Business Process Mapping and Development

A case study at Volvo Penta on mapping and recommendations for the development of the existing processes

Master's thesis in Product Development

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ABSTRACT

This project aims to provide knowledge to Volvo Penta about the current process of delivering 3D models to customers and how to improve it.

A key service for Volo Penta is delivering models to their customers, these models are used by the customers so that they can see the dimensions, the shape of the parts, where important components are, etc. Volvo Penta used to send out these models to customers after the product was done and ready to order but customers nowadays want the models even earlier so that they can have their newest boats and machines out on the market with the newest Volvo Penta motor. This has been an advantage for Volvo Penta to send out the models earlier than at the start of ordering but this has come with a risk. Sending out models before they are out on the market creates a risk that important and confidential information could leak out and have damaging repercussions for Volvo Penta.

In order to minimize the risk of models leaking out, Volvo Penta needs to know their current process and also improve it, the way to do this is by mapping the process first.
The main basis for the mapping will be the interviews that were held throughout the project. These interviews will be held with both internal and external stakeholders. The internal stakeholders at Volvo Penta were geometrical architects, sales engineers, and project managers to name a few. The external stakeholders that were interviewed were direct customers of Volvo Penta, retailers of Volvo Penta, and also stakeholders of interest. With the information gathered from these interviews and secondary sources, it was possible to map out the current process of delivering 3D models to customers.

The next part of this project is about improving the current process, this will be done by giving recommendations to Volvo Penta both in the short-term and in the long-term.
The short-term recommendations will focus on what Volvo Penta can do to immediately improve its process. The long-term recommendations will focus on what Volo Penta can do to opptimize the process even further, but that could take more time and resources.

Key: ACP, CAD, 3D-models, PDM system, Mapping,

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Arman Fazlagic & Johan Semmingsson
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Abbreviations

ACP - Automatic cad packaging
BPM - Business process management
CAD - computer-aided design
DVP - Development Product and Aftermarket Product Portfolio
FDG - Final development gate
IT - Information technologie
IoT - Internet of things
KOLA - Konstruktion Lastvagnar
PCI - Product Change Initiation
PDM - Product data management
PEST - Political, Economic, Social, Technological
PGT - Project Governance Tool
RQ - Research questions
SoO - Start of ordering
SSI - Semi structured interviews
SWOT - Strengths, Weakness, Opportunities, Threats

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1. Introduction

The introduction encompasses the background of the project and why the topic is of interest in the industry. It also covers the background of the case company Volvo Penta and a description of the underlying problem. This is followed by the aim and research questions with the project and also the objectives that are to be achieved. Subsequently, the scope and limitations of the project are presented. Finally, the introduction ends with presenting the outline of the report.

1.1 Background

Volvo Penta is a world-leading supplier of engines and complete power systems for marine and industrial applications. Volvo Penta has developed a global leadership and is one of the industry's strongest brands in their category. ("History | Volvo Penta", 2022)

The demand for 3D models has become an important feature in the sales process, both for existing and new potential customers. When Volvo Penta has developed a new engine and the engine can be ordered, the engine's 3D models are available for download on the Automatic CAD Packaging (ACP) application. That application downgrades/converts master models to envelope models. Envelope models are models that do not contain secret information and can thus be shared with customers. When this ACP application was launched, Volvo Pentas increased its sales sharply.

Recently, Volvo Penta has realized that customers send in requests for 3D models on the engines before it can be ordered so that customers have more time to design and construct their own products. Before the engine can be ordered, it is still under development and then it is not available in the ACP application. To meet customer requirements, the downgrade from master model to envelope models must be done by hand, when the engine is still under development. The ability to share 3D models with ease at early stages during development projects of new engines plays a crucial role in the decision making whether a customer will select Volvo Penta's engine or not.

The process of developing and displaying 3D models for customers during the development stage is today very complex. There are many different actors involved in the development chain, the actors must be competent in different projects and be able to navigate in different types of programs to extract the models without secret information leaking and damaging the project and company. What makes this issue even more complex is that today there are no clear routines for how this process should be handled. Today, this process is carried out at the individual request of each customer and the actors who carry out the work at Volvo Penta are able to do it thanks to the help of their contacts within the company.

1.2 Aim and research questions

The aim of this thesis is to determine and map the current process and the underlying causes and consequences. Based on the finding's recommendations will be made for improving the process from a strategic point of view to make sales more efficient and secure.

- RQ1: What does the mapping of the current process look like?
- RQ2: What recommendations can make the process better and safer in the short term?
- RQ3: What recommendations can make the process better and safer in the long term?

1.3 Objectives

In order to fulfill the aim of the degree project and the three research questions, two specified objectives must also be met. These two objectives are about collecting knowledge that will form the basis for the execution of the project.

1. Establish the current level of knowledge on business process management and process mapping by reviewing scientific literature
2. Identify internal and external key factors about the process through analysis of PEST, SWOT, mapping, and interviews.

1.4 Scope and limitations

Volvo Penta already has an internal portal for CAD models which is used to show customers models when the product has gone into production. This function does not exist for products in the development stage, which today makes sales to customers who are also developing new products difficult and inefficient. Volvo Penta wants to change this situation, so the main scope of the project is to analyze the current process with all the different actors and their individual roles and how they are connected. Based on the results, recommendations on process development will be presented for both short and long term.

A limitation in the project is that the software and the code of the various applications will not be examined and analyzed. What the final process will look like, the risk management of it or its implementation in Volvo Penta will not be covered in this thesis, this report will only focus on recommendations regarding strategy/process development. What the recommendations will mean in time and cost will also not be included in this work as pure speculation is not of interest.

1.5 Outline of the report

The report will be divided into seven sections. The first section is an introduction of the background, aim, objectives and limitations of the project. The next section is the literature review, here it will be presented what theory the report is based upon. The third section is methodology, it encompases the methods and processes that have been used during the phases. These phases are exploratory and explanatory. The following fourth section is mapping of the current process, and that chapter contains the execution of the project. The fifth section process development goes through potential improvements for the process. This is followed up by sixth section discussion, where the findings will be discussed. And the final section, Conclusion and further recommendations which will highlight the key findings and recommendations from the thesis.

2. Literature review

This section constitutes the theoretical framework for this thesis and contains various theories, concepts, and criteria regarding the area of business process management and process mapping. The aim of the section is to examine the existing knowledge in the field to then be able to use well-chosen parts during the degree project. The chapter thus fulfills Objective 1: *Establish the current level of knowledge on business process management and process mapping.* How the literature review was performed is explained in the chapter on methodology.

2.1 Business Process Management

In every company or organization there are several processes, and every process must be handled. It does not matter if it is an agency, a non-profit organization, a state-owned company, or an enterprise all have processes that need to be managed. (Mendling et al., 2019.) A clear example of a business process is the order-to-cash process. This process is usually performed by a salesperson. The process starts when a buyer submits an order to buy a service or product, activities for reviewing orders and stock checks, packaging and delivery of service or product, invoice management, and ends with the buyer making a matching payment. The quote-to-order process is another example of a standard business process. The quote-to-order process begins when the seller receives a quote on an order for either a service or product, includes activities that prepare the quote, and ends when the quote and its contained service or product are purchased by the buyer. (Dumas et al., 2018).

Both events and activities are described in these two examples of business processes (Lee & Dale, 1998). Events occur directly during the execution of the process and a typical event is when a buyer's order arrives. In activities, there are durations where resources are required to be used and can be seen from different levels of granularity. When an activity is only one unit of work, it can also be called a task. When it comes to work processes, the term task is used when referring to a fine-grained work where only one unit of work is done by a process participant. The opposite of fine-grained is coarse-grained where several units of work are performed by several participants. If activity is used to describe the business process, both fine-grained and coarse-grained can be meant. Different types of objects are used to perform activities in a business process. It can be both physical objects such as materials, tools or products or information objects such as electronic records or electronic invoices. The process also includes actors, and it is the actors who carry out the activities. In this case actors means either human agents, entire organizations or information systems that act at the request of the human agent. When a business process is performed by an actor via the use of one or more objects to solve an activity or task, the desired goal has been achieved. This has meant that the process has added value to both the organization that performs the process and to the buyer who buys the end-product or service. Based on this explanation, a business process can be defined, "*A business process is as a collection of inter-related events, activities, and decision points that involve a number of actors and objects, which collectively lead to an outcome that is of value to at least one buyer*" (Dumas et al., 2018).

A value-creating process is always central in an organization and that is why it is extremely important to be able to handle these processes systematically and developmentally. That is the goal of Business Process Management (BPM) and BPM can be defined as follows, "*BPM is a body of methods, techniques, and tools to identify, discover, analyze, redesign, execute, and monitor business processes in order to optimize their performance*" (Dumas et al., 2018).

It is difficult to determine exactly where BPM was born because it has several roots in both management science and computer science (van der Aalsr, 2013.).
Business processes and their productivity have constantly increased since the first industrial revolution as technology innovation, the organization's approach to work and information technology have evolved (van der Aalsr et al, 2016.). Some important birth roots are Adam Smith (1723–1790), who developed the organization when he advantageously divided the workforce into small but specialized teams or when the original principles of Frederick Taylor (1856–1915) were introduced regarding scientific management. Henry Ford (1863–1947) and the revolutionary production line and Alan Turing's (1912–1954) unique Turing machine inspired by early research in computer science are also good examples of birth roots to the modern version of BPM (van der Aalsr, 2013.). From the 1980s onwards, it is the development and use of information technology (IT) and its capacity and capability to organize and manage processes that have affected BPM the most. Today, it is the organizations' ability to improve existing IT areas and build new areas through IT that is central to process management. BPM also has a very progressive view of completely new technology with high potential such as blockchain, internet of things and robotic process automation. In this way, BPM is a key method for benefiting from both existing technology but also from the emergence of new technology (Mendling et al., 2019.).

For a process to continue to be valuable to an organization, the process must be constantly evaluated and continuously developed, otherwise the process will, in the long run, probably not be as successful as it once was. It can be due to several different things, but the most common are that customer requirements change, new or better competition, that new technology emerges or that the profitability of the end-product or service changes to the negative. To avoid this, BPM's life cycle can be used to maintain and develop the process. The work around the life cycle updates the process's events, activities, and objects together with the goals for the process, in order to be relevant to all stakeholders and customers (Dumas et al., 2018). Since the work of maintaining and developing a process for the better in an organization is continuous, BPM's life cycle should be seen as a circle with six different phases (Szelągowski, 2018.). Figure 2.1 shows the BPM lifecycle.

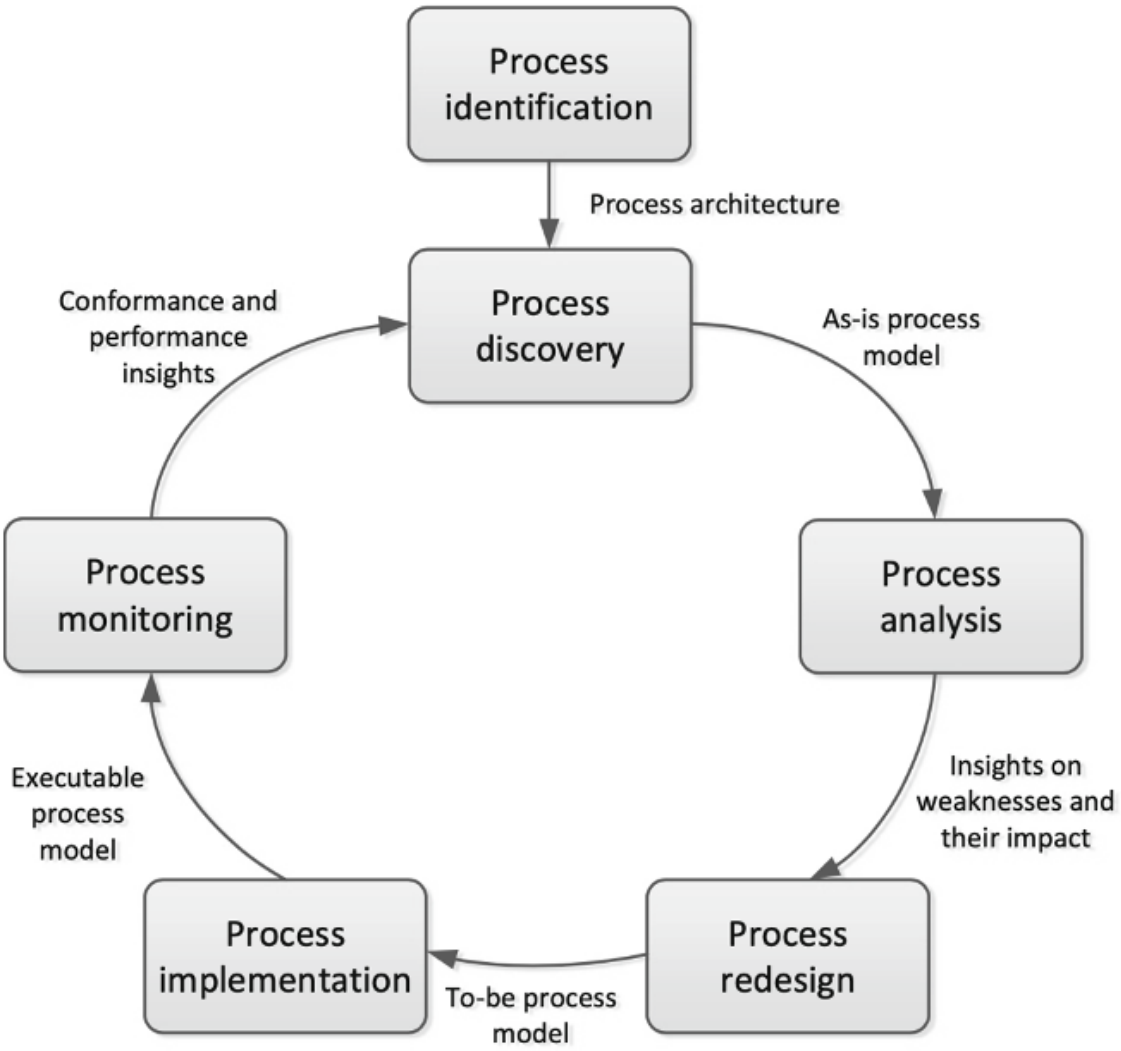

Figure 2.1: The BPM lifecycle. (Dumas et al., 2018).

Process identification. In the first phase, a problem with the business process has become known and work to identify the root of the problem is carried out together with all events, activities and actors that are directly or indirectly affected. The relationship between the root-cause of the problem and both the sub-driver and the symptom of the problem are also examined in this phase, and how the damaged process affects the whole organization. The result of this phase is a process architecture that provides a clear overall picture of the situation in the organization. The status report and process architecture then form the basis of the strategy for the remaining phases of the life cycle (Dumas et al., 2018).

Process discovery. In the second phase, which is also called process modeling, the process is carefully documented according to the results from the previous phase. A common model used in this phase is the process mapping model (Mendling et al., 2019.).

Process analysis. In the analysis phase, all questions and problems related to the damaged process are identified, documented, and quantified using performance measures. To do this,

there are several different methods, but a requirements specification for the process is common to ensure that all requirements are considered. In this phase, it is also important that the requirements are prioritized so that it is possible to determine which is most urgent (Dumas et al., 2018).

Process redesign. The fourth phase of the process, also called process improvement, has the goal of identifying functions and solutions to the requirements of the previous phase so that the process can meet performance targets. These possibilities and changes are analyzed and compared against each other in terms of which is best according to the requirements in the requirements specification. When a winning combination of solution alternatives is selected, a recommendation for a new process model is presented (Mendling et al., 2019.).

Process implementation. At this stage, the work of preparing and the actual execution of the transformation from the existing process to the new process is carried out. This phase of process implementation encompasses two aspects, organizational change management and automation. The first refers to the set of events and activities required to improve the way of working for all employees involved in the new process. The second refers to the development and use of the new IT systems, or improved versions of existing IT systems, that support the new process (Dumas et al., 2018).

Process monitoring. In the sixth and final phase, the new redesigned process is monitored first in a test-step until it is possible to extract data that proves that the process meets all the goals and requirements that it has. If deviations or recurring errors occur, they must be corrected immediately, and the test-step must be repeated. However, this phase cannot be completely completed as a process must be continuously monitored and analyzed. New problems may arise in the same or other processes in the organization that may affect this process, therefore this phase and the entire BPM life cycle must be repeated continuously to be sure that the process is used correctly (Mendling et al., 2019.).

Performing a BPM life cycle is demanding and requires a lot of work from many different parts and actors within an organization. Therefore, it is very important to know who all the stakeholders in a BPM life cycle are (Dumas et al., 2018). It is important that stakeholders are informed why a life cycle of a process is performed and what consequences it may have for the organization if the life cycle is not performed correctly. The following stakeholders will approve, perform, and pay for the work that a BPM life cycle includes management team, process owners, process participants, process analysts, process methodologist, system engineers and BPM group (Dumas et al., 2018).

Finding sufficiently credible information regarding a process in an organization is by far the most demanding but also the very important work when BPM's life cycle is to be performed (Lee & Dale, 1998). In BPM, this type of information gathering is called "Process Discovery Methods" and there are three different categories with a total of five process discovery methods. The first is “evidence-based discovery” and the methods in that category are based on the fact that there are already documents and other types of evidence on how an already

existing process works. The first method in the first category is “document analysis” and that method is based on the fact that the process already exists on documents. It is thus possible to obtain all the necessary information through mapping and analysis of the documents. The second method in the first category is “observations”. This method is about the actor who maps and collects data about the process following the process from start to finish and observing the entire course of events with completely objective eyes. The third and final method in the first category is "automated process discovery" and it means that there are event logs that can be mapped and thus collect information on how the process performs in practice (Dumas et al., 2018).

The second category "interview-based discovery" contains the method "interviews". This method must be performed on different actors and stakeholders for the process in order to be able to collect enough good data. When conducting interviews, there are three basic interview techniques that can be used. The first technique is the unstructured interview where the interviewer has not predetermined any question and the entire interview is conducted only on feeling. The second technique is semi-structured interview where there is a predetermined framework in the interview but where there is also room to ask questions that arise in the moment. The last interview technique is structured interview where all questions are completely predetermined and the person performing the interview keeps the predetermined schedule. If interviews are chosen as process discovery methods, it is important that the process mapping is done in parallel so that it is possible to get feedback on how the execution of the process and all involved actors are interpreted (Dumas et al., 2018). See Figure 2.2 for steps of the interview method.

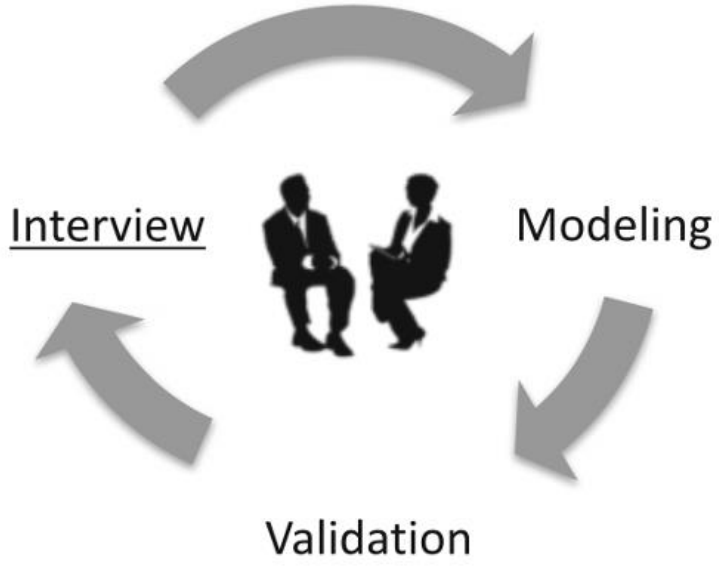

Figure 2.2: Steps of the interview method (Dumas et al., 2018).

The third and final category "workshop-based discovery" also has only one method called "workshops". This method works if all interviews were to be held as a group discussion. The

workshop is thus based on all different actors in the process being invited to a process game where everyone must participate as if it were real (Dumas et al., 2018).

Choosing process discovery methods can be difficult and there are several parameters to consider. Time, cost, and resources are some of them. A fourth parameter that must be considered is how well-documented today's process really is and whether that data can be trusted. Two additional parameters that must be included in the equation are the strengths and weaknesses of the different methods. In Table 2.1, all strengths and weaknesses per discovery method can be seen (Dumas et al., 2018).

