for a structured interview, and the processing and analysis of data can take a lot of time. If an interview is too unstructured it is possible that the interviewer gets too much data to process and maybe the data is also irrelevant. (Bell, 2000)

When performing a structured interview the processing and analysis of the data will be much easier because the structure of the questions has been drawn up in advance. A disadvantage is that since the interviewer has decided all the questions, it is possible that these questions are not really the important ones for the study. (Bell, 2000)

Motivation

Patel & Tebelius (1987) point out that people that are being interviewed are not always aware of the utility of answering the questions. Therefore it is very important to motivate these persons. Before starting the interview, it is a good idea to:

- Clarify the purpose of the interview.
- Emphasize the importance of the individual and make it clear to the respondent that his/her contribution is important.
- Explain how the contribution from the respondent will be used.
- Inform the respondent about the expectations on him/her.
- Estimate how long the interview is expected to last.

3.4.5 Observations

Patel & Davidson (2002) describe observations as studying events and behaviours of people in their natural environment. Observations can be used as the only method for collecting data or as a complement. The observer can participate in the observed situation, i.e. act as an active member in the observed group, or be outside the group and only observe. Patel & Davidson (2002) and Bell (2005) divide observations into *structured* and *unstructured* observations.

Degrees of structure

To be able to perform a structured observation the problem must be specified in detail and the situations and behaviours to observe should be known in advance. Before performing the actual observation an observation plan is prepared. This plan specifies what areas to observe. It is important to keep the observation plan simple and not include too many areas. To improve the quality of structured observations the observation plan should be tested carefully in advance. Since structured observations require some preparations these can be very time-consuming. (Patel & Davidson, 2002)

Unstructured observations are used when wanting to explore a certain problem area and gather a lot of information within this area. No observation plan is prepared before performing unstructured observations. Instead “everything” during the observation is registered. Unstructured observations require that the observer has a lot of knowledge regarding the observed problem, to be able to determine what information is relevant for the study. (Patel & Davidson, 2002)

3.4.6 Chosen method

We have chosen to use different types of research during different stages of our study. In the beginning of our thesis, when we had little knowledge of the situation, our study was exploratory. We asked a lot of general questions just to learn about the business and our assignment, to be able to decide what to focus on. Later on, as our knowledge grew, our study became more descriptive and explanatory. When understanding the business, what the problems were and where these originated from, we were able to include this in our report.

We chose to perform both quantitative and qualitative research. For example, when studying documentation of the PDP and other internal project work material, we used quantitative research. Qualitative research was used when performing interviews and interpreting the results.

We have performed our thesis as a case study. Besides performing interviews and studying internal documentation, we have observed the work environment during our time at the company. We have had our own space in an office landscape and we have participated in regular meetings with the Project Office and also attended other project meetings. Being involved in the daily business activities has provided a better understanding of how project work at FIG works in reality. When observing the work environment no observation plans were prepared in advance, i.e. all observations were unstructured.

Interviews have been an important source for obtaining information, especially during the pre-study. Early in the study we performed unstructured interviews. This was made because our knowledge about the PDP, the company and how project work was performed were very limited. During these interviews we asked questions about the respondent's main tasks and if the respondent worked according to the PDP. The interviews were booked in advance and performed in small secluded conference rooms.

As we learned more about the company, the PDP and the problems our interviews became more structured. More specific questions concerning the problem areas that we had identified were asked. After spending more time at the company we discovered that people at FIG in Linköping often go straight to each other to ask questions, instead of booking meetings in advance. This

informal way of communication is simplified by the open office landscape. When we only had a few questions that we knew would require a short amount of time, we went to the respondent and asked the questions directly. When having a larger amount of questions we booked the meeting in advance.

None of the interviews performed were recorded, instead both of us took notes. This was a deliberate choice since we believe that going through all the tapes afterwards would be too time-consuming. We also believe that the respondents might have felt uncomfortable during the interviews if they were recorded. The interviews helped us identify the problem situation. When setting up the interviews we carefully explained the purpose of the interview, how the results would be used and that the respondent would remain anonymous in our report.

3.5 Processing

We summarized the respondents' answers and grouped them according to the different problem areas that we had identified. In chapter *5 Problem areas* we chose only to include problem areas that were relevant for our study. For example, problems with the conference booking system were not included since these types of problem had nothing to do with our assignment.
After performing interviews and studying the PDP and other project documentation we developed new Industrialisation processes and corresponding checklists. This was done in collaboration with our company supervisor. To be able to describe the new Industrialisation processes in a way that is easy to understand, flowcharts in the program Microsoft Visio were designed. These flowcharts thoroughly describe the content of each process. The checklists were designed in the program Microsoft Excel. When designing the checklists we studied our process flowcharts and used existing checklists from the PDP.

3.6 Analysis

We have held presentations at the company of our on-going work to get input from more people that use or will be using the PDP. At several occasions we arranged review meetings, where people from the departments Project Office, Production Process Development, Production Test Development and Quality Management Systems examined the new processes and checklists. During these meetings approximately five to ten people participated every time. The review meetings started with a presentation of our work and then the participants were

able to ask questions which opened up for further discussions. We also put the latest versions of the solutions on a public area on the company network so everyone at the company could access them. This was a good way to make the solutions available, especially for those who were not able to attend all review meetings. The solutions were revised several times as more review meetings were held and more aspects could be taken into consideration.

3.7 Results

After the final review meetings we got an approval on our solutions, which were delivered to the company. Since a project normally lasts for 6-12 months it was not possible for us to verify our solutions by performing a whole pilot project. Nevertheless, a couple of project managers have already started to use our solutions, particularly the checklists. We have evaluated the project and documented our experiences in a conclusions report that has been delivered to the company. We have also held final presentations at both FIG in Linköping and at the university.

3.8 The quality of the study

When performing a study there are many risks for bias in the result. To be able to perform a study of good quality we have taken the following into consideration.

3.8.1 Reliability and validity

According to Bell (2000) any empirical study should satisfy two criteria; it must be valid and it must be reliable. Reliability means that the measurements are correctly made, that the measuring device is reliable. Coincidences must not affect the result. Thurén (1991) says that if different researchers, by using the same method, come to the same conclusion then the study has high reliability. Validity is ensuring to measure what was really intended to be measured. If a study does not have high validity it does not matter how high the reliability is, i.e. it does not matter how accurate the measurements are if the wrong things are measured.

3.8.2 Sources of errors

Bell (2000) warns of the risks for a certain bias in the results when conducting research. It is much easier to acknowledge the fact that bias can exist, than to eliminate this effect. One way to decrease the errors is to let the respondent read

the transcripts from the interviews to verify that the interpretations are right. Lekvall & Wahlbin (2001) mean that bias can be caused by the interviewer, the respondent and the measuring device. These three collaborate and it can be hard to distinguish where the effects derive from. Below is a description of these three possible sources of error.

The interviewer

The interviewer can influence the respondent in many ways. According to Lekvall & Wahlbin (2001) the interviewer's behaviour, clothes, facial expressions, age or gender can affect the responses. The same question asked by two different interviewers with different intonation can yield two entirely different responses.

Lekvall & Wahlbin (2001) mean that if the interviewer has a positive attitude towards the respondent, it is more likely that the answers are interpreted more favourably. It is common for the interviewer to interpret indistinct answers towards preconceived ideas or towards the average. When the interviewer chooses who to interview it is common to, consciously or unconsciously, be drawn to and choose certain types of people, e.g. people that look friendly or less stressed.

The respondent

If the respondent is insecure about a certain matter, it is possible to get different answers at different occasions. Sometimes the respondents can feel pressured to answer something they do not really know or do not have an opinion about. This can lead to misinterpretations of how well founded the results are. Respondents can also deliberately give false answers to try to please the interviewer and say what they believe the interviewer wants to hear. If the questions are presented in a leading way the respondents get influenced. If the respondents are tired or stressed with other work it can also influence the results. (Lekvall & Wahlbin, 2001)

The measuring device

The formulation of the questions is very important. Indistinct, sensitive or leading questions can affect the result. The order of the questions also tend to influence, the questions in the end are often more carefully answered than the

ones in the middle. If there are many pair-wise comparisons, the respondents can get tired at the end. A way of decreasing these effects is to test the questions for the survey or interview in advance, to be able to avoid misunderstandings. (Lekvall & Wahlbin, 2001)

3.8.3 Criticism of chosen method

During the entire thesis there has been a great focus on the output. We have put a lot of effort into developing and delivering a product, i.e. an application of the PDP to use when performing Industrialisation projects at FIG. We believe that the chosen work procedure was appropriate for this thesis because of the logic order of the phases. A disadvantage of performing the theory study relatively early was that we had to revise it several times once we had learned more about the assignment. Because the chosen work procedure was an iterative process we had the possibility to go back and revise former phases when entering a new one. This has made the substance of the report more relevant.

Collecting data by performing interviews always involve risks. We are not experienced interviewers and there are risks for misunderstandings or misinterpreting when gathering all information from the respondent. When performing interviews we tried to reduce bias in several ways. During the interviews both of us took notes. Shortly afterwards we typed them out and let the respondent read the transcripts to verify that the interpretations were correct. Several interviews with the same person were also held which made it possible to ask the same or similar questions more than once. Sometimes different people were asked the same questions to see if their versions were in accordance. Nevertheless, when the versions were contradicting it was sometimes hard to know what version to believe in.

We are aware of that our study has been affected of the fact that we were situated at the company during our study. Being involved in the daily business activities makes it hard not to get influenced by the people working there and their way of thinking. This is something we have had in mind when performing observations of the work environment. We have tried to be as objective as possible. Since all observations were unstructured, it was initially difficult to determine what information was useful for our study. Being in close contact with the organisation and the people we needed to interview has also been

positive. Whenever questions arose, we were able to go directly to the source and get the answers instantly.

Our thesis can be classified as an action research project. This makes it hard to apply theories on reliability and validity, which are often used in traditional empirical studies. The results would probably differ if the study was performed by other researchers.

When developing the new Industrialisation processes and checklists, we worked in close collaboration with our company supervisor. This probably implies that the results would get subjective to quite a large extent. As advocated in action research we have held review meetings to let our solutions get evaluated by other people too. We believe that this has compensated for some of the subjectivity caused by the close collaboration with our company supervisor.

During this study we detected a great will for making changes and improvements both among the employees and the company management at FIG. The business climate allows everyone to speak their mind. Since the problems with the PDP affect people's work in a negative way, we believe that the respondents have answered our questions sincerely.

4 Description of the Product Development Process

This chapter contains the first part of the empirical findings and describes the PDP to provide background and concepts for the remaining report.

