Degree project

A model to increase profitability by ensuring a reliable flow of information within the product development process: A case study

En modell för ökad lönsamhet genom säkerställande av tillförlitliga informationsflöden i produktutvecklingsprocessen: En fallstudie

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Sammanfattning

This section contains a summary of the thesis written in Swedish.

Studies have shown it is necessary for companies active in various industries to continuously, and cost-effectively, improve their product development process, in order to stay competitive and increase profitability. Existing improvement models, e.g. Plan Do Study Act (PDSA), Define Measure Analyse Improve Control (DMAIC), Identify Define Develop Optimize Verify (IDDOV), are either too general or too specific, and none incorporates improvement of information flows. Consequently, none is suitable for improving a product development process with respect to reliable information flows. Hence, the purpose of this study is to develop a model for systematically ensuring a reliable flow of information, by identifying and solving problem root-causes in the information flow. This ensures satisfied customers, reduced costs, and increased profits. Result of the study is a model and tool, tested empirically in a case company, proved suitable for streamlining product development processes, by ensuring a reliable flow of information. Application of the model identified three problems within the information flow: language barriers, vertical organization, and lack of suitable media for communication. Solutions to the problems has been concluded on through logical reasoning and together with recommendations provides a good indication of the positive effect on profitability, which a reliable flow of information within the product development process can have.
In this section, the authors thank contributors to the thesis.

We who are the authors, two Terotechnology-students at Linnaeus University, Växjö, have written this bachelor’s thesis as our final work before graduating from the Human Resource and Industrial Management programme.

However, a work of such magnitude is not a two-man job. We have had tremendous help from a number of persons and organizations, both inside and outside of the university, to whom we now would like to extend our appreciation. Order of appearance is without importance.

Our sincerest gratitude towards:

- Our tutor, Anders Ingwald at Linnaeus University, for his guidance, inspiration, and tireless positive spirit through both ups and downs.
- Our company tutor, Bo Larsson at Gemba Consulting, for his commitment and making this study possible.
- Anna Hammarstedt at Emballator Växjöplast and Roland Engnell at Emballator Lagan Plast, for their commitment and sharing invaluable time, information, and knowledge with us.
- Members of corporate network Polymernet, for participating in interesting seminars and presentations.
- Our examiner and tutor of the first chapter, Prof. Basim Al-Najjar at Linnaeus University, for sharing his experiences and knowledge with us.
- Employees of Emballator Växjöplast and Emballator Lagan Plast participating in interviews and providing insights.
- Teachers and students who have reviewed and provided feedback of the thesis.


Henric Sjörén

Erik Thun
Key definitions

In the following list, definitions to terms frequently used in the thesis are presented. Some terms may have different meaning depending on context and it is therefore important to state which definition is used.

**Communication** – “two-way process of reaching mutual understanding, in which participants not only exchange (encode-decode) information, news, ideas and feelings but also create and share meaning” (Business Dictionary, 2014)

**Continuous improvement** – the idea that development of a product or service is never finished and can always be better (Bergman & Klefsjö, 2010)

**Cost-effectiveness** – “Relationship between monetary inputs and the desired outcome” (Business Dictionary, 2014)

**Customer** – “a party that receives or consumes products (goods or services)” (Business Dictionary, 2014)

**Data** – a collection of values of e.g. different events, activities, or transactions, which are stored without a context (Pearlson & Saunders, 2010)

**Function** – “an action performed by a device, department, or person that produces a result” (Business Dictionary, 2014)

**Information** – processed data, used in a context in which it provides value for the data consumer (Pearlson & Saunders, 2010)

**Organization** – “[…] a social system that is deliberately designed to achieve set goals” (Jacobsen & Thorsvik, 2008, p. 13)

**Process** – “[…] a network of repeated activities with the purpose of creating value for an external or internal customer” (Bergman & Klefsjö, 2012, p. 457)

**Product development process** – procedures, extending from initial idea to finished prototype of a product (Hill, 2005)

**Profitability** – an indicator of financial success in a company (Keramidou, et al., 2013)

**Quality** – ability to satisfy, and preferably exceed, the customer’s needs and expectations (Bergman & Klefsjö, 2012)
**Reliability** – the ability of an item to perform its intended function on demand without failures (Business Dictionary, 2014)

**Supplier** – “a party that supplies goods or services” (Business Dictionary, 2014)
Abbreviations

This section contains a list of all abbreviations used in the thesis.

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<th>Description</th>
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<td>3D</td>
<td>Three-Dimensional</td>
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<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
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<tr>
<td>CAD</td>
<td>Computer-Aided Design</td>
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<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
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<td>DSM</td>
<td>Design Structure Matrix</td>
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<tr>
<td>DMAIC</td>
<td>Define, Measure, Analyse, Improve, Control</td>
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<td>FTA</td>
<td>Fault Tree Analysis</td>
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<tr>
<td>ICD</td>
<td>Information Channel Diagram</td>
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<tr>
<td>ICAM</td>
<td>Integrated Computer-Aided Manufacturing</td>
</tr>
<tr>
<td>ICOM</td>
<td>Input, Control, Output, Mechanism</td>
</tr>
<tr>
<td>IDDOV</td>
<td>Identify, Define, Develop, Optimize, Verify</td>
</tr>
<tr>
<td>IDEF0</td>
<td>ICAM DEFinition for Function Modelling</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ITSS</td>
<td>Information Transfer and Specification Structure</td>
</tr>
<tr>
<td>PDCA</td>
<td>Plan, Do, Check, Act</td>
</tr>
<tr>
<td>PDSA</td>
<td>Plan, Do, Study, Act</td>
</tr>
<tr>
<td>SADT</td>
<td>Structured Analysis and Design Technique</td>
</tr>
<tr>
<td>UML</td>
<td>Unified Modelling Language</td>
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1 Introduction

This section contains a discussion and presentation of the problem and the underlying background information. Practical and theoretical relevance is presented, as is the purpose and delimitations. The section also contains a preliminary time frame for the study.

1.1 Background

Economic profits, or profitability, is a usual measurement of financial success amongst companies in today’s business environment and describes the relationship between revenue and expenses (Keramidou, et al., 2013). A high level of profitability can be achieved by increasing revenues, decreasing expenses or by combining the both (Bergman & Klefsjö, 2012). Companies active in today’s age of globalisation, characterised by intense competition, are forced to find new ways of diminishing inefficiencies in order to retain their competitive position in the market (Keramidou, et al., 2013). There are according to Alsyouf (2007) two types of competitive advantages; value and cost. Preferably, a company should possess both in order to be in the most advantageous position and such advantages can be gained in different ways. Reducing cost for utilized resources, by minimizing failures and shortages, is a possible route and can be achieved by running different kinds of process improvement projects (Bergman & Klefsjö, 2012). Enhancing customer satisfaction is also a possible way. Staying competitive is key for company survival and an organization’s success or failure is dependent on its ability to attract new and keep existing customers (Sharma & Gadenne, 2008). It is highly dependable on a company’s ability to satisfy customer needs regarding multiple factors, e.g. costs and quality (Sharma & Gadenne, 2008). Studies have shown strong correlations between high quality products, services and profitability (Sharma & Gadenne, 2008). Furthermore, Griffin & Page (1996) states customer satisfaction can be achieved by introducing new products.

McNally et al. (2011) identifies product innovation as an important component for ensuring sustainable growth in companies and it is said by Nolsøe Grünbaum & Stenger (2013) that innovation is a prerequisite for retaining competitive advantages. Griffin & Page (1996) states that repeatedly commercializing successful new products is essential for staying competitive in the market. The concept of developing new products can be identified as a process, as defined by Bergman & Klefsjö (2012, p. 457) “a network of activities, repeated in time, with the purpose of creating value for internal and external customers”. As with any other concept, it is possible to adjust and tune the product development process to reduce costs and better utilize resources. According to McNally, et al. (2011) product development is associated with high risks and failure rates, thus putting more emphasizes
on improving the product development process and ensuring its quality. By identifying success factors for development of new products, company management can ensure good financial and market performance and it allows them to venture into previously unknown business opportunities (McNally, et al., 2011).

Product development is a complex process, which can serve many purposes and achieve many goals. Even though hardships and difficulties may be encountered and the process is complex, Griffin & Page (1996, p. 480) states, “when revenue growth is desired, product development may be used as the vehicle to attract a new customer or market segment”.

1.2 Problem discussion

The importance of product development is considered to form the basis for sustainable growth and competitive advantage in companies. Still, the product development process is hard for companies to perform with successful results (Nolsøe Grünbaum & Stenger, 2013); (McNally, et al., 2011). According to Graner & Mißler-Behr (2012) the success rate of processes for new product development remains low and failure rates for newly launched products exceed 60%. Such alarming figures, combined with the amount of required venture capital, are considered a major risk for companies when conducting product development projects (McNally, et al., 2011). Consequently, it is of vital managerial concern to identify different factors e.g. time, quality and expense, contributing to successful launch of a product (McNally, et al., 2011).

Majava et al. (2013) states that product development is a cross-functional effort in which most company functions participate, not only design, marketing and manufacturing, which is a common misconception. For new products to be successful, it is important that all functions maintain high quality communication. Jespersen (2012) describes new products as a function of its development process. The process is described as a path created based on information provided in each step of the process. The impact of communication on product quality is further strengthened by McNally et al. (2011) who states information integration exhibits both direct and indirect effects on improved product quality. Information integration is explained as sharing, paying attention to, and challenging information and perspectives between team-members to generate new product insights (McNally, et al., 2011).

In order to maintain successful communication within a company there has to be a will to communicate among the different functions. Lu & Botha (2006) explain an example on how product engineers are unwilling of sharing preliminary information to process engineers due to negative feedback on their fuzzy designs. Consequently, the degree of segregation between the two functions will increase. A two-way communication is
described as essential for a continuously updated development phase with respect to solving problems as early as possible. The reverse information flow provides feedback to product designers, which in turn will evolve the product design information (Lu & Botha, 2006). However, there is a risk of distancing the final product from the original idea without dependencies in the information (Jespersen, 2012). Information permeates the entire business and is a vital part of all company processes.

There are several different models for process improvement, which main purpose is to enhance and streamline processes. Some methods can be considered general, are applicable in several different situations, and are more of philosophical nature, which advocates an approach or way of work. Other models consist of more specified stages with clearly specified tools to use within the different steps of the process (Bergman & Klefsjö, 2012). Information is an essential part of a process, regardless of which kind of process improvement model that is used. Every model relies on that the flow of information is working in order to achieve a successful outcome of the process (Durugbo, et al., 2013). However, it is not specified in any existing model how the flow of information should be handled for the entire process.

1.3 Problem presentation

There is no perfect product development process and there are always possibilities for improvement. It is therefore important to find suitable ways of conducting improvements. Models used for process improvement may be either general or specific but regardless the reliability and flow of information are essential factors to consider. Using an improvement model that disregards information may lead to sub-optimized results, as it does not account for one of the most important factors information flow and reliability. Lacking information quality may distance the product from what was intended and having a sub-optimized product development processes will negatively affect customer satisfaction, which affects profitability.

1.4 Problem formulation

How to streamline product development processes with respect to a reliable information flow?