Table 2.1: Strengths and weaknesses per discovery method (Dumas et al., 2018)

Method	Strengths	Weaknesses
Document analysis	• Structured information • Independent from stakeholders availability	• Outdated material • Wrong level of abstraction
Observation	• Context-rich insights	• Potentially intrusive • Stakeholders likely to behave differently • Only few cases and not all processes can be observed
Automated discovery	• Extensive set of cases • Objective data	• Potential issue with data quality and level of abstraction • Data may not be available or be available only in part • Data extraction and preparation is time-consuming
Interviews	• Context-rich insights	• Requires sparse time of stakeholders • Time-consuming: several iterations required before sign-off
Workshops	• Context-rich insights • Direct resolution of conflicting views	• Requires simultaneous availability of multiple stakeholders • Time-consuming: multiple sessions typically required

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2.2 Process Mapping

Process mapping is a concept for describing and visualizing, using different types of flows and text, each part of a business process and the approach has, in BPM, become a proven communication and analysis tool for describing, developing, and creating business processes (Damelio, 2011).

When General Electric realized that there was value in visualizing the process at their manufacturing facility in Louisville, they realized that one-fifth of each part of each installation was unique. By reducing production on unique parts and instead starting to mass-produce standard solutions, the manufacturing process could be developed and streamlined (Hunt, 1996).

To be able to create successful process development, good and correct process mapping is required. To apply the correct process mapping approach, data collection must be collected and based on it a mapping method selected (Hunt, 1996). See Table 2.2 for type of map.

Table 2.2: Type of process map (Hunt, 1996).

Level of Performance	Map Used	"View" of Work Emphasized
Organization	Relationship map	**Organization:** The supplier–customer relationships that exist between "parts" of an organization
Process	Cross-functional process map, also known as a "swimlane diagram"	**Workflow:** The *path* of work that "crosses" several functions, plus the *architecture* that connects the relevant activities, people, information systems, and other resources along that path
Job/Performer	Flowchart	**Activity:** The value-creating or nonvalue-creating work performed

Relationship Map. A relationship map of a process visualizes how different actors in the process integrate with each other and what their relationship is. It is also common in this process map to see what external actors such as suppliers and customers have for interaction with the internal actors. In this map, it is not common for events, activities, or objects to be drawn. On the other hand, it may happen that the end-product or service can be followed

from the supplier through various departments and actors to the end customer. This type of map can also be referred to as the organization relation map (Hunt, 1996).

Cross-functional process map. This map describes and illustrates the organization's workflow in a process. In this map, all actors, events, activities, and objects that are important for the end-product or service must be marked. In the cross-functional process map, it should be possible to follow the raw materials to finished products, so it should be possible to follow the process from start to finish. However, this map should not describe the different relations between internal and external actors (Hunt, 1996).

Flowchart. In the process map flow chart, the work activities are in a straight sequence where the different activities have different shapes. The forms and order in which they lie describe which activity was performed first but also which activity added value to the process. This process map also does not describe which actors carry out the activities or which relationship the actors have with each other or with external parties (Hunt, 1996).

3. Methodology

This section will present the different methods used and also the different tools to achieve the project's objective.The methods are explained in detail and with its purpose and aim. The methods used throughout this project are SWOT analysis, PEST analysis, Semi structured interviews, analyses of data, mapping, requirement specification, process/concept development and verification. These methods were chosen as they are tools designed to solve the aim and objective this project has.

3.1 The method of the literature review

For this project the literature review was conducted in four steps; review of literature, analysis of the found literature, documentation, and final analysis of the literature. This literature review will mostly be composed of a collection of relevant reports, literature, and articles that are suitable regarding business process management, and process mapping. The main purpose of the literature review was to generate ideas and theories on the relevant topics.

In order to collect relevant literature, Chalmers library was used to gain access to different databases such as Science Direct and Scopus. Google Scholar was also used in order to gain a broader search pool and to avoid any type of biases. Initially, the search scope was quite broad because of the narrow topic that was encompassed which had limited literature on the topic. Thereafter when relatable topics were found, the scope was shrunken down in order to not have overwhelming amounts of data.

The snowballing method was applied in order to ensure the trustworthiness and desired relevant literature and authors (Wohlin, 2014). The snowballing procedure and its different steps, also how it was applied are illustrated in Figure 3.1 below. The snowballing procedure was deemed as a suitable approach, this is because the literature review was exploratory. Additionally, an internal brainstorming and snowballing of preliminary keywords were carried out in the process to generate productive search terms to find more relevant literature. This is done to ensure a wider field of view and more spontaneous results. Examples of keywords that were included are; "business process management" and "process mapping".

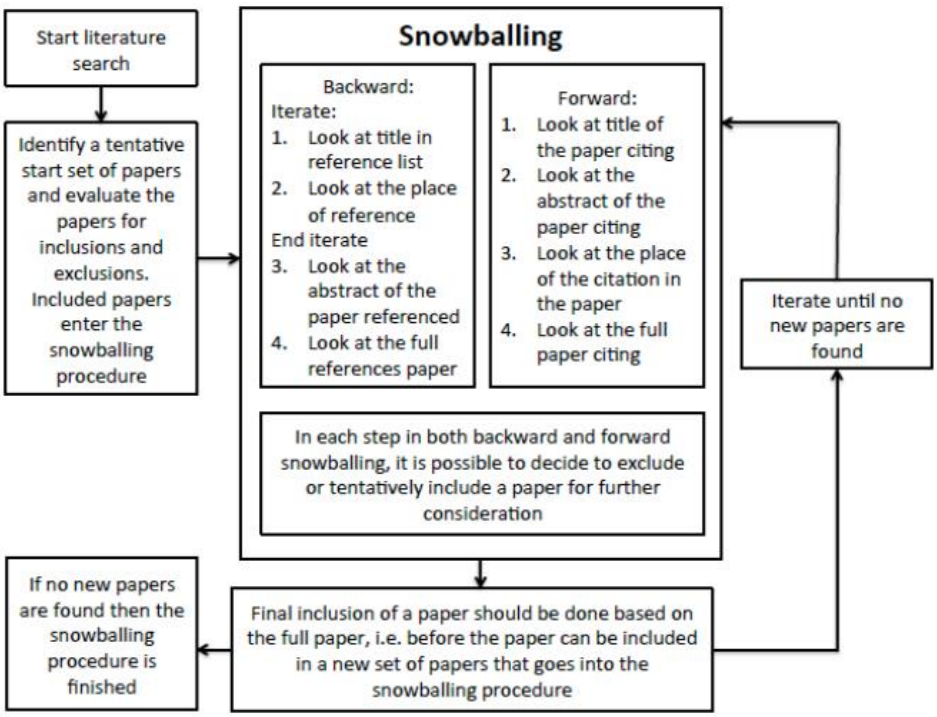


Figure 3.1: The snowballing method. (Wohlin, 2014.)

When the starting set is determined, the first iteration occurred and the articles to accompany it were decided.

In the first iteration, snowballing backward and forwards were conducted. After the former was done, the reference list was checked in order to identify new relevant papers for inclusion.

Decisions to exclude papers in the reference lists are based on basic criteria lists such as title relevance, year of publication, type of publication, and author. To make sure relevant papers were chosen, the following questions were discussed:

- Does the title imply preliminary content to be included?
- Has the author published relevant articles in the field?
- Is the article published in a relevant context and where publication is permitted?

After these steps, if the paper is still eligible for inclusion, the abstract is reviewed to assess the degree of relevance and whether a final decision can be made. After that, the whole paper was checked to decide if the paper should be used or not. In the snowballing process that follows, the identification of new papers was done on the premise of papers citing the studied papers. The first screening here was based on information that was provided by the database. Then after that, the same procedure as backward snowballing where the abstracts and full texts were reviewed (Wohlin, 2014.) .

Iterations were continuous and simultaneous throughout the project because new information seems to be necessary. Until the project team

had collected sufficient literature and multiple viewpoints had been discussed, or that no new papers had been found and the loop had ended (Wohlin, 2014.).

3.2 SWOT

To get a deeper understanding of Volvo Pentas opportunities and challenges with the current process, a SWOT-analysis was conducted. Doing a SWOT-analysis means that one presents the strength, weaknesses, opportunities and threats of the company or process (Bush, T., 2019). The four different sections can be divided into two categories where strength and weakness identify the *internal aspects* while opportunities and threats are *external aspects.*

Figure 3.2 shows what a typical SWOT-analysis looks like. A SWOT-analysis is a tool to analyze the company's or department's operations while also addressing what the operation is lacking or is at risk of, this is in order to minimize the risks and to maximize the biggest opportunities for success("SWOT Analysis: Strengths, Weaknesses, Opportunities, Threats", 2022).

A SWOT was used for this project to illustrate Volvo Pentas opportunities when it comes to Volvo Penta's potential sales and/or customer relations improvements by having an established and improved structure when it comes to delivering models to customers. The SWOT was conducted by going through the four different factors, one at a time, from strength to threats, and used qualified brainstorming based on information search and the interviews to answer all the different categories (Bush, T., 2019).

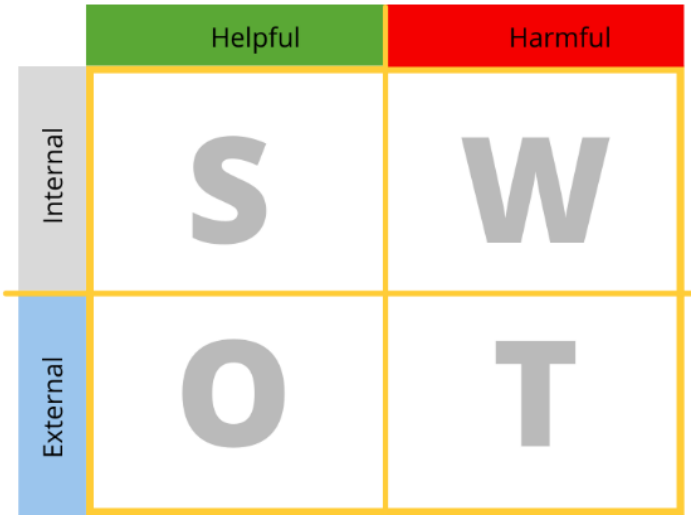


Figure 3.2: The SWOT-analysis.

3.3 PEST

To get a better understanding of the company's market opportunities a PEST-analysis can be conducted. The analysis is a method for showing how different factors affect a company. When using this method, four areas are observed and these are; Political, Economical, Social, and Technological. The results from the PEST-analysis are a good input in the external part of the SWOT-analysis (Broad Factors Analysis, 2022) .

When a PEST-analysis is conducted, every area is studied in order to get a final conclusion, this will then show what the company is facing (Broad Factors Analysis, 2022).

The PEST was created for this project in order to determine what some external factors might be for Penta and potentially the process of sending out 3D-models to customers. The PEST-analysis is based on information from the web but also from the interviews that were conducted throughout this project (Broad Factors Analysis, 2022).

3.4 Semi structured interviews

One of the key information collations for these projects are interviews held with different stakeholders throughout the chain of these models, starting from their creation to the customers receiving the models, also the back and forth between Penta and the customers. Because there are so many different stakeholders with different backgrounds in this process chain then it wouldn't be suitable to have a regular interview format, so for this thesis a semi structured interview model was more fitting. It has been called different things such as focused interviews, ethnographic interview, depth interviewing, and qualitative interviewing but for this project, it will simply be called Semi structured interviews or SSI for short (Adams, 2015).

SSI is managed conversationally with one respondent at a time, the interviews are a blend of closed-ended and open-ended questions, these questions are often accompanied by follow-up questions such as why and how types. The dialog between the interviewer and the interviewee roams around the different topics of the agenda rather than sticking to the topic strictly, this opens up a much more fluent interview that may delve into totally unpredicted issues. SSI tends to be more relaxed and can be easier to keep engaging. The interviews are maximum of one hour, this is in order to minimize fatigue for both interviewer and interviewee (Adams, 2015).

Some drawbacks of using SSI are that it is time-consuming, the interviewer needs to be poised, sensitive, smart, nimble, and also knowledgeable about the relevant substantive issues. It also takes a lot of time to prepare for the interviews, set up the interviews, perform the interviews, and afterward analyze the interviews. Analyzing the huge amount of notes and transcripts can take a lot of time. The time and effort required to do all of that are considerable (Adams, 2015).

SSI are well suited for many tasks, particularly when the open-ended questions require follow-up such as:

- If there is a need for probing questions and the independent thought of the interviewee is needed.
- If the probing questions would be difficult to answer in a focus group with your peers.
- If there is a need for a one-on-one with key program managers, staff, and front-line service providers.
- If the territory that is being examined is uncharted but potentially has momentus findings and there is a need for free-roaming on the subjects.

3.5 Analyses of data

Thematic analysis is one of the most common methods for analyzing qualitative data. The analysis method is used to interpret, identify and analyze patterns to find the meaning of the data (Braun and Clarke, 2012).

When doing the analysis, one is identifying the relationship and similarities between the different data. This can be performed in various ways, either in a more visualized way or through discussions. A combination of these could be the most beneficial, but when choosing a more visual approach then one can more clearly see the relationship and similarities in the data. Situations, where thematic analysis is beneficial, are when one wants to make a conclusion from scratch because this method does not require pre-decided findings. The drawbacks are that it can be difficult in some situations to capture the significance of the data and put it in a category, sometimes the significance disappears when it is summarized in a category (Insights, 2017).

Because there was a great deal of data in this project the thematic analysis was implemented. The interviews were all recorded and transcribed. In the first phase, the important findings were highlighted. The results were then divided into sub-groups depending on if the stakeholder was from Penta, a customer, or an external actor because some of the questions had direct relations to their part in the process. The group went through all of the questions and similarities in the answers could be identified (Braun and Clarke, 2012).

3.6 Mapping

To identify possibilities and challenges, a mapping of the current delivery situation of 3D-models was conducted. Maps and flowcharts can help make the work visible or it can at least make some of the work visible (Damelio, 2011).

In short, this is why mapping a process is worth doing. The mapping of a process adds to the knowledge of the process, it makes it easier to illustrate the current process and it also helps to apply the process or to improve it. Mapping shows important things like the flow of

information and also key personnel throughout the process. Mapping is an important tool because many companies already think they know their business process, but in reality, most managers do not know what their processes are or if they can be simplified, improved, or eliminated. Process mapping is therefore an excellent analytical and communication tool for helping improve your existing process or to implement a completely new process(Damelio, 2011).

There are typically 6 steps to process mapping and they are:
Step 1: First identify a process or problem to map; For this project that would be the process of delivering the 3D-models to the customers.

Step 2: List activities that are involved; Document what is needed for the process to be completed. Documenting the activities but also who is involved and responsible for each step. It is important to establish where begins and ends so that there are no gaps in the mapping.

Step 3: Note the sequence of steps; When all the activities are compiled the next step is to arrange them in their proper order, until the whole process is represented properly. This step is a good point to see if there are any gaps in the process that could have been missed.

Step 4: By using process mapping symbols, draw a process map; Use the appropriate format and draw the process, representing the different steps and stakeholders with symbols.

Step 5: Finalize and review the map; When the illustration is finished, review the process so that everybody understands and agrees on how the process is mapped leaving out no steps.

Step 6:Analyze the map and see if there are sections that can be improved; Now identify where the process is inefficient and what can be eliminated or improved.

Symbols are used in processing mapping to describe different actions. Every action is represented with a symbol such as a circle, arrow, box, etc. These symbols come from the unified modeling language (UML), which is an international standard for illustrating process maps (Anon,2018).

3.7 Requirements specification

Stakeholders can mention what they would like the process to be like, saying that they want it faster, smoother, fewer steps, and so on. This might be helpful in getting a clear sense of the issue but it provides very little specific guidance about how to design and engineer the process. The margin for subjective interpretation becomes too great. Because of this reason, development teams establish a set of specifications, which gives the precise measurable detail of what the process has to do. The specifications do not disclose how to address the needs, but rather present an obvious acord of what the team will attempt to achieve to satisfy the needs (Ulrich, Eppinger & Yang, 2020).

The intended meaning of the term process specification is the precise description of what the process has to do. To specify, a specification consists of a value and a metric. For example, “average delivery time” is the metric and “about 1 week” is the value of the metric. The value can have different forms, it can be anything from a range, a number, or an inequality. Therefore values are always labeled with the appropriate units such as minutes, kilograms, meters, etc. In a perfect situation then there would only need to be one process specification early in the development process and then proceed accordingly but that is rarely the case. The requirement specification has main functions which are the most important things about the product/process, after that it demands what the customer/company needs from the product/process, and after that you have the wishes which are given a number depending on their importance (Ulrich, Eppinger & Yang, 2020).

For many processes, the process is established twice. Something to consider when making a requirement specification is to refine the specifications, making trade-offs where it is necessary (Ulrich, Eppinger & Yang, 2020).

This project is divided in to mapping the current process and making recommendations for the further development of the process. To make it both clarify and to have guidelines, a requirement specification is necessary (Ulrich, Eppinger & Yang, 2020).

3.8 Process development

One of the objectives of this project is to give Volvo Penta recommendations both short-term and long-term. The thought is that the short-term recommendations should act as guidelines for how to structure the current operation moving forward and could be applied directly. While the long-term recommendations would act as a plan and process that could be implicated under a longer period for Volvo Penta (Ulrich, Eppinger & Yang, 2020).

A process concept is an approximate description of the operation, having the right stakeholders, working principles, etc. It also acts as a description of what will satisfy the customer. The action for generating process-concepts starts off with a set of customer needs and also target specifications, this results in a set of process concepts from which the team will make a final decision (Ulrich, Eppinger & Yang, 2020).
Important steps to take when doing a process development are:

1. Clarifying the problem, understand the problem at hand
2. Search information externally, look for information from experts, patents, published literature, related processes,
3. Search for information internally, use the knowledge that already exists within the team.
4. Systematically explore, use visualization to explore solutions
5. Reflect on the process and solution. Defy the opportunities for improvement.

3.9 Verification

After performing all the different methods then it is important to make sure that the result is an acceptable one, this is called verifying. Verifying means to make sure or demonstrate that something is accurate, justified, or true. By verifying the product/process, you can be sure that the result at least in theory achieves its goals. Verifications can be done in different ways such as testing a prototype, checking it against requirements specifications, making simulations, etc. After doing a requirements specification, it is an easy and simple way to make sure that the concept fulfills its goals (Ulrich, Eppinger & Yang, 2020).

Testing a prototype is straightforward as it implies that the prototype is tested in a situation where the product/process will be used to make sure that it achieves the set goals. Simulations work on the same premise but it is done in some sort of computer program, where the prototype can be tested and verified (Ulrich, Eppinger & Yang, 2020).

Because a part of this project is to make recommendations for further development of the process, then the recommendations need to be verified in order to make sure they fulfill their purpose. These recommendations will not be able to be tested because of time restraints so the verification will be done by screening it against the requirement specification (Ulrich, Eppinger & Yang, 2020).

4. Mapping and analysis of the current process

In this chapter, the interviews of the various actors, the mapping of the current process, the analyzes, and the requirements specification will be presented. The aim of this chapter is to answer RQ1: *What does the mapping of the current process look like?* and Objective 2: *Identify internal and external key factors about the process through analysis of PEST, SWOT, mapping, and interviews.*

4.1 PEST analysis

A PEST-analysis has been conducted to identify external factors that could possibly affect Volvo Penta. The broader scope was chosen in order to analyze the external factors and to identify trends (İhsan Yüksel, 2012). Data is extrapolated from the broader European level. Some trends such as unemployment will be excluded from this PEST because it does not directly affect the 3D delivery system. The aim of this analysis is to identify essential enablers and barriers. Input for the PEST-analysis will be done from annual reports and various websites.

Political
Sweden is currently a politically stable country and is unlikely to experience any radical political changes in the near future. Because the corporate tax rate is quite low
For companies, but with higher regulatory compliance requirements for the environment compared to other countries, Sweden is considered to have a friendly private business environment (Forbes, 2018).

In 2017, the Swedish Parliament decided by a political majority to introduce a climate policy framework and climate law for Sweden. The framework is the most important climate reform in Swedish history and provides the conditions for the implementation of the Paris Agreement in Sweden. Sweden aims to achieve net-zero greenhouse gas emissions into the atmosphere by 2045 (Government office of Sweden, 2022).