4.1 PDP background

The PDP was introduced worldwide at Flextronics in 2004. The project model was developed by a global cross-functional team comprised of representatives from all regions where Flextronics is active. The purpose of this project model was to ensure quality when developing new products and get all different companies and sites within Flextronics to work in a similar way. It is a way for Flextronics to be more standardized and act more as one company, even though there are great variations between different sites.

4.2 Phases

The Flextronics Product Life Cycle (FPLC) is a documentation of a method of working all the way from an idea to a completed product. It is a global standard for Flextronics. The FPLC is divided into two main phases; Time-To-Market Management and Continuous Improvement. These phases are then divided into five smaller phases; Opportunity, Concept, Development, Production and Phase-out.

The PDP consists of eight project phases that are synchronized with the phases in the FPLC, hence the names of the PDP phases. This is shown in Figure 8. Each project phase in the PDP contains a set of key activities that must be completed in order to enter the next phase.

Before each project phase there is a Gate Checkpoint (GCP). These are depicted as diamond shapes in Figure 8. For each GCP a review meeting is held to evaluate if the GCP criteria have been fulfilled. The output is a decision to *Go*, *Cancel*, *Hold* or *Restart* the project. A GCP approval is required to be able to enter the next phase.

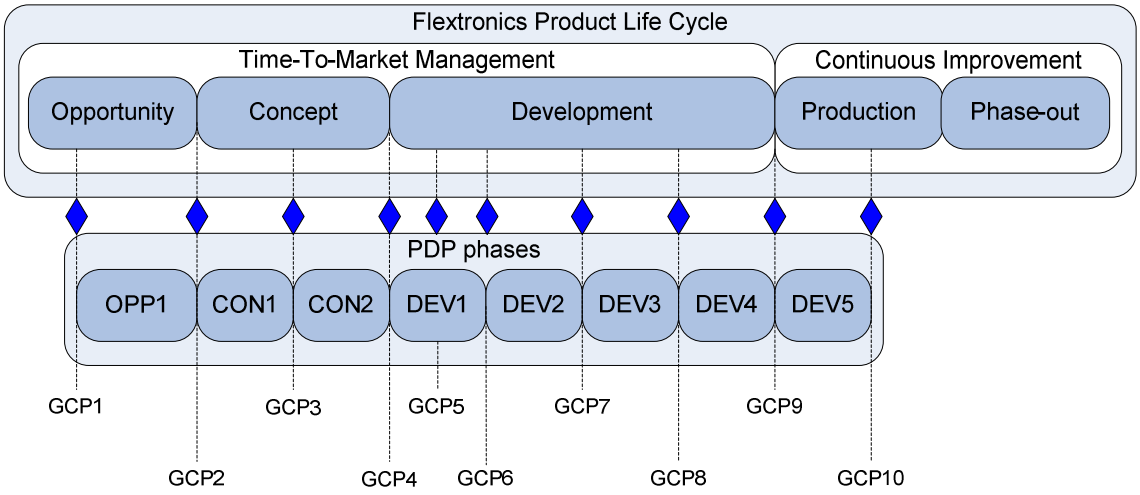


Figure 8: The interconnection between the phases in the FPLC and the PDP.

For FIG, a project ends after DEV5, i.e. in the FPLC phase Production. The purpose of each phase in the PDP is shortly described below.

OPP1

- Evaluate the opportunities to take on a certain project and decide if the company has the proper knowledge and resources.
- Create appropriate proposals that will enable the business unit to secure project agreements, contracts or internal project initiatives.

CON1

- Baseline an approved set of product requirements and a feasible concept for implementation, which will be refined during CON2.
- Evaluate the product feasibility from both technical and commercial viewpoints.

CON2

- Finalize the architectural design of the product.
- Create necessary specifications for the project and obtain customer approval.

DEV1

- Verify that the final product conforms to product requirements and obtain formal product approval.

DEV2

- Validate that the product conforms to customer requirements.
- Ensure that at the end of this phase, the product is validated against regulatory and customer requirements.

DEV3

- Secure that the supply of products can be started in a technically and commercially acceptable manner.

DEV4

- Secure that the supply of products meets all technical and commercial requirements.
- Ensure that the product and process are ready for HVM.

DEV5

- Conclude the project.
- File all project documentation.
- Free all resources.
- Report project and process improvements.

4.3 Main processes

The PDP consists of seven main processes. Every process is defined as a set of activities that transforms input into output.

Within the main processes there are Checkpoints (CP's), which are depicted as arrows in Figure 9 below.

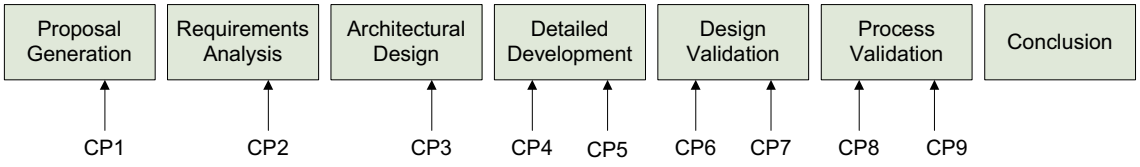


Figure 9: The main project processes in the PDP.

A CP is a technical evaluation with the purpose to review the status or result of a task. This is done during a review meeting. The outcome of a CP is normally an action list over issues that must be corrected. It is possible for the project to proceed even though there are unsolved issues. The purpose of each process is shortly described below.

Proposal Generation

- Create a proposal based on customer requirements and expectations.

Requirements Analysis

- Investigate technical and commercial opportunities that define one or more solutions to meet customer requirements.
- Transform customer requirements into product requirements.

Architectural Design

- Define the final product architecture and transform product requirements into specifications.

Detailed Development

- Execute detailed product development.
- Build and test products.
- Specify/develop product tooling, test and production equipment.

Design Validation

- Validate that the product complies with product, industry and regulatory requirements.

Process Validation

- Validate that the product complies with process requirements.

Conclusion

- Finalize the project.
- Release all resources.
- Receive and summarize internal and customer feedback.

4.4 Project team structure

In the PDP there are some key roles with corresponding responsibilities. When working in smaller projects it is possible for one person to assume more than one role. The roles in a project are shown in Figure 10 below.

A project consists of two parts; Industrialisation and Product Development. These can be seen as two separate projects and for each one there is a project manager (PJM) assigned. There is a lead project manager (LPJM) assigned to coordinate the Industrialisation project and the Product Development project.

The Industrialisation project can be divided into the following sub-projects; Production process, Test, Logistics and Material. The Product Development project can be divided into Electrical, Software, Mechanical and Verification/Validation. For each sub-project there is a sub-project manager (SPJM) assigned. The responsibilities for the roles shown in Figure 10 are shortly described below.

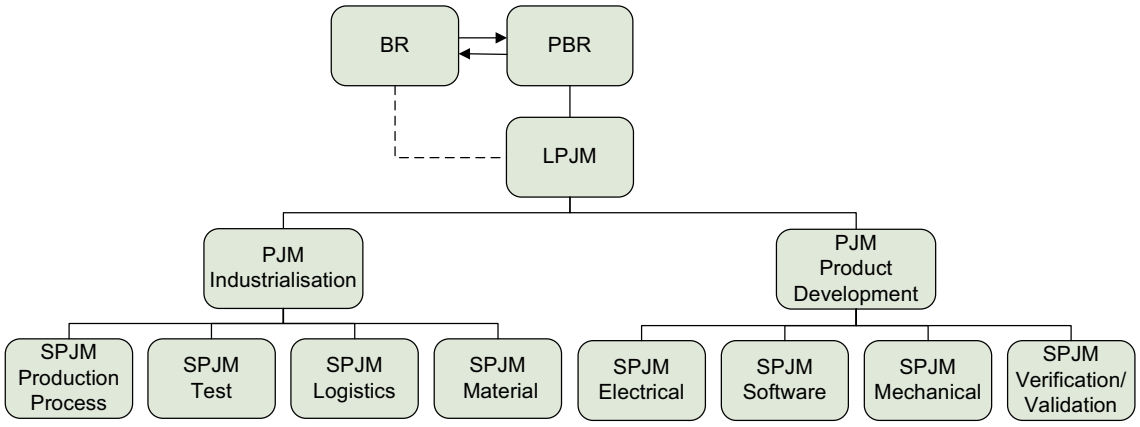


Figure 10: Example of a typical project team structure.

Business Responsible (BR)

- Primary responsible for the contact with the customer and the business.
- The internal customer of the project.
- Secures the finance for the business and takes the business risks.

Project Business Responsible (PBR)

- Focuses on the tactical issues that affect the strategic relationship with the customer.
- The internal requestor of the project.

Lead Project Manager (LPJM)

- Focuses on project coordination, structure, profitability and contracts, with an emphasis on Flextronics processes and guidelines.
- Works in complex projects with many resources, often with resources situated in more than one country.

Project Manager (PJM)

- Focuses on the tactical execution of project activities.
- Coordinates the sub-projects.

Sub-Project Manager (SPJM)

- Focuses on a sub-project within the project.

4.5 Flexibility

According to internal documentation the PDP is a flexible model, because of the possibility to start a project in any phase and create a customized process flow. The PDP may be tailored to meet customer requirements for any size of project. The project manager can choose from the *PDP Process Toolbox*, which is shown in Figure 11 below, and only use the main processes that are applicable for each project phase.

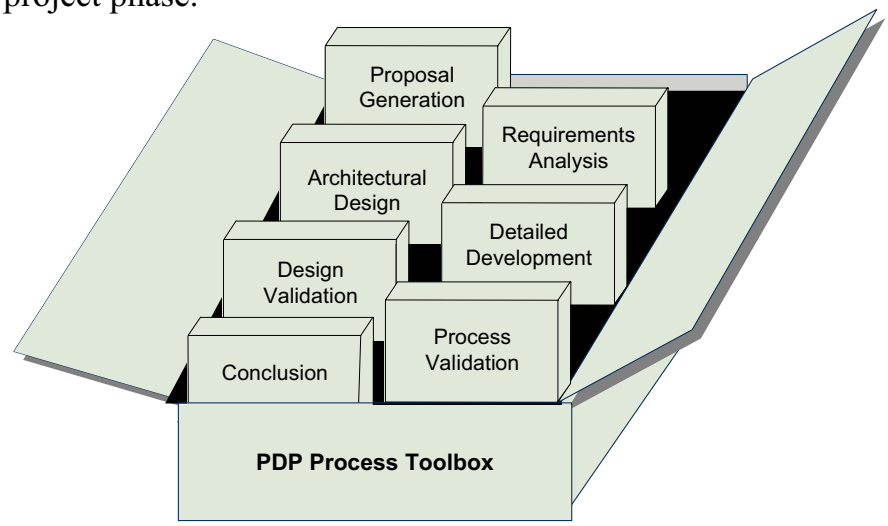


Figure 11: The main processes that best fulfil the needs of a project are chosen from the PDP Process Toolbox.