1.5 Purpose

To develop a model for systematically ensuring a reliable flow of information within product development processes in order to satisfy customer needs and demands, streamline the process, reduce costs, and increase profitability.
1.6 Relevance

Durugbo, et al. (2013) state that information is as vital for organizations as oxygen is for human life, and it is a critical factor in determining growth of companies. Flow of information is according to Durugbo, et al. (2013) the core of the product development process. Accordingly, it is relevant to find ways for cost-effectively ensuring a reliable flow of information within in the product development process, in order to satisfy customer needs and demands, increases profitability.

Existing models for process improvement, e.g. PDSA, DMAIC and IDDOV, create a good foundation for improvement work (Bergman & Klefsjö, 2012). Some are however too general while others too specific and very few, if any, takes information flow and information reliability into consideration, resulting in repudiation of a key component. E.g., Information Channel Diagrams (ICD) developed by Durugbo, et al. (2013) provides a tool for modelling information flows but it does not consider different information parameters or reliability. It is therefore relevant to develop a model that from a holistic perspective of the product development process can describe how reliable information should flow through the process.

A literature review, available in Appendix I, was conducted to see if there has been previous research regarding reliable information flows in product development processes. No articles addressing the subject of reliable information and information flows within the entire product development process were found, which strengthens the relevance of this study as it addresses a previously un-researched area.

During this project a set of actions relevant to an industrial company, e.g. process mapping and identification of deficiencies in communication, will be performed. The developed model will allow the company to streamline the process by ensuring a reliable flow of information, which positively affects profitability. The model will be susceptible to modifications, making it applicable in other cases with similar or identical traits, which further consolidates the relevance.

1.7 Delimitation/Limitations

The result will consist of improvement suggestions in order to streamline the model further. The study will be delimited to gathering empirical data from two companies with associated product development processes. The model will be limited and adjusted to one company and analysed accordingly. However, the design of the model will be in such a way so that other companies can adjust it to fit their product development process.
The study will focus on the product development process and flow of information, and will be limited to cover the steps between identification of customer needs to complete prototype.

1.8 Time frame

*Table 1.1. Time frame*

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Seminar 1

Final seminar
2 Methodology

This section contains information about different scientific perspectives, approaches, methodologies, and strategies. It also includes information about data gathering and verification.

2.1 Scientific perspective

According to Patel & Davidson (2011) a scientific study can be conducted from different perspectives, depending on which scientific area a researcher is active within. Knowledge about which perspective is used is essential when taking part of and criticising produced knowledge, with regard to chosen scientific approach. Positivism and hermeneutics are two such perspectives.

Positivism

According to Patel & Davidson (2011) positivism has its origins in an empirical and natural scientific tradition. Positivistic researchers strive to generate knowledge positive, enriching to humanity, and receptive to human mind and senses. Positive knowledge is useful and can improve society. Patel & Davidson (2011); Bryman & Bell (2011) states positive knowledge should be based on observations and gathered facts logically provable. Positivism supports a homogenous view of science advocating all science should fundamentally be built in the same way, so called scientific monism. Knowledge should consist of general laws formed in a formal, logical, and neutral way, describing interactive relationships of causes and effects. Accordingly, positivistic hypotheses and theories are often expressed in mathematic formulas (Patel & Davidson, 2011).

Hermeneutics

Hermeneutics is by Patel & Davidson (2011) stated to be the complete opposite of positivism. A scientific perspective and interpretation where researchers study interpret and gain understanding of the founding prerequisites for human existence. It is the predominant perspective within cultural, human and social science. Hermeneutic researchers strive to gain understanding about humans and their life situations through interpreting how human existence is expressed in written and spoken language as well as in actions and manifestations. Hermeneutics is often associated with qualitative models whilst positivism is associated to quantitative models (Patel & Davidson, 2011).

This thesis aims to produce both new knowledge and understanding within and about the subject, resulting in a perspective between hermeneutic and positivistic.
2.2 Scientific approach

Researchers seek to produce theories that give as accurate knowledge about reality as possible. Accordingly, data and information about the studied part of reality is used as foundation. In science, the foundation is identified as empirical information and a researcher’s mission is to relate theories and empirical information to each other. When conducting a study there are three different approaches applicable for relating theoretical and empirical information (Patel & Davidson, 2011), deduction, induction and abduction, which will be described more thoroughly in the following sections.

**Deduction**

According to Patel & Davidson (2011); Jacobsen (2002) the deductive approach uses available theory to draw conclusions about a specific phenomenon. Previous research determines necessary relevant information and hypothesis are derived from existing theory empirically examined in a specific case. A deductive approach enhances objectivity and is to a low degree influenced by the subjective apprehensions of the individual author. A disadvantage is that use of existing theories will implicate the study in a way that created theories disregards, or does not discover new findings. (Patel & Davidson, 2011).

**Induction**

An inductive approach is according to Patel & Davidson (2011) exploratory and empirical information is gathered without regard to expectations or hypothesis. The information is systematised and used as foundation for creating a theory. The objective of the inductive approach is for the individual researcher to be able to gather any data without constrictions. A negative aspect is the lack of generalisation as theories are based on findings from one specific case with certain parameters, e.g. a certain group of people or within a certain time frame. Furthermore, researchers working inductively have own conceptions influencing the theories created, regardless the effort to be unbiased (Patel & Davidson, 2011).

**Abduction**

The abductive approach is essentially a combination of deductive and inductive approaches. Initially a hypothetic pattern explaining a specific case is formulated. This step has inductive characteristics. Following, the researcher works deductively and the hypothesis is tested in other cases. Accordingly, further development, of the original hypothesis to be more generally applicable, is possible. The abductive approach does not constrict researchers as much as other approaches, which is advantageous. A risk is however, that researchers will unconsciously study cases and formulate hypotheses based on experience, excluding alternative interpretations (Patel & Davidson, 2011).
This thesis will have an abductive approach as it uses existing theories and empirical information as basis for developing a model, which later is tested empirically.

2.3 Scientific methodologies

In order to achieve desired results from research there has to be a choice of which method to use when conducting the study. According to Holme & Solvang (1997) methods consists of qualitative and quantitative research, and a combination of the two. The choice of which method to use shall be strategically decided upon based on purpose, problem formulation and resources of the study. Previous research experience could also be considered. Each method has advantages and disadvantages making them suitable for different kinds of studies. However, it is not common both methods could be applicable for the specific study. In order to choose which method to use it is necessary to identify what the desired result of the research is (Holme & Solvang, 1997).

The different scientific methodologies are explained more thoroughly in the following sections.

Quantitative research

Quantitative research is described by Bryman (1997) as a method for gathering quantifiable information presented as a numerical value. Quantitative research is often associated with survey studies, where quantifiable data is gathered from a significant amount of individuals in order to find results representing the whole group. Another example of quantitative research is structured observations where researchers quantify information according to a set scheme (Bryman, 1997). The result of quantitative research is a conversion of given information into numbers and quantities from which statistical analysis are conducted (Holme & Solvang, 1997).

Qualitative research

The qualitative research method is characterized by being conducted close to the object of research, studying it from an inside perspective. The researcher is required to be acquainted with the situation in order to understand it from the object’s point of view (Holme & Solvang, 1997). The philosophical assumption of qualitative research methods is stated by Merriam (1998, p. 6) as “[…] reality is constructed by individuals interacting with their social worlds”. This is described as a contrast to the quantitative research method by studying experience, as different individuals perceive it, and not only numbers.
The main method for conducting qualitative research is participating observations in which the researcher gets a profound picture of the research area and its actors. Another example is unstructured interviews in which researchers has minimum amount of involvement in order to give more space to respondents (Bryman, 1997).

**Combination of quantitative and qualitative research methodologies**

It is stated by Holme & Solvang (1997) that no right research method can be used for all situations. Different methods should be considered as equal tools to gain better understanding of a specific situation, where the advantages and disadvantages of each method cancel each other out.

The combination of quantitative and qualitative research methods can be conducted in several different ways. Holme & Solvang (1997) describes two of these combinations. One combination uses qualitative research as preparation for quantitative research, where the qualitative part acts as a phase of understanding the situation. A second combination uses quantitative research as preliminary investigation to find factors to focus on for qualitative research.

The thesis will use qualitative research, based on observations and interviews, in order to analyse relationships and gain understanding regarding the current situation within the organisation.

2.4 Scientific strategies

Good research is not achievable by persistently following a set of rules. Researchers face many choices and alternatives where strategic decisions have to be made. There is no correct way but there are strategies more suitable to handle certain issues than others. A strategy should be chosen based on its suitability in solving certain problems or answer certain questions (Denscombe, 2009).

**Case study**

Case studies are according to Denscombe (2009) focused around the occurrence of certain phenomena with purpose of providing in-depth information about actions, relationships, experiences and processes existing in a certain case. Case studies allow researchers to study objects in detail, making it suitable when studying complex processes and relationships, enabling researchers to deal with a case in its entirety. The true value of case studies is, according to Denscombe (2009), the explanation as to why certain results have developed, rather than concluding which results have developed. One advantage of case studies is versatility. It allows researchers to use different types of sources, data and methods for data gathering, observations, interviews and questionnaire, making use of both quantitative
and qualitative methods. It is however hard to generalise results achieved in case studies, as they are only applicable to the specific case or cases with very similar characteristics (Denscombe, 2009).

**Experiment**

Experiment is an empirical analysis designed to examine the properties and condition of specific factors in controlled environment. Experiments are according to Denscombe (2009) the basic principle for research within natural science. Experiments are conducted in order to isolate individual factors and study them and their effects in detail with the purpose of discovering new conditions and properties or to test existing theories. Successful experiments rely on three key factors; identifying cause factors, control key variables, careful meticulous observation and measuring (Denscombe, 2009).

**Survey study**

Survey-based studies are according to Denscombe (2009) multifaceted, can be conducted in many ways and make use of multiple research methods e.g. interviews, questionnaires and observations. Surveys aim to obtain information from samples of a population and present results representative to the entire population. It is important to carefully choose sample in order to ensure results conforms to the entire population. Surveys aim to depict conditions and relations of the present in an instantaneous picture and are due to their nature suitable for both quantitative and qualitative research, however slightly more attractive to quantitative researchers (Denscombe, 2009).

The thesis will use a case study as it enables gaining in-depth information about the studied phenomena and promotes understanding of why a result has develop rather than concluding on what result has developed.

### 2.5 Primary and secondary data

According to Holme & Solvang (1997) sources of data can be described as historical documents of researchers’ knowledge and perception derived from the origin of a specific situation. Sources for data gathering are divided into primary and secondary sources. Primary sources are experiences documented directly by the researcher, e.g. through observations or interviews. Secondary sources refer to situations where data is gathered or documented by someone else and further utilized by the researcher. Examples of secondary data are information gathered from literature reviews (Holme & Solvang, 1997); (Patel & Davidson, 2011).
2.6 Data gathering

There are several different techniques for gathering data and information. The purpose of data gathering is to gain knowledge in the field of research, enabling performance of a study (Patel & Davidson, 2011). In following sections three techniques for data gathering will be explained.