This is echoed throughout the world with the EU commission targeting climate neutrality by 2050 for all the countries as a whole, and reducing their greenhouse gas emissions by 55% by 2030 compared to 1990 levels (A European climatlaw, 2020).

Economic
Volvo Penta's net sales increased by 21% to SEK 14 billion in 2021 this is because of a strong market recovery and an increase in the utilization of Volvo Penta products. Adjusted operating income amounted to SEK 2,092 M (1,448), corresponding to an adjusted operating margin of 14.5% (12.2) (Volvo Penta annual report, 2022).

Social

According to the Ellen MacArthur Foundation (2020), recently, sustainable development is undoubtedly booming and attracting more interest, not only in academia but also in the whole society. Apparently, 80% want sustainable products and choose them relative to less environmentally friendly options. What we are seeing now is changing customer behavior and attitudes, toward policymakers and companies.

Technologie
The shift from mechanical parts to electronic parts is increasingly evident in both the marine and industry sides (Casper & Sundin, 2020).

The company also strives to have the highest employee engagement in the business to support its vision of becoming the world leader in sustainable power solutions. To be a world leader, Volvo Penta will leverage its innovativeness, lead the development and create industrialized and high-quality products and services that create true value for its customers to secure a long-term profitable business. Volvo Penta aims to accelerate transformation within uptime services, digital experiences, electric drivelines, and automation (Volvo Penta annual report ,2022).

Throughout 2021, Penta has launched several products with the goal of Reduce emissions and improve user experience. Started production of the new all-terrain 16-liter Stage V/Tier 4F engines offer many industry-leading advantages. In testing, the engine has been shown to save up to 10% of fuel consumption compared to the previous model. also improved Low to high torque and high altitude performance (Volvo Penta annual report ,2022).

4.2 The interviews

All 20 interviews conducted during the degree project are compiled in this section. All interviews were in-depth interviews and conducted using a semi-structured interview technique. The reason why this technique was used in this degree project is because previously collected information was used as a framework for the interviews, but that there would also be room to ask follow-up questions if any would arise in the moment. The frameworks with all predetermined questions are presented sequentially in Appendix A-T. The interviews were recorded and lasted between 30 minutes and 1.5 hours. Due to the scope of the project and the workload, it was decided that the interviews will not be transcribed but only summarized based on the predetermined framework and follow-up questions.

The interview objects can be divided into three categories. The first category is actors working at Volvo Penta, the second category is external actors who have a relationship to either Volvo Penta or to the scope of the project, and the third is customers of Volvo Penta. Table 4.1 gives an overview of all 20 interviews and the order in which they were interviewed, their names, the interview technique used, when the interview was conducted, which company they work for and what their position is at the company. All people who work for Volvo Penta are thus in the first category. The second category includes people from

the companies Volvo Trucks, Saab, and PTC. The customers of Volvo Penta are the companies Imatech, Nimbus, Disab, Konecreans and Rottne and thus belong the people who work at those companies to category three.

Table 4.1: Information regarding the interviews conducted.

Number	Interviewee	Characteristic	Date of interview	Category	Company	Job title
1	Sven Angervall	Semi-structured	12-02-2022	1	Volvo Penta	Geometrical Architech
2	Max Gunnhage	Semi-structured	22-02-2022	1	Volvo Penta	Sales & Application Engineer
3	Jimmy Kling	Semi-structured	23-02-2022	1	Volvo Penta	Sales & Application Engineer
4	Magnus Liske	Semi-structured	23-02-2022	1	Volvo Penta	Project Manager Process & IT
5	Fredrik Jägersvärd	Semi-structured	24-02-2022	1	Volvo Penta	Platform Manager & Project Leader
6	Freddy Fuxin	Semi-structured	25-02-2022	2	Volvo Trucks	Data Scientist
7	Tommy Olsen	Semi-structured	07-03-2022	1	Volvo Penta	Product Developer
8	Martin Olofsson	Semi-structured	07-03-2022	1	Volvo Penta	Product Developer
9	Conny Nilsson	Semi-structured	08-03-2022	3	Imatech	Sales Manager
10	Nick Andersson	Semi-structured	09-03-2022	1	Volvo Penta	Sales & Application Engineer
11	Magnus Lycklund	Semi-structured	10-03-2022	2	Saab	Systems Engineer Specialist
12	Per Lonnehede	Semi-structured	11-03-2022	2	PTC	Systems Engineer Specialist
13	Mats Törefeldt	Semi-structured	25-03-2022	3	Nimbus	Designer och Salesman
14	Erik Möller	Semi-structured	29-03-2022	3	Disab	Design Engineer
15	Johannes Karlsson	Semi-structured	29-03-2022	1	Volvo Penta	Regional Application Engineer
16	Peter Engqvist	Semi-structured	04-04-2022	3	Konecranes	Mechanical Engineer
17	Peter Helgeson	Semi-structured	04-04-2022	3	Konecranes	Mechanical Engineer
18	Christoffer Jivenius	Semi-structured	04-04-2022	3	Konecranes	Mechanical Engineer
19	Martin Holmberg	Semi-structured	05-04-2022	3	Rottne	Design Engineer
20	Lars Josephsson	Semi-structured	05-04-2022	3	Disab	Mechanical Engineer

Initially, the internal process at Volvo Penta wanted to be investigated. Therefore, the interview process was started with people from category one who work close to today's issue and based on them, more steps in the process could be identified and based on those steps, more actors could be interviewed. When all internal actors in the process were interviewed, phase two of the interview process began. The purpose of the second phase was to get a different perspective on the issue, so category number two was interviewed with three different external actors who have a relationship to either Volvo Penta or to the scope of the project. With all the information from the first and second phases, the information could be compiled and analyzed before the third phase with the third category of customers for Volvo Penta. In this way, this process puzzle could be put in order with certainty that no perspective would be missed since the interviews started with actors from the internal part of the process at Volvo Penta (category one), were followed up with external actors who have a relationship with the company or the issue (category two) and ended with actors in the external part of the process (category three).

Interview 1

Name: Sven Angervall
Title: Geometrical Architect
Institution: Volvo Penta, Gothenburg

Sven is the Geometrical Architect at Volvo Penta, Sven is one of the key personnel in product documentation. He is one of those who have pushed for there to be a structure and improvement in the current process of giving out models to customers. The process of simplifying models currently involves somebody going into the product and physically applying our coat over it or inside to cover up the insides or even the exterior of the model, meaning that manpower has to be put down which costs money and of course personnel. These simplified models are called envelope models. Right now when we receive the models from the designers we outsource the models to our team in Bangalore, they then simplify the models which take around one week, the models are then sent back to us and we can send them out to the Sales engineers or into the ACP which stands for Automatic CAD Packaging, this is all done around Start of Ordering (SoO). SoO is the period of which the models are out on the market and are ready to be sold, ACP then acts like a hub for the sales team to take out the models and send to customers.When that is done then anybody can take out the models that they need.

When the product is mentioned, we do as previously stated take the model and simplify it but now the product documentation department has started outsourcing this to their offices in Bangalore, This is because they have more manpower and because of lower cost.

There is usually a request for these models as soon as the customers find out that there is a new model coming out. realistically about the midway point of the development phase is when customers can receive these models in theory. The lowest level of quality in these models can be for the customers usually is the low-resolution envelope, Figure 4.1, this is the lowest that is still looking like something we made but is the least amount of power for the computer. Usually, the most important part of the model is the sheer size of the port and where the attachment point is, customers also want to know where the different service parts are located such as oil, gasoline, where parts that need to be changed regularly and so on.

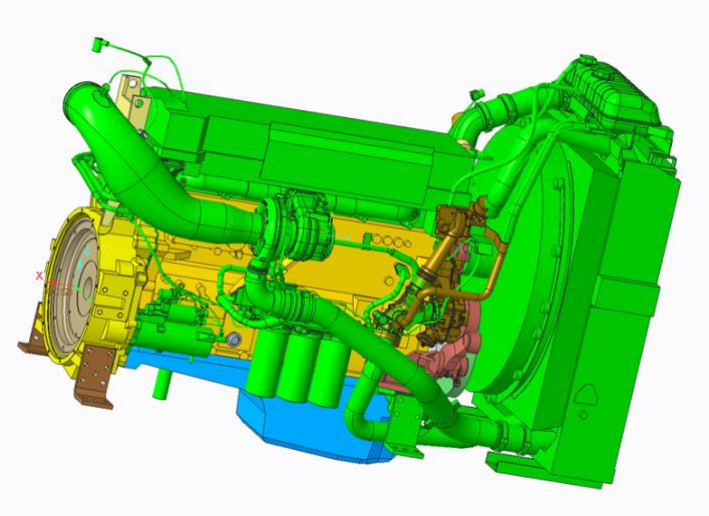


Figure 4.1: Low-resolution envelope model of an engine.

In Figure 4.2 it is possible to see what a high-resolution envelope model looks like and in Fgure 4.3 it is possible to see what a master model looks like. It is thus to either a low-resolution or a high-resolution envelope model that a master model is downgraded to. The downgrade must be done so that secret information is not leaked to an external actor when the models are handed over to customers. The handover is made so that customers can use Volvo Penta's models so that customers can design their own products. To prevent the models from containing secret information, the models have been filled in, i.e., converted to solid models.

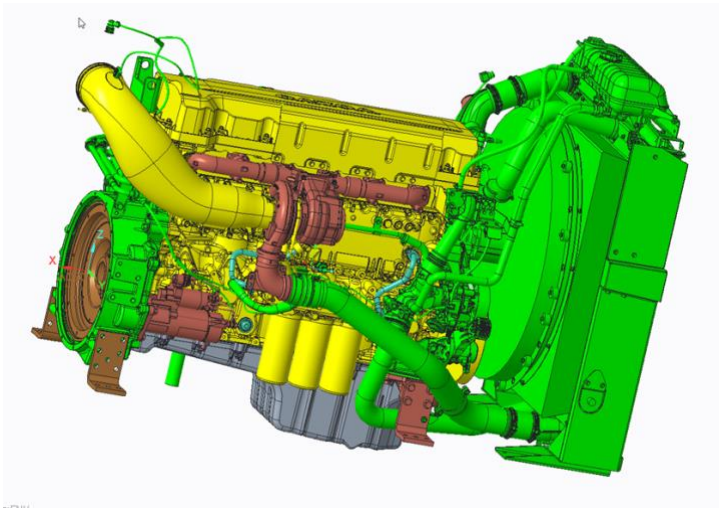
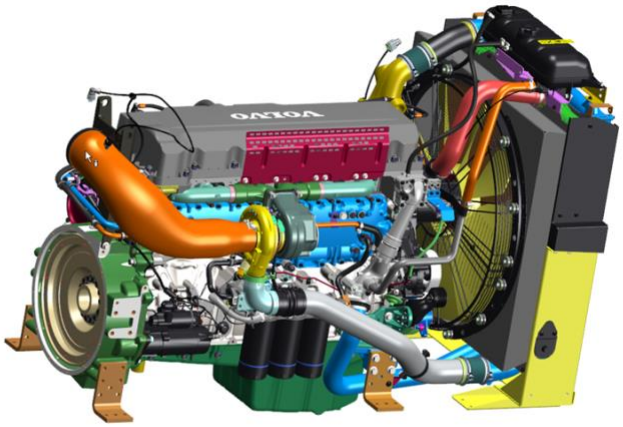


Figure 4.2: High-resolution envelope model an engine.



Fgure 4.3: Master model of an engine.

The biggest mishap that can happen when sending out these models is that some models could have too much information meaning that they could be a master file which if it ended up in the wrong hands could mean that they could duplicate that part which means that millions could be lost for Volvo Penta in work hours investment or ending time and so on. Generally, the most important part to protect a model is the inside of the model, this is where the most development happened, and this is what it's hardest to duplicate if you don't know exactly what it is. The benefits of giving out these modest customers are huge, it is almost a must for customers because they want to know when they make the new type of boat or truck that our parts will fit into their new component. The biggest concern when sending over models is the risk of secret information being leaked but at the same time if the models are not sent out then the customer relations could be damaged which could lead to a lost sales.

There is not currently an automatic system for customers to receive models in due time or when needed. There have been different issues because there is not an established work process for this. It would be good if there was a built-in way to encrypt these models into the current CAD program, but it doesn't work like we wanted to, it would make the models into surface models and more or less all the customers want it in solid models. Some research has been made into looking into a program that could make these solid models automatically, but not enough time has been put into it and it's not perfect. It is generally known what can and cannot be shown with the models. When the customers receive the models, they get them as a link to the ACP program, where they can take out models. In the future, it would be good if this process was automatic and there was no need for somebody to go in there and have to physically encrypt these models.

Interview 2

Name: Max Gunnhage
Title: Sales & Application Engineer – Industry
Institution: Volvo Penta, Gothenburg

Max Gunnehage is a sales engineer that works at Volvo Penta, he works towards the industry side of sales. His job involves talking to customers and a tool for him is these 3D-models, he says that these models are a key tool for him because of their importance. Customers usually ask for these models as soon as possible because they want to implement the new motors in their designs. Currently, he gives out models to customers at the SoO phase but giving out models at the half-point mark of the project would be possible because that is when there are no more big changes to the design of the models. The most important things for the Miles to keep safe are on the inside such as tubing and areas inside the model, the outside surface is not as important to protect and is quite important for the customers to know but the most important part for customers know is attachment points and also where things that lead to change gasoline and other parts are located. The outside measurements are very important for the Industry side, this is because the tolerance on the outer side is much smaller than it is on the marine side so the customers want to know the exact measurements so they can fit it perfectly in their components. The biggest concern we have when handing out the models is that information could be leaked, on the contrary, if we do not send the models to the customers then there is a risk that the relations with the customers might be damaged which could lead to lost deals.

There is currently no structure for delivering the message that a new part is underway or in development to customers. There is neither a structure right now for customers to receive the models when it has reached the start of ordering or so and so. Max says that he has worked a lot in Creo but he has never been taught how to use it properly meaning that there is a gap of knowledge for them, he also says that he's the one who knows the program best in his department. Models on the industry side are quite important because the customers need a more detailed picture or model or sketch of the motors because the motors have to fit into a much more compact body than it would maybe on the marine side. This is therefore very important for customer relations and also to establish new customers for the growing industrial market.

There is currently no official work structure for 3D models to be sent out to customers and this has led to a lot of problems because if there's not an established structure there's no real way of teaching somebody that is new to Penta and there is no default action for when a customer asks for models. Some customers have different arrangements depending on how big they are meaning that some customers could receive models earlier or even as master models. In the future it would be much easier if there was a way to encrypt these models or simplify them, also it is not always easy to know what you can show in the models and what you cannot, it would also help in the future too having established structure. Currently sending models to customers as step-files.

Interview 3

Name: Jimmy Kling
Title: Sales & Application Engineer – Marine
Institution: Volvo Penta, Gothenburg

Jimmy said that customers ask for models almost as soon as they find out that a new model is in the works. He said that the models right now were hard to deliver to customers before SoO because they had not been simplified. Giving out models earlier has many benefits such as having better relations with the already established customers and also connecting to potential customers. If the 3D-models end up in the wrong hands then there is a chance that secret information might leak, at the same time if we do not give our customers the models then customer relations could be damaged and business could be lost.
Jimmy said that he works as a sales engineer on the marine side and he said that the marine side was not as dependent on precise measurements as the industry side. The most important parts to protect are the insides of the models, this is tho more or less irrelevant for the customers considering that the outside of the model is the most important for the customers such as the size of the part and the attachment points. Right now there is not an establishment of announcing to customers of new models that are on their way. There is currently no way for customers to automatically receive models. Jimmy has never been properly trained to use the CAD program Creo but does have to use the program on a regular basis, he is the only one in his department that knows how to use it in a proficient way. Even though he is the most capable in his department when it comes to Creo it is still too difficult for him to generate these models that are needed to send to customers.

Interview 4

Name: Magnus Liske
Title: Project Manager Process & IT
Institution: Volvo Penta, Gothenburg

Here at Volvo Penta, development and change projects are carried out with the help of something called the DVP project handbook. DVP stands for Development Product and Aftermarket Product Portfolio and the handbook describes the life cycle and governance structure for technical and end-to-end product or process development projects. It thus describes the framework for how a project is to be carried out with everything from phases to deliveries and gates. This handbook is developed to be able to efficiently and safely develop products that meet both customer and market requirements every time.

Usually within Penta you can divide the people who in one way or another are part of the project into four categories. The first category is the steering group, and that group is ultimately responsible for ensuring that the goals are met and that they approve that the project can proceed to the next phase. To ensure that all parts of the framework are followed,

this group has a Project Governance Tool (PGT) to help them. PGT is a document that is created according to Volvo Penta's DVP project handbook and its phases, tasks, and gates. The second category is project management, and their task is to lead and delegate the project. The line organization is the third category, and it is this group that is the project's resource that performs the tasks. The last category is the "decision body" which is responsible for and approves budget issues and which also holds the dialogue with various stakeholders.

The tool support PGT contains about 1000 tasks and some tasks also have sub-tasks in them. It is usually very important to stick to the routines and go through all the tasks but sometimes there is not the time or resources to do it on all projects. Therefore, there are different versions of both the PGT tool support and the DVP manual where some sub-goals have been removed and some have been added. This is usually decided by the "decision body" as it is their task to approve changes in the scope of the project. The framework and the different tasks may vary from project to project, but the structure of the organization that carries out the projects are often the same. See Figure 4.4 for a typical project organization and its resource status and position.

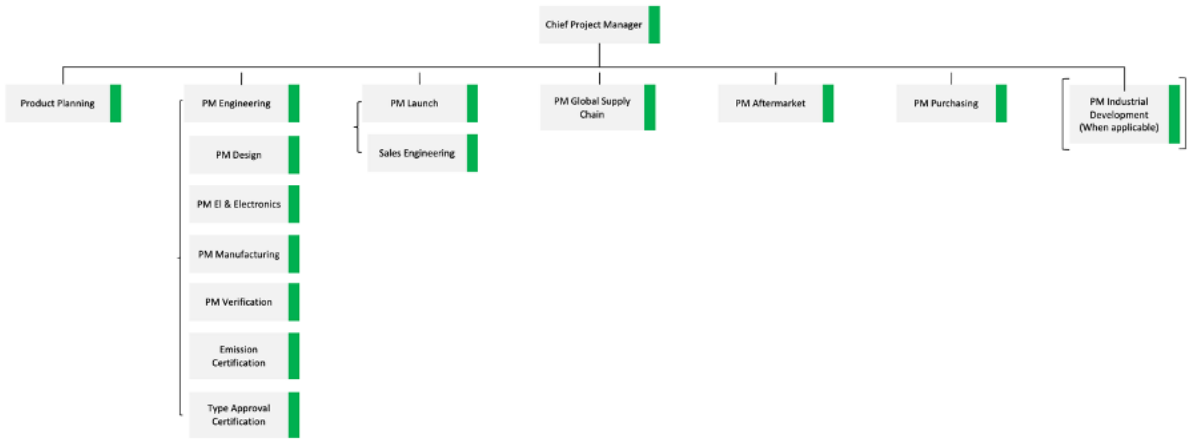


Figure 4.4: A typical project organization in Volvo Penta.

Although the framework and the various tasks may differ from project to project, there is a framework that Volvo Penta always starts from. That framework can be read in Figure 4.5. This framework is the original and the most common and it is also this that is modified if sub-goals are to be removed or added to. This project model can be described as a classic phase-stage model where Volvo Penta has expanded it a little further according to its own experiences and needs. But the principle is that the work is carried out in batches during the various phases and where the subsequent gate functions as a check-out station where all tasks are examined. If the work in the phase has been carried out correctly and the goals are met in the gate, the project can pass that gate and move on to the next phase and the next tasks.

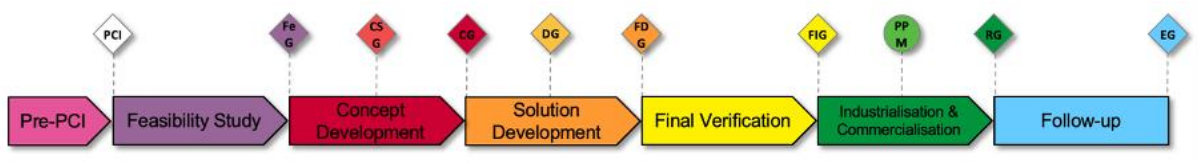


Figure 4.5: Volvo Penta's project framework.