5 Problem areas

This chapter contains the second part of the empirical findings. It describes the different problem areas relevant to our study that have been identified.

5.1 Description of the present problem situation

To get a deeper understanding of how project work at FIG in Linköping is carried out, and what the problems with the current working methods are, we interviewed project managers and sub-project managers and studied internal PDP documentation. Similar issues that were recurring and relevant for our study were grouped into different problem areas. These problem areas are described below.

5.1.1 Extensive and ambiguous project model

Several of the people that were interviewed feel that the PDP requires too many produced documents and that it is hard to know why and for whom they are produced. When studying the PDP we discovered that there are different notations in different documents. Many respondents feel that the PDP documentation is ambiguous and that it is hard to understand how to use the project model.

5.1.2 Not enough education

The PDP introduction and education at FIG in Linköping came late and was insufficient. Almost all respondents expressed this opinion and would like to have more education on how to use the PDP. A received suggestion was to go through a whole project and explain every step in the PDP. This is desirable in order to get the whole picture and to understand the purpose of every step. It would also prevent different interpretations.

5.1.3 Low usage of the PDP

Many people at FIG in Linköping do not work according to the PDP. Few respondents have tried to use the PDP and none of these have been able to follow it completely during a whole project. Instead experience from earlier projects is used and people work as they always have, using their own old templates. Some people that worked for Ericsson earlier and used their project model, Time-To-Market (TTM), have continued to do so.

5.1.4 Not applicable main processes

Several of the respondents feel that the PDP is not applicable for the Industrialisation projects performed at FIG. In the PDP, which was developed to support product development activities, the focus is on the product. But in an Industrialisation project the main deliverable is a production and test process, not a physical product. For example, according to the PDP the product should be developed in detail and validated in the processes *Design Validation* and *Process Validation*. Since FIG handles Industrialisation activities, it has been hard to use the PDP that describes product development activities.

Another issue is the support activities. When HVM has started and the line organisation at the HVM site runs the production, FIG provides support for approximately three months. This is an important part of Industrialisation but several respondents have pointed out that these support activities are not described at all in the PDP.

5.1.5 Insufficient checklists

The majority of the respondents are of the opinion that the available checklists are difficult to understand. A lot of the questions in the checklists do not apply to their projects. In the PDP the only existing checklists are the ones for GCP decisions, and these are used on several decision levels. Some people have pointed out that the checklists are not applicable for either one of these situations. The level of the questions in the GCP checklists varies a lot, from being on a business level to concerning very technical issues. This has led to many people not using the checklists since they feel these are too complicated.

The checklists, which are made in the program Microsoft Excel, consist of a great number of questions; some of them include as many as 70 questions. Almost all respondents have pointed out that the checklists are ambiguous, badly proofread and do not cover the appropriate issues for Industrialisation projects. Another problem with the checklists is that the templates are badly edited. For example, when too much text is inserted, it is not possible to see all text at once and when printing a checklist some information may get lost.

5.1.6 Unclear checkpoint decision structure

As pointed out by many of the respondents, the checkpoint decision structure in the PDP is indistinct. It is not clearly defined by whom the CP and GCP decisions should be made. Figure 12 below describes how decisions currently are made at FIG in Linköping. The dotted boxes imply that no actual decision is made, only prepared.

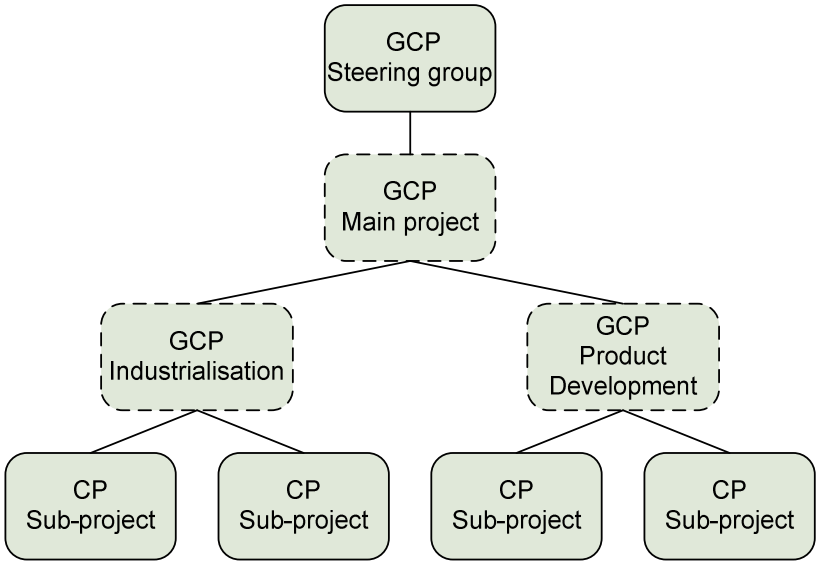


Figure 12: Existing decision structure.

There are no CP checklists in the PDP. Therefore, the sub-project managers have made their own CP checklists to use when deciding if a CP can be passed. On the next level, the Industrialisation project and the Product Development project use the GCP checklists to see if the project is on track, but no GCP decision is made. Instead the project managers in these projects report to the lead project manager in the main project. The main project uses the same GCP checklists, but no decision is made here either. The GCP decision is made by the main project's steering group.

5.1.7 Unclear connection between PDP and TTM

When the customer is SEMC, the main project and all deliverables must follow the TTM model. This means that the project managers at FIG must consider both TTM and PDP when working in a SEMC project. Many of the respondents feel that it would be easier to use PDP in these projects if it was synchronized with TTM, but there is currently no thorough mapping between these two project models.

5.1.8 No guidelines for learning between projects

There are no guidelines for documenting lessons learned in a project and there is no central area or folder where these are stored. Because of this, many feel that experiences from other projects are hard to find.

5.1.9 Lack of steering group

Some project managers have pointed out the need for a steering group. Not every project has a steering group or it is not yet working as it is supposed to. Several of the respondents want a steering group that can fix problems, act as back-up, coordinate and prioritize between different projects.

During our thesis, a steering group was established at FIG in Linköping. This steering group has the following responsibilities:

- Participate in GCP review meetings.
- Prioritize between projects and/or resources if needed.
- Adopt regular knowledge about project status, progress and risks.
- Be a support and natural interface for the project managers at FIG.
- Assure that regular project status meetings are held.

The steering group consists of the Head of FIG and representatives from the departments Production Process Development, Production Test Development, Project Office and Quality Management Systems. Each role in the steering group has a deputy, in case someone cannot attend a meeting. Steering group meetings are held every two weeks, and during these meetings project managers can discuss issues in their projects.

6 Frame of reference

This chapter constitutes the theoretical frame of reference for the thesis, and consists of theories on basic project management, process management and roles and responsibilities.

6.1 Introduction

Most of the work performed at FIG is carried out as projects. This chapter starts by providing basic theories on basic project management. During this master thesis we have studied the PDP and especially the main processes that describe the activities in a project. Therefore a section about processes and process improving has been included. During the case study we discovered that it is unclear who is responsible for making what decisions. This is indistinct also in the internal PDP documentation, which is why the last section in this chapter concerns roles and responsibilities.

The use of projects and project management has become more common in our society and its organisations and it continues to increase. In the early stages, project management was used mainly for large, complex research and development projects. Later, as the techniques of project management were developed, the use of project organisation began to spread. More recently, the use of project management by international organisations has grown rapidly. This applies to both companies producing services as well as products. (Meredith & Mantel, 2003)

Project as an organisational form has been developed to make companies more flexible to be able to survive among tough competition and increasing technical complexity. Competition makes great demands on the companies' abilities to cope with changed market conditions. Working in projects can supply flexibility and the possibility to make fast changes. (Andersson & Åslund, 1996)

6.2 Definition of a project

A project is defined quite similarly in various literature. According to the Project Management Institute (1996), a project is a temporary endeavor undertaken to create a unique product or service. Temporary means that every project has a definite beginning and a definite end. Unique means that the product or service is different in some way from all similar products or services on the market.

Other authors, such as Tonnquist (2004) and Wisén & Lindblom (2004) mean that a project is defined by the following: (All these four criteria must be fulfilled in order to call it a project.)

- The goals are well-defined and delimited.
- The period of time is limited.
- The resources and budget are defined.
- There are specific working methods.

Yet another definition is the one from Turner (1999, p.3): *A project is an endeavor in which human, financial and material resources are organized in a novel way to undertake unique scope of work, of a given specification, within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives.*

6.3 Project vs. line organisation

Many companies work according to a matrix organisation, trying to utilize the best from both the project and the line organisation. According to Wenell (2004) and Tonnquist (2004) this often creates conflicts when it comes to resources and loyalty. The employee has two superiors; a line manager and a project manager. This is depicted in Figure 13 below.

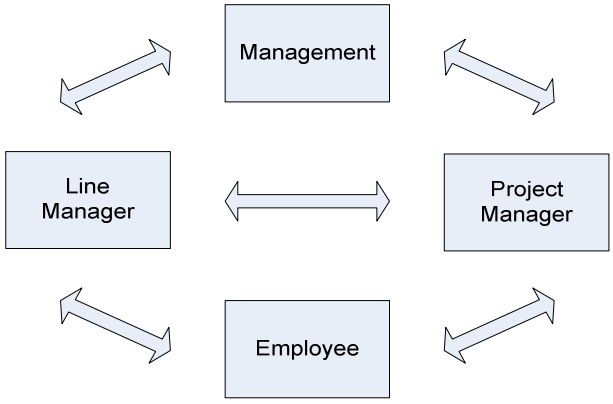


Figure 13: The employee in a matrix organisation has two superiors. (Tonnquist, 2004, p.8)

If the priority between line work and project work is unclear, the employee may get a problem with loyalty. It is hard for the employee to know what work has the highest priority. This leads to the employees prioritizing themselves and focusing on what is most rewarding for them. (Tonnquist, 2004)

Tonnquist (2004) points out that a successful project result depends on the cooperation between the line and the project organisation. Line managers often see the project managers as competitors, and the project managers often see the line managers as obstacles. They do not always see the mutual utility and the fact that they are dependent on each other.

The people working in projects are employed by the line organisation but are lent to the projects. When a project or a person's part of the project is finished, that person goes back to being a resource in the line organisation. (Andersson & Åslund, 1996)

Engwall (1999) describes the project organisation as a temporary organisation created to conduct a project. It is put together to solve a specific task and afterwards the project organisation is dissolved. Wisén & Lindblom (2004) point out that the prerequisites differ for a project manager and a traditional manager for the line organisation. Being a project manager is temporary. A line manager on the other hand stays in the same position for a longer period of time and therefore has the possibility to do more long-term planning.

