Integrated Product Development in Truck Industry

- A Case Study on Product Development Processes

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Lina Hagström
Abstract
This paper presents the result from a case study at Scania on product development processes. The objective with the case study was to gather information on Scania’s product development process (PDP) including the use of CAD and simulation tools, and project work. The objective was also to find any deviations or different interpretations among the employees on the PDP. To gather the information, semi-structured tape-recorded interviews have been used to ensure that individual interpretations from the interviewees could be gathered.

Scania uses a defined and structured PDP which facilitates concurrent and cross-functional work. The PDP is implemented and followed to various degrees. The newly employed personnel may have difficulties with communication, both to find and to give information. Although, newly graduated personnel may find it easier to adapt to changes, and also to use a structured process which they have studied at universities. It was also known during the case study that the PDP is a major support for the newly employed personnel, which in turn decreases the time to get into the same working process as the more experienced personnel.

Employees with decades of experience know the right sources from which to both give and gather information. Also, the terminology and definitions in the product development process may not be used as intended. This makes it difficult for other project members or teams who need to interpret the information received. At the same time, the routines among the more experienced personnel, which have been set-up throughout the years, make them more inflexible in adapting changes.

The findings in the case study as well as challenges with implementing the PDP are known to Scania and are a part of the continuing work with improvement.
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INTRODUCTION

This section introduces Integrated Product Development in the context of increased demands from customers and from the company itself. It also presents the objective of the paper.

There is an ever ongoing search for the optimized product, satisfying both the internal needs within a company and, maybe the most important, the external needs among the end users. The internal, company specific, needs may be the ability to create several product variants from fewer components, or a product designed to facilitate assembly and manufacturing. The external needs of the end user are the most difficult needs to interpret and embody into a product. In order to meet both the internal and external needs companies can follow a product development process with defined steps. The defined steps make up the product development method, and should be seen as a guideline for the companies to follow in order to have an effective and competitive product development process.

The product development methods are a support for the involved engineers in the product development process. The method can be a strict and structured path to follow or a framework which gives a more flexible use of the skill among the engineers. The methods themselves have their origin from all the necessary steps needed to develop a product which satisfy the customer.

In [Ulrich and Eppinger 2000] the product development process is defined as “the sequences of steps or activities, which an enterprise employs to conceive, design, and commercialise a product”. According to this definition, every company has a product development process, whether structured or not, provided the company develops, manufactures and sells products. Although, it is not until the product development process becomes more structured that the benefits are disclosed.

1.1 THE NEED FOR INTEGRATED PRODUCT DEVELOPMENT

The need today for a decreased lead-time to customer is essential to remaining competitive. At the same time, the development of new products has to increase and be steadily ongoing in an iterative process, fulfilling new needs in the changing market. Several authors have discussed the importance of a short lead-time. Three benefits of launching a product ahead of the competitors are suggested by [Preston & Reinertsen 1991]. Firstly the market share increases, secondly the product’s sales life is extended, and thirdly a higher profit margin is achievable due to initial pricing freedom.

Modularisation of the product assortment has proven to decrease lead-time as a result of parallel activities in module assembly [Erixon 1998]. Modules can be assembled in separate assembly workshops and supplied to the main flow for the final assembly into a finished product. The decreased lead-time is due to the parallel assembly instead of assembling the product part by part on a serial assembly line. Parallel activities require specifications of interfaces which in turn allow parallelism both in product development and manufacturing [Stake 2000] and, at the same time, concurrent processing of independent blocks will reduce the cycling time dramatically [Baldwin & Clark 2000].

However, modularisation as an approach to decrease the lead-time is not enough, there is a need for parallelism within all the activities in a company. Parallelism in turn calls for
integration between the involved activities. According to [Andreasen 1987] Integrated Product Development “is an idealised model for product development, which is integrated in terms of creation of market, product and production, and which clarifies integration between project and management, including the need for continual product planning”. To carry out product development [Andreasen 1987] argues that the result is made up of three elements, see also Figure 1.

- Recognition and creation of the market and establishment of sales outlets
- Creation of a product which satisfies the market and at the same time can be produced
- The production system which has been developed for the purpose (to produce products)

Figure 1: Business as an interaction between market, product and production [Andreasen 1987]

All three elements need to be integrated as it is not enough to only develop an optimized product. In other words, “No product is so good that it will ‘sell itself’, or that it doesn’t matter what it costs to produce it” [Andreasen 1987].

1.2 THE PAPER’S OBJECTIVE

This paper is the result of a course in Integrated Product Development at post graduate level covering 15 credits. The course is held by the Swedish Design Research Education Agenda (ENDREA) in collaboration with the Royal Institute of Technology, Chalmers University of Technology, Luleå University of Technology, and Linköping University.