The first phase, called Pre-PCI (Product Change Initiation) in Figure 4.5, involves questions and decision-making documents being arranged by the person ordering the project. In the second phase, the Feasibility Study, the scope, and goals of the project are defined. During this phase, a target description is also formulated where the terms and requirements for the project and the product are clearly described. After that the business opportunities are evaluated and whether the capacity exists within the company to develop, produce, market, sell and support the product. Concept development is the third phase and in it the wishes and requirements from both customers and other stakeholders are analyzed. Based on the results of that analysis, a knowledge analysis is also performed where different concept possibilities are reviewed. In the fourth phase, Solution Development, the possibilities are carefully examined and then the best combination of sub-solutions for final development is chosen. It is also examined here whether the final concept can meet the needs of both customers and stakeholders. When the final concept is developed, the fifth phase, Final Verification, begins. In this phase, the solution is examined if it will really meet all needs. In addition to that, it is also verified that the manufacturing, logistics, service, and repair around the product work as intended. After the fifth phase, the product is finished and verified. The product is then launched, and the aftermarket solutions are implemented throughout the business. This phase is called Industrialization and Commercialization and it is at the following gate the product is released to customers. When this phase is over, only the seventh and final phase remains. It is called Follow-up and it means that the product is handed over to the existing line organization for further maintenance and then at the last gate, End-Gate, the project is closed.

There are also guidelines as to who is responsible for which delivery in each gate. When it comes to 3D models there is an interesting gate that is related to the scope of the degree project. The master model and all its parts must be ready and inspected at the gate FDG, see figure 4.2 for more information about actors involved in that delivery.

Table 4.2: Information about actors involved in the 3D models delivery in the FDG gate.

Document	Creator	Requester	Content provider	Publisher	Sing off	Deadline
3D Models	Product development	Sales Engineering	Product development	Sales information	Product development Sales Engineering	FDG

This project model is very elaborate and specifically developed to run projects at Volvo Penta. With that said, there is also development potential. Volvo Penta must become better at researching and adapting to new customer requirements. Another thing is that the different sub-goals in each gate must be defined more clearly. Today, questions may arise about the level or standard of a solution and whether it is high enough.

Interview 5

Name: Fredrik Jägersvärd
Title: Medium Duty Engine Platform Manager and Project Leader
Institution: Volvo Penta, Gothenburg

During my 15 years at Volvo Penta, I have held several different positions, but in one way or another I have always worked on leading projects and usually development projects where we develop new engines. As both the product and the project cycles go faster and faster, our projects and our customers' projects must bridge each other. This means that Volvo Penta and our customers develop new products in parallel and not one after the other. This means that there must be an exchange of information regarding the products so that it is possible to run the projects in parallel. In the case of Volvo Penta, this means that 3D models of engines in the development stage must be handed over so that the customer can develop, for example, a boat or a container lift.

About 10 years ago, this type of handover of information, i.e., 3D models, was just a wish of the customers. But that has changed because time to market is very important nowadays. This has meant that this transfer of information is no longer a wish but a demand from customers, otherwise it will not be a deal.

What is tricky about handing over 3D models is that the models must be downgraded to something called Envelope models internally at Volvo Penta. This downgrade to Envelope models is done so that secret information is not leaked and so that it will not be possible to pirate-copy the engines. What a downgrade from a master model in CAD to an Envelope model means in practice is that everything that cannot be seen with the eyes on the outside of the model has been transformed into a solid model, i.e., the engine is not hollow in an envelope model but completely filled. In this way, it can be established with certainty that secret information about the engine's functions and constructions will not be leaked. This downgrade to Envelope models is today done manually and usually only at the request of customers. Since it is currently done by a person manually, this downgrade involves great risk as that person himself decides what the limit is, what you see with your eyes and what is ok to share with the customer and not. Another risk with this is that the design of the engine can be changed along the course of the project, i.e. there is a risk that the customer will receive an Envelope model that is not fully relevant if the downgrade from the master CAD file is done too soon. But the most important thing from a risk perspective is that if Volvo Penta hands over 3D models, the biggest risk is that secret information may be leaked, and the biggest risk if 3D models are not handed over to the customer is that the relationship with the customer can be damaged and that business can be lost.

The progress in this matter has been such that customers want this type of information as early as possible while the representative from Volvo Penta waits until the PPM gate that is in the middle of phase six, Industrialisation and Commercialisation, see Figure 4.5.

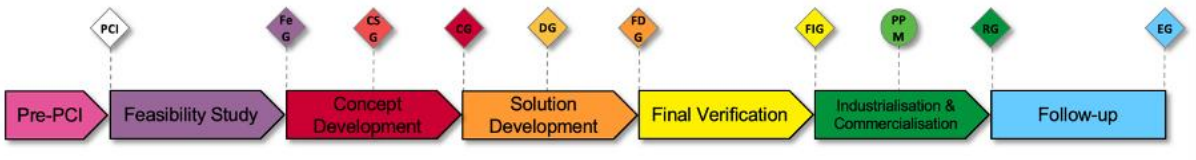


Figure 4.5: Volvo Penta's project framework.

The reason why representatives from Volvo Penta are waiting is simply because this is how it has always worked, and it has now developed into a problem because the company no longer meets customer requirements in time. As there is no clear routine for handing out Envelope models to customers today, it is difficult to determine whether the current way of working is the best. It is our CAD department in India that performs the downgrade to Envelope models, and it is usually at the request of our various sales organizations. It could be possible to make this downgrade earlier as there are mainly changes to the construction inside the engine and not to the design and exterior dimensions in the final three phases. Most often, the exterior of the engine is already constructed at the fourth stage, Solution Development, the gate FDG.

Interview 6

Name: Freddy Fuxin
Title: Data Scientist, Vehicle and Business
Institution: Volvo Trucks, Gothenburg

Has worked for the Volvo Group for over 20 years and for the majority of the time the employer has been Volvo Trucks, which is also today's employer. The tasks have mainly been method development, process development and different types of integration of information between different systems. In addition, research at the doctoral level has also been conducted in the latter area, integration of information between different systems. Since work has been done for both Volvo Penta and Volvo Trucks, there is knowledge and insights about similarities but also differences.

When it comes to producing downgraded Envelope models that can be shown to external people, such as customers and brokers, there is a difference between Volvo Penta and Volvo Trucks. At Volvo Penta, it is possible to produce geometry models with an ACP application via the Prosales system. But that process is based on the entire product being fully developed and stored on Volvo's own product data management (PDM) system Konstruktion Lastvagnar (KOLA). So, when it comes to Volvo Penta, the master version is not stored at KOLA to begin with, it is stored in the CAD program Creo. After about half the project time, a transformation is made to KOLA, and this is one of the reasons why it is not possible to use the ACP application to get downgraded Envelope models earlier in the project.

That is not the case with Volvo Trucks. Here, KOLA is used as the real PDM system directly from the beginning in the projects and the reason for this structural difference is about both culture and needs. First and foremost, KOLA was developed specifically for Volvo Trucks, it

is also because Volvo Trucks is so much larger and thus a more comprehensive system is needed to store data. In addition, two different CAD programs, Creo and CATIA, are also used in Volvo Trucks, which means that it would be impossible to use one of them as a common PDM system.

Changing the structure of how to store data on Volvo Penta could solve this problem in the long run, but it would mean that the projects would be more extensive and require more staff and money. Another idea that could solve this in the long run is that additional functions in CAD programs Creo are developed by the software company PTC. In the short term, a development and tightening of the existing project model can be a good alternative, especially considering that the models that would solve the customer requirements that your issue is about involve quite a high risk.

Interview 7

Name: Tommy Olsen
Title: Product Developer
Institution: Volvo Penta, Gothenburg

Tommy works as a product developer at Penta and he is one of they started this initiative about wanting to simplify and make a structure for giving out models to customers. Volvo Penta has a program called Automatic cad packaging (ACP). Tommy mentioned how the use of ACP had increased sales for Volvo Penta as there was an easier way for the sales engineers to take out finished models that have also been modified so they can show customers, Figure 4.6, Sales increased by 1111.91% since its launch. The goal with this current system is to make it in the same way as the ACP, automated completely so that the developers only need to push a button and the models will already have been modified and then the sales team could easily take them out and show customers. There is always a risk when we are handing over the 3D-models to the customers, the biggest risk is that sensitive information could be leaked but it is also bad for business if customers do not receive the models, as it ruins customer relations and could cost us sales.

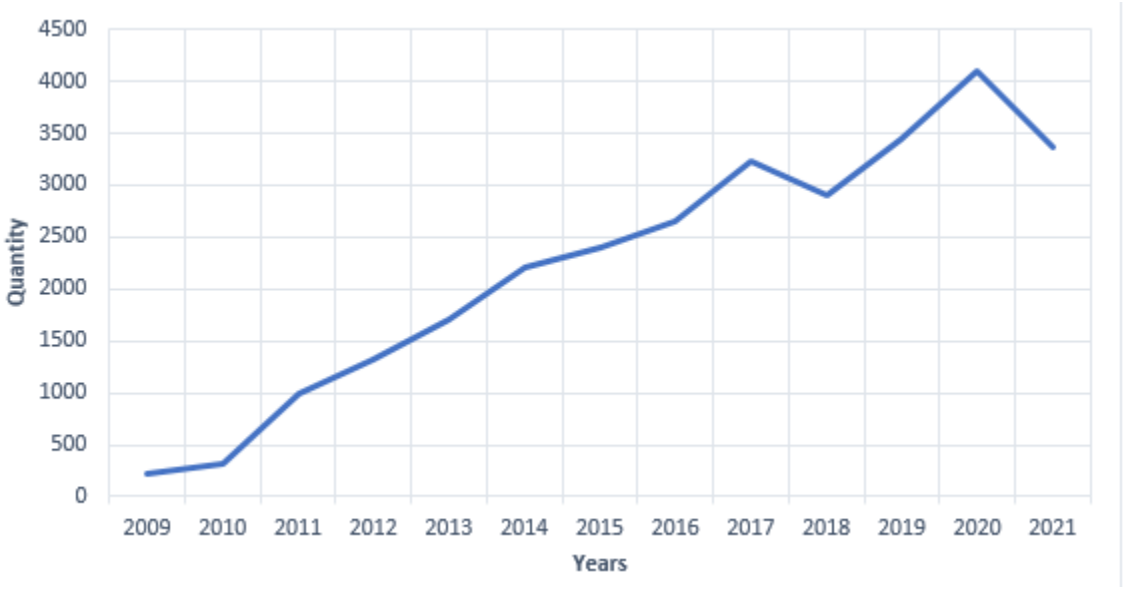


Figure 4.6: Sales after the launch of the ACP application

Customers asked for the models as early as possible but they're OK with getting it halfway through the development process as they see the models potentially changing if they ask for the models before that time. Currently, there is a way to simplify models within Creo, it makes surface models when simplifying but it is not a widely used method for some reason. The outer surface of the model is more important than the inside for the customers simply because the outer surface is what the customers are working with, they want to see if our components fit in their components and how well it does. When we send the files to our customers, they get a link to the ACP where they can take out the models either in low or high res and we send them in step files. Tommy says that I would like the process to be fully automated so that the designers only had to press a button to simplify the models and the customers could easily access them. Nobody is supposed to assemble these packages for customers it's supposed to be automatic in the ACP but on occasions, we do have to put together a package. Sometimes customers have to reach us again because they've gotten the wrong “package” and need somebody to send them the correct one. The most important thing about these models is for customers to receive what they want and that means that they can see the attachment points, the size, the materials, and where everything is located.

Interview 8

Name: Martin Olofsson
Title: Product Developer
Institution: Volvo Penta, Gothenburg

Martin Olofsson works as a product developer at Penta and he is one of they started this initiative about wanting to simplify and make a structure for giving out models to customers. Volvo Penta has a program called ACP Which stands for Automatic Cad Packaging. The goal with this current system is to make it in the same way as the ACP, automated completely so that the developers only need to push a button and the models will already have been

modified and then the sales team could easily take them out and show customers when they need it.
Customers asked for the models as early as possible but they're OK with getting them halfway through the development process as they see the models potentially changing if they ask for the models before that time. There is always a concern when we are handing over 3D-models, the concern is that secret information could get out to the wrong hands but on the other hand, if we do not give out the models then we could lose customers and business.

Currently, there is a way to simplify models within Creo, it makes surface models when simplifying but it is not a widely used method for some reason. The outer surface of the model is more important than the inside for the customers simply because the outer surface is what the customers are working with, they want to see if our components fit in their components and how well it does.

When we send the files to our customers, they get a link to ACP where they can take out the models either in low or high res and we send them in step files. The customers receive the models in a big clump meaning that it is hard for them to pick out exactly what they want or need from the models. Martin says that I would like the process to be fully automated so that the designers only had to press a button to simplify the models and the customers could easily access them. He also mentions that it would be great if the models could be smaller (in data size) because that would be better for a lot of customers. Nobody is supposed to assemble these packages for customers that are supposed to be automatic in the ACP but on occasions, we do have to put together a package. If somebody took charge and taught everybody that needed these models then it would take a couple of months to teach everybody. Sometimes customers have to reach us again because they've gotten the wrong "package" and need somebody to send them the correct one. The most important thing about these models is for customers to receive what they want and that means that they can see the attachment points, the size, the materials, and where everything is located.

Interview 9

Name: Conny Nilsson
Title: Sales Manager
Institution: – Imatech, Gothenburg

Conny Nilsson works for Imatech, which is a retailer for Penta and also other companies. So even though he works outside Penta technically he has a lot of communication with their customers and therefore has a lot of communication with Penta. He discussed how it could be difficult to receive models especially because he's not working at Penta. He says that it could take up to one week to receive models in some cases it could even be months before he receives a model, Conny mentioned that it's been part of projects where customers needed information from Penta while they were still in the development phase and this has been instrumental for customers to receive information in time.

He has said that customers sometimes need the high res and low reads depending on the situation and customers, he does point out that customers from the marine side tend to only need low-res and the reasoning for this tends to be that the low res envelopes or easier for the computers to generate the models. I usually receive information about new models from Max Gunnehage (SEI), he is also the person from whom I receive the models.
There have been instances where a deal has been lost because the customers didn't receive the models in time and potentially Penta could close deals if they had models out quicker. Customer relations are dependent upon these models. Customers also like to know different kinds of metrics such as the weight and materials of the components, this helps with the placement of the part. The most important parts of a model are the attachment points, The service part such as where to put in more oil, gasoline and parts that frequently need to be changed.

Connie either gets his models from Volvo Pentas program called pro-sales or by contacting a sales engineer at Penta. Customers usually want the models in step-files as it works with their programs. There are some measures to be able to take out the models during the development phases, it would be preferable if Conny could take out specific parts instead of having to download the whole model which takes time and computer power. Sadly only people with access to KOLA can take out the models if they're not in pro-sale. The exact measurements are much more important on the industry side compared to the marine side; it is also echoed by Conny as the industry side works with much smaller tolerances. It takes approximately one week for the models to get from customers asking for the models to Penta sending them to the customers. In worst-case scenarios with customers, it has happened that it's taken as long as two months for them to receive models.

Interview 10

Name: Nick Andersson
Title: Sales & Application Engineer
Institution: Volvo Trucks, Gothenburg

The position at Volvo Penta is called Sales and Application Engineer and it includes tasks such as supplying internal and external sales organizations with all technical details on both products and services to the marine customer segment. In this position, a sharp increase has been noted in recent years regarding customers requesting 3D models. Inquiries regarding these models come at different times depending on the customer, but it is estimated that it is a must from the customers that 3D-models are handed over after about a year after the project started at Volvo Penta. The timing itself is quite good because it is also when it is possible to meet that requirement, ie about a year into the development projects. . The reason for this is that the customers must have the information that the 3D models contain to be able to further design of their own products. The information in the 3D models that customers from the marine segment are primarily interested in is the dimensions on the outside of the engine, the attachment points, the connection points, where on the engine the parts that need service are

located and the center of gravity. It is also good if it is possible to read or see from the model where and how the heat is to be diverted.

When a request is received regarding 3D models of products that are still in the development phase, the question must be forwarded to a colleague who also works as a Sales Engineer for the marine customer segment or to our Geo Architect. After that, the process may look a little different depending on the case, but it is our office in India that does the actual downgrades to Envelope models.

This work is quite complicated among our colleagues as Volvo Penta's Sales Engineer does not work in the CAD program Creo. It is thus expected in this position that this request will be received and understood and then forwarded without proper knowledge of the craft. This means that this process contains several direct and indirect risks. The most common direct risks are that the request is misinterpreted and that the 3D models do not contain the information that customers request or that the entire development of the downgraded Envelope models takes too long. Usually it may take a working week to develop models that the customer asks for, but it has sometimes taken much longer than that. This means that customers cannot continue working on their projects and it creates a great deal of irritation. In the long run, relationships can deteriorate and possibly Volvo Penta can lose business and important customers. The biggest indirect risk with this is that the downgrade to envelope models is performed manually and it is the person who does the actual work who assesses what the customer gets access to and not. It has happened that classified information about the contents of the engine has been leaked, which is extremely serious. This risk will increase eventually as this request from the customer becomes more and more common and that Volvo Penta is growing. This means that new staff without experience or a network whining Volvo Penta are expected to decide what the customer gets access to in the Envelope models and not. To minimize these risks, a well-thought-out routine must be added so that Volvo Penta can meet customer requirements with certainty in a safe and efficient manner.

Interview 11

Name: Magnus Lycklund
Title: Systems Engineer Specialist
Institution: Saab, Gothenburg

The position of system engineer specialist is currently held and an important part of that role is to follow a routine where installation documents are to be created for the customer. These documents must be created at least four times during the development period of our products, which in this case are a radar system. This is to make it as easy as possible for our customers to adapt their projects and build their ships according to our radar systems. The reason why it is just four times during our development phase is quite simple, our customers demand it, and this routine is now fully integrated into the existing project structure. As a world-leading player, customer needs must be met, and it is a constant process where Saab evaluate

customer requirements and anticipate which wishes will be transferred to strict requirements in the near future. In this way, you always stay current and relevant to the customer.

The installation document is a collective name and contains several different documents such as interface drawings, drawings for electricity, requirements for capacity for power supply, 2D drawings and 3D models. When 3D models are designed and constructed, Saab does so via the CAD program Creo by the software company PTC. As a leading player in the market, the documents must be created with a very high degree of accuracy to internal rules so that no secret information is leaked. This is especially true when the 3D models are "washed" from secret details. This washing (downgrading is called on Volvo Penta) is done by converting the models to surface models through the "shrinkwrap" tool in Creo. Saab has chosen to convert master 3D models into surface models because then it can be guaranteed that no secret information will ever be leaked, i.e. the routine is completely safe.

However, this approach places demands on customers' computers and CAD programs as it is more demanding to run surface models than solid models. Since the orders that customers buy are extremely valuable, the assessment was made that customers could meet a higher technical performance requirement and therefore this routine with surface models was chosen as it is in this case safe and efficient.

About five years ago, an effort was made regarding the installation documents at Saab and this routine was the result. It has been very profitable on several different levels, mainly considering that the customer requirements in this respect are met every time but also because the relationships with the customers have become much better. The indirect value of better customer relationships is difficult to evaluate, but it is clearly the best that has come out of this routine. What could be developed are of course the internal processes so that the production of the installation documents would be less time consuming but also if it could be possible to develop a function in Creo like shrinkwrap but the function converts master models into solid models.

Interview 12

Name: Per Lonnehede
Title: Systems Engineer Specialist
Institution: Saab, Gothenburg

Is Fellow and Technical Specialist the American software company PTC. Works mainly with new technology such as our IoT platform Thinkworx and how it can be integrated in all parts of society but also with technology that PTC has worked with for some time as with the CAD program Creo. Our program Creo and its first version were released just over 10 years ago and during that period there have been eight upgrades. Creo is today a world leader in the CAD segment and a giant in the market regardless of which industry our customers operate in, which of course is great.

In Creo there are different approaches to keeping well-selected parts of a model secret. But the most effective way, which is also recommended, is to use the shrinkwrap function. That function in Creo converts a model to only a surface model, i.e. all details disappear on the inside, which makes this function very good in these cases because it always removes the information that is secret to the external party.