6.4 Phases

A project is often described as a sequence of phases. These phases often form the foundation of the project model. The Project Management Institute (1996) collectively describes these phases as the *Project life cycle*.

There are close points of similarity between most project models. The biggest differences are the amount of phases they include and what the phases are called. Each project phase demands the completion of one or several deliverables. The Project Management Institute (1996) defines a deliverable as a tangible, verifiable work product. This can for example mean a feasibility study or a working prototype.

According to Tonnquist (2004) and Engwall (1999) a project is described as a sequence of four phases; *Pre-study*, *Planning*, *Implementation* and *Conclusion*. These are described below.

6.4.1 Pre-study

Tonnquist (2004) points out that the purpose of a pre-study is to identify the scope of work, decrease the uncertainty in the project and most important of all decide if the project is feasible or not. According to Wisén & Lindblom (2004) a project directive, that describes the essential parts of the project, should be produced and given to the client, who is the internal customer and also the one who decides if the project should start or not.

During the pre-study, it is important to identify all stakeholders and evaluate how they will affect the project. Business benefits from the project should also be evaluated. The expected outcome of the project should lie within the framework of the business and its strategies. It is hard to conduct a project without a requirements specification. Expectations and requirements, both on the product and on the project, are hard to comply with when not knowing exactly what they are. Both product requirements and project requirements should be collected carefully through workshops and interviews. (Tonnquist, 2004)

Andersen et al (1994) accentuate that during the pre-study, creativity is an important element when trying to find different solutions to the problem. Both Engwall (1999) and Tonnquist (2004) emphasize the importance of choosing a solution that meets all expectations and achieves all goals set on the project. There are three dimensions that affect a project; *time*, *cost* and *performance*. Time stands for how long time the project can take. Cost means the amount of resources dedicated to the project, in terms of money or working hours for example. Performance corresponds to the level of ambition and quality wanted. These three parameters are jointly interdependent and shown in Figure 14. For example, if the project must be finished in a shorter time, more resources will be needed and the costs will increase.

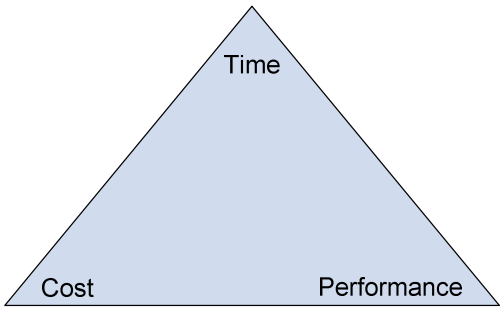


Figure 14: The three dimensions of a project. (Engwall, 1999 p.46)

Projects have different priorities and the emphasis is different on the parameters in the triangle depending on the nature of the project. There is always one of these steering parameters that has higher priority in a project. (Engwall, 1999; Tonnquist, 2004)

The knowledge of a project is very limited in the beginning, but the effect on the result of a decision made at this point is very extensive. This is depicted in Figure 15 below. It is important to carry out a thorough pre-study to be able to make decisions that are more accurate. (Engwall, 1999; Wenell, 2004)

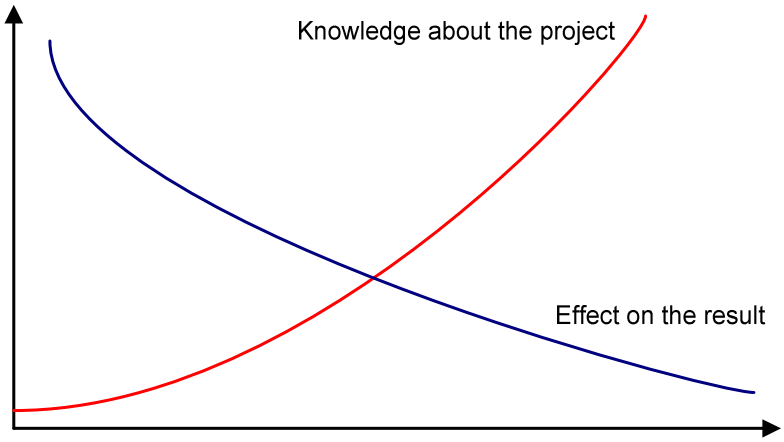


Figure 15: Decisions made early in a project have most impact on the result. (Wenell, 2004, p.48)

6.4.2 Planning

All planning of the project is made during the planning phase and results in a project plan. According to Wisén & Lindblom (2004) a project plan should contain the stated parts below:

- Background description
- Goal formulation and delimitations
- Strategy and choice of method
- General activity plan
- Time plan
- Project budget
- Project organisation
- Information structure
- Expected end product
- Expected effects

Besides the project plan, Tonnquist (2004) means that a way to handle risks, quality issues and corrections should also be worked out and documented.

6.4.3 Execution

The project manager leads the project organisation towards the goal during the execution phase. If the project plan has been made properly, it will simplify the future work for the entire project. Some activities that are performed during the execution phase are; allocating resources, managing corrections and follow-ups on the project plan, maintaining the communication channels and performing project evaluations. It is important that results from the project are verified against the specified project goals. This is made by regular inspections during all phases in the project. (Tonnquist, 2004)

6.4.4 Conclusion

In the conclusion phase the project is evaluated and a final report is written. Evaluations of the project give the organisation a chance to develop their project knowledge. The final report should contain relevant questions that the project has had to deal with. (Wisén & Lindblom, 2004)

During the project evaluation it is important that the actual project situation is analysed and not the desired one. It is important to have well-defined criteria

when performing evaluations. Decisions concerning proceedings must also be implemented to improve the situation for future work. (Andersen et al 1994)

6.5 Project goals

Goals are very important parameters when managing projects. Indistinct goals yield uncertainty and insecurity in a project. According to Wenell (2004) goals can be described on several levels; *main*, *intermediate*, *primary*, *secondary* and *effect goals*. These are described more below. Knowing what to achieve makes it easier to find a way to get there. According to Ortman (1999) the goals should be explicit, measurable, challenging, realistic and delimited. Wenell (2004) points out that gathering expectations on a project and transforming them into demands and goals is one of the most important assignments for the project manager.

6.5.1 Main and intermediate goals

The end result of a project is described by a main goal and intermediate goals. The main goal is a brief and overall description of what is to be accomplished and it can be divided into several intermediate goals. It is important to distinguish intermediate goals from stage goals. The intermediate goals help describe the project's end goal and result, while the stage goals are time-bound control stations on the way towards the end goal. (Wenell, 2004)

6.5.2 Primary and secondary goals

Goals can be divided into primary and secondary goals. Primary goals *must* be achieved in order to complete the project and secondary goals represent goals that are desirable. The secondary goals are not decisive for the success of a project but they are desirable. The primary goals are the ones the effort should be spent on. (Wenell, 2004)

6.5.3 Effect goals

It is the effects of the project that are important. The project or the main goal can be seen as means to achieve the effect goals. Examples of effect goals are; increased profitability, larger market shares, more efficient working methods, better image, improved environment and happier employees. It is more important to achieve the effect goals than the actual project goals. The effect goals are often achieved far later than the project is finalized. (Wenell, 2004)

6.6 Stakeholders

According to the Project Management Institute (1996) project stakeholders are individuals and organisations who are actively involved in the project, or whose interests may be positively or negatively affected as a result of the project.

The expectations from the stakeholders are often unexpressed. Sometimes the stakeholders do not even know themselves what they expect. These expectations can even change during the course of the project. The expectations from the stakeholders can be indistinct, variable and incompatible and it can be hard to balance the different expectations and goals. It is up to the project manager to identify and elucidate the needs and expectations and transform these into explicit project goals. When the stakeholders evaluate the project, they will compare the results against their own expectations, so therefore it is very important to collect these expectations in an early stage. (Wenell, 2004)

Wenell (2004) and Tonnquist (2004) classify stakeholders into different groups; *core stakeholders*, *primary* and *secondary stakeholders*. The core stakeholders have decision-making and driving roles in the project and can include the customer, sponsors, users of the project product or service and project organisation such as steering group and project team. The primary stakeholders are those who are affected by the project and therefore want to influence. Line managers, sub-project managers, team members in concurrent projects, colleagues and sometimes consultants, suppliers, collaborators and reference group are primary stakeholders. Even family can be included in this group. The hardest stakeholders to identify are the secondary stakeholders. The people in this group can affect the result of the project in unexpected ways and can include interest groups, authorities, society at large and even friends.

The Project Management Institute (1996) emphasizes that stakeholders often have very different objectives that can come into conflict. For example, when developing an information system the department manager may desire low cost, the system architect may emphasize technical excellence and the contractor may be most interested in maximizing its profit. One major challenge for the project management is to find solutions to these differences.

6.7 Processes

In every business, there are several activities that are performed repeatedly, using the same principles or routines. For example, when purchasing material the same routine is used at different occasions. Bergman & Klefsjö (2001) define a process as a network of recurring activities with the purpose to create value for an external or internal customer. A process can also be described as having a beginning and an end, it has a customer or assigner and a supplier, it consists of a network of activities, it produces value and it is repeated over and over again.

Rentzhog (1998) uses a similar definition and describes a process as a series of activities that creates value for a customer in a recurrent flow. These activities are linked and transforms input into a result. The result does not have to be a physical product. It could be something more abstract, such as a decision or higher knowledge. According to Tonnquist (2004), a project, or the phases in a project, can be described as a process. The purpose of describing a task as a process is to make sure that the task is being performed in a predetermined way every time it is being executed.

There are several reasons to expect that the need to focus on processes will increase. According to Rentzhog (1998), this is due to the following trends in the commercial and industrial community:

- Increased focus on the customers.
- Service has become a more important part of a product's value.
- Increased organisational complexity.
- Change has become the normal condition.
- Information technology creates new possibilities.

6.7.1 Different types of processes

Processes can be categorized in several different ways. Rentzhog (1998) uses the concepts *core processes*, *supporting processes* and *sub-processes*. The core processes are the ones that together fulfil the overall business concept. The supporting processes provide necessary support to the core processes and have decisive impact on how successful the core processes are. An example of supporting processes is maintenance and repair in a manufacturing industry. A core process in one company can be a supporting process in another. This

depends on what the core business is. Processes can also be broken down into smaller parts, and Rentzhog (1998) refers to these as sub-processes.

6.7.2 Process management

Rentzhog (1998) defines process management as a way to continuously manage and improve processes. Every organisation must, based on its own unique situation, develop a suitable approach to process management.