The objective of this paper is to present the results from a case study at Scania Södertälje in Sweden. The case study is based on interviews and literature studies with the aim to clarify the use of engineering management, design methods and processes, and the use of computer support tools.
2 RESEARCH METHOD

This section discusses the method used for the completion of the paper and the case studies. Interviewing as a methodology to collect data is presented as well as the questions which were used in the case study.

2.1 QUALITATIVE RESEARCH INTERVIEWS AS A METHOD

The research method used in this study is qualitative research interviews supported by literature studies (see references). The aim of this method is to get a deeper understanding of the interviewee from different points of view. [Kvale 1983] defines the qualitative research interview as an interview with the purpose to gather descriptions of the life-world of the interviewee with respect to interpretation of the meaning of the described phenomena. The objective of this case study is to gather information on Scania’s product development process (PDP), and also to establish to what extent the process is followed. To gather individual perspectives from the interviewees on the definitions and work in the PDP qualitative research interviews have been used as a support. There are different forms of asking questions, but technically the qualitative research interview is semi-structured, see Table 1.

Table 1: Forms of question asking [Westlander 2000]

<table>
<thead>
<tr>
<th>Study method</th>
<th>Role of the interviewer</th>
<th>Role of the interviewee</th>
<th>Interview aids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A: Unstructured personal interview</td>
<td>Wants to investigate the individual’s own view of the existential situation</td>
<td>Decides what shall be discussed and to what extent</td>
<td>Notes taken freely during/after the interview, possibly following a predetermined frame, tape-recording in case of interviewee’s permission</td>
</tr>
<tr>
<td>Type B: Semi-structured personal interview</td>
<td>Wants to investigate the individual’s own view of conditions within each subject area</td>
<td>Has the freedom to specify what shall be taken within the frame of the topic (conversation theme)</td>
<td>Interview guide + notes taken freely during/after the interview; tape-recording in case of interviewee’s permission</td>
</tr>
<tr>
<td>Type C: Structured interview</td>
<td>Wants to access and compare responses of a number of specific questions set up in advance</td>
<td>Tied to the questions posed by the interviewer</td>
<td>Interview form</td>
</tr>
<tr>
<td>Type D: Printed questionnaire</td>
<td>As “C” above</td>
<td>As “C” above</td>
<td>Questionnaire</td>
</tr>
</tbody>
</table>
2.2 DATA COLLECTION
The process of data collection in this study is similar to the sequence [Kvale 1997] recommends for research purposes. Kvale divides the data collection into seven stages, which can be seen in Figure 2. The interviews discussed in this paper are divided into four stages, Selection of interviewee, Interview guide, Interviews and Validity and Reliability, which are described below.

![Diagram of data collection process]

Figure 2: Procedure for performing qualitative research interviews [Kvale 1997] and discussed areas.

**Selection of interviewees**
To get an overview of the PDP at Scania, the interviewees were handpicked from different departments with the help of personnel at Scania. In total, six people were interviewed at the company who had the following roles:

- Object Leader, Basic Chassis Development and Truck Development
- Object Leader, Engine Development
- Designer, Engine Development
- Designer, Cable System
- Testing Engineer
- Process Manager, Global Product Development Process

**Interview guide**
The interview guide provides a support for the researcher during the interview. A semi-structured interview gives the interviewee the freedom to decide what should be discussed within the frame work of the topic chosen by the researcher [Westlander 2000]. This means that the interview is structured through the interview guide, although the order, and to what extent the subject is discussed may be decided by the interviewee.

The same interview guide was used in all six interviews, see appendix 1, although the focus has been different depending on the interviewed person’s part in the product development. The questions in the guide are divided into three groups; working in project, product development process and technical support tools.
Interviews
All six interviews were carried out by the authors when visiting Scania during one day. To get an overview of the PDP, the first interviewee was an experienced process manager who was interviewed during 90 minutes. The duration of the other interviews was approximately 40 minutes. All interviews were tape-recorded in order to help the authors to focus on the interview rather than note taking. Also, two interviewers reduce the risk of forgetting important questions and to ensure that the answers are understood.

The same week the tape-recorded material was transcribed into text. The texts were analysed by both authors and the findings were structured to find common patterns relevant to the paper’s objective.

Validity and Reliability
“Independent of research method you have to think critically to decide how reliable and valid the information you get is” [Bell 1993]. Reliability measures in what way the instrument or the procedure gives the same result of different times – the consistency of the results. Validity means whether the method investigates the content it is intended to investigate. The interview has often been denied scientific status, as it hardly fulfils the requirements of reliability and validity [Kvale 1983].

It is very difficult to improve reliability because the situation of the interviewee cannot be repeated and the purpose of doing qualitative research interviews is to describe the interviewee’s life-world. By interviewing different people from different levels in the company, it will result in several individual pictures that together may provide a common overview of the studied phenomenon.

The authors have contributed equally to the interviews, literature studies, transcription and analysis, and the final paper. This has been supportive, specifically during the interview due to decreased subjective interpretations, confirmation that the understanding of the answers is correct; and also the writing and reflections upon this paper. This collaboration has to a great extent improved the validity.