Observation

Merriam (1998); Patel & Davidson (2011) describe observations as a natural behaviour of humans, performed in their everyday life. For observations to be considered a research tool it has to fulfil a purpose and not be performed on random. Merriam (1998) further explains that observations offers a first-hand experience of situations, which, combined with other data gathering techniques, offers a holistic interpretation of the research area. A participant observation, referred to as fieldwork, allows researchers to study situations and their actors in natural environment and provides information based on reality (Merriam, 1998) (Patel & Davidson, 2011).

Interview

Interviews are a technique for gathering data based on questions. According to Patel & Davidson (2011) an interview is normally referred to as personal meetings where researchers and respondents meet face to face while the respondent answer questions from the researcher. The purpose of interviews is to obtain information known by somebody else. In order to obtain satisfying results it is important that researchers conduct interviews with focus on the respondent so that they are able and willing to share knowledge. Important factors to focus on could be; anonymity for the respondent, correct formulated questions for desired results, and general motivation for the respondent to answer questions (Merriam, 1998).

Literature review

Researchers perform literature reviews in order to gain knowledge about previous research in the field; to secure the study is unique. Further, authors can gain experience in methods suitable and not suitable for a specific research area (Merriam, 1998).

Patel & Davidson (2011) describes literature as the most common source of knowledge. Examples of literature are books, published articles, documents and reports, which have suitable characteristics for different situations. E.g., books often consist of authors’ attempts to compile known information about a specific topic based on previous research in the specific area. Studying books is considered the easiest way to find fully developed theories and models. Published articles contain the latest research on the market as they are published faster than a book, making them suitable for
finding new and possibly untested models or theories (Patel & Davidson, 2011).

The thesis will incorporate observations, interviews and a literature review as measures for empirical and theoretical data gathering. Interviews and observations are suitable due to the investigative nature of the study and the literature review provides a theoretical foundation.

2.7 Data verification

According to Denscombe (2009) verification of data is of outmost importance. A researcher must be able to prove achieved results are ‘right’ and veracious. The quality of results should not be taken for granted and to be trustworthy, research has to prove that it conform to methods and approaches identified as basis for proper research. According to Denscombe (2009) there are four basic factors to consider when determining quality of research, validity, reliability, generalizability, and objectivity.

Validity

Validity refers to accuracy and precision of data and its suitability with regard to investigated research questions. According to Lincoln & Guba (1985) there is no way for qualitative researchers to prove that their results are authentic. However, there are measures that can be taken to convince the audience that results with reasonable trustworthiness are exact and precise:

- Triangulation by using and comparing multiple contrasting sources regarding the same data allows confirmation of trustworthiness.
- Validation of respondents allows researchers to revisit respondents with data and results as a way of controlling validity of results.
- Using established data and base results on empirical data gives solid foundation for drawing trustworthy conclusions.

It is not possible to give guarantees regarding validity of a study, but it is possible to ensure data has been produced and controlled following good practice (Denscombe, 2009).

Reliability

According to Merriam (1998) research reliability refers to what extent a report could be repeated with identical results, based on assumptions that there is only one existing reality with one correct answer. Accordingly, it is possible to identify studies with high reliability based on studies in the same research, by comparing if results are similar. To compare reliability between quantitative studies is easy as results often consist of numbers (Merriam, 1998). Qualitative studies are considered harder to compare as their results are affected by human behaviour, which change over time. To identify
reliability when conducting qualitative studies it is required to analyse provided information with respect to background of a specific situation, during the time of study. Consequently, it is more interesting the answer to a question is reflecting the unique situation rather than the answer being the same as last time (Patel & Davidson, 2011).

**Objectivity**

Objectivity refers to of what degree qualitative researchers can produce results without affecting them. It is a complex question, as research cannot be conducted without influence from its facilitator. Qualitative data is according to Denscombe (2009) always the product of an interpretation process. It is important for qualitative researchers to have an open mind and rather try to falsify their results than verifying them. This can be done by accepting data not conforming to analysis and by controlling contradicting explanations or solutions (Denscombe, 2009).

**Generalizability**

According to Bryman & Bell (2011) quantitative researchers often want to state results can be generalized, thus not being confined to the particular studied case. It is said by Denscombe (2009) that such statements often are met with doubt and questions how it is possible to make generalisations based on small amounts. Another term for generalizability is external validity, which is defined by Lincoln & Guba (1985, p. 291) as “the approximate validity with which we infer that the presumed causal relationship can be generalized to and across alternate measures of the cause and effect and across different types of persons, settings and times”. Accordingly, a study made form a sample would be general to an entire population (Lincoln & Guba, 1985).

According to Lincoln & Guba (1985) there are problems when studies consider both validity and generalizability as they are in a trade-off situation. Controls implemented to ensure validity are opposed by generalization. Lincoln & Guba (1985) argues that due to contradictions the question should be re-focused from generalizability to transferability. Transferability requires knowledge about context regarding the studied object and the object on which result will be applied. In order for transferability to be possible, it is necessary to consider the representativeness of objects and identify their defining factors in order to compare and see if they conform to each other (Lincoln & Guba, 1985).

**2.8 Our research**

The thesis will have its foundation in a case study with abductive research approach made from a perspective between positivistic and hermeneutic. The developed model will be based on existing theories and empirical
information, and following development tested empirically in a case company. The study will be conducted with quantitative research methodology as formulated problem is of such characteristics. Literature search will been used for gathering theoretical information in form of relevant books and scientific articles, which will aid in solving the problem. A literature review will be incorporated in order to confirm relevance of the study and shed light on previous research within the field. The study will use scientific literature and interpretations made during observations and interviews, in order to gain new knowledge and understanding within the subject.

Validity of the study will be ensured by criticism and reviews from supervisors, an examiner, and opponents acquainted with the thesis. Confirming information by triangulating different sources and conducting the study at two companies will emphasize validity. High reliability will be achieved by consulting persons with understanding and know-how in the studied area. Objectivity will be emphasized, as the authors possess neither previous connection to the case companies, nor have any financial ties to the work or results of the study. Developing a model applicable in other plastic producing companies’ product development processes with similar characteristics, as described by the authors, will ensure generalizability and transferability of results.

An illustration of the research approach is presented in Figure 2.1.

![Figure 2.1. Our research](image-url)
3 Theory

This section presents necessary theoretical concepts and methods used in the thesis in order to solve the formulated problem.

3.1 Process: Theoretical description

According to Rentzhog (1998) processes refine objects into results and are defined by Bergman & Klefsjö (2012, p. 457) as “[…] a network of repeated activities with the purpose of creating value for an external or internal customer”, e.g. manufacturing of products. Raw material is acquired and transformed into a result, through a series of activities and mechanisms. A number of factors can characterize a process. It has beginning and end, customer and supplier, it consists of a chain of ingoing activities, it produces value-adding results, and it is repeated in time (Rentzhog, 1998; Bergman & Klefsjö, 2012). The purpose of each activity is to satisfy its customer with minimal use of resources e.g. time, energy and information. Within companies, processes are often divided into three categories: main, support and management processes. Product development is an example of a main process, which purpose is to create value for customers in order to create revenues for the company (Bergman & Klefsjö, 2012). Processes are often depicted as mechanical but according to Bergman & Klefsjö (2012) it is a question of teamwork and collaboration between humans, including exchange of information, which should be emphasized as most improvement opportunities exist within administrative work (Bergman & Klefsjö, 2012). Process owners are appointed by management in order to facilitate process improvement, development, and has strategic responsibility of the process and making sure the process flows with as little friction as possible (Bergman & Klefsjö, 2012).

3.1.1 Process flowchart

Understanding of processes is important before attempting to improve them and can be gained by using flowcharts (Bergman & Klefsjö, 2012). Flowcharts provide graphical description of the process flow that is easy to understand, even for complex processes (Rentzhog, 1998). Flowcharts allow users to define and map processes and are of great value in improvement work as it provides participants with a common platform to work from (Bergman & Klefsjö, 2012). Flowcharts can be depicted different ways and shapes. Rentzhog (1998) advocates use of the American National Standards Institute-standard (ANSI), as it provides a common language and facilitates communication. A graphical description of some of the most common shapes and their meaning is presented in Figure 3.1.
3.1.2 The customer/supplier model

The customer/supplier model presented by Rentzhog (1998) advocates customer focus, i.e. customers legitimize the process and consequently should be affecting its contents and results. “To understand the actual needs of the customer, how these can be satisfied and to what degree you are successful are necessary questions in order to succeed with process management” (Rentzhog, 1998, p. 27). To gain understanding about customer needs it is rarely enough to just ask. Active collaboration with customers should be established where both parties discuss results and what the customers hopes to achieve. Continuous feedback enables process improvement and further satisfaction of customer needs (Rentzhog, 1998). The model is presented in Figure 3.2.

3.1.3 Product development process

Hill (2005) explains product development processes as procedures, extending from initial idea to finished prototype of a product. Successful product development processes consists of seven steps before the final product can be produced: generating ideas, screening ideas, feasibility study, preliminary design and development, testing prototypes, market sensing and testing target markets, and final design. The process is described as sequential, but still contains reiteration as each stage of the process generates questions and feedback to one or multiple previous stages. Feedback is important in order to clarify and resolve newly detected issues within product development (Hill, 2005).
Handfield & Lawson (2007) presents a similar description of the product development process, consisting of five stages: idea generation, business/technical assessment, concept development, engineering and design, and prototype testing. Handfield & Lawson (2007) also include full-scale production as final activity, which is not considered a separate stage. Jespersen (2012) also describes product development as sequential but simplifies the process by using the five stages: idea, concept, design, test, and launch. This process is presented in Figure 3.3.

![Figure 3.3. Product development process (Jespersen, 2012)](image)

Product development processes can include parallel processes and are then referred to as integrated product development or simultaneous engineering. It is a cross-functional view based on ideas where marketing, product development, and production, act as separate actors within product development processes. Each actor is connected to specific functions performed in parallel with functions for other actors. E.g. during design phase, marketing actors conduct market research, product development actors produce a preliminary product design, and production actors decide on production principles (Bergman & Klefsjö, 2012).

According to Bergman & Klefsjö (2012) product development creates opportunities for achieving higher product and process quality to lower cost. It is described that cost of changes in products is a function of time, i.e. the cost of changes in a product increase the longer the product development process progresses. This is illustrated in Figure 3.4.

![Figure 3.4. Cost of changes during a product development process](image)
In addition to the benefits of cost reduction, Bergman & Klefsjö (2012) also emphasize the importance of product development processes due to shorter lifecycles in modern products. Shorter lifecycles limit the possibility of making successive improvements for already launched products, unless modified products are launched as new products. Products need to be tested more thoroughly before entering the market in order to be profitable already from the launch (Bergman & Klefsjö, 2012).

### 3.2 Plan Do Study Act

Bergman & Klefsjö (2010, p. 43) states “anyone who stops improving soon stops being good”. The reason is explained as a consequence to customers increasing demands along with new technological solutions and business activities. Continuous improvement involves the idea that development of a product or service is never finished and can always be better. However, it is not necessarily quality of the improvement object that should be increased. Other improvement factors could be reduced price, increased availability or reduced resources used for production (Bergman & Klefsjö, 2010). A common symbol of continuous improvement is the PDSA cycle, which is illustrated in Figure 3.5.