If the external party does not have the capacity to handle surface models as they are "heavier", it should be possible to automate a "filling" function that converts a master model into a solid model. Since this request regarding a "filling" function is very unusual, it is not possible to guarantee that this process will work painlessly as it is relatively untested. What is needed to be able to perform a "filling" work automatically with Creo is that Windchill is used as a PDM system. Then the command "simplified response on demand" must be set and then it should be possible to decide that everything inside the outer surface of the model is filled.

Developing a program or specific function in one of the existing programs can be done. First, however, a proper investigation must be made as to whether the need and knowledge exist and if the function the customer wants to be developed will be relevant in the future. If these three criteria are met, it is only a cost issue that the customer must decide on. If this specific master's thesis is discussed and if your background to the thesis is correct, this is probably not impossible to carry out on the part of PTC. The knowledge to develop a function that converts master models into surface models exists and the Volvo Group is one of PTC's key customers, so PTC is always curious to hear what Volvo Penta says, but this dialogue must of course go through our existing channels.

Interview 13

Name: Mats Törefeldt
Title: Designer och Salesman
Institution: Nimbus, Gothenburg

Mats is a designer and salesman for the company Nimbus, Numbers is a customer of Volvo Penta on the marine side so they are ordering the marine parts for their boats. Mats has worked for four different boot manufacturers due to the fact that he is a consultant and because of that, he has a lot of information and experience. He was asked what kind of models he would prefer high-res envelopes or low-res envelopes and he said that he does prefer low res envelopes. This is because most companies that he has worked for do not have the computing power to process the high-res envelopes or it would take much longer, he has also stated that there is nothing really important to take out from a high-resolution envelope for them because they only need to know the approximate size of what they're putting into their boats and of course, the most standard attachment points where their different parts are and everything else that has to be fixed, changed or replaced, he even stated that he would

like to have even lower risk envelopes than the ones were shown to him. Mats said that it doesn't take long for him to receive a model from his people at Volvo Penta but sometimes it has taken a bit longer than expected especially from other suppliers, where it's taken up to over two months to receive a model and by that time the sale has fallen apart and the customer relations have been damaged. It has happened on different occasions that a deal has been broken or lost because a model had not arrived in time, which meant that they had to move on with another competitor because a model did not arrive in time.

Numbers usually ask for models a year before the launch of the components from Volvo Penta this is because they want to develop their own boats with the newest hardware so approximately half the time of the development for Volvo Penta. Also why it's halfway through the development phase because anything earlier would be uncertain for Nimbus, even if there was a disclaimer saying that the early models were not certain and could be changed it would not be so beneficial for Nimbus. Mats got his information from Jimmy Kling (SEM) about new projects that are in the works, he also mentioned that Jimmy is also the one that sends him the models.

Nimbus preferably liked their format to be in step files, this is because it works with their CAD program. It is also preferable to receive the models as solid models than surface models because it takes less computing power to show and use solid models. Mostly when nimbus asked for models they have been what they were asked for but sometimes it has happened that the information has been lost or they got the wrong component.

It has happened that nimbus has received a master file that has not been simplified which consists of all the needed information to duplicate the components from Penta, but because nimbus has such a good reputation and relations with Penta they immediately contacted them and reported the error but this does mean that sometimes it is possible for a complete file to be sent to customers by accident. Mats said that he has never used a hi-res envelope, but he knows that once in a while somebody in the company has needed one. Nimbus receives information from Volvo Penta occasionally about new projects and sometimes they'll be invited to test out and see the new concepts at Penta but Penta's competitors have in the past not informed members of their new project which has led to nimbus dropping them as partners. Matt feels that they are receiving information in time but would like to receive information even earlier or as soon as possible.

Interview 14

Name: Erik Möller
Title: Design Engineer
Institution: Disab, Gothenburg

Erik Möller is a design engineer at Disab he works towards the industry side as he works for a company that makes giant industrial-sized vacuums for sucking up debris in construction. When asked if he prefers low res or high res envelopes he said that he prefers hi res

envelopes and the reasoning for that is because they are working with much smaller tolerances and the high res envelopes show a more precise model of the part. Low-resolution envelopes can sometimes be beneficial when you need some quick data because they don't need as much computing power but preferably the most used is the hi-resolution envelopes. Disab needs the models as soon as possible because not only are they working on new models because Penta is coming out with new motors but also because of the constant law changes that are being made. We receive all our information more or less from Conny Nilsson and he is also the one that is providing us with the models.

If it was possible to receive the models even earlier than the midpoint of the project for Volvo Penta it would be beneficial for us to know approximately the size, and length of the component even if it might change a bit. It is preferable to receive the models as step files because it is the simplest and will always work with the program or at least most of the time. It could take somewhere between one week to a couple of months for Disab to receive their models because their contact with Volvo Penta is quite long in a chain because they have to contact the retailer that has contacted a sales engineer Volvo Penta that later has to contact somebody from documentation and if no somebody is really busy in that chain then the whole process gets longer. Eric says that they receive information on a regular basis about upcoming models. Solid models are better than surface models because they are easier for the computer to generate. They say that they have never received a model that has too much information so to say, they have always been simplified. As far as he knows there has never been a deal that has been lost because the models arrived too late or the models were not up to par. Sometimes it can even be helpful to have low res models because it could be an easy way to quickly see an approximate measurement, it is also helpful to have 2D models because you can quickly get out some quick measurements. Erik says that he wishes that it would be possible to take specific components out of the models so that you wouldn't have to generate the whole motor to take out just maybe the gas line. Volvo Penta sent somebody over to do tests to make sure that the motors have been installed properly and that everything works.

Interview 15

Name: Johannes Karlsson
Title: Regional Application Engineer
Institution: Volvo Penta, Gothenburg

Johannes Karlsson is a regional application engineer at Volvo Penta, he works with the customers closely and a big tool for him are these models. He says that different customers and different situations need different types of resolution on the envelopes, lower resolution envelopes are much faster to use because they don't need that much computing power which means they operate much faster and are quicker to use and can get quick information out of them, on the other hand, high-res envelopes are more detailed and tell you more where everything is and so on. Customers ask for these models as soon as they find out that a new one is about to hit the market some customers will ask if a project is underway depending on

if they must update or change something because of laws. The models can be sent out to customers and the start of order, if we want to send a model earlier to the customers then we must hope that the sales engineers have sent a request to the development team for these models. What is most important to protect on the model can sometimes change depending on what customers we are working with but mostly it's the inside of the components that are the most important for Volvo Penta.
Usually, I just have a contact person at Volvo that sends the models to me, and that is done through a link where I can download the models. There is a risk of secrets leaking out when we hand out the models, there is also a big risk if we do not send out models because we could lose customers and business.
It takes about one week from the time that their customers request a model until they have received it. There have been plenty of times where information has been lost because our customer has said that they want one particular thing and when the model has reached them, it has not been what they wanted because the chain can be so long and involves so many different people. The benefits of sending out these models early to customers is almost crucial, it makes it easier for the customers to get their products out on the market quicker and it makes the relationship between us and the customers much stronger and better. It's a little bit mixed when the customers received information about new models, there's not really a way or structure right now for customers to receive the information about new models. Customers usually want their files in step files.

I do not work in Creo, do you know how to navigate it lightly but not construct or use it anything more than that advanced. Models tend to be a little more crucial on the industry side, the industry side is the one side that usually asks for the high-resolution envelopes more often. The most important thing to know about models is attachment points and the size, where the service parts are.

Interview 16

Name: Peter Engqvist
Title: Mechanical Engineer
Institution: Konecranes, Gothenburg

Peter Engqvist is a Mechanical engineer at Konecranes he works towards the industry side as he works for a company that makes cranes for the industry. When asked if he prefers low res or high res envelopes he said that he prefers hi res envelopes and the reasoning for that is because they are working with much smaller tolerances and the high res envelopes show a more precise model of the part. Low-resolution envelopes can sometimes be beneficial when you need some quick data because they don't need as much computing power but preferably the most used is the hi-resolution envelopes. Konecranes would like the envelope models as soon as possible but at least 10 months before Volvo Penta's engine goes into production is a must. The following things must be readable in the model: the outer dimensions, attachment points, parts that need to be serviced, wiring diagram, the center of gravity, and preferably where the engine would overheat if possible. We receive all our information about upcoming

projects from Penta from Conny Nilsson at Imatech, we also receive the models from him when he gets the models.

The models need to be in the file format step because it is the simplest and will always work in the CAD program used in the office. It could take somewhere between one week to a couple of months for Konecranes to receive their models because their contact with Volvo Penta is quite long in a chain because they have to contact the retailer that has contact a sales engineer Volvo Penta that later has to contact somebody from documentation and if no somebody is really busy in that chain then the whole process gets longer. Peter says that they receive information on a regular basis about upcoming models. Solid models are better than surface models because they are easier for the computer to generate. They say that they have never received a model that has too much information so to say, they have always been simplified. As far as he knows there has never been a deal that has been lost because the models arrived too late or the models were not up to par. Sometimes it can even be helpful to have low res models because it could be an easy way to quickly see an approximate measurement, it is also helpful to have 2D models because you can quickly get out some quick measurements. Peter says that he wishes that it would be possible to take specific components out of the models so that you wouldn't have to generate the whole motor to take out a specific part.

Interview 17

Name: Peter Helgeson
Title: Mechanical Engineer
Institution: Konecranes, Gothenburg

Is a mechanical engineer at the company Konecranes, which means that the design and construction of new products or new versions of products are performed very often. As it is important for our customers that Konecranes' new lifts contain Volvo Penta's new engines, it is extremely important that Volvo Penta provides good information about them, even though the engines are not fully developed. Thus, it is necessary that the development projects overlap with each other, otherwise in the long run it will not be possible to do business between us. To be able to develop products at Konecranes the high-resolution version is needed because information about all the engine's external details is needed. This means dimensions of the engine's outer dimensions, attachment points, how the engine is connected to other external components, the center of gravity, and where the components that need recurring service are located.

The dialogue about handing over information is always done through Volvo Penta's sales engineers, as they work with all technical aspects of the product in a potential deal. It is also that department that sends the information, the 3D models, when it is ready. Regarding the format, it is important that it is in "step" and that the model is a solid model because solid models are much easier to handle in the CAD program Solidworks, which is used at

Konecranes. In addition to high-resolution 3D models, it would also be good if Volvo Penta sent with 2D drawings as it is easier to read the outer dimensions and the radius of them. It would be good if the information could be handed over as early as possible, but no later than 10 months before the engine goes into production, the models must be handed over. If the models could be handed over earlier, there would be an understanding if they were not completely finished, i.e. there could be a disclaimer on the design. It would also be good if a fixed routine with a clear channel was established so that the customer side knew that Volvo Penta handles all matters like this in the same way every time, because now it can sometimes be experienced as disorganized.

Interview 18

Name: Christoffer Jivenius
Title: Mechanical Engineer
Institution: Konecranes, Gothenburg

The task performed at the company Konecranes is mainly the design and construction of new versions of existing products and the development of completely new products. During the development of new products, brand new or just new versions, information is needed about what Volvo Penta's engine looks like as it is important that the products developed here contain Volvo Penta's new products. This is a requirement from our customers, so it is very important that Volvo Penta provides that information.

The submitted material from Volvo Penta must contain information regarding the engine's dimensions, attachment points, center of gravity and how the engine should be serviced and where on the engine these parts are mounted. Of the high-resolution and the low-resolution, the high-resolution would be preferred as it is more detailed and therefore easier to see all the small parts that the engine consists of. At Konecranes, the design and construction are performed in the CAD program Solidworks and then it is easier if the 3D models are handed over in the file format "step" and that the models are solid. If the models were surface models, they would not be usable as the models would be far too "heavy" and difficult to handle. When this type of handover is to take place, it is handled via contact with Volvo Penta's Sales Engineer department or with their Regional Application Engineer. It is also through these two actors that information regarding new products is delivered. From experience, it is usually when Volvo Penta's new engine has six months left to production that the information and later the 3D models can be handed over to Konecranes. But if it were possible that the handover took place earlier during their project, it would be very good, preferably a year before production so that there is plenty of time to design the products from our side. If it would mean that the models would not be finished, it would still have been good, but then it may be accompanied by a description or disclaimer that points out which parts of the engine may change.

In addition to the models being delivered earlier, it would also be good if other documents regarding the engine could be delivered at the same time. Mainly installation documents and 2D drawings so that the engine can analyze from more than one source. In addition, it would also be good if Volvo Penta acted the same way every time when it comes to these matters, because now it feels as if they act differently depending on who you talk to in Volvo Penta's organization and because of that it sometimes can take several weeks to get the models.

Interview 19

Name: Martin Holmberg
Title: Design Engineer
Institution: Rottne, Gothenburg

Has the role of Design Engineer at the company Rottne, which manufactures different types of forest machines. The development projects of the machines are done in parallel with Volvo Penta's development projects of their engines because it is important that the new forest machines are powered by Volvo Penta's new engines. For it to be possible to run the project in parallel with Volvo Penta’s, a handover of 3D models of the engine they are developing must be done. It is important that the 3D models are solid models and as detailed as possible because it is then easier to design the forest machines. Therefore, the high-resolution version is better because then it is easier to see the key aspects. The key aspects are attachment points, wiring diagram, center of gravity and the outer dimensions.

From Rottne's perspective, it is good if the 3D models are handed over as quickly as possible, but preferably 10-11 months before Volvo Penta's engine goes into production. But it is only when the engine is completely ready that the 3D models are needed, i.e. it is not good if the 3D models change because then it will only be extra work. In addition to 3D models, it would also be good if an installation document and a 2D drawings of the engine's exterior parts could be included in the submission of documents.

Both information regarding Volvo Penta's new engines and the discussion about the handover of the 3D models are done via their Regional Application Engineer or with the Sales Engineer department. The people who handle these tasks are great, but it would be good if they had a fixed routine regarding this process so it could be performed more efficiently. It has happened that several inquiries have had to be sent because our wishes have been misinterpreted or that the models have been incorrect. Once it took over a month to get the models that were requested.

Interview 20

Name: Lars Josephsson
Title: Mechanical Engineer
Institution: Disab, Gothenburg

Disab is a company that manufactures various tools and vehicles that can perform work where special vacuum technology is required. In the role of mechanical engineer, these types of vehicles are designed and constructed. In order for the work to be carried out, Volvo Penta must supply 3D models of the engine that will supply the vacuum technology with energy. Since time to market is important, our development projects are carried out in parallel with Volvo Penta's development projects, so that the new vehicles will contain new engines. The high-resolution version is better as it contains more details, but it must be a solid model as solid models are easier to handle in the CAD program used in the office compared to surface models. When the vehicles are to be designed, details such as center of gravity, dimensions on the outside and attachment points must be readable in the 3D model.

To get these models, Volvo Penta's Sales Engineer department must be contacted, and it can, in the worst case, take up to two to three weeks to get the models that are in demand. But when Volvo Penta hands over the models, there is never anything wrong with them. If it was possible to develop a process or that it was possible to contact a specific person for these tasks, it would be very good as these issues are sometimes handled differently depending on which person handles the specific case.

4.3 Mapping of the current process

One of the research questions for this project is “what does the process look like today”, the answer to that question will be the foundation for the other research questions.

The first thing that happens is that Volvo Penta decides that a new product needs to be created and the reasoning for this can be because there are emerging technologies that need to be implemented, efforts have been made within innovation at Penta and need to be implemented. Or can be external reasons as there have been regulations which means that existing models must be updated or customers have given feedback about a product that needs to be applied, this is based on the information from interviews 4&5. When it is decided that a project should be started then the next step is to forward the information to the design team that starts the process of creating the models, from interview 2 it was said that the information is also forwarded to the sales engineers with the purpose to potentially forward this information to customers. If the customers receive the information that there is a new model in development then they usually want to receive models as early as possible, sometimes it is as early as the beginning of the development phase as discussed in interview 7. In interview 3 it is mentioned that there is not really a current structure for notifying customers about upcoming projects. In interviews 1, 2, 4, 7 & 8 it is mentioned that the most desirable time to be able to deliver models to customers is around halfway point of the project. This is because the models are generally completed at the midway point of the project, this gate is called FDG. At the FDG gate, the geo architect receives the models and examines them, after that, they outsource the models to their offices in Bangalore, where they create the hi-res and low-res envelopes. They turn the models into solid models instead of

surface models and the reasoning for this is that solid models use less computing power when they are being generated.

The envelopes are then sent back to the geo architect who examines the envelopes and proceeds to send them out to the sales engineers or whoever is in direct contact with customers and needs to send them the models. The models are then sent to the customers that sent a request to get the models before SoO. The envelopes are sent as a link where the customers can download the models, the file format that is used is step-files, which is also the format that is preferable for the customers as not all customers are using Creo which is the primary CAD tool that is used by Volvo Penta. Sales engineers send models to both customers directly but also to retailers as mentioned in interview 3. Customers then receive the models from retailers or sales engineers. If there are any issues with the models they have received then the customers have to send their grievances through the same channels as they got the models.

With the prior research about Penta as a company and the interview with the stakeholders, it was possible to create a mapping overview of the current process of delivering 3D-model to the customers. In Figure 4.7 the process mapping is presented. The mapping was shown as a rough sketch to the supervisors, it was discussed to verify the mapping in a midway presentation.

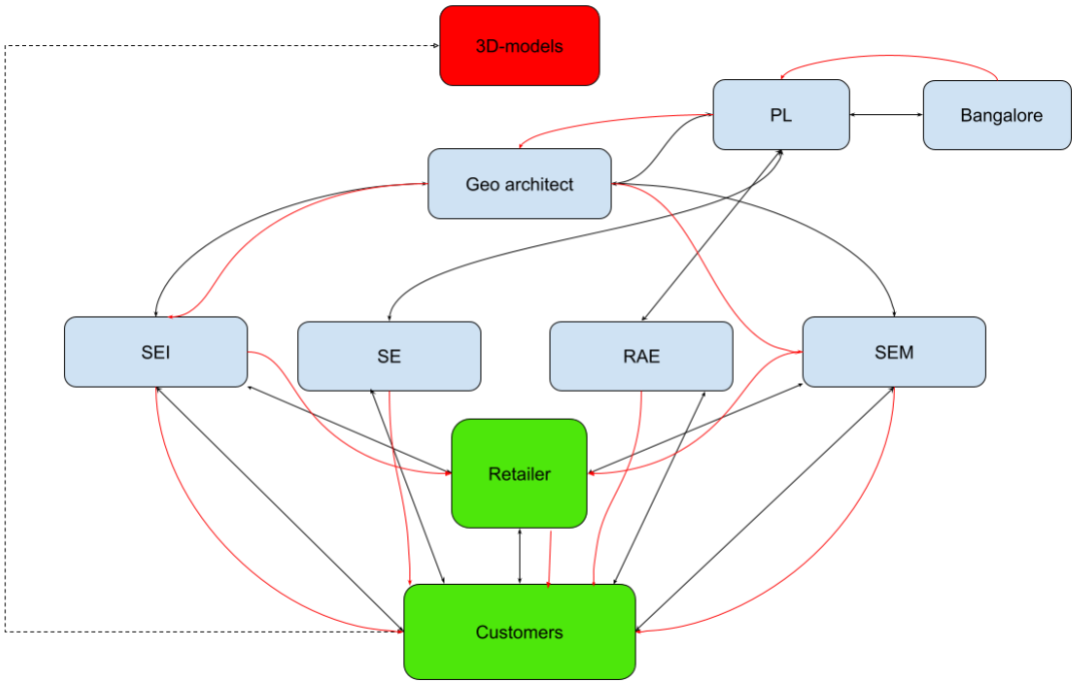


Figure 4.7: Mapping of the current process.

The green boxes were deemed to represent external stakeholders such as customers and retailers, and the blue boxes were deemed to represent the internal stakeholders such as geo architects, sales engineers, and the outsourcing department in Bangalore. Additionally, the solid arrows demonstrate direct communication, while the dashed lines represent what the

customers want. The red arrows represent the flow of the models. The when and where have been left out, so to make the map easier to understand and more straightforward.

4.4 Analysis of the interviews

The analyzes of the interviews were performed separately on the three different categories of interview objects as it is important to keep apart findings from the internal part of the process with findings from the external part of the process. It must be possible to follow the finding to the root if necessary when a requirements specification of the process is then to be constructed. The analysis of the interviews is also limited so that it contains only findings related to the current process and thoughts about a developed process. The analysis in this section consists of both visual models and through discussion of findings.