After the case study the interviewees were given a paper manuscript (in line with this final version). The interviewees have agreed on the contents of the report (after some corrections) which also increases the validity of the paper.
3 PRODUCT DEVELOPMENT AT SCANIA

This section briefly introduces product development at Scania and the methodology that is used. Due to confidential materials which have been gathered during the case study, the method is not presented in detail nor completely covered.

3.1 COMPANY INTRODUCTION

Scania is one of the world’s leading manufacturers of heavy trucks and buses [Scania 1999]. The company was founded in 1891 and has so far delivered 1 million trucks and buses, Figure 3, produced by their 26,900 employees. Scania only produce heavy trucks, weighing more than 16 tonnes. Due to high quality, the trucks are attractive on the second-hand market, which makes it profitable to own a Scania truck even when it has served its purpose. The majority part (97%) of produced trucks and buses is exported. Scania is facing increased competition in a market with smaller margins, which is a fact for almost all companies. Its major competitors are Mercedes, Volvo, Daff, and MAN.

Figure 3: Scania R164 4x2 580 with 16-litre V8-engine (Scania archive).

Scania has been profitable every year during the last six decades; this success is partly due to the modular concept. The chassis is designed to be combined in numerous combinations which also make it possible for the designers to work within a smaller number of basic components, Figure 4. Since modules increase the potential for combining basic ranges into different configurations, “a Scania truck can be tailored to fit the transport needs of each individual customer” [Scania 1999]. Another advantage is that a modular product assortment decreases the number of parts, resulting in increased profit even in smaller production series. The quality improvements and upgrades reach the market more rapidly due to simultaneous upgrades. New variants are also introduced onto the market more quickly than might otherwise be the case [Scania 1999].
Figure 4: Modularised chassis makes it possible build up numerous of truck variants using common units among the chassis. Cab variants, clockwise from upper left: CT14 bonneted, CP19, CP19L, CP28, CR19, CT19, CT19 bonneted, CR19L, CR19, and CP31 (Scania archive).

The range of cabin variants is discussed in [Erixon 1998] who mentions that eight different cabin types can be built from cabin modules, all with several variants in each, Figure 5. The changeover from one variant to another is done in almost no time at all.

Figure 5: Eight cabin types can be built from a module assortment, all with different variants [Erixon 1998].

The effects from the cabin modularisation shows that the parts assortment have noticeably decreased, Table 2.

Table 2: Effects on cabin parts, [Erixon 1998]

<table>
<thead>
<tr>
<th>Number of:</th>
<th>Decrease %</th>
</tr>
</thead>
<tbody>
<tr>
<td>sheet metal parts</td>
<td>72</td>
</tr>
<tr>
<td>interior fitting parts</td>
<td>66</td>
</tr>
<tr>
<td>parts in top</td>
<td>57</td>
</tr>
<tr>
<td>parts in front</td>
<td>62</td>
</tr>
<tr>
<td>parts in door</td>
<td>33</td>
</tr>
<tr>
<td>windscreens</td>
<td>66</td>
</tr>
<tr>
<td>sheet metal tools</td>
<td>82</td>
</tr>
</tbody>
</table>
3.2 THE NEED FOR A PRODUCT DEVELOPMENT METHOD
Scania have developed a structured work method to reach their common goal, which is to,

- Create products with the right quality
- Within approved cost frameworks
- At the right time and with reduced lead-time to market

These three points are probably the common goal for many companies; although, Scania have gone further to realize the goal. It is stated that Scania “requires a method for technical development, which can translate customer demands into the right products delivered at the right time in a quality-assured way” [Scania 2002]. The method itself should be systematic, holistic, and cross functional. According to [Norstedts 1988] the word “holistic” means that one should first of all study the whole, and that the whole cannot be considered as the sum of the parts. To have a holistic view of product development in a cross functional, systematic process is argued by many authors to be an optimal way of developing products, see for example [Pahl & Beitz 1996], [Ulrich & Eppinger 2000], [Pugh 1991], and [Andreasen 1991].

The PDP at Scania ensures that the products and services produced, sold, and taken care of are continuously being developed; this process comprises Scania world wide [Scania 2002], Figure 6.

The reasons for implementing a PDP may be summarised as follows [Scania 2002].

- Inadequate product quality in conjunction with larger product introductions
- An increasingly tough competition situation
- More stringent legislation
- Deteriorated margins
- A much more complex product range
- Greater personnel turnover, a larger organisation and frequent organisational changes
- Co-workers need for information and the possibility to influence the work method
**Product identity**

Scania’s product identity is the starting point for the product development. The product identity provides a common perception of the goals in product development. The products from Scania should be characterised by Prestige and Performance. Customer surveys, covering instils proud and reliability shows that Scania is among the top truck manufacturers regarding the best reputation. The result from the survey may be seen as a proof of payment of a well functioning PDP with the right goals.