![Plan Do Study Act cycle](image-url)

The Plan Do Study Act (PDSA) cycle, also known as the Deming cycle, is an approach for continuous improvement work. According to Hill (2005) the approach uses a series of linked activities to identify opportunities. The model was developed by W. Edwards Deming, based on the Shewhart cycle, as a tool for continuous improvement within processes. It describes how work in all kinds of processes should be performed with the steps Plan, Do, Study and Act. The cycle was previously referred to as the PDCA cycle where the C stands for Check, but Deming changed this in 1990 as he
considered Study to be a more suitable description of the step (Evans & Lindsay, 2001).

The cycle starts with Plan, which involves studying of the current situation and describing the process with its associated factors, e.g. inputs, outputs, customers and suppliers. It also contains identification of problems and development of solutions. The plan is implemented in the Do stage, first conducted at a trial basis in order to secure that it provides satisfying results. In the Study stage it is determined if the trial plan is sufficient and if it contains deficiencies, which results in recommendation of new solutions for the Do stage. In the final stage, Act, changes becomes standardized and implemented as the new current best practice. However, the cycle is never-ending and should be conducted over again in order to find new deficiencies within the process (Evans & Lindsay, 2001; Bergman & Klefsjö, 2010).

3.3 Information quality & flow

To describe the importance and use of information it is necessary to understand the concept of data and its connection to information. According to Pearlson & Saunders (2010) data is described as a collection of values of e.g. different events, activities, or transactions, stored without context. Information is created data is processed and used in context in which it provides value for the data consumer. Wang et al. (1995) describes data as raw material for producing information.

Information quality

Information quality is defined by Kenett & Shmueli (2014, p. 3) as “the potential of a data set to achieve a specific (scientific or practical) goal by using a given empirical analysis method”. The definition is based on the connection between data and information described in the previous section, i.e. the quality of information is a direct reflection of the data from which it has been produced. Furthermore, Strong et al. (1997) states information quality and data quality can be used synonymously due to that deficiencies in data will result in information shortcomings. However, high quality data does not guarantee high quality information, as it is a matter of context. With this clarification, Strong et al. (1997, p. 104) defines high-quality data as “data that is fit for use by data consumers”. The definition is further explained in four different categories: intrinsic, accessibility, contextual, and representational. Intrinsic data quality refers to the accuracy, objectivity and believability of the data. Accessibility in data quality refers to make it accessible to the right person with the desired security. The contextual category refers to data that is relevant, complete, value adding and delivered on time with a correct amount. Representational refers to the interpretability of data and its ease of understanding, as well as having a concise and consistent representation (Strong, et al., 1997).
Information flow

Information flow is described as the main core of all processes, e.g. product development, and flows between multiple connected or related actors by a set of structural and behavioural rules (Durugbo, et al., 2013). Information flow refers to communication of information between different actors, dependent on accessibility of information resources and occurs in verbal, written, or electronic form. Organizational information flow involves four kinds of actors: individuals in an organization, organizational departments, other organizations, and the environment of an organization (Durugbo, et al., 2013). According to Petkova et al. (2005) the function of an information flow is to deliver required information to the right person at the right time. The flow can be fed forward and backward depending on what information it contains, e.g. feedback is described as an essential tool for product improvement (Petkova, et al., 2005). Information is stated to be a critical factor for growth and prosperity in profit-driven organizations.

Reliability in information and information flows

The term reliability refers to the ability of an item to perform its intended function on demand without failures (Business Dictionary, 2014). Thus, reliability with respect to information seeks to retain high quality information. As stated by Pearlson & Saunders (2010) the intended function of information is to increase the knowledge for a data consumer, which demands high information quality. If the information is not complete, contains deficiencies, or is not accessible on time it is not considered to be high quality and consequently cannot perform its intended function (Strong, et al., 1997).

Information systems and the human role in information flows

Information systems are defined Murthy, et al. (2010, p. 3) as”[...] a set of organised procedures that, when executed provide information for decision-making, communications, and/or control of the organisation”. Information systems use hardware, software and people as resources to process input and output, for storage and control of data transforming activities. Information is a vital resource to any firm and information systems are designed to satisfy information needs within organisations. Its purpose is to make sure information fulfils requirements of quality, timeliness, completeness and relevance (Murthy, et al., 2010). Information flows through the organisation in different forms, e.g. verbal, electronic or written, and is an interaction between sender and receiver. Within organisations, information is often exchanged between individuals, departments, and organisations or between organisations and its operating environment (Durugbo, et al., 2013). Information can be exchanged in different ways, through different media and be supported by different tools. Information systems can act as media and support the exchange of information within organisations (Murthy, et al., 2010).
3.4 Tools for modelling function relationships

According to Dorador & Young (2000) concurrent engineering have intense exchange of information in early stages of product design, e.g. regarding resources, products and processes. To evaluate and improve information exchanges, it is important to model and present them (Dorador & Young, 2000). Two modelling tools available are Integrated Computer-Aided Manufacturing Definition for Functional Modelling (IDEF0) and Design Structure Matrix (DSM), presented in Sections 3.4.1 and 0.

3.4.1 ICAM Definition for Function Modelling

ICAM Definition for Function Modelling (IDEF0) was derived from the graphical language SADT (Structured Analysis and Design Technique) (Kim & Jang, 2002). The model was presented in the 1970s as ICAM (Integrated Computer-Aided Manufacturing) and developed a suit of different definitions. One of these definitions is the IDEF0, where 0 stands for activity or function modelling (Sturdy, 2010; Dorador & Young, 2000).

Sturdy (2010, p. 50) defines IDEF0 as “a method designed to model the decisions, actions, and activities of an organisation or system”. It works on the principle of transforming process activities by using some function. According to Dorador & Young (2000) it can be conducted in two different embodiments: ‘as is’ or ‘as should be’. The ‘as is’ model is used for analysing the current state of the system while the ‘as should be’ model present a model of the desired state. The later could be used for setting up strategies for improvement work.

Each step of the model consists of one activity, or function, along with four different interfaces: inputs, outputs, controls, and mechanisms (ICOMs) (Ang, et al., 1997). Inputs are described as “parameters that are altered by the activity”, e.g. data or material; Controls refer to “factors that constrain the activity”; Outputs are the “results of the activity” and Mechanisms refer to the resources or “means used to perform the activity”, e.g. people or machines (Kim & Jang, 2002, p. 123). The graphical elements of IDEF0 consist of boxes and arrows, where boxes represent the activities while arrows represent the ICOMs (Sturdy, 2010). An example of IDEF0 is presented in Figure 3.6.
3.4.2 Design Structure Matrix

Design Structure Matrix (DSM) is a technique to binary present relation between two activities, each activity exemplified by a row of input relations and a column of output relations. By re-arranging rows and columns, transferring the activity relations below the diagonal, it is possible to find activities that are, or can be, conducted parallel, sequential or coupled (Cronemyr, et al., 2001). Examples of such activities are illustrated in Figure 3.7.

A process flowchart depicting inputs and outputs within the different process steps is used for making the matrix. DSM can map, visualize, and simulate complex development processes and the exchange of information.
within the process from a holistic perspective. X’s in the matrix indicates what output of an activity is necessary as input to other activities, boxes indicates planned iterations the company recognizes as repeating and O’s are unplanned iterations (Cronemyr, et al., 2001). It is possible to assign weights to indicate strength and dependency between different activities (Cronemyr, et al., 2001; Eppinger, 2001; Yang, et al., 2014). An example DSM is presented in Table 3.1.

Table 3.1. Design Structure Matrix (Eppinger, 2001, p. 151)

It is said by Cronemyr, et al. (2001; Eppinger, 2001; Maheswari, et al., 2006; Yang, et al., 2014) DSM can be used successfully for simulating and quantifying results of process development and improvement, as a technique for evaluating the impact of different process improvement alternatives.

3.5 Cost-effectiveness and profitability

Keramidou, et al. (2013) identifies economic profits as an indicator of financial success in a company, being profitable denotes that incomes exceed expenses. However, being profitable alone does not show level of financial performance. In order to measure and evaluate performance it is necessary to compare results to investment. This gives comparability over time and it is possible to financially evaluate projects and investments regardless of their nature. Profitability is often defined as:

\[
\text{Profitability} = \frac{\text{Results}}{\text{Invested capital}}
\]

Sullivan, et al. (2012) states that since financial patterns can differ widely between projects and companies there is no one method for performing profitability analysis. Consequently, multiple methods are accepted for
calculating profitability, e.g., Present Worth, Future Worth, and Internal Rate of Return. Key performance indexes applicable for showing profitability in companies are Return on Equity and Return on Investment. A term closely knit to profitability is cost-effectiveness, described by Al-Najjar (1997, p. 21) as “cost-effectiveness, $C_e$, of each improvement may be examined by using the proportion of the difference between the long run average cost per unit time before, $(B)_a$, and that after the improvement $(B)_b$, to the $(B)_b$, i.e.

\[ C_e = 1 - \frac{(B)_a}{(B)_b} \]

[...] Thus, $C_e$, can be considered as a measure of the cost-effectiveness of improvements”.

3.6 Fault Tree Analysis

Fault Tree Analysis (FTA) enables systematic breakdown of a problem, idea or need into different levels of constituents. FTA is a form of tree diagram and essentially an example of the “Five Why” technique. Focus is put on a problem and for each level the question ‘Why’ is asked until root causes of the problem are discovered, to discover the root causes one should ask ‘Why’ five times (Bergman & Klefsjö, 2012). FTA can be used for prioritization as it is possible to assign weights to the different causes, indicating how much the individual cause affects the problem, and for decision-making by implementing gates, e.g., AND, OR. An example of FTA is presented in Figure 3.8.

![Fault Tree Analysis](image-url)
FTA is according to Bergman & Klefsjö (2012) applicable for:

- Breaking down customer needs of a product.
- Investigating problem root-causes.
- Investigating milestones that have to be achieved for achieving greater goals.
- Decision-making.

3.7 Checklists: Theoretical description

Wilson (2013, p. 2) defines checklists as ”predefined lists of guidelines, tasks, questions, or other items against which products, processes, behaviours, tasks […] are compared”. Checklists may be used for different reasons e.g.:

- Evaluating products or processes against predefined criteria.
- Verifying if steps within a process has been completed properly.
- For defining requirements and design in development processes.

Checklists are often easy to use and require very little training, output is immediately usable and does not require further interpretation, and are also easily customized depending on which parameters the user wants to incorporate. Simplicity may however be negative in some cases as checklists can be argued to be too general and lack context. It is also hard to create checklists that account for all possible or necessary parameters (Wilson, 2013).

3.8 Organization: Theoretical description

Most people have a perception of organizations as companies, hospitals, or schools. The essential factor for groups to be considered as organizations is that participants strive towards common goals with set procedures or guidelines for achieving them (Jacobsen & Thorsvik, 2008). The term organization has its origin in the Greek word organon, which translates as a tool or an instrument. With regard to the word’s origin Jäverberg & Taravosh (1997, p. 72) define an organization as “[…] a tool to reach set goals”. A more specified definition is given by Jacobsen & Thorsvik (2008, p. 13) who define an organization as “[…] a social system that is deliberately designed to achieve set goals”. The definition consists of four central parts: social, system, deliberate design, and reach goals. Social refers to that organizations consist of people acting together. System refers to the organizations dependence of external resources and dependence of customer’s willing to pay for its products or services. Deliberate design means that organizations are intentionally designed to solve problems in the most effective way. Reach goals refers to the fundamental part of the
organization, to solve the underlying problems for which the organization originally was founded.