Finds from category one, employees at Volvo Penta.
This category contains nine employees who work in various positions at Volvo Penta. Although the interviewees work in different positions, they all have a relationship to the process that is mapped further down in this chapter.

All employees at Volvo Penta experienced that the frequency of inquiries regarding envelope models began to increase sharply when there is approximately one year left until the engine can be ordered. This is also in line with the answers regarding when a master model can be downgraded to an envelope model. It is first possible to produce an envelope model at the gate FDG, i.e., approximately in the middle of the project and one year left until it can be ordered. This could be guaranteed as after that gate, all solutions have been fully developed and if there were to be changes, it is only on the inside of the engine which does not matter to the customer in this case.

Regarding the inside of the model, all employees at Volvo Penta agreed that it is the information, the inside of the engine, that is secret and must not be shown to any external player. The rule of not showing the inside of the engine was described in all interviews as something important and that it is not possible under any circumstances to change it. The work of downgrading a master model of an engine to an envelope model in CAD takes between 10 minutes and a working day, the time depends on how advanced the master model is and who performs the downgrade in CAD.

The interviews show that this area contains several different risks for Volvo Penta. The following two risks are the two biggest risks in this area. If Volvo Penta hands over an envelope model, the biggest risk factor is that the model contains secret information that must not be leaked. But if Volvo Penta does not hand over an envelope model to customers when customers ask for it, their relationship may be damaged, and business may be lost in the long run. Everyone who has been interviewed during this project has described that Volvo Penta as a company must hand over envelope models, i.e., Volvo Penta is only exposed to the first of the two biggest risks.

Most of the employees at Volvo Penta also thought that it would be good if a new process was to be developed as this issue regarding envelope models is perceived as increasing. Another dimension of the risk aspect is also that Volvo Penta is growing, and that new people will be hired in the company. Some of the new employees will work daily with issues related to this process. It would then be good if there was a fixed new process so that there would be both well-documented how the work is carried out and who you can talk to, i.e. so that the risks are minimized.

Finds from category two, actors who have a relationship to either Volvo Penta or the scope of the thesis.

This category consists of external actors who either have a relationship with the company Volvo Penta or have knowledge of handing over sensitive information to customers. This section thus consists of findings from three in-depth interviews with people who work at Volvo Trucks, Saab, and PTC.

The company Saab has a similar problem with handing over sensitive information to its customers. Their solution is to use the existing Shrinkwrap function in the CAD program Creo which converts 3D models to surface models. Saab considers this solution to work very well as it is effective and completely safe every time. This type of handover is made four times during the development phase of their product and in addition, Saab also includes installation documents and 2D drawings to increase customer satisfaction.

The method of using the built-in function Shrinkwrap in Creo is also something that the developer of Creo recommends for this type of purpose. Shrinkwrap is efficient and completely safe since the human factor has been replaced by an automated function. However, there is no built-in function that converts master models to surface models. To make that conversion process automatic, Creo's own PDM system must be implemented. Then the "simplified response on demand" command could possibly be used, but it was not fully determined yet. Automating processes by linking the CAD program with the company's PDM system is something that Volvo Trucks has done. But that integration is extensive and requires the entire organization to change its way of documenting products and processes.

It can also be said that Creo's developer PTC has the knowledge and technology to develop a fixed function in the CAD program that can downgrade / convert master models to solid models. There have also been other situations where other customers of PTC have placed an order for a specific function in a program before. If PTC were to develop a function that could downgrade models for Volvo Penta, it would not take long or require new technology, but the only factor is the amount that Volvo Penta must pay for the work.

Finds from category three, customers of Volvo Penta.

This analysis is the result and the compilation of the eight different customer interviews. The fact that some of them work for the same company has not been considered in this analysis,

everyone's voice is valued equally. This section will start with questions related to the envelope models and then move on to process questions.

When Volvo Penta hands over an envelope model, it is important that that model contains information that customers can use for their own projects. The responses from the customers interviewed were quite similar, see Figure 4.8 for all responses. All eight answered that the center of gravity, the outer diameters of the engine, and the attachment points were information that they really needed to see in the model. Even engine parts that need to be serviced were a popular category with seven votes. This constitutes these four categories to the key categories in this case. A little less popular were both the heat map and the wiring diagram, which received two votes each.

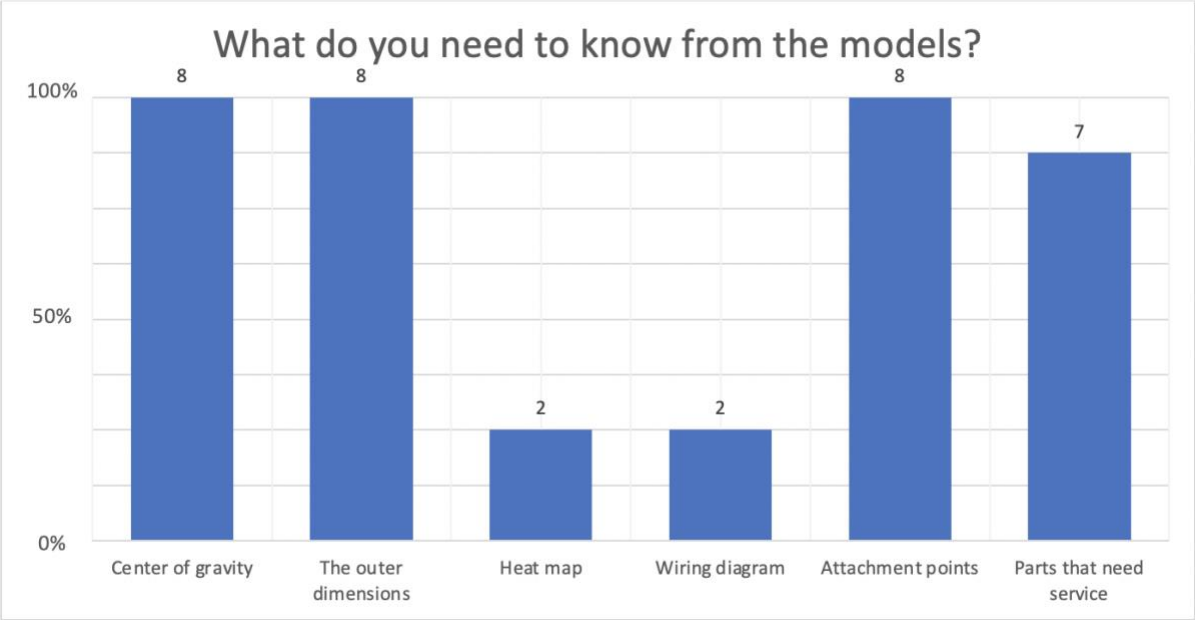


Figure 4.8: What do you need to know from the models?

Furthermore, it can also be determined that the high-resolution model was much more popular than the low-resolution one. Of the eight people interviewed, seven answered that the high-resolution would be more useful in their work, see Figure 4.9 for the result. What should be added here is that everyone who answered the high-resolution version works in the industrial sector. The only one who answered the low-resolution works at Nimbus, which manufactures boats and thus works in the marine sector. This means that there is a difference in what customers choose for models based on which sector they work in. This shift in customer requirements is very important for later parts of this degree project.

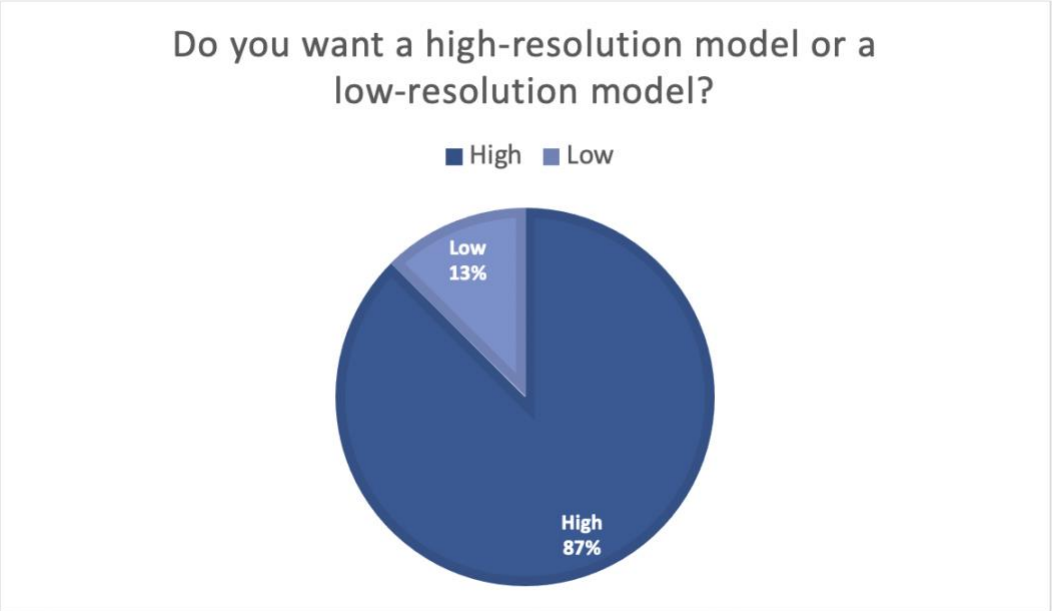


Figure 4.9: Do you want a high-resolution model or a low-resolution model?

Everyone agreed when customers had to choose between either a solid model or a surface model. The solid model received 100% of the votes with the argument that that file is much smaller and thus easier to manage and add to their own existing product. The reason why everyone chose the model that "weighed" less was that everyone worked in a slightly simpler CAD program, often Solidworks. This is also the reason why 100% answered "step" when selecting the file format of the envelope model. For customers to be able to use the models that Volvo Penta hands over to them, these two criteria must be met, otherwise there is no point because customers cannot handle "heavier" models or any other file format than step.

The answers became very varied when customers were asked how long it can take for Volvo Penta to hand over a model when customers had submitted a request for one. When the request was sent through a reseller, it could vary greatly in time. At worst, it could take up to a month. When the request was sent directly to someone in Volvo Penta's organization, it always went much faster, usually a couple of days. Another reflection made on the same theme is that the more steps that the inquiry took down in Volvo Penta's organization from the customer, the more common the misunderstandings became. This shows that it is possible to trim down both the misunderstandings and the waiting time for customers if a fixed process were to be developed.

Six out of eight customers answered that Volvo Penta must hand over the models at least 12 months before the engines go into "start of ordering", see Figure 4.10 for all results. The other two customers responded 10 months respectively 8 months before SoO. This means if Volvo Penta can hand over the models as early as 12 months before SoO Volvo Penta meets all customer requirements in this matter. It can also be added that all customers wanted the models as early as possible, but that the answers in this table are their absolute latest limit.

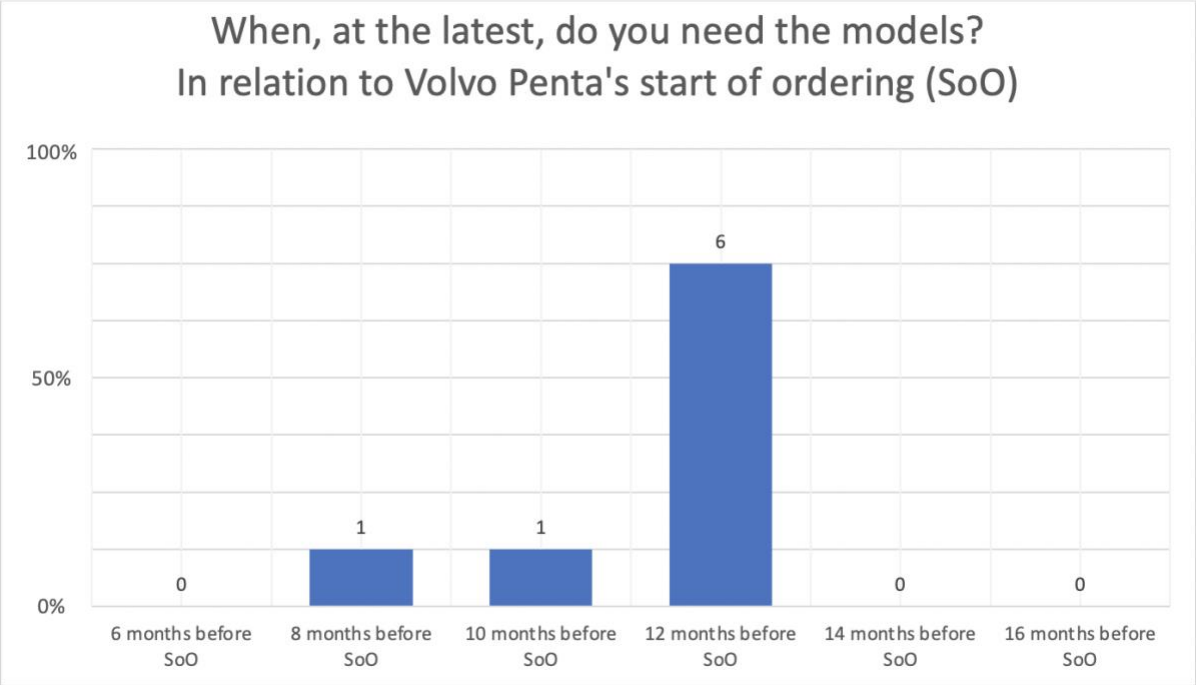


Figure 4.10: When, at the latest, do you need the models?

In addition to receiving envelope models, the majority of all customers also wanted 2D drawings and installation documents on the engine to be included in the handover. This is because the two files would complement a 3D model very well and thus make their work easier. If these two files were included, the number of follow-up questions would also decrease, which in the long run would reduce the workload in Volvo Penta's Sales Engineer department.

During one interview, it was revealed that Volvo Penta had sent out a master version of an engine and thus shared secret information to a customer of an engine that had not yet gone into production. Mistakes like these can damage Volvo Penta but also highlight the risk in this matter. This finding is very serious and supports the idea that a fixed routine is needed so that this is not repeated. The idea of a fixed process can also be found from elsewhere in the interviews. A common comment at the end of each customer interview was that customers hoped that a fixed routine would be developed in this case so that these issues regarding the envelope models would be handled more smoothly in the future.

4.5 SWOT-analysis

Analyzing the interviews, mapping, and discussing the results it was possible to determine the strength, weaknesses, opportunities, and threats of the current situation. This was then put into a SWOT-analysis to easier illustrate the findings, see Figure 4.11.

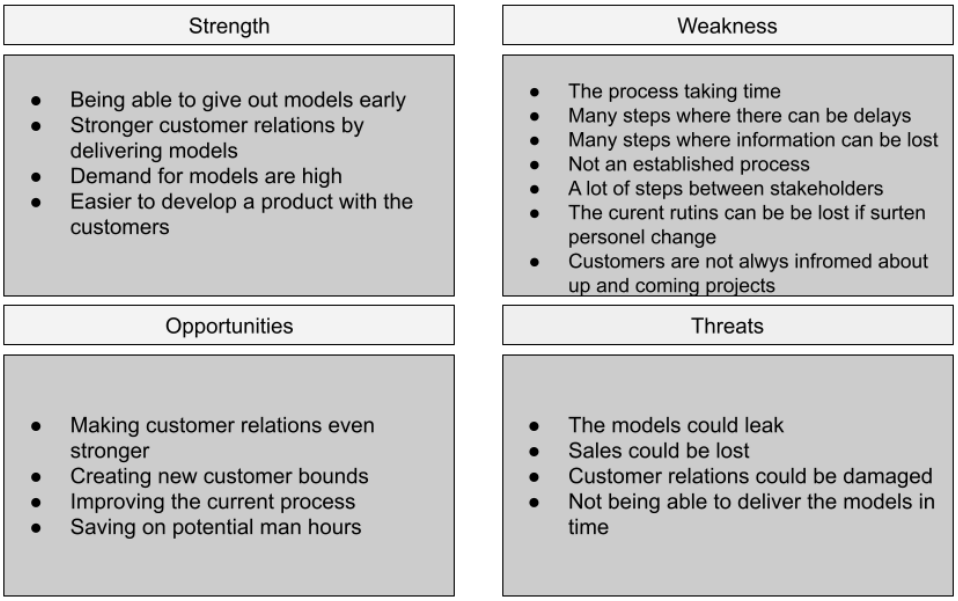


Figure 4.11: The SWOT-analysis.

The biggest strength of the current system is to be able to give out models before SoO, this makes it easier for customers to design their products and have their products out on the market. Because of this customer relations become stronger, which means that Penta will have a reliable customer base for upcoming projects. The demand for models is high, this is because the customers are expecting the models at this point, they do not see it as a desire but rather a demand. It is also beneficial for Penta to be able to design their products parallel with their customers, as it assures that their products will fit the customers which means that Penta can be sure that they have a sale.

The current structure is not perfect and has its flaws. Some of the bigger weaknesses with the structure is that the current process takes a lot of time, meaning that in some cases the customer does not get its models until a couple of weeks which can be problematic for many customers as fitting the Penta components is a very important and sensitive step for them, which means that it drags out their development stage and costs them money. The current process has a lot of different stakeholders and a lot of steps between these stakeholders which adds to the longer delivery times. Because there are extra steps that lead to a bullwhip effect, where information is lost and could lead to the customers receiving incorrect files which in turn leads to longer delivery times (What is the Bullwhip Effect? - Definition from WhatIs.com, 2016).
Currently, there is not an established process for delivering 3D models to customers, the process that is used currently has formed more than it has developed meaning that it has not

been streamlined or optimized but it has rather formed to perform scarcely. Because the process is not established and only a few stakeholders understand the current structure, which means that the current process is dependent on a few actors and if those actors would change then the whole process could stop. There is also no well-established way of informing customers about upcoming projects, which means that customer relations can take a hit.

There are a lot of opportunities when it comes to the current process. The first one is to improve it, establishing a process structure that is effective and broadly used would make it less fragile if an actor would leave the process. The defined structure would make the process more streamlined and faster which could improve customer relations even further. An improved structure would also help with gaining new customers as it would be a competitive edge for Penta. Streamlining the process could also save a lot of man-hours that could be put to better use for the company.

There are also some threats to giving out models to customers. If a model is not correctly changed then that could mean that a master model could leak out to customers and if that model would end up with the wrong customer then they could be sold or used to replicate the product based on those models, this would be an enormous loss for Penta. A threat with this process is that there is a possibility that Penta does not deliver the models in time. Customers not receiving their models in time could lead to a potential sale being lost for Penta. A lost sale could destroy the customer relationship because it shows unreliable performance.

4.6 Requirements specification based on findings from the analyzes

Based on the analyzes of the different models, the mapping and the three different categories of actors interviewed in the earlier phase of the project, a requirements specification has been created, see Table 4.2. The most important criteria in the requirements specification are classified as demands (D) and the others are classified as wishes (W). The wishes are ranked from 1-5, where 5 is the highest and thus the most important among the wishes.

This requirements specification contains both requirements for the main function, the envelope models and for the process of handing over envelope models to customers. To distinguish between these three, the following three categories have been created in the requirements specification:

1. Deliver envelope models to customers safely and on time
2. Requirements on the envelope model
3. Requirements on the process

The entire requirements specification is structured so that the main function must meet all internal and external criteria. Another reason why it is structured in this way is that it should be possible to see who makes which requirement and how that requirement is related to other requirements.

Table 4.3: Requirements specification based on findings from the analyzes.