The Performance of the product identity covers characteristics important to the customer, for example total economy and the driver’s work and rest place. Performance often implies a requirement balance among different characteristics. In Performance, new techniques have to be estimated with regard to the characteristics, with focus on the total economy for the customer.

The Prestige comprises the customer’s expectations of Scania, established over a long period of time [Scania 2002].

### 3.3 PRE-DEVELOPMENT, CONCENTRATED INTRODUCTION AND PRODUCT FOLLOW UP

To organise and structure the PDP the tasks have been divided into three major assignment types: Pre-development (yellow projects), Concentrated Introduction (green projects), and Product follow up (red projects), Figure 7.

![Figure 7: Yellow, green and red projects which structure the PDP at Scania](image)

**Pre-development**

Scania sees many reasons for working with Pre-development [Scania 2002]. For example,

- Reduce the risk in product projects by finding out before the start of the project if the ideas presented are being sustained.
- Increase the number of available ideas and innovations, and if possible protect them with Scania patents
- Create a portfolio of interesting concepts and technical solutions
- Increase the planning precision in the product development projects
- Reduce the Time-To-Market for new functions and characteristics

The Pre-development assignments should be performed in a free and administratively lighter steering form [Scania 2002]. The structured work method in Pre-development is divided into three phases, shown in Figure 8.
The first phase, Ideas, formulates a pre-development assignment in an assignment directive which is based on ideas from customers, legislative requirements, Scania’s own ideas, benchmarking and results from research [Scania 2002].

Research and Testing is the second phase which comprises thorough investigation and testing of ideas. This phase starts with a formulation of problems and ends with a proposal for technical choice [Scania 2002].

In the third phase, Analysis, a closer analysis of the technical choice is carried out, comprising analysis assessment of the result, discussion of the result, and a paper [Scania 2002]. The three phases result in a final paper containing,

- The problem
- Technical choice
- Customer value
- Scania value
- The maturity of the technique, and
- “Lesson learned”

“Lesson learned” means that everyone shall document the experiences gained. These experiences shall be summarised in the final paper and be available for other personnel.
**Concentrated Introduction**

The structured work method in Concentrated Introduction is characterised by project work divided into five phases, Pre-study, Development, Verification, Implementation and Termination, Figure 9. Success factors [Scania 2002] which measure the five phases are:

- Approved assignment directive
- Project manager with overall responsibility
- Planning seminar and team building
- Approved project definition
- All MDs shall be identified early and put into the plan (see section Meetings and papers)
- Approved phase transitions with sign-off
- Status paper with financial results
- Approved project results
- Follow up of effect objective

![Figure 9: Concentrated Introduction through five phases [Scania 2002]](image)

In the **first phase**, Figure 9, Pre-study, the organisation of the project is created and the project manager creates a team. The document “Project definition” is created and will be established at the end of the phase. Everyone contributes to the demand made on the product and ends up with a design concept [Scania 20002].

The **second phase** is a Development phase where the final demands are made on the product. The design is finished and preliminarily documented [Scania 2002].

In the **third phase**, Verification, the product is completed and verified with serial approved documentation. The strategy for Ramp-Up/Phase-Out is decided as well as performed field tests providing information for continued development work. In this phase, considerations regarding the manufacturing and assembly process begin. Parts are ordered from suppliers and spare part assortment is ready [Scania 2002].

During the **fourth phase** the marketing documentation is completed and parts are designed for production and after sales purposes. In addition, Spare parts, Purchase, Planning and Production are also ready. To ensure serial products and production quality, Scania performs early production starts which are done with the aid of a Start of Production (SOP), Figure 9. The time between SOP and Start of Customer Order Production (SOCOP), Figure 9, is used
to verify the production process with serial parts. At the same time, Scania and their suppliers make sure that they manage the necessary production capacity.

In the fifth phase the customers receive their ordered products with the help of a Ramp-Up plan. Replaced products are removed from the production via the Phase-Out plan. From SOCOP until project closure, further development of products takes place based on customer experiences. The project is terminated and transferred to the administration within their line functions.

**Product follow-up**
Product follow-up maintains and updates the current product range and may be divided into assignments such as [Scania 2002]:

- Field quality
- Product change request
- Design adjustments
- Specification adjustments and
- Cost reduction

The field quality assignment handles defects occurred or defects which may occur. Since these type of defects directly affect the customers and the quality image of Scania, it also affects Scania’s business [Scania 2002].

**Product change request** may be described as a request for a product change made by a function within a design department [Scania 2002].

The design adjustments are made due to, for example, legislation or standards. The adjustments are initiated by the designers themselves and shall be documented in an engineering change order (ECO). An ECO is explained as “the change order system used for registering and handling each change or new development of Scania products. The objective is a unified, rational and co-ordinated registration of improvements that have been made in the technical design documentation and which results in activities to be done by e.g. the production and marketing functions at the planned dates” [Scania 2002].