3.8.1 Organizational goals, visions and strategies

Stated purpose of organizations is solving specific problems or fulfilling some kind of function. To achieve this it is necessary to clarify where to focus and how this should be obtained. Goals, visions and strategies are used to fulfil the organizations purpose. (Jacobsen & Thorsvik, 2008).

Organizational goals are described as desired outcomes of what to be achieved in the future. Goals should be tangible and realistic with associated time frame in which they should be obtained. The origin of organizational goals should be directly connected to the organizations purpose. Purpose is a description of the fundamental existence of the organization, e.g. in which social functions the organization should fulfil or what differentiate them from other organizations (Jacobsen & Thorsvik, 2008).

The organizational vision is located in between organizational goals and purpose. A vision is described as the ideal future situation for the organization. It should be conducted as a long-term idea and do not have to be as realistic or obtainable as an organizational goal. An example of a vision is the Vision Zero, which is a Nordic road traffic safety project that strives for zero casualties in road accidents (Jacobsen & Thorsvik, 2008).

The connection between organizational goals, visions and purpose is illustrated with a goal hierarchy in Figure 3.9.

![Figure 3.9. Goal hierarchy (Jacobsen & Thorsvik, 2008)](image-url)
Organizational strategies are a description of how to obtain specified goals. There are two kinds of strategy categories: generic and resource-based strategies. The generic strategy focuses on how an organization positions itself in comparison to its surroundings and the resource-based strategy focuses on internal factors within the organization (Jacobsen & Thorsvik, 2008).

3.8.2 Organizational structures

Organizations can be structured in various ways but the most common organizational structures are line and matrix organizations.

Line organizations

A line organization is considered to be the oldest organizational structure and can be constructed in different ways based on, e.g. function, market, or division organizations. Content varies depending structure but basic principles are the same. The structure is a hierarchical pyramid where business management, generally the CEO, is positioned on top. Underlying positions reflect degree of authority on personnel within the organization. Breakdown of these steps depend on how it is constructed, e.g. in a function organization business management is followed by different function managers within the organization, e.g. sales, human resource, economy, and construction (Jäverberg & Taravosh, 1997). An example of a line organization is presented in Figure 3.10.

Matrix organisations

The matrix structure of organizations were created for combining advantages of both functional and division organization structures, joining effectiveness of functional structures with flexibility and sensitivity of divisional structures (Hatch, 2002). Matrix structures are not limited to a combination of functional and divisional structures; combinations can be made in any way that is desired (Jäverberg & Taravosh, 1997).
Matrix structures can also be implemented when conducting different projects including cross-functional contributors. Projects are defined by Bergman & Klefsjö (2012, p. 508) as a “unique process, consisting of a number of coordinated and controlled activities with start and finish dates, initiated to achieve a goal that meet specific requirements, including constraints of time, costs, and resources”. Purpose of a project structure is solving cross-functional problems within organizations. It is a possible approach for structuring product development (Jäverberg & Taravosh, 1997). An example matrix structure of project organisation is presented in Figure 3.11.
4 Model development

In this section, the developed model and tool are presented, containing information about theoretical inspiration, an in-depth explanation of the model and a suggested approach for model application.

4.1 Model introduction and theoretical inspiration

Problem formulation of this study focus on improving product development processes by ensuring reliable flow of information. Information is stated to be an essential part of processes and every process improvement model relies on well-functioning flow of information. Regardless, previous models do not cover how a reliable flow of information should be structured, e.g. the PDSA cycle is a general model of how to work with continuous improvement, but it only defines which stages that should be included in a process. DMAIC takes it one step further by adding a stage and defining how each stage can be implemented. The IDDOV model breaks it down even further by splitting stages into smaller steps. Still, these models lack specifications on how to ensure a reliable flow of information between the different steps.

The developed model strives to streamline a product development process from an information flow perspective, in order to ensure a reliable flow of information. Product development processes tends to differ from project to project within a company or between companies. Consequently, the model has been designed with a general layout to make it applicable for a higher number of companies and processes. Companies are able to adjust the model, as to which tools to use, in order to make it suitable to their specific process.

As stated by Bergman & Klefsjö (2011) cost-effective continuous improvements are critical for companies in order to remain competitive. However, product development processes are defined as sequential, ending when final design of the product is specified. The developed model approaches this by implementing cost-effective continuous improvement between different product development projects. By identifying deficiencies and obstacles within the information flow of a process, it is possible to improve these for upcoming development of future products. The developed model is described further in Section 4.2, and illustrated in Figure 4.1.

A tool has been developed in order for companies to make fully use of the model. The tool strives to facilitate structuring and specifying information transfers within product development processes. It is designed in a way that makes it easy to both use and understand to make it applicable for as many companies as possible. A further presentation of this tool is provided in Section 4.3, and illustrated in Figure 4.2.
4.2 Model presentation

Product development is conducted through projects and is consequently not a continuous process, e.g. the production process. Regardless if a process is continuous or recurring it requires improvement to maintain effectiveness. The traditional improvement model PDSA has been incorporated with the developed model to allow improvement of the product development process, from project to project. The model is used as an improvement process alongside the product development process, thus some steps may be shared. The model is presented in Figure 4.1 below.

Figure 4.1. Model for ensuring a reliable information flow
Step 1: Plan and document process

The product development process is general and has predefined steps that are always present. Nevertheless, no product is the other alike and accordingly there is need of process adjustment in each individual development project. First step of the model is to plan and document the product development process, including information flow, for the individual project. This step could be included in the improvement and product development process, to ensure all actors and functions has their information needs satisfied. Taking into consideration external factors e.g. management decisions, demands of information security, information in external systems, company goals and policies etc. It is vital planned information flow considers previous improvement suggestions. Clear documentation and planning of processes and information flows provide structured and systematic ways of working, necessary in complex cross-functional processes.

There are different functions within product development processes e.g. sales, maintenance, construction, operation etc., represented in companies as departments or individual persons. Within product development processes, they form a chain of functions, placed sequentially or in parallel. In the chain, functions act as suppliers, customers or both, meaning they receive information from previous function(s) and transmits information to following one(s).

Supplier outputs, transmitted information, should fulfil information needs of receiving function(s), which enables them to perform their tasks with highest performance possible and in the most effective way. This type of relationship should be present between all functions active within the product development process, it is important in- and outputs are clearly specified and documented in the process plan. It is important the planned information flow is available in a visual format.

Step 1 is the foundation for how to structure information flow in the product development process and foundation of what to strive for in the improvement process.

Step 2: Observation of product development process

First step provide plan and structure for how information should be transferred within the product development process. Information parameters are defined and information flow specified. Thus, second step of the improvement model is observing the actual information flow within the product development process. The purpose is to keep track of the information flow with regard to how it was planned and if information was up to par with needs and requirements, which is documented and used for evaluating the process. Observation of the process in reality sheds light on
aspects or factors, which may have been overlooked when forming the original process and information plan.

Observations are made by all functions participating in the product development process, regarding individual function’s experience of the information flow and if received information was according to specification. It is done in a clear and easy to understand format, which can be composed and interpreted quickly. It is important observations exclude experiences and perceptions of transmitted information as it may cause a wrongful assessment of reality.

All observations regarding the actual information flow are compiled and documented.

Step 3: Evaluation of information flow

Documentation gathered during observation is analysed in order to visualize the actual information flow during the process, illustrating the information flow in reality. After observing the process, the information flow is evaluated in order to discover flaws or miscommunication between functions.

The planned and actual states of the information flow are compared so that any deviations or problems within information flow and quality are identified. Doing visual comparisons provides clear and easy way of identifying and highlighting problematic areas. The visualization technique used shall be easy to work with in order to keep time spent to a minimum.

One person, preferably project manager, using the function’s observations and planned flow as foundation, shall perform evaluation. Observations concurring with the planned flow and specifications shall be communicated back to the affected functions as positive feedback. Observations not concurring shall be investigated further.

Step 4: Identification of problem root-causes

When problems are identified it is necessary to investigate the root-causes behind the problems. This is crucial in order to see where focus shall be placed and where improvements can be implemented as problems may have multiple underlying root-causes. When all root-causes has been identified it is important to assign weights or numerical values to them to see which of them is of highest importance or has the most impact on the problem.

Problem root-cause investigation shall be conducted in a structured way by all involved functions and it is important that all root-causes are fully investigated. The investigation shall also include prioritisation of the root-causes showing which has the highest impact on the problem.
Simplicity, usability, and speed are key and therefore it is advocated to take a visual approach to this step.

**Step 5: Determination of suitable improvement(s)**

Based on identified root-causes there shall be suggestion of suitable improvements, considering identified information needs of affected function(s), cost-effectiveness, and profitability. If investment is needed, benefits have to be cost-effective and conform to company goals. A plan for improvement implementation should also be concluded upon.

Suitable improvements shall be decided upon by discussion between involved functions. It is important to have collaboration between all involved functions so that improvement covers the entirety of the problem.

Improvements that are suggest for implementation shall be documented in a comprehensive way, including a plan for how improvements can be implemented in coming projects, and made available to future project groups.

**Step 6: Implementation of improvement(s) in next process**

As the process is recurring and not continuous, suggested improvements are implemented during the next product development project. Following the plan and implementing the identified improvements into Step 1 of the new project enhance areas that were previously lacking. In this way it is possible to work with improvements continuously, even with a non-continuous process.

The implementation plan shall be available to all new project groups and be used in the process and information flow planning in future projects.

### 4.3 Information Transfer and Specification Structure

Information Transfer and Specification Structure (ITSS) is incorporated in the first step of the improvement model. It is a tool, developed by the authors, applicable for specifying and transferring information in a structured format. The tool has been created with inspiration from the customer/supplier model and IDEF0. IDEF0 is used due to its simplicity in illustrating in- and outputs and external factors. However, it does not consider relations between functions, which is crucial. ITSS utilizes strong points of IDEF0 together with the relationship advocated by the customer/supplier model. This creates a tool suitable for structuring and specifying information flows, considering needs and requirements of individual functions, within the product development process. An illustration of the ITSS is presented in Figure 4.2.
ITSS is applicable for the entire product development process, structuring information transfer for individual process functions. Number of functions and feedback iterations within processes can vary; however, there is always a first and a final process function. Each process function has one of three roles: customer, supplier, or both, i.e. receiving information, transmitting information, or both. The functions communicate by transferring information through inputs and outputs, specified by four parameters:

- **What** – should the transfer contain, e.g. requirement specifications, cost calculations etc.
- **How** – to transfer, electronically, verbally, written. Different file formats etc.
- **Where** – to transfer, person, department, company etc.
- **When** – to transfer, at a specific time, when a certain condition is fulfilled etc.

It is advocated by the authors that supplier information outputs be specified in collaboration with customers.