Chalmers		Document type	Requirements specification						
		Project	Volvo Penta						
			Created: 2022-05-3						
			Modified: 2022-06-03						
	Criteria		*Target value*	*D/W*	*Rank*	*Industry*	*Marine*	*Verification method*	*Reference (setter of requirements)*
1.	***Main function***								
	1.1	Deliver envelope models to customers safely and on time		***D***		Yes	Yes	Test	Volvo Penta
2.	**Requirements on the envelope model**								
	2.1	Center of gravity	Can be read in model	D		Yes	Yes	Test	Customer
	2.2	External dimensions	Can be read in model	D		Yes	Yes	Test	Customer
	2.3	Attachment points	Can be read in model	D		Yes	Yes	Test	Customer
	2.4	Parts that need service	Can be read in model	D		Yes	Yes	Test	Customer
	2.5	High-resolution	Version of envelope model	D		Yes	No	Test	Customer
	2.6	Low-resolution	Version of envelope model	D		No	Yes	Test	Customer
	2.7	File format	STEP	D		Yes	Yes	Test	Customer
	2.8	Solid model	Can be read in model	D		Yes	Yes	Test	Customer
	2.9	Contains no secret information	Can be read in model	D		Yes	Yes	Test	Volvo Penta
3.	**Requirements on the process**								
	3.1	Time of handover	Gate: FDG (12 months before SoO)	D		Yes	Yes	Test	Customer
	3.2	2D drawings	Included in the handover	W	2	Yes	Yes	Test	Customer
	3.3	Installation document	Included in the handover	W	2	Yes	Yes	Test	Customer
	3.4	Meet all customer requirements	True.	D		Yes	Yes	Test	Volvo Penta
	3.5	Does not leak any secret information	True.	D		Yes	Yes	Test	Volvo Penta
	3.6	The process is mapped	All actors and their relationship must be mapped	D		Yes	Yes	Test	Volvo Penta
	3.7	The work must be documented	All activities in the process must be documented	W	4	Yes	Yes	Test	Volvo Penta
	3.8	Educational opportunities	It should be possible to learn the process as a new employ	W	3	Yes	Yes	Test	Volvo Penta

Deliver envelope models to customers safely and on time. This is the main function of the whole process and the purpose of it is that Volvo Penta wants to achieve customer satisfaction. This function is a demand and applies to both the marine and industrial sectors. All other criteria in this requirements specification are intended to help the main function to achieve its goal.

Requirements on the envelope model. This category contains nine different criteria that apply to the envelope model. All are demands and must therefore be met for the new process to be considered successful. All criteria except the last 2.9 "Contains no secret information" are required by the customer. In this category there is also a criterion that differs depending on which sector Volvo Penta's customer operates in. The high-resolution criterion only applies to the industrial sector and the low-resolution criterion only applies to the marine sector. This means that regardless of which customer the envelope model is to be handed over to, eight criteria must be met in this category as one is not relevant for that sector.

Requirements on the process. The last category contains a total of eight criteria, both demands and wishes. One demand is from the customers and that is that the model must be handed over at least 12 months before SoO. The other three requirements are from Volvo Penta, one is that no secret information may leak out of the process and the other is that the process must be mapped. The last demand for the process from Volvo Penta is that all criteria aimed at the envelope model must be met. Out of the four wishes in this category, the wish "the work must be documented" has a ranking of 4 and is thus the most important of the wishes.

5. Short-term and long-term recommendations

In this chapter, both RQ2: *What recommendations can make the process better and safer in the short term?* and RQ3: *What recommendations can make the process better and safer in the long term?* will be answered together with the respective verification against the criteria in the requirements specification.

5.1 Short-term recommendations

One of the research questions for this project is what recommendations can make the process better and safer in the short term? Some important factors to consider before making these recommendations is that the short-term recommendations will be recommendations that Volvo Penta could implement immediately. Meaning that the short-term recommendations will look at the current process and try to streamline it without making any radical changes but by establishing the process so that all the actors are aware of what their role is and what actions to take. It is also important that the recommendations do not affect the current process in a negative way. Looking at the current development process in Figure 4.5 and based on interview 4, it is possible to see where the customers could receive fully accurate models. Receiving the models too early could be counterproductive as it would have to be multiple iterations because of the potential incremental changes. These incremental changes could be costly for the customers if they do not receive information in time about the changes.

After examining the information that was gathered, it was determined that at the FDG gate, the models should be finished and ready to be outsourced to Bangalore. In interview 4 and figure 4.5 it is also mentioned that there is a guideline for who is responsible for these models. Based on the interviews, mapping of the current system, the guidelines for the current process, and the requirement specification it was possible to make recommendations.

It is important to verify the recommendations against the requirement specification because it is not possible to perform any test with the recommendations because of time constraints. The main goal of the short recommendation is to make an established process that all the actors can relate to, meaning that a new actor should be able to understand and be able to implement it. Another goal is to streamline the process and remove unnecessary steps. The goal for the customers is still to receive the models before the SoO and as soon as possible without having to worry about the models changing. This is so they can have their products out on the market as soon as possible and to make sure to have the newest components from Volvo Penta. The stage where all of this is feasible is the FDG gate, this is the moment during the development phase where all actors should be aware that it is possible to deliver the models to customers.

The reason for the models needing to be modified is to protect the sensitive information of the models, preventing this from leaking is a top priority. It is also important that the models that the customers receive are the correct ones, this makes the process more time and economically efficient as there wouldn't be a need to correct the mistakes. A potential

solution for this is to follow Tabel 4.2 for who is in charge and has to approve the release of the models, this, in turn, makes sure that all models have been verified by the correct actors. For this to work, means that every actor involved in Table 4.2 has to be aware of what needs to be protected in order to improve the models.

Figure 5.1 illustrates a more streamlined process. The blue boxes represent the internal stakeholders and the green represent the external stakeholders. The black solid lines represent information flow and communication, the black dashed lines represent what the customer wants. The red arrows represent the flow of the models. The when and where have been left out, so to make the map easier to understand and more straightforward. Comparing this model to the current one in Figure 4.7, it has clearly fewer steps between customers and the actual model and even has a direct connection between the two actors which represents the customer directly taking the models out as it would with the ACP.

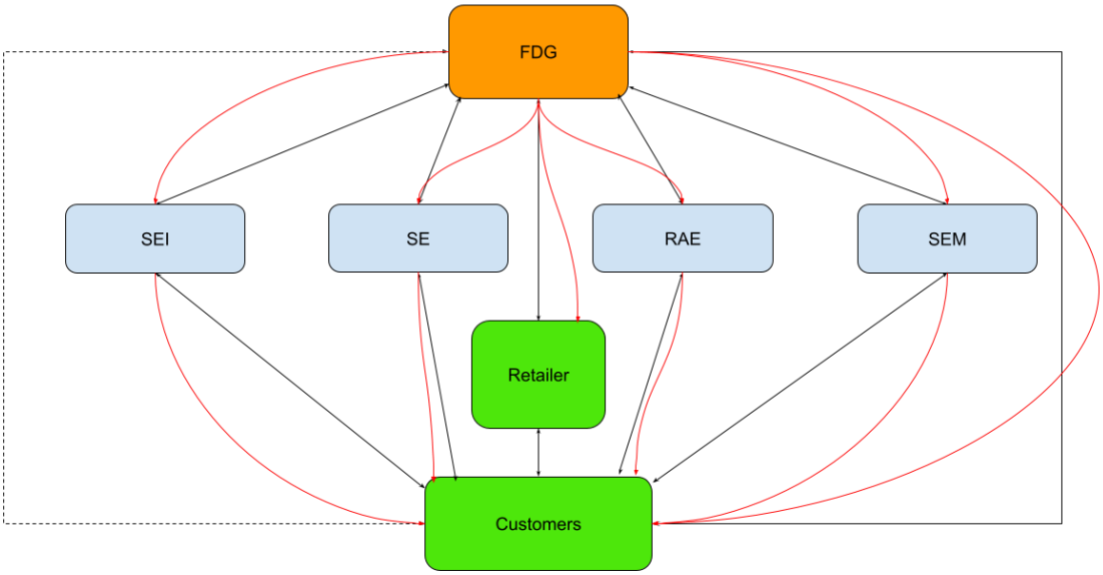


Figure 5.1: Process mapping of short-term recommendations.

5.1.1 Verification of short-term recommendations

It is not possible to test the short-term recommendations because of time constraints and lack of resources. Because the project is only 4 months, it is not possible to implement the resources and verify that the recommendations performed as intended. It would have needed multiple tests with different customers, with different needs, different conditions, and different timespans. It would also be hard to implement the recommendations currently as Volvo Penta is in the midst of expanding its Bangalore offices which means that personnel and resources were too thin to conduct any type of tests. This means that any type of real-world testing was inconceivable.

One way that was possible to verify this process was to screen it against the requirements specification. This is done by seeing if all the recommendations cover the requirements specification and possibly cover both demands and wishes.

The recommended improvements do not affect the requirements on the envelope, because the potential changes are not about the product. The recommendations are all in the process. The time for handover is at the FDG gate which is a demand by the customers as they see this as the ideal time to receive the models. 2D drawings and installation documents can still be sent to the customers if needed. This process would have all the stakeholders mapet out their relations with each other. All the work must be documented and approved by the determined actors, this will also lead to a safer process as somebody has to sign off on the models that are being sent out to the customers. Because the process would be established and mapped then it would be much easier for a new employee to learn the process.

5.2 Long-term recommendations

Even in the long term, Volvo Penta's existing project structure and gate FDG will be the dominant factor in this matter. It is only when the master model is completely constructed in CAD that it is possible to downgrade it to an envelope model. Under these conditions, it is still possible to streamline and secure the process further in comparison with the short-term recommendations.

In the long term, it is recommended that Volvo Penta invests in a function that can systematize the downgrade from a master model to an envelope model, both high-resolution and low-resolution, completely automatically, i.e., without human intervention. There are two alternatives to make that feature real. The first alternative is to integrate PTC's PDM system Windchill and then synchronize it with the CAD program Creo and then use the existing "simplified response on demand" function to transform the master model into an envelope. The second alternative to an automated process without human intervention is to purchase a downgrade function in Creo from the software developer PTC. These alternatives must of course be weighed against each other and be thoroughly evaluated, but at this point the second alternative is recommended. There are several reasons for this. The first reason is that in interview 12 it was said that alternative one would probably work in comparison with alternative two which would definitely work. The second reason is that Volvo Penta would not have to change PDM systems and thus avoid a lot of costs, work, and uncertainty that it would bring. The third reason is that if Volvo Penta were to buy a function, PTC would be able to tailor it exactly to Volvo Penta's wishes. The final reason why option two is recommended is that a function in Creo would be much smoother to use on a daily basis, just like in interview 11 and the comments about the function that converts master models to surface models.

With a purchased function, the unit responsible for the creation of the master model, product development, can directly downgrade the model when it is completed into an envelope model

in the gate FDG. This would allow customers to receive the envelope model immediately after it is done, thereby reducing time, and increasing customer satisfaction. In addition to reducing time to the customer, Volvo Penta would have a function that would always work in a fast and secure way, i.e., a way that would never risk leaking secret information to an external actor.

Together with a function that automatically downgrades master models to envelope models, it is also recommended that a course be created, where the entire process is mapped and documented, that will act as training in the whole process but specifically on Creo and in the downgrade function. Even though there is a function, it is possible to make mistakes without training in the area. This training will also serve as a protection as the company grows and more people will be hired.

Customer requirements change all the time and it is not uncommon for customer requirements classified as wishes to change to demands over time. Therefore, it is important to precede it when long-term recommendations are presented. It means that 2D drawings and installation documents should also be integrated in the FDG gate in addition to envelope models to be sure that all customer requirements will be met for the foreseeable future.

Finally, it is also recommended that Volvo Penta develop a plan for how and when customers will be informed about new products. Findings from many customer interviews indicate that there is dissatisfaction with today's dialogue and how they are informed. In this case, it is recommended to inform the customer directly when a new engine is decided to be developed because it gives the customer longer reflection time and more room for the customer to plan their products. This, together with the other recommendations in this section, would in the short term make the customer more positive to Volvo Penta and in the long term gain a strong trust and good relationship.

5.2.1 Verification of long-term recommendations

To examine and verify that the long-term recommendations would meet all the criteria in the requirements specification, a review is now initiated. Category two, requirements for the envelope model, are examined first.

With a downgrade feature in Creo that can convert master models to envelope models, both high-resolution and low-resolution, it can be determined that no secret information can be leaked. The same function also guarantees that the models become solid models where it is possible to read the center of gravity, external dimensions, attachment points and which parts on the outside of the engine need service. In Creo, it is also possible to save a CAD file to the file format step, and thus it can be decided that the long-term recommendations meet all criteria in category two in the requirements specification.

According to the long-term recommendations, in the gate FDG a delivery has been added that contains three documents, envelope model, installation document and 2D drawings. Thus, all customer requirements in category three "requirements on the process" have been met. When it comes to the requirements from Volvo Penta, it can also be decided that all criteria are met, as these recommendations contain a plan for training where the process is mapped and documented.

The requirements specification is built around a main function with several different other criteria, both wishes and demands. When all other criteria in a requirements specification are considered to be met, it can be concluded that the main function is also considered to be met, and thus have the long-term recommendations passed the verification.

6. Discussion

In this chapter, the project's planning, execution, and results will be discussed. The results are divided into three categories based on the three different research questions.

Planning

The project began with the supervisors at Volvo Penta presenting the topic and what opportunities there were to shape the scope of the project. Initially, the idea was that the project would have a more technical focus where the core of the thesis would be on designing an internal portal and its functions for displaying 3D models. After a period of study on the subject and interviews with internal actors, it emerged that the execution of the current process was neither mapped, documented nor predetermined. After consultation with supervisors at both Volvo Penta and Chalmers University of Technology, an alternative project scope could be presented where the focus should be on mapping the current process and making recommendations on process development based on the requirements of both internal and external actors. This change in the scope of the project was, now in retrospect, a good decision as it would be difficult to carry out the idea of origin and design an internal portal and its functions without knowledge of the current process and all the requirements of the process.

When the project's goals, objectives and scope were determined, an extensive literature review was initiated, and it shaped the project's planning, execution, and results. If another method for conducting the literature review had been chosen instead of the snowballing method, the project might have looked different. It is thanks to the very comprehensive snowballing method that so much interesting literature could be found in the business process management area, and thus fulfilled the project's first objective. It was when it could be found that the execution of the project crystallized and could gain momentum with the knowledge that the direction and methods were right. The literature review, together with the interviews, is probably the two most important parts of why the findings turned out as they did in the end.

Execution

Execution of the project was based on these methods; a literature review, SWOT, PEST, Semi structured interviews, analysis of the interviews, mapping of the current situation, requirement specifications, process/product generation, and verification. These methods were chosen as they were methods that had been partially used by the writer and/or because they fit the aim of this project.
There were methods that were considered at the beginning of the project but were left out for various reasons.

A method that was considered at the start was the use of quantitative data collection in the form of a questionnaire. The idea was to send out the questionnaire to all the stakeholders that would then forward it to their colleagues in their departments. This method was disregarded because of the information that needed to be gathered. For the use of a

questionnaire to work then you need to know exactly what questions you need to ask and what answers you need to receive but this approach did not work for this project as the questions needed to be more open-ended for the exploratory research. It was also no real point for the stakeholders to send out the questionnaires to the rest of the department as it was mostly the stakeholder that worked with the models.

Using workshops was also considered for this project but was deemed a bit redundant and also very hard to orchestrate. Considering that the interview format that was used was SSI, it seemed dependent on later having a workshop with the same format. It was also very challenging to try to book different stakeholders for a workshop, so this method was scrapped early in the project.

There were a few difficulties with this project. The first one was that at the start of the project Covid was still a big concern, meaning that it was not possible to be at the facilities 100% at the start, and many stakeholders were either sick or hard to contact at the beginning of the project. The main information gathering for this project was the interviews which means that the project was very dependent on the interviews, but there were a lot of difficulties and obstacles with the interviews. Because the process was not mapped, it was difficult to know who to interview, so the interviewee always had to recommend the next stakeholder which made it harder to plan the interviews. It took a lot of time to prepare before the interviews with the right questions and doing research about the person in question, transcribing the interview, and analyzing the information afterward took a lot of time.

Some issues appeared later in the project such as if the information that was discussed and gathered was allowed to be published or written about. Meaning that it would be hard to justify the thesis if the findings were not allowed to be shown. It was also hard to know how many potential stakeholders needed to be interviewed beforehand. This made it also harder to plan ahead and to know how many interviewees were needed for the best result, considering the timespan.

Potential improvements for this project were to have a second series of interviews with specific stakeholders. For example, having a second set of interviewees with PTC with the findings that had been gathered, considering that some things they mentioned like customers wanted surface models contradicted the answers from the customers. Having a second interview with the project managers would have been beneficial and checking with them about these recommendations but none of this was possible because of time restraints.

Mapping

The question “What does the mapping of the current process look like?” receives an answer. The mapping of the current system was successful in establishing what the process looks like today. This will make it easier for the company to see what their process looks like and what flaws it has. It could have been beneficial to make the mapping with an integrated time plan that would present the process in comparison to the project's time. If this project were to be redone then it could be interesting to ask the company to make the mapping before any

research had been done in order to show how hard it is to keep track of a process if it is not established.

Short-term

Based on the results from the mapping, recommendations for the process were made in the short term. These recommendations were presented with a new more streamlined mapping of the process and establishing which actors are accountable. These things were recommended so that Volvo Penta could implement them immediately without having to restructure the whole process. These recommendations were made with the base that was already existing at Volvo Penta but now it would be established. The actors that are acountable in the process might not be the ones that should be accountable, there might be other actors that are more suitable to be accountable but to make the process ready to use, the already established actors were deemed accountable.

The benefits of this structure are that it is easier to comprehend, which makes it easier for new workers to learn the system. A potential drawback is that everybody involved has to have a comprehensive knowledge of the process and the models in order to make it safer but the benefit is that anybody can use the system and detect a potential threat within the process, such as if a model has not been downgraded. What could also help the development of the process if all the actors made input about the process. A thing to consider is that the longer it takes to develop the process and more people are involved, the more expensive it will become for the company.

Long-term

Based on the requirements specification, there was room for several different alternatives when the long-term recommendations for the new process were to be developed and presented. After analysis of the interviews, it was obvious that some form of automatic function was needed to meet both the internal and external requirements and an increased frequency of requests for envelope models. What is also good about an automatic function is that it removes human interference in the downgrading work and thus significantly reduces the risk of secret information being leaked. In addition to the risk perspective, it can also be said that an automatic function would reduce both the steps in the process and the time it takes to perform the process. So, it was clear that an automatic function would be needed in the long run to make the process more efficient and safer.

Automating the process of converting a master model into an envelope model can be done in several different ways. An alternative that was discussed was to buy and use an external program whose only task is to import master files and then convert them to envelope files. This option was not chosen as it cannot guarantee with certainty that this investment would solve the problem, as no programs with that function could be found when research was done. Another option, which was briefly presented in Chapter 5, is to integrate PTC's PDM system Windchill and to use the existing "simplified response on demand" command to systematically convert master models to envelope models. This option would possibly have been the best if Volvo Penta, like Volvo Trucks, had already used Windchill as a PDM

system, but now this proposal is considered too extensive for only this area of use. Implementing a new PDM system is very expensive and must be synchronized with all other projects and existing systems used on Volvo Penta. It would also entail a risk that the daily operations would be affected and that an uncertainty would spread, which would have a negative effect on the company over a long period.

The option that was finally recommended, to buy a downgrade function of PTC, is also expensive, but that purchase would not jeopardize the daily operations in the same way as the previous alternative. In addition, this option is today the only option that PTC can guarantee will work and based on these reasons, this option was chosen. When a company buys a specific function of PTC, the buyer can also be involved and determine exactly how the function should work, which is also a contributing factor in the choice.

Since these recommendations will eventually be applied in the long run, it is important to anticipate wishes that will over time be transformed into demands. There is no guarantee, but it is common for this to be the case. That is why the two low-ranking requests, 2D drawings and installation documents, were also packed into the joint delivery in the gate FDG. Increasing customer satisfaction was discussed, and these two additional documents are a sign of the desire to make customers happy in all situations.

In conclusion, it was considered important to include the training course in the long-term recommendations. A course would provide several positive effects that can be difficult to measure in numbers. Education and understanding would mean that all actors in the process would understand what part they contribute but also what the customers expect of them. It is a key factor in the future to be able to meet customer requirements and act according to them. Finally, training in the area would also act as a risk measure for new employees who are expected to participate in the process without experience.

7. Conclusion and future recommendations

In this chapter, the conclusion of the thesis and of the three research questions will be presented together with future recommendations on what lies ahead of the thesis.

The aim of this thesis is to determine and map the current process and the underlying causes and consequences. Based on these findings recommendations were made to further improve the process from a strategic point of view in order for sales to be more secure and efficient. In order to achieve this, 20 interviews were conducted both with internal actors from Volvo Penta and external actors such as retailers, customers, and outside actors in a similar field. An extensive literature was also conducted so as to have outside information and to avoid biased information.

The project achieved its goals of mapping out the current process and identifying all the different actors involved, it was also possible to build upon these findings and make further recommendations. The answers to the four research questions formulated to guide the analysis are presented below:

RQ1: What does the mapping of the current process look like?
Based on the analysis from the interviews, internal and external, regarding the current process of giving out models, it could be concluded that it was possible to map out the current process. The map is illustrated in section 4.3 and shows the stakeholders that are involved, how the information flows, what steps are in the process, and the general glow of the models. It also shows the different flaws of the current process such as not having an actual established process but rather having a process that has been created through rutin, which means it is not optimized and could be streamlined.