Within the specification adjustments the product architecture and their internal relationship is updated. For example, when the assembly sequences do not comply with the product’s architecture or with a new variant that is introduced [Scania 2002].

**Cost reduction** is a rationalisation proposal which may be initiated by the purchasing department, and requires design changes, verification or risk analysis. The reductions shall always be treated with respect as the risks may involve, for example a change of supplier in a product range during its production [Scania 2002]. The structured work method to support the handling of the five assignment types is shown in Figure 10.
The *info phase*, Figure 10, should provide a signal to the market and the design department that the problem has been noticed and that action will be taken. The info phase shall result in an opening criterion so the Assignment Leader takes care of the identified problem immediately [Scania 2002].

In the *opening phase*, Figure 10, the market is informed via a failure paper system which is updated by the field quality engineer. In this phase, a team starts to plan the work during meetings which is documented according to a specific template. A rough time schedule (Estimated Time to Solution) is made which also, via a failure paper system, informs the market. The solution to the problems is identified [Scania 2002].

In the *pending phase*, Figure 10, the solution to the problems is verified and parts are ordered. This phase also includes measures which cannot be carried out before technical solutions are ready, for example production engineering preparation [Scania 2002].

In the *closed phase*, Figure 10, the problem has a solution in production and spare parts and methods are available. Improved parts are introduced into production and after sales activities begin. As far as the development department is concerned the assignment is concluded [Scania 2002].

In the final *termination phase*, Figure 10, the assignment is terminated by following up the solution in the field. A follow-up takes place to verify that the solution satisfies both Scania’s and the customer’s expectations, if not, the assignment restarts at the *info phase*.

### 3.4 FOLLOWING THE DEFINED PRODUCT DEVELOPMENT PROCESS

A structured product development process gives several benefits, for example shorter lead-times and increased product quality. Although to implement new methods or techniques in a company takes time and effort, even for small companies. Implement means in this paper to install and fully understand the subject matter. Scania has had, and may still have, a major challenge to drive many of the 26 900 employees towards the same goal, that is the implementation of the PDP.

**Challenges**

The fact that the truck business differs from the regular automobile market may be a challenge which makes a PDP more difficult to follow or define. A regular automobile customer buys a car and leaves it parked the majority of the day. In comparison, a truck customer uses the
vehicle as much as possible, it is a production machine. The truck customer has more needs to be fulfilled than just low price and high quality, e.g. load carrying performance.

It is also important to make information and assembly sequences available to the assembly operators in a structured way. At present, the work is carried out in several shifts and communications between different employees vary depending on the employee involved. Also, the assembly operators should be involved in the test-assembly of new parts in order to attain their opinion. The assembly operators have the experience of what may be difficult to assemble, or what may cause a defect. To involve them earlier may prevent some of the red projects, Product follow-ups, which occur.

The yellow projects, Pre-development, are sometimes let into the green projects, Concentrated introduction, too early. It is not entirely clear to all which is Pre-development or Concentrated introduction. The words “preliminary finished” is also difficult to interpret when it comes to the different assignments. For some object leaders, it is difficult to have everyone finished at the same time before going into the next phase. This probably arises because of several projects that the object leaders may be involved in and should control at the same time. In this case study, one of the object leaders was controlling seven objects at the same time. The PDP probably works better if the project or object leaders only control one project or object. The fact that several projects running at the same time extend the project lead-time is confirmed by one of the interviewees.

The PDP has had a bad reputation at Scania, even though it is the day-to-day work which is clarified in it. This probably has to do with the employees who have not studied the given PDP information brochure. Also, not everybody has taken the course on the PDP. If one employee has recently studied product development methods at a university, it may be easier to follow the PDP; but many of the employees at Scania have worked there for several years, or decades, and may be more inflexible to new methods or techniques.

There is no defined division of work between the designers which may result in some always working with red projects, Product follow up. The red projects are constrained by time, and a common feeling among the employees is that it is more stressed out than the yellow and green projects. At the same time, some red projects tend to last longer than others, sometimes more than two years.

Communication does not work satisfactorily. It is not always clear which person to contact if needed. At the same time, the communication differs, as well as the PDP work, depending on how well the team members know each other in the different projects or objects (see the definitions of project and object in section 4). Communication is further complicated by the different cultures in the different departments. Many of the employees are not aware that they follow the PDP; new words, forms and definitions are not fully understood by everyone. Even if the assignments are done correctly it is difficult to report it as completed due to new definitions. It is also difficult to know when assignments are finished, the employee often has to make their own interpretations if one assignment is finished or not. The information that is available is also known to be difficult to find which calls for an easy way to find information.