Information is also affected by external *Controls*, e.g. demands on information security and quality, decisions made by the board or management and also conformity to company goals and policies. It is also affected by *Mechanisms*, e.g. personnel, external information as in blueprints or sales information available in different systems and improvements decided upon after previous processes.

Each time customers receive information from a supplier, feedback regarding information is sent back to the supplier. The feedback states if
received information fulfilled the customer’s needs regarding the specified parameters, what, how where and when.

4.4 Approach for model application

A suggested approach for use of the model within a product development project is presented as support for incorporating suitable tools and work methods. By making use of adequate tools for each step of the model it is ensured work will be conducted systematically and each step will produce a beneficial foundation for following steps to work on. A suggested approach for model application is illustrated in Figure 4.3.
**Step 1: Plan and document process**

A suitable tool for planning and documenting a process is Information Transfer and Specification Structure (ITSS). It provides a systematic approach for identifying and specifying four parameters crucial for information transfer: Where, When, How and What. The tool is implementable for all functions within the product development process and it incorporates factors e.g. external information sources, previous experience, corporate goals and policies. ITSS also makes use of feedback loops between functions during the process. During observations it has been identified that a tool advocating a horizontal way working is needed.

There are multiple ways for visualising the planned information flow, e.g. Unified Modelling Language (UML), Flowcharts and DSM. However, DSM is the only one showing what functions should iterate with each other and in what way, receiving or transmitting information. It also shows if iterations are planned or unplanned, using a simple interface.

**Step 2: Observation of product development process**

Second step is observation of the information flow within the product development process and documenting if it performs as intended. Checklists provide an easy and fast way to document whether information fulfil needs and requirements or not with regard to defined parameters. Checklists should be distributed to and filled in by each function within the product development process.

Checklists should be designed as a series of Yes/No question based on a set of parameters decided upon in Step 1, followed by a short space for additional comments if necessary. Questions should be based on documentation from the planning step and only take into consideration experience of received information for an individual function.

**Step 3: Evaluation of information flow**

Checklists are compiled and analysed in order to show how the information flow has been in reality, then compared to how the information flow was planned originally, highlighting discrepancies or faults in the flow. DSM is a tool applicable for visualizing the information flow in a clear way. By compiling data from checklists into a DSM it is possible to in a clear way see how the information flow looked like throughout the process. Comparing a planned DSM to one reflecting the actual information flow gives good indication of miscommunication and problems in the information flow.
Step 4: Identification of problem root-causes

Identified problems must be investigated further to identify root-causes. A good way to work with identification of root-causes in a structured way is tree diagrams. It provides a structured approach to breaking down problems into smaller constituents and allows for prioritization and rating of impact for each root-cause. This is essential for picking the root-cause with most potential of improvement.

Step 5: Determination of suitable improvement(s)

When root-causes are identified, it is possible to determine suitable improvements. Improvements should be concluded on by cross-functional discussions with all involved functions in order to come up with a solution fulfilling the needs of all stakeholders.

A plan for implementation of the chosen improvement should be formed including information about the underlying root-cause, where it was identified, the affected functions and how it could be solved. The plan should be short and concise, but depending on nature of the improvement a more in-depth plan may be necessary. Improvements should be formed in a general manner, for applicability in other projects.

Step 6: Implementation of improvement(s) in next process

The implementation documentation is used as external input during the information flow planning of future projects.
5 Empirical findings

This section contains a brief description of the two case companies and their product development processes.

5.1 Emballator

The Emballator Group has its main core in packaging and consists of seven companies within different industries. The business concept is to offer packaging solutions with added value in knowledge, experience, innovation, and service. All companies within the Emballator Group are independent with separated operations, but all strive towards a common goal: To become the leading family-owned packaging group in Northern Europe. The companies’ joint core values are summarized as durability, development, dedication, and simplicity.

The Emballator Group is owned by Herenco, which is a family-owned company with an annual turnover of about 3 billion SEK and has a total of 1700 employees. Besides Emballator, Herenco has business operations in five areas, including publishing of local newspapers and development of graphic services. Herenco’s core values include ethics, local presence, economic efficiency and entrepreneurship, and long-term customer relations.

5.2 Lagan Plast

Lagan Plast develop, produce, and market plastic buckets and cans for food and chemical products. Lagan Plast has one plant located in Ljungby, centrally in southern Sweden, and three sales offices located in Finland, Norway and England. The plant in Ljungby is certified according to ISO 9001, 14001, and 22000 (quality, environment, and food safety). Furthermore Lagan Plast also meet the requirements of Normpack, which is a system for self-monitoring of products and material intended for use in contact with food. Empirical information at Lagan Plast has been gathered through a discussion-like interview with the Chief of Development and observations.

5.2.1 Goals and vision

The company conducts continuous improvement in their everyday work with ambition to supply the market’s best packaging solution. Focus is on quality and environment, which are explained as equally important and one cannot exclude the other. E.g. a product with high quality but bad environmental impact is considered unapproved, and vice versa.
Lagan Plast operate with a Lean philosophy to achieve maximum cost-effectiveness in production. As a step the collected knowledge of all employees is utilized for eliminating all types of waste and problems. The purpose is to increase production using the same amount of resources by implementing smarter ways of working.

5.2.2 Product development at Laganplast

Lagan Plast has an in-house product development department that allows developing of packaging solutions in close collaboration with the customers. Regular meetings with designers, engineers and product designers are conducted along with product developers representing the customer’s organization. The purpose of product development is both to improve the quality of existing products, as well as develop new products. Some products are customer-specific, but Lagan Plast still owns the design, i.e. all product specifications belong to the company. Lagan Plast uses both internal and external product designers, and work in a 3D CAD environment. Necessary tools for manufacturing are built in-house, which shortens the development of new products significantly.

5.2.2.1 Product development process

Emballator Lagan Plast performs product development in projects or works depending on magnitude of time and monetary investment needed. Missions have timeframes shorter than 8 weeks and costs below 100 000 SEK. Projects have timeframes longer than 8 weeks and costs 100 000 SEK or above. Working methods for development projects are standardised in order to ensure high quality performance regarding precision, cost-effectiveness, and delivery security. A flowchart describing the general product development process is presented in Figure 5.1.

![Documented product development process, Lagan Plast](image_url)
Pre-study

Chief of Development or management group initiate pre-studies by conducting current state analysis, a simply way to see differences between actual and desired state. Stakeholders affected by the project or its result, are identified, and classified as Core, Primary, or Secondary stakeholder for easier mapping of information dependencies. Furthermore, business benefits are surveyed and pre-calculations are made concerning project effects on corporate results. Lastly, requirement analysis is performed, and combined with previous steps produces a documented requirement specification, which is the pre-study’s end result.

Plan

Chief of Development or management group creates a temporary project organization, project group and assigns project manager. If needed, a reference group of project stakeholders are also appointed. Furthermore, a time and resource plan is created, budget is calculated and determined. A communication plan with set appointments is created and if needed, communication schedules can be established as well. Additionally, a risk analysis is conducted and a plan for changes is established, to better facilitate changes during the project. Lastly, a documented project plan is formed as end result.

Perform

The perform step consists of four phases, each followed by a tollgate for deciding to continue or terminate the project. Each phase has sub-processes and is iterative, last step in each phase is evaluation. If not approved, and depending on failing aspects, sub-processes are repeated until approval is reached.

Phase-out

Upon completion results of the project are delivered to customer, on time. Project evaluation is initiated by comparing requirement specification with result and pre-calculations are compared to post-calculations to determine actual costs. The project method is evaluated to facilitate internal improvement of the method in future projects. The project manager composes an end report as a final activity before the project organization is disbanded.
5.2.2.2 Information flow in documented product development process

DSM has been used to depict information flow present in the documented product development process, presented in Appendix II. Table 5.1 shows the exchange of information between different steps in the process.

Table 5.1. Design Structure Matrix documented process Lagan Plast

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5.3 Växjöplast

Växjöplast develop and produce caps and enclosures for leading brands in the world, with focus on the Nordic countries. The plant is located in Växjö, in southern Sweden. The production premises have classifications for both food and medical supplies and the plant is further certified according to ISO 9001, 14001 and 22000 (quality, environment, and food safety). Växjöplast have a yearly turnover on about 100 MSEK and about 50 employees. Empirical findings at Växjöplast has been gathered through multiple discussion-like interviews with Account Manager, Development Engineer and the Chief of Development and Construction and observations. The authors have proposed a subject for the interview and then held a discussion between the participants.
5.3.1 Goals and vision

Växjöplast strives to produce products that attract new customers for their clients. The company seeks long-term customer relationships through innovative thinking and close collaboration with customers. These collaborations expect to result in smart, user-friendly, and appealing designed caps & enclosures for all sectors of the market. Växjöplast strives to keep growing and remain one of the greatest Nordic suppliers of enclosures. Focus lies on customer needs with security and quality as the number one priority.

5.3.2 Product development at Växjöplast

Växjöplast holds the longest experience in the Nordic countries for development of caps. The work extends from concept ideas to finished product. The product development process is divided in two parts. The form, functionality, and user-friendliness must be guaranteed first in order for the product to be attractive for the consumers. The next step is making the production process cost-effective, repeatable, and safe. To attain a high quality product development process, Växjöplast has a construction unit with experience of how to succeed in designing and developing caps and enclosures. A successful product development process will result in a product that fulfils requirements in identity, functionality, and sales.

5.3.2.1 Product development process

![Flowchart of product development process, Växjöplast](image)

*Figure 5.2. Documented product development process, Växjöplast*

The flowchart presented in Figure 5.2 is a simplification of the product development process described in Appendix III. Following below is an explanation of the flow.
Plan

Received prospects or identified possibilities are examined and approved or declined. Upon approval Sales has a briefing of the new product, which is the foundation of the project. Sales also create project plan specifying requirements, activities, and responsibilities. Following is preparation work in the different departments, also including preliminary product design:

- **Product development**, 3-D model is created to show design.
- **Purchasing** of third-party material
- **Quality**
- **Production**

Preparation work and product development are examined and used as basis for calculating and concluding on final quotation. If customer approves quotation, an order is placed and project starts.

Perform

Projects are initiated by establishing the previously created project plan during launch meetings. Construction of the product is finalized, then reviewed, and approved by customer and also reviewed internally. Further, the four previously mentioned departments perform different project activities. Assembly and tool testing is performed through process test order and later tested in zero-series production.

Phase-out

Upon successful zero-series involved department chiefs in the project group turns the project over to production, which starts series production. Lastly, projects are evaluated internally and externally.
5.3.2.2 Information flow in documented product development process

DSM has been used to depict information flow present in the documented product development process, presented in Appendix III. Table 5.2 shows the exchange of information between different steps in the process.

*Table 5.2. Design Structure Matrix documented process Växjöplast*

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<tr>
<th>ACTIVITY</th>
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</tbody>
</table>

- **X** Information flows
- Planned iterations
- Planning phase
- Performing phase
- Termination phase
MODEL TESTING

6 Model testing

In this section, the model is empirically tested in a case company according to the different model steps. The model is applied in a previously performed product development case, conducted by the case company. Step 6.1 is not performed by the authors as the case company has already performed this step.

6.1 Step 1. Plan and document process

The general process used in product development projects is illustrated in a process flowchart presented in Appendix III. However, documents regarding the specific case will not be presented, as it is ongoing and thus kept secret.