To be able to manage and improve a process, process owners and process management teams must be appointed and develop an understanding for the process. This understanding is created by mapping out and analysing the process. Rentzhog (1998) proposes the following questions as a basis for this understanding:

- Why does the process exist?
- How does the process work?
- How can the process be improved?

Why does the process exist?

To understand why a process exists, the process management team must analyse the scope of the process, the customers and their real needs. It is important to clearly define the purpose and the boundaries of the process. It is also essential to clarify why the process exists, for whom it creates value and how. The interconnections to other projects are also something that needs to be elucidated. According to Rentzhog (1998) customers are everyone that the process creates value for. This can be compared to performing a stakeholder analysis. Stakeholders are all these who, besides the customers, gets affected by the process. When the customers have been identified it is important to understand what their needs are. Then these needs can be transformed into process characteristics, which can be used when managing and improving the processes.

How does the process work?

A common approach to investigate how a process works is to systematically break down the process into more detailed sub-processes. Rentzhog (1998) points out that it is important to create an overall understanding of the process flow to be able to break down the overall process into distinctly related sub-processes. When having a complex process, this can be difficult. Some common

approaches to process breakdown are; *the vertical approach*, *the phase approach* and *the pareto approach*.

In the vertical approach the process is divided into more or less sequential links of sub-processes. In the phase approach the process is broken down into different phases. This is common when describing project models. To be able to enter the next phase there are often some criteria listed that must be fulfilled. The pareto approach utilizes the "80-20 rule" which means that 80 % of a problem can be explained by 20 % of its causes. According to Rentzhog (1998), this explains why it can be more useful to focus on a few vital issues instead of trying to deal with all.

The pareto approach can also be interpreted into the following terms:

- If 80 % of the customer value is created within 20 % of the activities in the process, is it then meaningful to break down all sub-processes in detail?
- If 80 % of the projects only utilize 20 % of the process, is it then meaningful to try and create a universal process that covers all cases?

When trying to find out how an existing process works, Rentzhog (1998) recommends using flowcharts. They provide a graphical description of the process flow and are easy to understand, even for quite complex processes. One way to draw flowcharts is to use the American National Standards Institute symbols. This standard uses standardized symbols for activities and decisions. Below in Figure 16 is an example of a flowchart based on these symbols. When using flowcharts it can also be interesting to clarify who is responsible for each sub-process or activity.

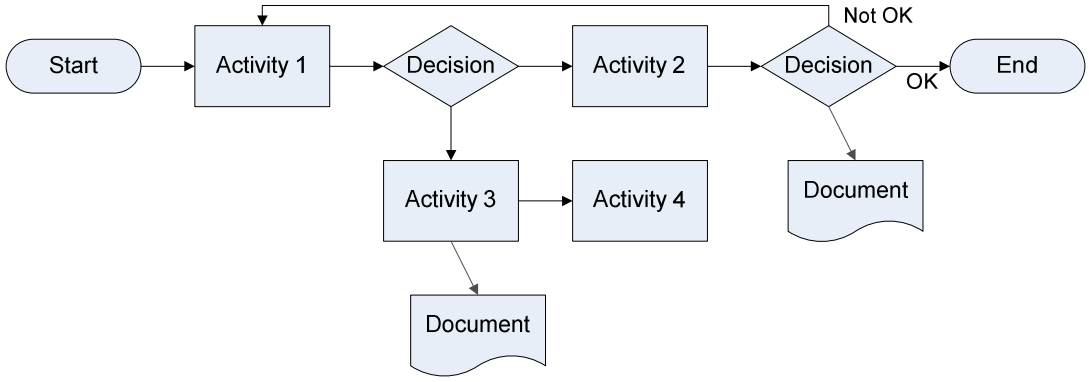


Figure 16: Example of a flowchart. (Rentzhog, 1998, p.117)

How can the process be improved?

When understanding why the process exists and how it works it is possible to improve the process. Rentzhog (1998) groups improvement work into preventive and correcting activities. Preventive improvement work is done by seeking opportunities to make improvements before problems have occurred. Correcting improvement work on the other hand is always initiated by a problem that needs to be solved.

When improving a process, Rentzhog (1998) presents two different approaches; *process improving* and *process redesign*. Process improving means starting from an existing process, analysing how improvements can be made and performing suitable adjustments. This approach can be used for both larger projects and when only making smaller adjustments. A benefit of this approach is that parts that are already working fine do not have to be invented again. A disadvantage is that the possibilities for making improvements are smaller than when using process redesign. Process redesign implies designing a whole new process, by emanating from the purpose of the process and the customer needs. This approach supports innovative thinking and creates a whole new way of looking at the process. There are however risks that the new process does not meet all requirements or that some already solved problems must be solved again.

According to Rentzhog (1998) the following principles can be used when improving processes:

- **Eliminate bureaucracy**. Remove all unnecessary administrative routines and paperwork.
- **Eliminate duplication of work**. Remove all identical activities that are being performed throughout the entire process.
- **Analyse value creating activities**. Increase the proportion of activities that brings value to the customer.
- **Simplification**. Strive to make processes as simple as possible, for example by removing unnecessary decision points, activities and documentation.
- **Cycle time reduction**. Shorter cycle times do not only save time, it also promotes improvements within various areas.
- **Standardization**. Getting everyone in a process to work in a similar way is important to reduce variation in the result.

When redesigning processes Rentzhog (1998) recommends the following principles:

- **Avoid hand-offs**. It is preferable if a single person or team can perform all steps of a process.
- **Let those who use the result perform the work in the process.** A good example of simplifying the process by letting the customers perform parts of the process is IKEA, who lets its customers assemble the furniture themselves.
- **Link parallel activities**. When performing parallel activities it is useful to keep track of how far other teams have come. This can for example be done by using a joint database. This makes it possible to link the activities on the way, instead of just integrating their results.

6.7.3 Implementing changes

Resistance towards change is a common explanation of unsuccessful attempts to change processes. To successfully implement changes and improvements, Rentzhog (1998) suggests the following:

- **Create participation**. The more the staff is involved in the work with designing the change, the more likely they are to accept the change.
- **Avoid surprises**. It is important to keep people well-informed about what is going on and why the changes need to be made.
- **Give the change time**. When introducing changes people must be given time to get used to them.
- **Treat people with respect**. Forcing people into changes is something that probably only will work temporary. In the long term it is important that everyone is committed to the changes.
- **Handle resistance immediately**. If people that are resisting the changes are not attended to there is a risk that the resistance will spread and grow stronger. It is always easier to prevent resistance before implementing the changes than trying to set it right later on.

6.8 Roles and responsibilities

A project should be organised in a way that all roles and responsibilities are very clear. Every role should have a unique role description. When the project has an external customer, the customer usually has a corresponding organisation. (Tonnquist, 2004)

In Figure 17 is a typical project organisation according to Engwall (1999). These roles are described below.

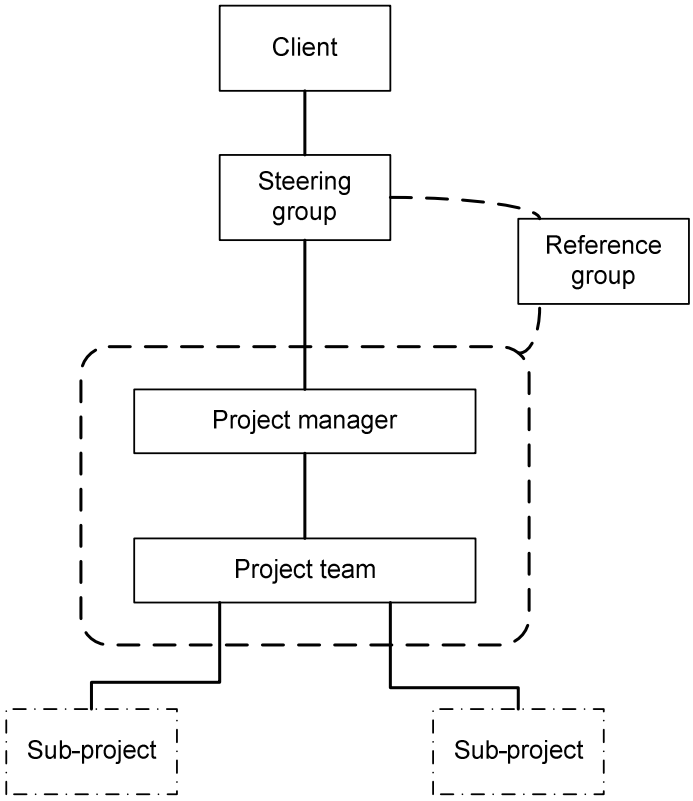


Figure 17: A typical project organisation (Engwall, 1999, p.69).

6.8.1 Client

Wisén & Lindblom (2004) describe the client as the internal customer, the one who owns the assignment and is responsible for making sure that a project directive has been produced. The client also establishes the purpose and direction of the project and sets the project manager's authorities. Other responsibilities for the client are electing a project manager and members for the steering group, setting the framework for how much time and resources the project will get and also making sure that the project gets the resources needed.

6.8.2 Steering group

The steering group interprets the project directive and approves the goals and the project plan. It also makes decisions concerning important administrative questions, for example budget and time schedules. Some other steering group responsibilities are; following and supporting the ongoing work in the project, estimating and discussing proposals prepared by the project team, informing the client about the results in the project and examining the final report before handing it over to the client. (Wisén & Lindblom, 2004)

6.8.3 Reference group

According to Wisén & Lindblom (2004) the reference group is responsible for the expertise and has a consultative role in the project.

6.8.4 Project manager

The project manager administers and coordinates all the work in the project and makes sure that the project progresses and follows established directives, goals and plans. The project manager is also responsible for having contact with both internal and external stakeholders, reporting regularly to the steering group, taking appropriate actions when disturbance threatens the project and is also responsible for all documentation in the project. (Wisén & Lindblom, 2004)

6.8.5 Sub-project manager

The sub-project manager handles a sub-project and is responsible for making sure that the sub-project delivers the right results to the main project (Tonnquist, 2004).

6.8.6 Project team

The project team participates in the project planning and performs mappings, summaries, analyses and prepares proposals. It also contributes to the ongoing follow-ups and participates in debriefings. (Wisén & Lindblom, 2004)

7 Analysis

This chapter specifies and breaks down the assignment into smaller and more manageable parts. It also describes how we have arrived at our solutions.

7.1 Specifying and breaking down the assignment

After performing the pre-study we realized that many of the problems when using the PDP derive from the fact that the project model was originally designed for product development, and not for Industrialisation activities. Another issue is that the PDP was released before it was fully developed and tested.