RQ2: What recommendations can make the process better and safer in the short term?
The recommendations for the short-term are based on what Volvo Penta could do imminently to improve the current process for the sales of 3D models. The basic idea is to make an established process for Volvo Penta that all the actors could fall back on and use so that everybody involved knows the procedure. A goal is also to streamline the process in order to remove any unnecessary steps that the current process has. In section 5.1 there is an illustration of what the improved mapping could look like in order to improve the process, it focuses on removing unnecessary steps in the process so as to make the process simpler. Section 5.1 also covers who and when should be accountable for the process.

RQ3: What recommendations can make the process better and safer in the long term?
The long-term recommendations, section 5.2, are based on the purchase of a downgrade function in the CAD program Creo that will reduce the time, steps, and risks in the process. Together with that function, it is also proposed that a training course be launched where all actors who work somewhere in the process can train and understand how to perform it correctly and what risks may arise. To meet future customer demands, it is also considered necessary to include, in addition to the envelope model, 2D drawings and the installation

document in the hand over document. Finally, Volvo Penta should also expand and determine an overall plan for how customers are informed about new products.

Future recommendations:
After this thesis, there are three steps that are worth investigating further. The first step is to evaluate the short-term recommendations and make a detailed plan of what the execution of that process should look like. Then it is recommended to implement and test the process on a couple of independent projects for further evaluation and development.

The second step is to design a plan for risk management based on findings after evaluation of the first step. This must be done so that the short-term process can be applied to greater breadth in the organization.

The third and final step is to start a conversation with the software developers PTC about a downgrade function in Creo and what it would cost and how long it would take to develop. Then a compilation should be made in comparison with the short-term recommendations on what is best for Volvo Penta based on cost, safety, customer satisfaction, resource use and time perspective.

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Johannes Karlsson 04-04-2022
Josephsson, L 23-03-2022
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Liske,M 23-02-2022
Lonnehede, P 04-03-2022
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Möller, E 29-03-2022
Nilsson, C 08-03-2022
Olsen, T 07-03-2022
Olofsson, M 07-03-2022
Törefeldt, M 25-03-2022

Appendix A

Interview 1

Name: Sven Angervall
Title: Geometrical Architect

Institution: Volvo Penta, Gothenburg
Date: 12-02-2022
Time: 10.10-10.50

Question:

1. What does the process of simplifying look like?
2. What does the internal process look like when you receive a request regarding geometry model
3. Who simplifies these models?
4. How long does it take to simplify these models?
5. What does the current timeline look like?
6. When do your customers ask for 3D-models?
7. When could you deliver a model to the customers?
8. What level of quality do the models need to be for the customers?
9. What is the most important part of the model to protect?
10. What are the benefits of giving out models early to customers?
11. What is the biggest mishap that can happen when giving out non-simplified models to customers?
12. Is there a structure currently for customers to receive models automatically after a certain time?
13. Have there been any issues because there is not an official work structure for 3D-models?
14. What is the biggest risk of handing over 3D models to customers
15. Would you like there to be a built-in way to encrypt models?
16. Have you looked into using other programs?
17. Is it known what you can show and can not show when it comes to the models?
18. Is there something you wish for in the future with this process?
19. How do you send the models to the customers?

Appendix B

Interview 2

Name: Max Gunnhage
Title: Sales & Application Engineer – Industry

Institution: Volvo Penta, Gothenburg
Date: 22-02-2022
Time: 10.10-10.50

Question:

1. When do your customers ask for 3D-models?
2. When could you deliver a model to the customers?
3. What level of quality do the models need to be for the customers?
4. What is the most important part of the model to protect?
5. What are the benefits of giving out models early to customers?
6. What is the biggest risk of handing over 3D models to customers
7. When do customers receive the information that there is a new model on the way?
8. Is there a structure currently for customers to receive models automatically after a certin time?
9. Do you work in Creo?
10. Have you been taught how to use Creo?
11. Are the models more important on the industry side?
12. Have there been any issues because there is not an official work structure for 3D-models?
13. Are there customers that have different arrangements?
14. Would you like there to be a built-in way to encrypt models?
15. Is it to know what you can show and can not show when it comes to the models?
16. Is there something you wish for in the future with this process?
17. How do you send the models to the customers?

Appendix C

Interview 3

Name: Jimmy Kling
Title: Sales & Application Engineer – Marine

Institution: Volvo Penta, Gothenburg
Date: 23-02-2022
Time: 09.40-10.20

Question:

1. When do your customers ask for 3D-models?
2. When could you deliver a model to the customers?
3. What level of quality do the models need to be for the customers?
4. What is the most important part of the model to protect?
5. What are the benefits of giving out models early to customers?
6. What is the biggest risk of handing over 3D models to customers?
7. When do customers receive the information that there is a new model on the way?
8. Is there a structure currently for customers to receive models automatically after a certain time?
9. Do you work in Creo?
10. Have you been taught how to use Creo?
11. Is there an established process for sending out models to customers?
12. Are the models as crucial as on the industry side?
13. What is the most important thing to know about a model?
14. How often do you have to generate these models?
15. Is there something you wish that would be simpler for the program?

Appendix D

Interview 4

Name: Magnus Liske
Title: Project Manager Process & IT

Institution: Volvo Penta, Gothenburg
Date: 23-02-2022
Time: 14.00-15.00

Questions:

1. What does the project structure of Volvo Penta look like?
2. What guidelines does Volvo Penta have that always apply when you run a project?
3. Which phases and gates are always included?
4. Which people with which positions are involved in a typical project?
5. Who or what is responsible for you meeting the goals contained in the project model?
6. Are there different types of frameworks for different types of projects?
7. What would you like to improve with your existing project model?

Appendix E

Interview 5

Name: Fredrik Jägersvärd
Title: Medium Duty Engine Platform Manager and Project Leader

Institution: Volvo Penta, Gothenburg
Date: 24-02-2022
Time: 09.00-10.00

Questions:

1. Can you tell us a little about your role at Volvo Penta?
2. How long have you held the position of project manager?
3. Can you describe your view on being able to show 3D models on products during the development stage of the product for customers to meet their desires and requirements?
4. How would you say the development has gone in this matter?
5. What is most important from both Volvo Penta's perspective and from the customer's perspective?
6. During which phase or gate is a product's construction and design determined?
7. When can Volvo Penta deliver a credible model to customers at the earliest?
8. Which people within Volvo Penta produce the 3D models and which downgrade them to Envelope models that you can show customers?
9. Who handles that contact?
10. What is the biggest risk of handing over 3D models to customers?

Appendix F

Interview 6

Name: Freddy Fuxin
Title: Data Scientist, Vehicle and Business

Institution: Volvo Trucks, Gothenburg
Date: 25-02-2022
Time: 09.00-10.00

Questions:

1. Can you tell us about your position in the group?
2. Can you tell us how Volvo Trucks work?
3. Can you tell us about the difference between Volvo Penta and Volvo Trucks regarding geometry models and the systems that make the models possible?
4. Why have the needs been different between Penta and Trucks?
5. What could be done in the short term to develop this area?
6. What could be done in the long term to develop this area?
7. What would these changes mean both internally and externally?

Appendix G

Interview 7

Name: Tommy Olsen
Title: Product Developer

Institution: Volvo Penta, Gothenburg
Date: 07-03-2022
Time: 10.00-11.00

Questions

1. When did you get into this project?
2. What is an ACP?
3. How has the ACP affect sales?
4. What is your goal with the current process?
5. What is the biggest risk of handing over 3D models to customers
6. During the development process, when do the customers want a 3D-model?
7. Are there any customers that ask for 3D-models even earlier than the preconceived time of "1 year"?
8. Are there any tools currently for simplifying models?
9. How widely used is the tool for simplifying?
10. Why is it important to have a more detailed outer model?
11. What does it look like when you send the customers the models?
12. What would you like that this process looked like?
13. Do you or anybody in your department ever have to assemble these packages for customers?
14. Does it happen that customers have to reach you again after receiving their "packages"?
15. What is the most important thing about the models?

Appendix H

Interview 8

Name: Martin Olofsson
Title: Product Developer

Institution: Volvo Penta, Gothenburg
Date: 07-03-2022
Time: 10.00-11.00

Questions

1. When did you get into this project?
2. What is an ACP?
3. What is your goal with the current process?
4. During the development process, when do the customers want a 3D-model?
5. What is the biggest risk of handing over 3D models to customers
6. Are there any customers that ask for 3D-models even earlier than the preconceived time of “1 year”?
7. Are there any tools currently for simplifying models?
8. How widely used is the tool for simplifying?
9. Why is it important to have a more detailed outer model?
10. What does it look like when you send the customers the models?
11. What would you like that this process looked like?
12. Do you or anybody in your department ever have to assemble these packages for customers?
13. How long would it take to teach a person to use Creo and to simplify models?
14. Does it happen that customers have to reach you again after receiving their “packages”?
15. What is the most important thing about the models?

Appendix I

Interview 9

Name: Conny Nilsson
Title: Sales Manager

Institution: – Imatech, Gothenburg
Date: 08-03-2022
Time: 10.00-11.00

Questions:

1. How long does it take to receive the models?
2. Have you ever been part of a project where you were developing something and needed information from Penta?
3. Which of these models (hi- or low-res models) is preferable for you?
4. Approximately when do customers ask for 3D-models from Penta?
5. When do you get information about the new models?
6. From whom within Volvo Penta's organization do you get information about new products?
7. To whom within Volvo Penta's organization do you send inquiries regarding 3D models?
8. Are customers aware and are they fine with that models that they receive early could go through a lot of changes?
9. Has there ever been that customer receives models way too late and what have the consequences been?
10. Could Penta have gotten a sale if they had gotten their models out quicker?
11. Are the customer relations affected by the models?
12. Would it help to know different metrics about the parts such as weights, material, etc?
13. What are some of the most important parts of a model?
14. Who at Penta are you directing your questions to?
15. Where do you get the models?
16. If you cannot take out the models through prosales how do you proceed?
17. Do you wish to change the current process?
18. What format is preferable for customers?
19. Do you wish to be able during the development stage be able to take out specific parts?
20. Who has access to picking out models currently?
21. Is space more crucial on the marine side or industry side?
22. How long does it take for you to receive a model after request?
23. What is the extreme when it comes to waiting time?

Appendix J

Interview 10

Name: Nick Andersson
Title: Sales & Application Engineer

Institution: Volvo Trucks, Gothenburg
Date: 09-03-2022
Time: 09.00-10.00

Questions:

1. What position do you have at Volvo Penta?
2. What is your view of customers' needs for 3D models during the development phase of the products?
3. In what situation do inquiries regarding geometry models come in from customers?
4. What is the most important thing for customers in that regard?
5. What does the internal process look like when you receive a request regarding geometry models?
6. How long does it take to produce an Envelope model that meets customer needs?
7. Are there any risks with the way you work at the moment?
8. What can be done to make this process better?

Appendix K

Interview 11

Name: Magnus Lycklund
Title: Systems Engineer Specialist

Institution: Saab, Gothenburg
Date: 04-03-2022
Time: 13.15-14.00

Questions:

1. What is your position at Saab?
2. How do you work with 3D models?
3. What routines do you have when it comes to showing customers 3D models during the development phase of your product?
4. Which CAD program do you work in?
5. How do you create 3D models that you can show to your customers without the risk of sensitive information being leaked?
6. Do you think your way of working works well?

Appendix L

Interview 12

Name: Per Lonnehede
Title: Systems Engineer Specialist

Institution: Saab, Gothenburg
Date: 04-03-2022
Time: 13.15-14.00

Questions:

1. Can you tell us about your job at PTC?
2. Can you tell us about PTC's CAD program Creo and how you look at functions that can "wash" geometry models so that it is possible to show them to customers without showing classified parts in the models?
3. If customers do not have the capacity for using surface models in their own CAD program, do you have a method or function where it is possible to convert models to solid models in Creo?
4. Is it possible to develop a specific function in Creo for a customer like Volvo Group?
5. What would it require from you and what would it require from the customer?

Appendix M

Interview 13

Name: Mats Törefeldt
Title: Designer och Salesman

Institution: Nimbus, Gothenburg
Date: 25-03-2022
Time: 13.30-14.30

Questions:

1. What kind of models do you need? (High or low res)
2. How long does it take for you to receive these models?
3. What do you need to know from the models?
4. When do you guys need the models compared to your development?
5. From whom within Volvo Penta's organization do you get information about new products?
6. To whom within Volvo Penta's organization do you send inquiries regarding 3D models?
7. Would you like to receive models earlier but with a disclaimer?
8. What format do you like to receive your files?
9. Do you prefer solid models or surface models?
10. Do you receive what you ask for or has there been information lost in the process?
11. Can a sale be lost because a model has not arrived in time or been wrong/broken?
12. Have you ever received models with too much information?
13. What do you need to see on a model?
14. Do you ever need a Hi-res?
15. Do you receive information directly about their new projects?
16. Are you receiving the information in time?

Appendix N

Interview 14

Name: Erik Möller
Title: Design Engineer

Institution: Disab, Gothenburg
Date: 29-03-2022
Time: 13.30-14.30

Questions:

1. What kind of models do you need? (High or low res)
2. How long does it take for you to receive these models?
3. What do you need to know from the models?
4. When do you guys need the models compared to your development?
5. From whom within Volvo Penta's organization do you get information about new products?
6. To whom within Volvo Penta's organization do you send inquiries regarding 3D models?
7. Would you like to receive models earlier but with a disclaimer?
8. Would you like to receive multiple updates with models?
9. What format do you like to receive your files?
10. Do you prefer solid models or surface models?
11. Do you receive what you ask for or has there been information lost in the process?
12. Can a sale be lost because a model has not arrived in time or been wrong/broken?
13. Have you ever received models with too much information?
14. What do you need to see on a model?
15. Do you ever need a low-res?
16. Do you need 2D-models?
17. Do you receive information directly about their new projects?
18. Are you receiving the information in time?
19. Is there something you wish to add to the current process?
20. Is there anybody from Penta that checks that you have installed their motors correctly?

Appendix O

Interview 15

Name: Johannes Karlsson
Title: Regional Application Engineer

Institution: Volvo Penta, Gothenburg
Date: 04-04-2022
Time: 09.30-10.30

Questions:

1. What type of models are customers asking for?
2. When do your customers ask for 3D-models?
3. When could you deliver a model to the customers?
4. What is the most important part of the model to protect?
5. How do you receive the models from Volvo Penta?
6. How long does it take from the time that customers request a model to the time that they receive it?
7. Has there ever been information that's been lost because of the different steps and people that are involved in receiving the models?
8. What are the benefits of giving out models early to customers?
9. What is the biggest risk of handing over 3D models to customers?
10. When do customers receive the information that there is a new model on the way?
11. What format do the customers want these models?
12. Do you work in Creo?
13. Are the models as crucial as on the industry side?
14. What is the most important thing to know about a model?

Appendix P

Interview 16

Name: Peter Engqvist
Title: Mechanical Engineer

Institution: Konecranes, Gothenburg
Date: 29-03-2022
Time: 09.30-10.20

Questions:

1. What kind of models do you need? (High or low res)
2. How long does it take for you to receive these models?
3. What do you need to know from the models?
4. When do you guys need the models compared to your development?
5. Would you like to receive models earlier but with a disclaimer?
6. Would you like to receive multiple updates with models?
7. From whom within Volvo Penta's organization do you get information about new products?
8. To whom within Volvo Penta's organization do you send inquiries regarding 3D models?
9. What format do you like to receive your files?
10. Do you prefer solid models or surface models?
11. Do you receive what you ask for or has there been information lost in the process?
12. Can a sale be lost because a model has not arrived in time or been wrong/broken?
13. Have you ever received models with too much information?
14. What do you need to see on a model?
15. Do you ever need a low-res?
16. Do you need 2D-models?
17. Do you receive information directly about their new projects?
18. Are you receiving the information in time?
19. Is there something you wish to add to the current process?

Appendix Q

Interview 17

Name: Peter Helgeson
Title: Mechanical Engineer

Institution: Konecranes, Gothenburg
Date: 29-03-2022
Time: 11.00-12.00

Questions:

1. What position do you have within Konecranes?
2. What do you need to know from the models?
3. What kind of models do you prefer? (High or low res)
4. How long does it take for you to receive these models?
5. From whom within Volvo Penta's organization do you get information about new products?
6. To whom within Volvo Penta's organization do you send inquiries regarding 3D models?
7. When do you guys need the models compared to your development?
8. Would you like to receive models earlier but with a disclaimer?
9. Would you like to receive multiple updates with models?
10. What format do you like to receive your files?
11. Do you prefer solid models or surface models?
12. Do you receive what you ask for or has there been information lost in the process?
13. Can a sale be lost because a model has not arrived in time or been wrong/broken?
14. Have you ever received models with too much information?
15. Do you ever need a low-res?
16. Do you need 2D-models?
17. Is there something you wish to add to the current process?
18. Is there anybody from Penta that checks that you have installed their motors correctly?

Appendix R

Interview 18

Name: Christoffer Jivenius
Title: Mechanical Engineer

Institution: Konecranes, Gothenburg
Date: 29-03-2022
Time: 15.00-16.00

Questions:

1. What position do you have within Konecranes?
2. What do you need to know from the models?
3. What kind of models do you prefer? (High or low res)
4. How long does it take for you to receive these models?
5. From whom within Volvo Penta's organization do you get information about new products?
6. To whom within Volvo Penta's organization do you send inquiries regarding 3D models?
7. When do you guys need the models compared to your development?
8. Would you like to receive models earlier but with a disclaimer?
9. Would you like to receive multiple updates with models?
10. What format do you like to receive your files?
11. Do you prefer solid models or surface models?
12. Do you receive what you ask for or has there been information lost in the process?
13. Can a sale be lost because a model has not arrived in time or been wrong/broken?
14. Have you ever received models with too much information?
15. Do you ever need a low-res?
16. Do you need 2D-models?
17. Is there something you wish to add to the current process?
18. Is there anybody from Penta that checks that you have installed their motors correctly?

Appendix S

Interview 19

Name: Martin Holmberg
Title: Design Engineer

Institution: Rottne, Gothenburg
Date: 22-03-2022
Time: 09.20-10.00

Questions:

1. What position do you have within Rottne?
2. What do you need to know from the models?
3. What kind of models do you prefer? (High or low res)
4. How long does it take for you to receive these models?
5. From whom within Volvo Penta's organization do you get information about new products?
6. To whom within Volvo Penta's organization do you send inquiries regarding 3D models?
7. When do you guys need the models compared to your development?
8. Would you like to receive models earlier but with a disclaimer?
9. Would you like to receive multiple updates with models?
10. What format do you like to receive your files?
11. Do you prefer solid models or surface models?
12. Do you receive what you ask for or has there been information lost in the process?
13. Can a sale be lost because a model has not arrived in time or been wrong/broken?
14. Have you ever received models with too much information?
15. Do you ever need a low-res?
16. Do you need 2D-models?
17. Is there something you wish to add to the current process?
18. Is there anybody from Penta that checks that you have installed their motors correctly?

Appendix T

Interview 20

Name: Lars Josephsson
Title: Mechanical Engineer

Institution: Disab, Gothenburg
Date: 23-03-2022
Time: 10.20-11.00

Questions:

1. What position do you have within Disab?
2. What do you need to know from the models?
3. What kind of models do you prefer? (High or low res)
4. How long does it take for you to receive these Envelope models?
5. From whom within Volvo Penta's organization do you get information about new products?
6. To whom within Volvo Penta's organization do you send inquiries regarding 3D models?
7. When do you guys need the models compared to your development?
8. Would you like to receive models earlier but with a disclaimer?
9. Would you like to receive multiple updates with models?
10. What format do you like to receive your files?
11. Do you prefer solid models or surface models?
12. Do you receive what you ask for or has there been information lost in the process?
13. Can a sale be lost because a model has not arrived in time or been wrong/broken?
14. Have you ever received models with too much information?
15. Do you ever need a low-res?
16. Do you need 2D-models?
17. Is there something you wish to add to the current process?
18. Is there anybody from Penta that checks that you have installed their motors correctly?

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