Ideally, all documentation regarding the project and its information, e.g. plans, flowcharts, structures, specifications, and communication, is available in the improvement process. Documentation is compiled and presented visually, to enable comparison in following steps by using DSM.

Due to lack of documentation and the incorporation of general process flowchart, it may be assumed that results will be improvement suggestions in general, rather than for the specific case.

6.2 Step 2. Observation of product development process

Regardless how well documented and planned information flows are it is necessary to observe and experience them in reality, to map actual information flows and find areas of improvement. For the specific case, interviews has been conducted with project members as the authors could not participate during the project. Interviews reflects the members’ general experience of received information during the project. To cover the entirety of the product development process interviews has been conducted with persons presented in different stages and with different areas of expertise, including account manager, development engineer, and chief of construction & development. Each interviewee stated stages of the product development project in which they were involved and how they experienced the information. Interview results are presented as a checklist in Table 6.1.

Interviewees were asked questions regarding four information parameters.

- What – Was received information the needed information?
- How – Was received information delivered in a desired way?
- When – Was information received at the desired time?
- Where – Was received information delivered to the correct person?
Table 6.1. Checklist of information flow experiences

<table>
<thead>
<tr>
<th>Position</th>
<th>What</th>
<th>How</th>
<th>When</th>
<th>Where</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Construction</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Development</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

‘Yes’ indicates information fulfilled needs and requirements, ‘No’ indicates lack in the specific parameter. As can be seen Sales has one No-answer, Construction none and Development two. However, answers only consider internally transferred information and neglects external customer interactions.

Ideally, checklists should be filled in after each step of the product development process to form a sound foundation to base improvements on. Unfortunately, it was not possible in this case as most steps had already been performed. Consequently, modifications were made and checklist of the general information flow in addition with results of more investigative interviews were used to illustrate the actual information flow presented in Section 6.3.

6.3 Step 3. Evaluation of information flow

The actual flow of information within the specific case project, chosen for this study, has been mapped through interviews with personnel involved within the project. Interviewees representing the company were the chief of construction & development, accounting manager, and development engineer.

Interviews were conducted based on the documented process presented in Section 5.3.2.1. The original activities were adjusted to reflect the interviewees’ perception of the actual case project, i.e. activities conducted during the case project, not included within the documented process, were added to the information flow. Accordingly, the original 17 activities were increased to 27, including an individual entry for the chief of construction & development. It was concluded by the authors that the role held by the chief of construction & development pervades all phases and are of such significance that it required an individual entry. All added activities are listed below:

- Pre-study report
- Intern brief of project
- Extern project start-up
- Create time plan
- Create blueprint
- Test-tool
- Create tool report
- Material planning
- Production planning
- Chief of Construction & Development

The specific case project was currently ongoing, thus not all activities had been conducted at the time of study. Consequently, five activities were not possible to analyse during the interviews:

- Tool & assembly testing
- Zero-series production
- Hand over to production
- Series production
- Project evaluation

### Table 6.2. Design Structure Matrix actual process Växjöplast

| ACTIVITY                        | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Pre-study report                | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Prospect                        | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Briefing new product            | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Intern brief of project         | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Create project plan             | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Extern project startup          | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Create Time plan                | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Create Blueprint                | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Test-tool                       | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Create tool report              | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Preparation work                | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Pre quotation                   | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Calculations                    | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Final quotation                 | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Project launch                  | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Construction of product         | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| External & internal construction review | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Project activities              | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Material planning               | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Production planning             | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Pre Testing                     | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Tool & Assembly testing         | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Zero-series production          | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Pre manufacture production      | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Series production               | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Project evaluation              | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Chief of Construction & Development | O |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

6.4 Step 4. Identification of problem root-causes

By analysing the DSM presented in Table 6.2 it is concluded the product development process is sub-optimized due to unreliable information flows and consequently in need of improvements. To determine root-causes it is needed to further investigate the problem. When root-causes are identified, it is possible to conclude on suitable improvements. Observations and
interviews has been used to create a FTA of the identified problem, breaking it down into root-causes. Weights can be added to problem root-causes in FTAs to identify where most focus for improvement is needed. The authors have chosen not to implement weights to identified root-causes as it is considered to demand a deeper investigation in the subject. Weights applied without further investigation are assumed to affect reliability of this study negatively and are consequently left out. Interviews and observations has been used to conclude on the most significant problems and logical reasoning and discussion has been used for problem breakdown. The same applies to solution FTAs in Step 5 as well. Following in Figure 6.1, Figure 6.2, and Figure 6.3 is a presentation of the root-cause breakdown.

Unreliable information flows can be caused by two factors, bad information quality or bad communication. Information of high quality has to conform to three factors, correct information to correct destination at correct time. Consequently, bad quality means failure in one or more factors.

Figure 6.1. Fault-tree analysis of problem root-causes
Incorrect information

Customer or developer supplies information used in the product development process either externally or internally. Documentation supplied by the customer, e.g. requirement specification, technical blueprints, may be incorrect or insufficient leading to high costs, if changes has to be made later in the product development process. Another factor affecting information correctness is language barriers, between customer and developer or internally in the developing company. A factor related to internal language barriers is lack of knowledge, or differences in knowledge, in different company departments, e.g. sales, construction, production, quality, and environment. Sales and environment departments may not be acquainted with terms used by construction, and vice versa.

Not on time

Regardless if information is correct or not it needs to be available on time. Not having information on time slows down the process and may cause unnecessary costs. Information may be delivered late due to lack of time caused by tight time schedules or high workloads. It may also be the case customer must approve before the process can go further.

Incorrect destination

Information may be correct and on time but it does not matter if delivered to wrong destination, e.g. person, department, organization. Unclear specifications, roles, or authorities may cause wrongful deliveries.
Bad communication refers to deficiencies in transferring information between actors within processes. Underlying reasons for unreliable information flows due to bad communication are identified in three categories: lack of cross-functional understanding, lack of communication policies and protocols, and insufficient media for communication, and presented in Figure 6.3.

Personnel working in cross-functional processes must understand how their individual function contributes to the final result. Processes are chains of functions connected to some extent, i.e. changes in individual functions might affect others as well. Thus, improvement changes in functions within processes must be made with consideration to potential effects on other functions. Lack of collaboration between functions lead to vertical organizations with multiple individual functions, which acts on their own. As a result of lacking cross-functional coordination, changes are made regardless of potential effects in other functions, causing problems previously non-existing. Furthermore, miscommunication can be a result from lack of feedback. Improvements cannot be performed if processes are not evaluated and problems identified. However, feedback can be given but neglected by the receiver due to professional pride.
Lack of communication policies and protocols

Structured policies and protocols for communication within a company are used for having unified ways of working. Lack of communication policies and protocols might lead to several individual solutions in structuring information and consequently, hampering information absorption.

Insufficient media for communication

Communication must be transferred through some kind of media or event, e.g. information system or meeting. Communication is performed in several ways and the media used must be suitable to its purpose. Using an information system not suitable for the specific information transfer could result in deficiencies in communication. Meetings are common events for communication but are time consuming. Arranging meetings for big project groups are hard, as the schedule must consider all involved actors. High workloads and tight time schedules complicates the coordination of meetings further more.

6.5 Step 5. Determination of suitable improvements

FTA of two root-causes is created to determine suitable improvements; observations and interviews have been used to conclude which root-causes to focus on. Often, one root-cause is enough to identify improvements but language barriers and vertical organization permeates each other, thus both were chosen. However, improvements for language barriers does only account for internal issues. In addition, the authors want to emphasize the importance of using suitable media for communication. This suggestion will not be broken down in a FTA as it is deemed superfluous.

Erasing language barriers in the organization can be done in two ways: increasing personnel’s knowledge in other functions or establishing clear rules for communication. FTA of how to erase internal language barriers is presented in Figure 6.4, and how to discard vertical organizations is presented in Figure 6.5.
Erase Language barriers

**Increase personnel knowledge in other functions**

- Increase knowledge demands on new-hires
- Create documentation of company functions

**Establish clear rules for communication**

- Establish cross-functional communication protocols/templates
- Cross-functional education period for existing personnel
- Cross-functional introduction period for new employees

---

**Figure 6.4. Fault-tree analysis of how to erase language barriers**

**Increase personnel knowledge in other functions**

By increasing knowledge in other functions, e.g. sales familiarizing with construction or production, departments and persons get more acquainted with other’s terminology. The same terms may be used by different functions but with different meaning and one way of solving such problems is to get familiar with all meanings. Increased knowledge can be achieved by either increasing demands on new-hires or education of personnel. Documentation of different functions within the company and their purpose can be used for educating personnel in adjacent functions. Other possibilities is to provide cross-functional education to existing personnel or cross-functional introduction to new employees, e.g. a new construction engineer spends some time and all departments before assuming the position for which he or she were employed. Same example could be made for existing personnel.
**Establish clear rules for communication**

By establishing clear rules for communication it is possible to steer the way personnel interact, thus avoiding misinterpretations or miscommunication caused by language barriers. Protocols, templates and policies, defining and describing how communication should be conducted cross-functionally in organizations, are possible ways for controlling how personnel interact across functions and ensuring it is done correctly.

Discard vertical organization and working towards a horizontal is the other advocated solution, it too has two possible routes. Vertical and horizontal, or line and matrix, organizations are described in Section 3.8.2. FTA for this solution is presented in Figure 6.5.

**Increase cross-functional collaboration**

To increase cross-functional collaboration it is important personnel learn they are part of a chain of functions and should not identify themselves as individuals. Each link is related to and affects the chain and as always, a chain is not stronger than its weakest link. To ensure employees grasp this concept it is advocated to implement an internal customer/supplier philosophy as presented in Section 3.1.2.

Another possible solution is to educate personnel in adjacent functions, showing how functions are connected to others. By doing or observing work
done by other functions, information received and transmitted, making them aware of how they affect the result of others. There are three ways advocated for educating personnel, documentation of company functions, cross-functional education for existing personnel, and cross-functional introduction period for new personnel.

Conduct projects cross-functionally

Product development is a cross-functional matter, thus it is important to conduct product development projects as such. For successful product development projects it is important to make resources available and coordinate them. Before making resources available it is necessary to identify needed resources for the specific project, e.g. amount of time needed, personnel, and costs. The identified resources then needs to be planned and made available at the appointed time. Cross-functional projects require co-ordination of resources to ensure success. Accordingly, organizations should appoint cross-functional project teams and appoint a designated project manager.

6.6 Step 6. Implementation of improvements in next process

The model application has been conducted with Step 1 based on a general product development process. Consequently, some identified problem root-causes, and associated solutions, are general and too extensive to be applicable in a single process. Suitable solutions for implementation at the case company needs to be more specified and detailed before they can be applicable. The subject requires more investigation and the result of this model testing should be seen as a guide for the company, providing information on potential areas of improvement. Identified improvement areas are: language barriers, vertical organization, and insufficient media for communication.
7 Results

This section contains the results from both model application and general results of the study.