Benefits
It is interpreted as good with different phases which makes it easy to know when assignments are finished (although, it is sometimes difficult, see Challenges). The phases themselves are good to work within, as well as the complete PDP. If the PDP is followed, it is known to
work. The project leaders and object leaders have a contextual overview of the assignments which is beneficial (this may not be the case for the designers). Basically everyone works according to the PDP. It may be easier to follow the PDP for newly graduate engineers since product development methods normally are taught at the universities. Also, the PDP process is an aid for new employees who use the instructions in the beginning, which shorten the implementation time. The PDP is also valuable since many projects stretch over many years and employees leave and enter the projects. It is then easy for newcomers to adapt to the routines in a relatively short period of time.

The PDP process itself is flexible; the order in which the assignments are carried out may vary as long as everything is completed within the time limits. This may be seen as the complement to the sometimes complicated communications between and within projects or objects. The designers may carry on working with the next phase and are not hindered by e.g. not knowing who to communicate with at that very instant.

The PDP makes it possible to get a contextual overview which may be helpful when it comes to communication within and between projects. As commented by a designer “it is better to know more than necessary which may facilitate the understanding of why assignments need to be carried out in a certain way”. The PDP makes everyone to use the same “yard” and the work shall be carried out in parallel.

The work according to the PDP is the same for all the products and controls the phases and the transitions between the phases. The PDP makes everyone to stay on track with the others and to give an “ok” to move onto the next phase. There is a common time schedule and a common plan which makes it possible to push time limits if necessary. The PDP divides all assignments into different classes (yellow, green and red), and all assignments are placed in one of these classes. In this way, every assignment may be controlled which is necessary. However, the PDP should provide for some flexibility or creative freedom; but it is not possible for everyone to work in their own individual way. There is a need for control if the complete organisation shall work efficiently. The work according to the PDP is measured according to success factors and is followed by 90% in the latest survey at Scania, see also section Concentrated introduction. The fact that it is possible to control and measure product development is also a foundation for increased product quality; i.e. if the quality is not controlled or measured one does not know what to improve.
4 ENGINEERING MANAGEMENT

The focus in this section is management and project organisation at Scania. The matrix organisation is discussed as well as the work and definition of project and object.

4.1 PRODUCT DEVELOPMENT ORGANISATION

Scania have a matrix organisation or a so-called Heavyweight Project Matrix Organisation [Ulrich & Eppinger 2000], see Figure 11.

![Heavyweight Project Matrix Organization](image1.png)

![Scania Matrix Organization](image2.png)

Figure 11: Comparing Scania’s product development organisation and product development organisation by [Ulrich and Eppinger 2000].

The project management defines what shall be produced in a project and when it shall be finished. [Scania 2002] define a project as “a time restricted work in a temporary organisation that shall lead a new form of savings, quality improvement, etc. The work is directed towards a series of established project targets with consideration given to the agreed upon priorities of time, costs and results”. Every project has a project manager and all projects have a general project manager. The project manager is the link between the overall control of the project and the production of results. Normally, a project manager has one to three projects to manage. If a project manager has too many projects they do not have time to follow-up the projects - therefore the optimum is only one project.

The line management decide and plan how assignments shall be carried out. The main task for the line manager is to ensure that people with the right competence achieve the targets. Every project has an object manager from each line. Objects are defined as “a cross-functional part of the project in the PD method created for the purpose of defining the design of the product and realising targets according to the specification of requirements” [Scania 2002]. The object manager is the link between the line management and the project management, i.e. manager for the cross-functional undertaking in the project. Normally an object leader is participating in a couple of projects with different project managers. Figure 12 describes the co-operation between the project management and the line management at Scania.
4.2 WORKING IN PROJECT

As mentioned earlier, Scania have yellow, red and green assignments or projects. The project work according to the definition above is the green projects. When a new organisation is created to run a green project, the project manager creates a team (phase 1, see Figure 9). In the beginning of the project they have a planning seminar and create teams with the object managers.

*Project definition*

The most important document for the project is the project definition, which includes all basic information such as targets, economic framework, requirement specification, activities and time schedule. The project definition is created by the members in the project together with the project manager in phase 1, see Figure 9. A foundation and a commitment within the line and project organisation are created in the project definition. The project manager is responsible for creating this undertaking. The project definition is updated in phase 2 and 3, see Figure 9 [Scania 2002].

*Object definition*

The object definition is the most important basis for the object and is created by the object members supervised by the object manager. It is essential that the project targets are broken down into object targets, which is the project manager’s responsibility [Scania 2002]. The object definition just like the project definition is completed at the end of phase 1.

*Communication*

Project members in different line functions have to be good at communicating and cooperating, and simultaneously keep to the common time schedule [Scania 2002]. Communication may often cause problems; there is no need of more support material or meetings, rather better personal contacts. It is important to know who to communicate with and their part in the project, and also how their work affects the project. Good personal contacts can create better communication in the project or the company.
Cross-functional work put demands on all project members to get the same information at the same time, therefore papers and meetings are needed. The object manager is an important information link between the project management and the line management. It is sometimes a problem for project members that they get information from the object manager or the head of the project instead of from the decision-maker directly. Therefore, information in the form of decisions is sometimes badly motivated. For example, it is important to know why something is delayed to decrease a lead-time in design. For this reason and to help the object manager to work cross-functionally, the project members should take part in different meetings.