We followed the approach suggested by Rentzhog (1998) and chose to focus on a few vital issues, instead of trying to deal with them all. After reviewing the findings from the pre-study, which were described in the chapters *4 Description of the Product Development Process* and *5 Problem areas*, we decided in collaboration with our company supervisor to focus on the processes in the PDP. We believe that many issues will be solved or at least made easier by designing new processes that are better adapted to Industrialisation. We also think it will be much easier to follow a working method that is adapted to the specific business performed at FIG.

To be able to clarify our assignment further, we decided to break it down into smaller and more manageable parts. We divided the task to develop Industrialisation processes into four sub-assignments, which are shown in Figure 18 below. Our solutions to these four sub-assignments are presented in chapter *8 Results*.

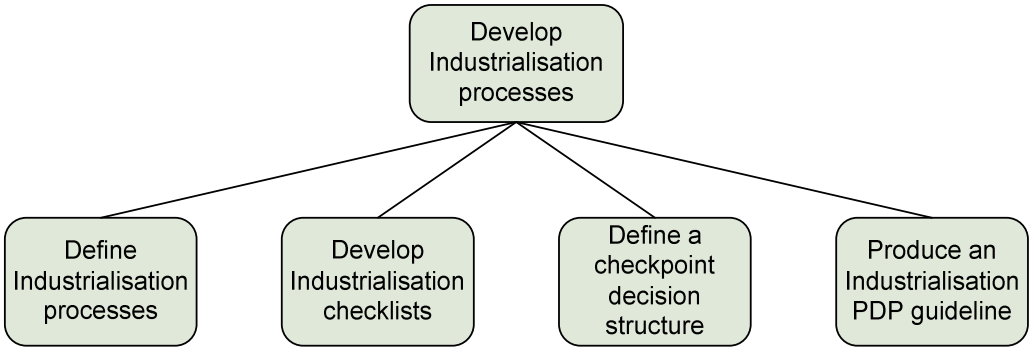


Figure 18: The four sub-assignments for this master thesis.

7.1.1 Industrialisation processes

Tonnquist (2004) and Wisén & Lindblom (2004) emphasize the importance of having specific working methods when working in a project. The need for common working processes has increased and has almost become a prerequisite for a successful business. Designing processes requires an extensive knowledge of the business and an understanding for how different tasks are performed. Even though it takes a lot of time it is however an important issue; the lack of common working methods makes it hard to keep a high and even quality.

At FIG there is a need for applicable working methods for Industrialisation projects. When performing an Industrialisation project, the main processes in the PDP are not applicable, which was mentioned in chapter 5.1.4 *Not applicable main processes*. Therefore we have investigated the need for new ones. We have modified the existing main processes and also developed new ones when necessary, to create a more suitable process flow for Industrialisation.

When defining new Industrialisation processes we chose to first study the existing main processes to understand these, to then be able to improve them, as described by Rentzhog (1998). We studied internal PDP documentation and we performed interviews with several project managers and sub-project managers. When comparing how the main processes were described in the PDP documentation and how project work was performed in reality, we realized that these were not in accordance. There were also distinctions between how the different project managers handled their projects. One thing they had in common was that no one had been able to completely follow the PDP. The main processes described in the PDP were not applicable to the Industrialisation activities performed at FIG.

Rentzhog (1998) presents two ways of improving processes; *process improving* and *process redesigning*. During an Industrialisation project there are certain deliverables to the main project and the main project follows the main processes in the PDP. Therefore it was important to make sure the new Industrialisation processes were synchronised with the main processes in the PDP. To be able to do this, we chose the process improving approach, i.e. modify and improve the existing main processes when developing the Industrialisation processes.

When developing the Industrialisation processes we considered the principles recommended by Rentzhog (1998); we tried to reduce the amount of bureaucracy and simplified the processes by removing unnecessary steps and documentation. We did this by concentrating on activities that *must* be done in a project, instead of including all that *can* be done. For example, it is not meaningful to include all possible updates of a certain document. This was important to be able to keep the processes easy to understand.

In our project there are different stakeholders, and as the Project Management Institute (1996) points out, these often have different objectives that can come into conflict. To make sure that the new processes would satisfy the needs from as many stakeholders as possible, we identified and invited people that are, or will be, using the PDP to get their input. Several review meetings were held with people representing the different departments at FIG in Linköping.

Holding these review meetings was also a way to reduce resistance when implementing our solutions. Rentzhog (1998) points out that involving the staff in the improvement work will make them more willing to accept the change. The primary goals when defining the new processes were to make them easy to use and as standardized as possible.

To be able to describe the new Industrialisation processes in a way easy to understand, flowcharts were used, as recommended by Rentzhog (1998). The flowcharts were designed in the program Microsoft Visio and we have made one flowchart for each Industrialisation process.

7.1.2 Industrialisation checklists

As mentioned in chapter *5.1.5 Insufficient checklists*, there is a need for new checklists. When we had developed the Industrialisation processes we started working on the corresponding checklists. The purpose of the checklists is to be a support when deciding whether to pass a CP or not. In the PDP there are only checklists for GCP decisions. Since these GCP checklists are not adapted to the Industrialisation level, many of the questions are not applicable to the projects performed at FIG. Furthermore, the GCP checklists contain a lot of ambiguous formulations and misspelled words. Some useable questions were however

included, so when creating new checklists the old GCP checklists were studied to make sure nothing important would be missed.
In collaboration with our company supervisor, who has good insight into the project work at FIG, we developed Industrialisation checklists. When developing the checklists we once again involved the employees at FIG in Linköping, by holding several review meetings. At these review meetings we got feedback and suggestions for improvements. The checklists were revised several times during our work.

7.1.3 Checkpoint decision structure

As Tonnquist (2004) points out, it is very important to clearly define roles and responsibilities. In the PDP documentation there are contradictions concerning who should decide whether to pass a checkpoint or not. It is ambiguous both for CP and GCP decisions. This was described in chapter *5.1.6 Unclear checkpoint decision structure*.

When we started working at FIG, some project managers at the Project Office had already started on a proposal for a decision structure, and we continued working on it. We questioned it and revised it several times.

When defining the checkpoint decision structure we wanted to clarify the responsibilities of the project manager and the sub-project managers. The sub-project managers are responsible for coordinating the sub-projects and for the Industrialisation project there is a project manager assigned. We considered it appropriate for the sub-project managers to make a checkpoint decision for their respective sub-project and then report this to the project manager in the Industrialisation project. When all sub-projects managers have reported their checkpoint decision, the project manager can make a checkpoint decision for the entire Industrialisation project. An advantage with this decision structure is that when the project manager is about to make a checkpoint decision, questions concerning specific sub-projects will not have to be dealt with. These issues, often concerning technical questions, have already been dealt with by the sub-project managers.

In collaboration with our company supervisor we defined a decision structure that clearly shows who makes what checkpoint decisions. After this solution had

been reviewed by other project managers at the Project Office we revised it further. Eventually the decision structure was finalized and approved.

7.1.4 Guideline

The existing PDP documentation is quite ambiguous and includes different notations, which was described in chapter *5.1.1 Extensive and ambiguous project model*. This has made us realize the importance of a clear and usable guideline. To get people to adopt the new Industrialisation PDP application it must be presented in a way that is easy to understand. This is why we wrote a guideline. The purpose of the guideline is to contain the basic information needed to run an Industrialisation project.

7.2 Proposed assignment for further studies

As mentioned earlier, the preferred project model at SEMC when developing new mobile phones is TTM, and when performing a SEMC project the project managers must consider both TTM and PDP. As mentioned in chapter *5.1.7 Unclear connection between PDP and TTM*, many people feel that it would be easier to use the PDP in SEMC projects if it was synchronized with TTM. That is why we believe the Industrialisation PDP should be mapped to TTM.

One of the things that need to be done when mapping the two models is to match the TTM model's decision points, i.e. milestones and tollgates to the Indus PDP's Checkpoints and Gate Checkpoints. It would also be useful to translate SEMC concepts and document names into FIG terms. Mapping the PDP and the TTM would help avoiding misunderstandings and clarify what is meant with different concepts. This mapping would simplify the project work at FIG considerably, since the majority of projects performed at FIG are SEMC projects.

Even though the mapping of the TTM and the PDP is very important to be able to completely use the new Industrialisation PDP for SEMC projects, we have chosen not to include it in the scope for this thesis. This is due to limitations in both time and knowledge. To be able to perform the mapping it was necessary to first develop the Industrialisation processes. We had to choose what issues to focus on and we chose not to include the mapping. We also felt that we did not have sufficient knowledge about SEMC projects and the TTM model to be able to perform a reliable mapping.

8 Results

This chapter presents our proposed solutions to the identified problem areas. It also includes further recommendations on how to proceed when implementing the solutions.

8.1 Solutions

In this chapter, the solutions to the four sub-assignments, described in the previous chapter, *7 Analysis*, are presented. Due to confidentiality reasons the solutions could not be included in their entirety. Our solutions have been approved and delivered to FIG, published on the internal network and will be presented to management and other employees at FIG in Linköping.

8.2 Industrialisation processes

The new Industrialisation processes that we have defined during the master thesis are the following:

- Proposal Generation
- Requirements Analysis
- Architectural Design
- Detailed Development
- Transfer Qualification
- Line Qualification
- Handover Qualification
- Ramp-up
- Support
- Conclusion

These processes will be described in the next section, *8.2.1 Description of the Industrialisation processes*. By using the new processes that are suitable for Industrialisation, we believe that it will be easier for the project managers to work according to the PDP. Having processes that describe the actual flow in a project will support them in their work and promote a more similar way of working. It will also be easier to compare the status of different projects when using the same vocabulary.

8.2.1 Description of the Industrialisation processes

A big difference from the main processes in the PDP is that the Industrialisation processes must be performed sequential, i.e. the Industrialisation processes actually function as phases. This is due to how Industrialisation projects at FIG are performed; the order of the activities is in most cases predetermined. Due to confidentiality reasons the Industrialisation processes are only described shortly below.

The Industrialisation processes, like the main processes in the PDP, include CP's. In our new application these are called Industrialisation CP's. How Industrialisation CP's are handled is described in section *8.3 Industrialisation checklists*.

Proposal Generation

When FIG receives a request for quotation from a potential customer, a project manager is assigned. The project manager investigates if there are enough resources and competence available to perform the project. If FIG decides to make a bid on the business deal a proposal is prepared. The proposal is a type of quotation and is delivered to the customer. If the customer accepts the proposal the project work starts.

Requirements Analysis

During this process all requirements on the production process are identified, interpreted and documented. There are both internal requirements and others that come from the customer and from the HVM sites. It is important to identify requirements that are conflicting and then prioritize between these. The project organisation is also defined and manned during Requirements Analysis.