7.1 General study results

Main result of this study is the developed model, which has been tested for improving reliability of information flows in a product development process. Application of the model has shown possibility of streamlining a product development process by systematic breakdown of information flow problems into root-causes. Solutions to identified root-causes leads to increased customer satisfaction and profitability in projects. The developed tool, ITSS, incorporated in Step 1 of the model has shown proficiency in structuring information transfer, even though it was not implemented as intended. Other tools suggested have proven suitable and has contributed to the model with simplicity and visualization, as intended. Purpose of the study was to develop a model for systematically ensuring a reliable flow of information within product development processes in order to satisfy customer needs and demands, streamline the process, reduce costs, and increase profitability. This has been proven possible, though costs and profitability has not been possible to present in monetary values.

7.2 Results of model application

Model application showed the case company has problems with unreliable information flows in their product development process. Further investigation showed it could be contributed by two factors: bad information quality and bad communication. These factors were broken down further to identify multiple problem root-causes, from which language barriers and vertical organization was been identified as most significant. In addition to the identified root-causes an additional problem were recognized as suitable improvement area: insufficient media for communication. The significance of each improvement area, on the information flow, was identified through observations and interviews with personnel in different functions of the product development process. The result is presented below, in Table 7.1.

Table 7.1. Significant root-causes

<table>
<thead>
<tr>
<th>Root-cause</th>
<th>Observations</th>
<th>Sales</th>
<th>Construction</th>
<th>Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language barriers</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
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<tr>
<td>Vertical organization</td>
<td>High</td>
<td>High</td>
<td>High</td>
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<tr>
<td>Insufficient media for communication</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>None</td>
</tr>
</tbody>
</table>
RESULTS

Different solutions to the identified root-cause were determined through logical reasoning based on knowledge from observations and interviews, and are presented in Table 7.2 and Table 7.3, including possible benefits and downsides.

Erase language barriers

Table 7.2. Solutions to erase language barriers

<table>
<thead>
<tr>
<th>Solution</th>
<th>Possible benefits</th>
<th>Possible downsides</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increase knowledge demands on new-hires</td>
<td>No monetary investment needed and will increase personnel competence in long-term</td>
<td>Hard to find competent personnel and may bring demands on higher salary</td>
</tr>
<tr>
<td>2. Create documentation of company functions</td>
<td>Increased cross-functional awareness in personnel</td>
<td>Requires monetary investment and there is no guarantee personnel will read the information</td>
</tr>
<tr>
<td>3. Cross-functional education period for existing personnel</td>
<td>Increased cross-functional awareness in personnel and increased competence without needing to hire new people</td>
<td>Time consuming and requires that personnel have a willingness to learn</td>
</tr>
<tr>
<td>4. Cross-functional introduction period for new employees</td>
<td>Increased cross-functional awareness in personnel and increased competence</td>
<td>Requires longer introduction period for new personnel</td>
</tr>
<tr>
<td>5. Establish cross-functional communication protocols/templates</td>
<td>Unified structure for communication between functions and reduces chance of misconceptions</td>
<td>Time consuming and reduces freedom of employees</td>
</tr>
<tr>
<td>6. Establish cross-functional communication policies</td>
<td>Shared rules for communication between functions</td>
<td>Reduces freedom of employees and no guarantee personnel will conform to policy</td>
</tr>
</tbody>
</table>
**RESULTS**

*Discard vertical organization*

*Table 7.3. Solutions to discard vertical organization*

<table>
<thead>
<tr>
<th>Solution</th>
<th>Possible benefits</th>
<th>Possible downsides</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Create documentation of company functions</td>
<td>Increased cross-functional awareness in personnel</td>
<td>Requires monetary investment and there is no guarantee personnel will read the information</td>
</tr>
<tr>
<td>2. Cross-functional education period for existing personnel</td>
<td>Increased cross-functional awareness in personnel and increased competence without needing to hire new people</td>
<td>Time consuming and requires that personnel have a willingness to learn</td>
</tr>
<tr>
<td>3. Cross-functional introduction period for new employees</td>
<td>Increased cross-functional awareness in personnel and increased competence</td>
<td>Requires longer introduction period for new personnel</td>
</tr>
<tr>
<td>4. Implement internal customer/supplier philosophy</td>
<td>Requires no monetary investment and enhances in/outputs between functions. Cross-functional awareness is also improved</td>
<td>Requires commitment from all personnel, which may be hard to achieve</td>
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<tr>
<td>5. Identify required resources &amp; plan use of resources</td>
<td>Optimized use of resources and reduced risk of overburdening personnel</td>
<td>Requires extra planning</td>
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<tr>
<td>6. Create cross-functional project teams</td>
<td>Easier planning personnel and increased cross-functional collaboration</td>
<td>Requires re-structuring the organization</td>
</tr>
<tr>
<td>7. Appoint designated project manager</td>
<td>Increased project coordination and increases efficiency in resources used</td>
<td>Cost of hiring new personnel</td>
</tr>
</tbody>
</table>
RESULTS

Usage of suitable media for communication

Large project groups and many projects conducted simultaneously require suitable media for communication. During model application it can be seen that meetings is the only planned point for information exchange. This requires physical presence and is hard to co-ordinate with larger project groups, which results in fragmented meetings and wry spreading of information. Persons who lack this information seek to compensate by interacting with others who has it, thus disturbing them in their work. This problem can be avoided by relying on other media for information transference, e.g. various information systems, e-mail, intranet communication. However, this is associated with sizeable monetary investment.

Summarized results of model application

Application of the model has resulted in multiple possible solutions. Some have direct effect on reliability in information flows whilst others have an indirect effect as they concern the organization. Majority of suggested improvements extend beyond project limits but some improvements are directly affecting the investigated case project, e.g. Solution 6 & 7 in discarding vertical organization, and are believed to greatly affect profitability and required time of the project. A reliable information flow will streamline the product development process, enhancing product quality, reducing required time for development, and reducing costs. These factors have a positive influence on the profitability of the company.

Neither benefits nor downsides have been associated with costs or financial gains. It is recommended the case company conducts cost analysis of the possible solutions before implementing them.
8 Conclusions and Recommendations

This section contains conclusions of the study and an answer to the formulated problem question. Criticism towards the developed model, suggestions for future research and recommendations to the case companies based on the results, will be presented.

8.1 Conclusions: Solving the formulated problem

The formulated problem for this thesis is *How to streamline product development processes with respect to a reliable information flow?* The problem is solved by developing a model for systematically ensuring a reliable information flow while satisfying customer needs and demands, streamlining the process, reducing costs, and increasing profitability.

To identify underlying root-causes for problems in information within product development processes it is important to have a clear view of how an optimal process would proceed. Striving to achieve the optimal state of information flows will in theory result in improvements and elimination of problems. Accordingly, the model has its basis in planning and structuring information within processes. Identifying desired information flows, for specific cases, provide foundations for conducting improvement work within processes.

Planning and structuring information within product development processes is facilitated by the authors with the developed tool ITSS. It is a tool developed to visualize and simplify structuring of information specifications. In combination to the developed model it is a powerful, yet user-friendly, tool for providing a clear view of a desired process information flow.

Structured plans must be followed up in practice to get a result of differences between theory and actual process flow. By adding checklists between functions answering *Yes* or *No* if planned state of information is achieved, the model identifies areas of deficiencies within the process. It further provides holistic views of information flows within processes, clearly visualizing potential problems.

Problems identified within companies may be superficial and caused by underlying reasons concealed to companies. Approaching problems without knowing its cause is ineffective and costly. The model systematically breaks down problems into root-causes to identify focus areas for improvement. As problems often can be solved in multiple ways, the model systematically breaks down solutions as well to find solutions suitable for both specific cases and different companies.
CONCLUSIONS AND RECOMMENDATIONS

Continuous improvements are stated as the foundation for successful companies. Sequential non-repeating processes, e.g. product development, needs continuous improvements as well but require a different approach. Consequently, the model approach this by documenting improvements for usage in future projects, i.e. learn from previous experiences of similar processes.

In conclusion, the model provide a user-friendly step by step approach, which can be used by most companies for structuring information flows within product development process. Following the steps using suitable tools will provide a clear view on the information flow within a specific process with identified problem areas. Implementation of identified solutions to problem root-causes will result in reliable information flows, and further reducing costs and increased profitability.

8.2 Criticism of the model

Regardless of its many strong and positive characteristics, the developed model has some weaknesses that users has to be aware of and consider. Suggested tools may have alternatives with similar functions, which may be more suitable for some certain areas or factors. By choosing these tools for this thesis the authors aim to maintain high generalizability of model application amongst organizations within the specific area.

Lastly, reliability of data used for evaluation may be questioned. Evaluation is based on personal experience, thus it may be biased depending on personal relationships or preconceptions. Consequently, interviews conducted in this thesis have been done separately so that interviewees does not affect each other’s answers.

8.3 Future research

Suggestions for future research is to further investigate possibilities for ensuring reliability in data used for evaluation. In addition, investigation of other tools possible to use in the model could be done. However, the model should be tested in its entirety before making any bigger changes, implementing it in full scale may shed light on other possibilities of future research.

It may also be interesting to investigate how use of information systems affect information flow quality and reliability in product development processes.
8.4 Comparison of case companies

The study has been performed abductively based on observations at two case companies with many similarities, but also differences. This section contains declaration of aforementioned similarities and differences, to enable comparison of the two companies.

The companies are active in the vicinity of each other, both geographically and production wise, but products differ quite a lot even though production techniques are similar. One company produces a majority of standardized products whilst the other produce customer unique, which result in some differences between their product development processes, as can be seen in Figure 5.1 and Figure 5.2.

Regardless, the biggest difference is in the approach to product development. Emballator Lagan Plast executes product development in a seemingly methodical and structured manner. Each step of the process is meticulously specified and visualized in flowcharts etc. They have adopted the LEAN-philosophy and it permeates the product development process as well.

Växjöplast is quite the opposite. They are seemingly unstructured and relies heavily on individual competences to solve situations as they arise. Documentation of the product development process is scarce.

Despite their differences, they are both successful companies and strong competitors in their markets. The developed model were tested at Växjöplast and a full-scale implementation of the model is believed to result in a streamlined product development process much like the documented process at Lagan Plast.
8.5 Recommendations

Our recommendation to the case company, Växjöplast, to erase language barriers, discard their vertical organization structure, and use a suitable media for communication, by implementing the solutions presented in Section 7.1. However, it is advocated to perform a cost-analysis before implementation to make sure solutions are cost-effective. The authors recommend the company to fully implement the model in upcoming product development projects.

Following in Table 8.1, is a DSM of how information flow in a project could look like with all solutions implemented, based on a combination of processes at Växjöplast, Lagan Plast, and existing theories.

Table 8.1. Design Structure Matrix, recommended improvements

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Each phase during the process has a corresponding team, which is responsible for the quality of work in their activities, handing over the best quality possible to next team. Teams consist of people with competence in activities of their specific phase and co-ordinated by a project manager whose task is to make the project flow with as little friction as possible. The project manager is present throughout the entire product development project until it is handed over to the production phase, where the industrialization & production team starts their work. Upon hand over, the entire product development project is evaluated and possible improvements are identified, to be implemented in upcoming projects.
9 References

Books:


Articles:


REFERENCES

Websites:


## Appendix I: Literature review

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Appendix II: Lagan Plast Product development process
Appendix III: Växjöplast Product development process