**Meetings and papers**
A lot of meetings are held during a project and the most important is the Kick-off meeting in phase 1, Figure 10. A kick-off meeting is a start-up meeting with the cross-functional project organisation and is held early in each phase. Results and activities are defined and planned, but most importantly is the creation of teams.

The project manager and the object manager have cross-functional meetings and individual contacts with project/object members to analyse the status of the project/object. The presentation of the status is supported by a paper, and the object manager is responsible for their own object aided by an object status paper. Each project also has a MD-checklist (Main Deliverables) which is a detailed work list of what shall be accomplished based on a gross list of all MDs which shall be created and delivered in a project. MD are also a communication concept between the project and the line functions when documenting the project status. In each phase different MDs have to be delivered, and the line manager is responsible for delivery before the transition phase.

Each week, the project manager presents a project review, called PULSE. It is a cross-functionally organised meeting to ensure the quality of the project result. An account of where the project is and where it should be is provided at PULSE.

At the end of a project, the project manager, object manager, and project co-ordinators create a final paper detailing the project.
5 SIMULATION AND DIGITAL PROTOTYPING

This section describes briefly how the designers are using support tools in the product development process with focus on how and why the designer uses CAD and the CAD model.

The use of support tools depends on what kind of project the designer works on. Normally the designers at Scania are working in green or red projects. The red projects are divided into short- and long-term and the designer works in the long-term projects.

A project has different phases and after each phase specific requirements have to be fulfilled. For example all drawings have different status depending on the phase of the project. The purchase department cannot order before the drawing has a specific status. All changes on a product are described in the Engineering Change Orders (ECO) and should be completed in phase 4. Therefore the designers work in the phases before that, in phase 1-3.

5.1 SUPPORT TOOLS FOR THE DESIGNER
CATIA is the main system the designer uses. CATIA is a system for the production of geometrical documentation of, for instance, parts, tools as well as workshop layouts. With the help of the product geometry a digital mock-up (DMU) is created, which may be used to verify the ability to mount and repair [Scania 2002]. CATIA has been used within product design at Scania for many years. In the beginning there were only two-dimensional (2D) drawings, but today the can also create three-dimensional models (3D), see Figure 13. Some parts are only in 2D and others only in 3D. The different dimensions are a problem during assembly or DMU.

![Figure 13: CAD construction of chassis (Scania archive)](image)

Another tool used is CIMCAD which is used for the design of production aids (tools) and machining drawings. The designer does not use this tool. The designers have compatibility problems between “construction” and “production” in CATIA and CIMCAD. If the systems were compatible it could save time and minimise factors of failure. MODARC handles sawed drawings (CAD-3D/Drawings archives) and is a model archive for CAD documentation, product and tools. The models and drawings in MODARC have to be accepted before other employees see them. This acceptance may take time; therefore the designer has to send the purchaser the drawing early for an order. All designers can access and import the drawings or models from MODARC to CATIA. The designer can then easily re-use old drawings and models. There is also an industrial design group at Scania who use the 3D models for making a VR (Virtual Reality) model of a whole truck.
**CAD in product development at Scania**

Today's 3D environment in CATIA permits all project participants within various development groups and organisations to contribute with a geometric product description with their competence. The use of 3D design as a joint development environment makes it possible to run several operations in parallel, helping to ensure on time delivery and to avoid the risk of working on obsolete or incorrect information [Scania 1999].

As mentioned earlier, the designers work with CATIA, but depending of what kind of product they are developing, or which department they belong to, they use the CAD system differently. The designers in this case study worked in two different departments and their way of using CAD is described briefly below.

**Engine development**

The designers normally use the modules for 2D and 3D models in CATIA for design. They normally start to create or reconstruct the model in the 3D module and thereafter create the drawings in 2D. It is difficult to create a truly realistic model, but adjustments can bring it close to reality. Another problem is that in the process of converting from 3D to 2D some of the information disappears. To solve this problem, the designers also need to control and moderate the new drawing.

**Cable system development**

At the cable system department, the designers first open other products in the 3D module of CATIA and thereafter build the product upon earlier designs. The reason for this is that the cable system is dependent on other products, i.e. the engine, and is developed late in the product development process. Other products have to be finished before the start of the cable system development. The 3D module is used to determine the cable length and to generate assembly instructions in 2D. When creating new parts in CATIA they re-use old models up to 75%. Cutting instructions and wiring diagrams are created in SAVER.
5.2 SIMULATION AND TESTING
If the designers need to analyse the strength, durability targets, etc. they have the possibility to do this themselves, but normally they forward the problem to specialised engineers in the same department for calculations. There is also a group of engineers who daily perform different kinds of calculations, and also finite element analysis. If the designer needs to consult this group, they write a request for the test. This department uses the FEM program ABAQUS, but also LastRand for calculations on the engine.