Architectural Design

All the process requirements are transformed into specifications and all concepts that will be used during the project are evaluated and selected. This for example includes defining production and test flows, what fixtures and other equipment to use, what to test during prototype builds and how the process will be verified. During this process time schedule, project organisation, budget and a documentation plan are also defined for the entire project.

Detailed Development

During Detailed Development product unique tooling, production and test equipment are designed and manufactured. All process steps are designed and verified individually. Prototypes are built to verify the manufacturability. This is the process that requires the largest amount of man hours in the project.

Transfer Qualification

More prototypes are built to verify the complete process. The team that will run the production at the HVM site receives training to learn and later take over the production process. After Transfer Qualification the project is transferred to the first HVM site. Production is often performed at several sites in different low-income countries.

Line Qualification

When the process has been transferred to the HVM site the process must once again be verified. This is done by building more prototypes. Also the new process environment must be verified. Even though the production process was functioning at the FIG site it does not necessarily mean that it will work at the HVM site.

Handover Qualification

More prototypes are built to verify that the quality and capacity targets are reached before the HVM can start. At the end of this process the production is handed over to the sustaining line organisation at the HVM site. This line organisation takes over the responsibility for running the production.

Ramp-up

The production starts and the produced volume is increased until reaching full production capacity. When having more than one HVM site, the processes Line Qualification and Handover Qualification are repeated for each site. The ownership of the process is then handed over to the customer (for OEM projects), or to an internal Flextronics line organisation (for ODM projects).

Support
During the Support process many of the resources from FIG have been released, and only a few people are still involved in the project. The remaining resources in the project support the HVM, work on improving capacity and quality and try to make sure the HVM site can manage on its own.

Conclusion
During this last process internal and customer feedback is received and remaining resources are released and can be assigned in new projects. When learnings from the entire project have been summarized in a conclusions report the project ends.

8.2.2 Flowcharts

For each Industrialisation process we have created a corresponding flowchart. The flowcharts describe the content of each process by defining; input, process steps, output, updated documents and who is responsible. In each flowchart the purpose of the process is described and it also clearly shows the included CP's. In the flowcharts we have used the symbols shown in Figure 19 below. This makes it easy to distinguish between process steps, decisions, checkpoints and documents.

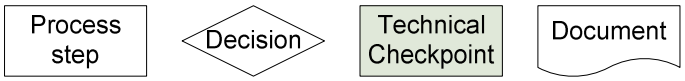


Figure 19: The symbols used in the flowcharts.

For each produced document in the flowchart it is specified who is responsible (R), contributes (C) and who only needs to receive the information (I). For decisions it is stated who is responsible for making the decision (D). These responsibilities are distributed on the project manager (PJM), Production Process Development (PPD), Production Test Development (PTD) and Quality and Verification (Q&V).

Due to confidentiality reasons all flowcharts can not be presented in this thesis, but Figure 20 shows an example of what the Industrialisation process flowcharts look like.

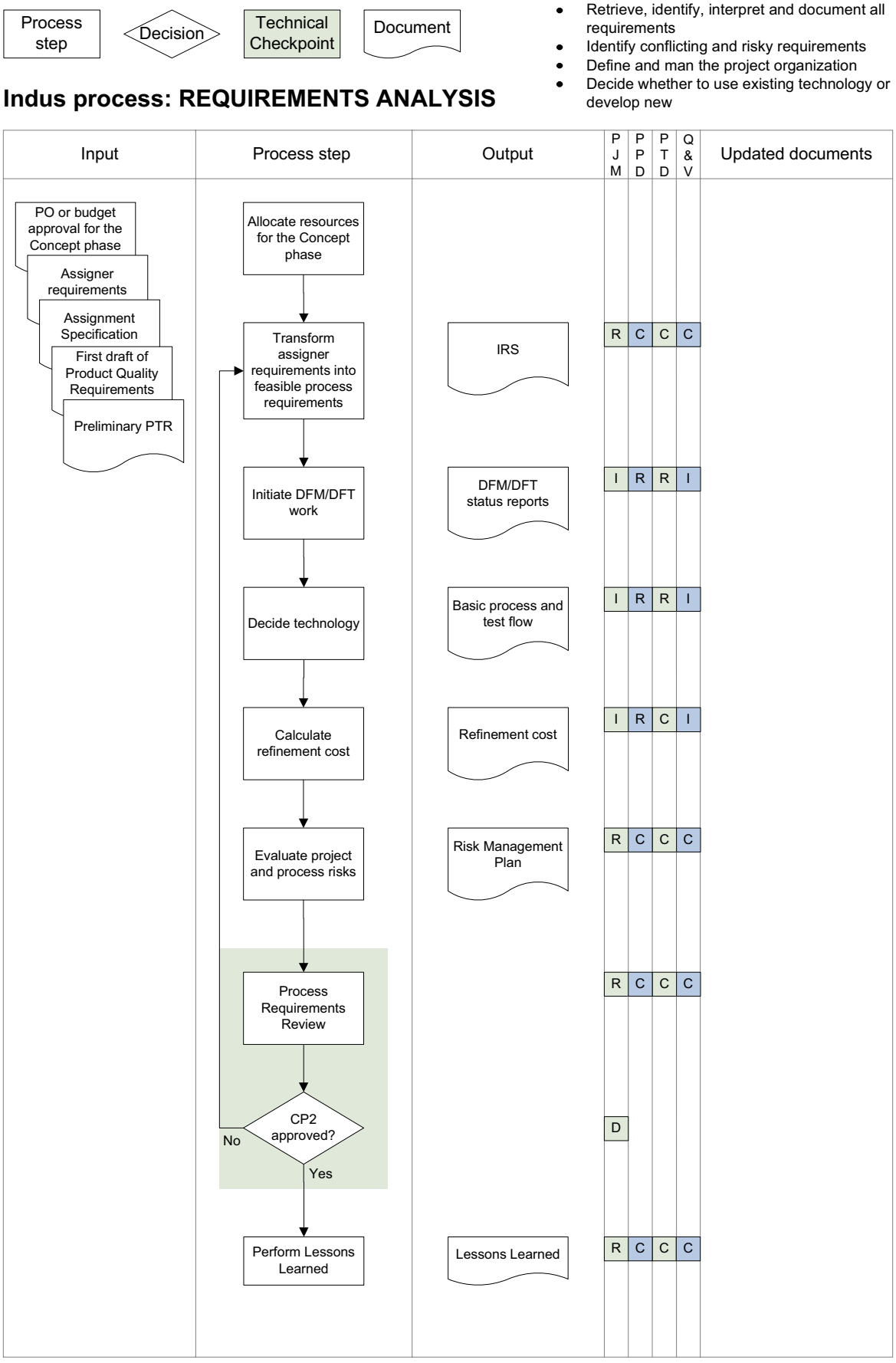


Figure 20: Example of an Industrialisation process flowchart.

8.3 Industrialisation checklists

For every Industrialisation CP we have developed a corresponding checklist that should be used as support when deciding whether to pass a CP or not. This is normally done at a review meeting, where the questions in the checklist are reviewed. The new checklists consist of fewer, more explicit and adapted questions. By only containing questions that concern the Industrialisation level the new checklists will simplify the decision making and make it easier to determine whether the project is on track or not.

Each checklist consists of a number of questions. For every question the possible answers are; *OK*, *OK with remarks*, *Not OK* and *Not Applicable*. To make it simple, the answer is chosen directly in the template from a scroll-down list. OK is chosen when the issue has been solved. If the main part of the issue is solved, but there are some remarks, OK with remarks is chosen. It is possible to pass a CP with issues that have remarks. This is up to the project manager to decide. Issues that have remarks or are Not OK end up on a remaining items list and will be evaluated at the next CP review. Open issues should also be reported to the steering group at next GCP meeting. Since the scope of different projects can vary, some issues can be set to Not applicable.

There are some key questions in the checklists that are more important than the other questions. In order to pass a CP, these issues should have been solved and the key questions should have been marked as OK in the checklists. The key questions were chosen in collaboration with our company supervisor and have been marked with bold typeface in the checklists.

When filling out the answers to the questions in the template, a pie-chart is automatically updated. This pie-chart, which is shown in Figure 21 below, indicates the distribution between the answers and makes it easy to see the current status of the CP.

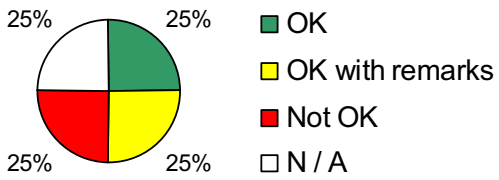


Figure 21: When answering a question, a pie-chart is automatically updated.

In every checklist, there is a CP score value included. This is a value that automatically is calculated and updated when a question has been answered. This value is an indicator of the progress or status of the CP. The more issues that have been answered OK, the higher the value is. How the value of the CP score is calculated and how it is presented in the checklists is shown in Figure 22 below.

$$\frac{\sum(OK * 1 \; + \; OK\ with\ remarks * 0{,}5)}{\sum(OK \; + \; OK\ with\ remarks \; + \; Not\ OK)}$$

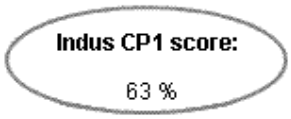


Figure 22: The Industrialisation CP score is automatically calculated in each checklist.

Except for the Industrialisation CP checklists, we have also created a template for the GCP checklists. The GCP checklists should be used by the steering group, when deciding whether to pass a GCP or not. The GCP checklists are very similar to the Industrialisation CP checklists; they are also made in Microsoft Excel, with the same formatting and layout. This is to make it easier for the user who will recognize the format. The GCP checklists consist of fewer questions though and the questions are more on an extensive business level.

Due to confidentiality reasons all of the checklists can not be presented in this thesis, but Figure 23 shows an example of what the Industrialisation checklists look like.