Scania have in recent years also invested in an upgrading of their equipment for measuring exhaust emissions, noise, strength, vibrations, fatigue and other parameters [Scania 1999]. This equipment simulates various everyday environments. There are different kinds of test groups, for example one is trying winter motoring and another is doing strength, vibration and fatigue tests on parts or on the whole truck.

The group of test engineers who performs vibration (shake) and fatigue tests, Figure 14, get orders from the designer or the project manager to test some specific areas (chassis and cab). The test engineer simulates the service conditions in a test rig, thereafter the result of the test is sent back to the designer or project manager. The calculation group have often done a rough analysis before they test the physical product. The result from the rougher analysis is useful and may be used as input to the simulation in the test rig.

Figure 14: Shake test of T164 cab Södertälje (Scania archive).
6 CONCLUSIONS

Scania has been developing heavy trucks and buses for more than a hundred years which makes it an experienced company when it comes to product development. Scania has today a product development process (PDP) that is systematic, holistic and cross-functional. To have a holistic view of the product development in a cross functional, systematic process is argued by many authors to be an optimal way of developing products.

The work according to the product development process is the same even when working with different products, and controls the phases and the transitions between the phases. Different phases complete the PDP and make it easy to know when assignments are finished. Basically all employees work according to the PDP, although some more or less unconsciously. Employees who have worked for a long time at Scania may be more inflexible to new methods than newly graduated employees. The PDP is a major support to new employees at Scania and in the day-to-day work. A structured product development process gives several benefits, but the implementation takes time and effort. At Scania, the implementation of the product development process has been adapted by the employees, although to different extents. Even if the employees do not work exactly after the PDP, the work gets done. Some employees have not studied the PDP brochure, which may be one reason why some do not follow the PDP. Another reason could be that they have not participated in a course on the PDP.

The project organisation at Scania may be defined as a heavy project matrix organisation which includes both a project and line organisation. The advantages with this are that they can take the experience from one project/object to another and that they get an insight in more than one project. The disadvantages are that it is difficult to follow up all projects and it could be a problem for the object manager to have every object finished at the same time before going into the next phase. It is not always clear which person to communicate with in or between the projects or objects. In addition, communication may differ, as well as the PDP work, depending on how well the team members know each other.

Also, it is not clear to everyone why decisions are made, e.g. the designers get to know the "how" not the "why". The communication may need to be more controlled and defined in the PDP; at the same time the assignments may need to be more clearly explained to disclose their origin. The interviews showed that the employees with only a few years of experience at Scania have more difficulties in knowing who to communicate with. The employees with several years of experience at Scania may have difficulties to adapt to the new definitions and terminology in the PDP. It also seems as if objects which are involved late in the projects, for example cable system development, become a red project more often than objects involved early. The red projects demand reactive resources from the employees who should be working with proactive product development in the green projects. Scania use common software programmes both for design, visualisation, simulation and calculations. The simulation and calculation programs make it possible to perform experiments and pre-development analysis even though the physical product does not exist. Also, the use of the simulation programmes makes it possible to avoid tests. This is valuable since Scania competes with high quality products which go through numerous tests.

Due to the relatively short work with this study, no specific recommendations will be made. The objective of this paper was to present a case study with the aim of clarify the use of engineering management, design methods and processes, and the use of computer support tools. The objective has been reached and any recommendations are not part of the study. Scania is aware of areas for improvement, which is not the case in numerous of companies, and continues improvement is part of the day-to-day work.
7 REFERENCES


Appendix: Interview guide (in Swedish)


**Introduktion**
- Vilka arbetsuppgifter har ni?
- Vilken utbildning?
- Hur länge har ni arbetat på Scania?
- Vilken avdelning arbetar ni på?
- Vilka projekt/objekt arbetar ni i?
- Vad har ni jobbat med/som tidigare?

**Engineering Management**
- Hur definierar ni ett projekt/objekt?
- Hur planeras ett projekt/objekt?
- Hur genomförs ett projekt/objekt?
- Beslutsfattandet?
- Hur sker kommunikationen mellan olika projekt/objekt?
- Hur sker kommunikationen inom ett projekt/objekt (deltagare, ledare)?
- Ser ni några för- respektive nackdelar med projekt/objektarbetet?

**Design Theory and Methodology**
- Har ni någon metod/modell över produktutvecklingsprocessen (formell modell)?
- Hur går arbetet i produktutvecklingsprocessen till?
- Hur väl följs den formella processen?
- Är PU-processen produktspecifik?
- Vilka för- och nackdelar ser ni med den formella modellen?

**Simulation and Digital Prototyping**
- Vilka verktyg har ni tillgång till?
- Till vad används verktygen?
- Varför används de och hur?
- För- och nackdelar med verktygen?
- Vilka/vilket verktyg som ni inte har idag skulle förbättra arbetet?