Process Requirements Review
Indus CP2 Checklist

Doc. No: _____
Rev: _____

Project: <Project name>
Customer: <Customer name>

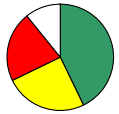
FLEXTRONICS

Checkpoint objectives:
- Retrieve, identify, interpret and document all requirements
- Identify conflicting and risky requirements
- Define and man the project organization
- Decide whether to use existing technology or develop new

Proposal Generation	Requirements Analysis	Architectural Design	Detailed Development	Transfer Qualification	Line Qualification	Handover Qualification	Ramp-up	Support	Conclusion

Review Date: _____
Review Location: _____
Review Participants: _____
Copy: _____

BR: _____
PBR: _____
LPJM: _____
PJM: _____



Indus CP2 score: 62 %

	OK / OK with remarks / Not OK / N / A	OWNER	DOCUMENT # or REFERENCE	REMARKS
1. Activities				
1.1 Has the Proposal been delivered to the assigner?	OK			
1.2 Have the resource and competence been secured?	OK with remarks			
1.3 Has the technology been decided?	Not OK			
1.3.1 - Has information from technology and engineering road-maps been taken into consideration?	N / A			
1.3.2 - Are all technologies required to execute the project available?	OK			
2. Produced documents				
2.1 Has Lessons Learned for Proposal Generation been performed and documented?	OK			
2.2 Are all requirements gathered in the IRS?	OK with remarks			
2.2.1 - Are the requirements reasonable?	OK			
2.2.2 - Are Flextronics environmental requirements included in the IRS?	OK with remarks			
2.2.3 - Are customer environmental requirements included in the IRS?	OK			
2.2.4 - Is the IRS approved by the assigner?	Not OK			
2.3 Has a DFM status report been prepared?	OK			
2.4 Has a DFT status report been prepared?	Not OK			
2.5 Have basic process flows been prepared?	N / A			
2.6 Have basic test flows been prepared?	OK with remarks			
2.7 Has the refinement cost been calculated?	Not OK			
2.8 Has a Risk Management Plan been prepared?	OK			
2.8.1 - Have all risks been considered?	OK with remarks			
2.8.2 - Can the project handle the risks?	OK			
2.9 Have the correct templates been used?	OK			
2.10 Are all other applicable documents up-to-date?	Not OK			
3. Updated documents				
3.1 Is the project documentation updated in the applicable project database?	OK with remarks			
4. Project				
4.1 Have the relevant functional CP checklists been approved?	OK			
4.2 Are all open issues from previous CP's closed?	N / A			
4.3 Is the project on schedule?	OK with remarks			
4.4 Has experience from former projects been considered?	OK			
5. Contract/Business				
5.1 Has the invoicing been made?	OK			
5.2 Have all license agreements with the customer, sub-contractor or supplier been established?	Not OK			

Decision:
_____ Pass
_____ Pass with remarks
_____ Fail, new review will be held

Decided by: _____ _____
PJM *Date*

Figure 23: Example of an Industrialisation CP checklist.

8.4 Checkpoint decision structure

To clearly show who makes the checkpoint decisions we have defined a checkpoint decision structure, which includes both CP and GCP decisions. We believe that this new checkpoint decision structure will simplify the project work by promoting a more similar way of working. This decision structure is included in the Industrialisation PDP guideline, which is described in section *8.5 Guideline*.

We have chosen to divide a project into three different levels; sub-project level, project level and main project level, these are described below. The CP and GCP decisions are made according to Figure 24. The GCP decisions are always made by a steering group. In an ODM project the GCP decision is made by the steering group at the main project level and in OEM projects the GCP decision is made by the steering group at the project level.

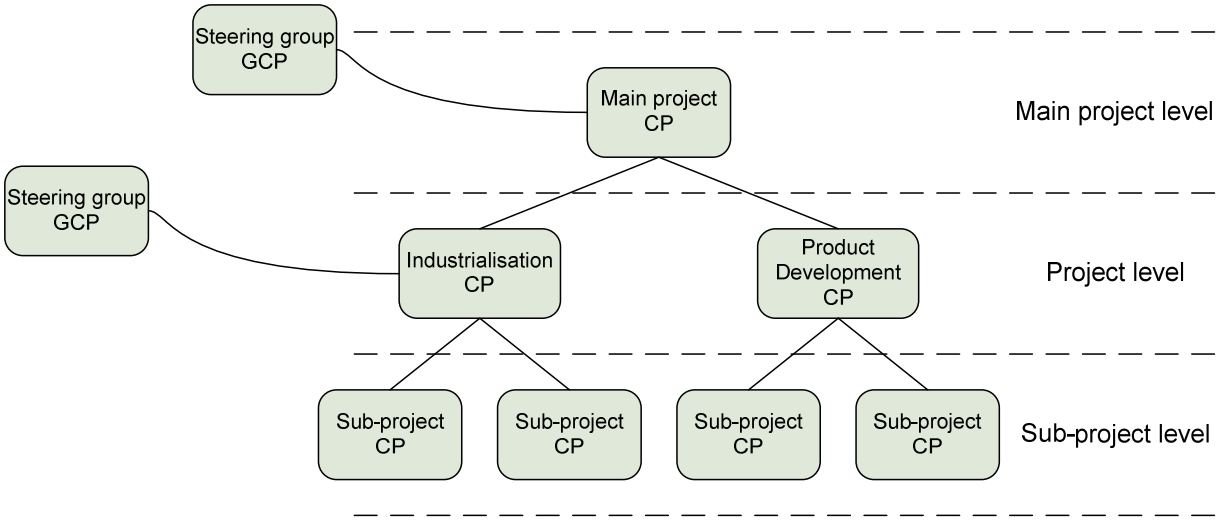


Figure 24: Checkpoint decision structure.

8.4.1 Sub-project level

For the Industrialisation project the sub-projects are; Production Process Development, Production Test Development, Product Logistics Development and Material Supply Development. Each sub-project has its own unique CP checklists. The decision to pass a CP or not is made by the sub-project manager.

8.4.2 Project level

Industrialisation and Product Development are on the project level. The checklists that we have developed should be used by the Industrialisation project. The project manager makes the decision to pass the Industrialisation CP or not. To be able to pass a CP, all lower level CP's must have been approved first.

When the Industrialisation project has passed a CP, this is reported to the local steering group that makes the GCP decision. When the GCP has been passed the Industrialisation project can enter the next phase.

8.4.3 Main project level

For an ODM project, there is also a main project level. The Industrialisation and the Product Development projects both report their CP's to the main project, where the lead project manager makes a CP decision for the entire project.

When the main project has passed a CP, this is reported to the main project steering group. This steering group makes the GCP decision. When the GCP is passed the entire project can enter the next phase.

8.5 Guideline

To be able to understand the new Industrialisation PDP and learn about and follow the new Industrialisation processes we have developed a guideline. We refer to this document as the Industrialisation PDP guideline. This guideline provides a framework for Industrialisation projects.

The Industrialisation PDP guideline explains the interconnection between the PDP and our new Industrialisation PDP application. The Industrialisation processes have been synchronized with the existing main processes in the PDP. This is described in the guideline and shown in the Appendix.

Due to confidentiality reasons the Industrialisation PDP guideline could not be included in its entirety in this thesis. Below is short summary of the contents of the guideline.

PDP introduction

- Brief description of the FPLC.
- Background to the PDP.
- Description of the phases and the main processes in the PDP.
- Clarification of the CP's and GCP's.

Industrialisation PDP Introduction

- Brief introduction of the Industrialisation processes.
- Description of the Industrialisation concept.
- Clarification of the interconnection between the main processes in the PDP and the Industrialisation processes.
- Description of the Industrialisation process flowcharts.
- Description of the Industrialisation checklists.

Decision structure

- Description and clarification of by whom and on what level CP and GCP decisions should be made.

Project organisation

- Description of a typical project organisation with corresponding roles and responsibilities.

Industrialisation PDP procedures

- How to use the checklists.
- How to handle documents, including templates and best practices.
- How to perform risk management.
- How to report project status, including budget follow-up.
- How to run prototype builds.

Industrialisation processes

- Detailed description of each Industrialisation process.

Updates

- How to update the Industrialisation PDP, i.e. mainly how to update the Industrialisation processes, corresponding process flows and checklists.

The guideline can be used when teaching new project managers how projects are run at FIG. We believe that this guideline will make it easier for the people working at FIG to accept and adapt to the new Industrialisation PDP. Having the same vocabulary and working methods will make the project work more efficient and it will also make it easier to learn from other projects.

8.6 Further recommendations and conclusions

Below are some further recommendations on what we think should be done in order to improve the project work at FIG more.

When performing interviews during the pre-study, almost all respondents requested additional education on how to use the PDP. Our recommendation is to hold one or several workshops, where a smaller project is gone through, from start to finish. During these workshops the purpose of each process in the new Industrialisation PDP should be discussed and clarified. It is important that everyone gets a similar conception. The Industrialisation PDP guideline should be used as support during these workshops. Having these workshops will reduce the risks for misinterpretations and simplify the adaptation to the PDP.

Many respondents have pointed out that experiences from other projects are hard to find and that there are no guidelines for documenting lessons learned. We recommend that a template for lessons learned is prepared and a central area is set up, where all these produced documents can be stored. It is also important to inform the employees about this.

Since we have only created a template for the GCP checklists, we recommend finalizing the GCP checklists, i.e. decide what questions to include. We suggest this should be done in collaboration between the steering group and the project managers.

Another issue pointed out in the pre-study was the need of a steering group, and during our time at the company a steering group was established. We recommend evaluating this steering group after a while, to find out how well it is working. For example, concerned project managers should be asked if they obtain enough support through the steering group.

Since most projects at FIG are SEMC projects, and SEMC uses the TTM model, we recommend mapping the PDP and the TTM. This was described in chapter *7.2 Proposed assignment for further studies*.

When performing this thesis we decided to only investigate the project work performed at FIG in Linköping, but FIG also has a unit in Malaysia. At the end of our thesis FIG Malaysia was involved in reviewing our solutions. We recommend that FIG continues with this synchronization work to bring the two units closer together.

The purpose of our thesis was to provide a standardized way of working in Industrialisation projects. As described in chapter *5 Problem areas* FIG currently does not have this. From the positive response we have gotten from the project managers at FIG during the final stages of our thesis, we know there is a desire to implement our results, which were described earlier in this chapter. To some extent this has already been done, e.g. some project managers have started to use the new checklists and there is a will to further implement the results as soon as possible. We believe this means that the people involved consider this new way of working to be easier and more efficient. Some of the people involved in reviewing our solutions have also said that they are very pleased with the results and that they believe the implementation of the Industrialisation PDP application will improve the efficiency of Industrialisation projects at FIG. Based on this we conclude that the purpose of the thesis has been fulfilled and that the processes we have developed are more standardized and better suited for the needs at FIG. We believe that having the same working methods in the entire company will improve the efficiency and increase FIG's ability to compete on the market.

Glossary

BR	Business Responsible
CP	Checkpoint
DV	Design Validation
EV	Engineering Verification
FIG	Flextronics Industrialization Group
FPLC	Flextronics Product Life Cycle
GCP	Gate checkpoint
HVM	High-volume manufacturing
LPJM	Lead project manager
ODM	Original Design Manufacturing
OEM	Original Equipment Manufacturing
PBR	Project Business Responsible
PDP	Product Development Process
PJM	Project manager
PPD	Production Process Development
PTD	Production Test Development
PV	Process Validation
Q&V	Quality and Verification
SEMC	Sony Ericsson Mobile Communications
SPJM	Sub-project manager
TTM	Time-To-Market (Project model based on PROPS, used by SEMC when developing mobile phones)

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