Speeding up Development Projects' Investment Decisions in a Fast-Changing Environment

Master's thesis in Quality and Operations Management

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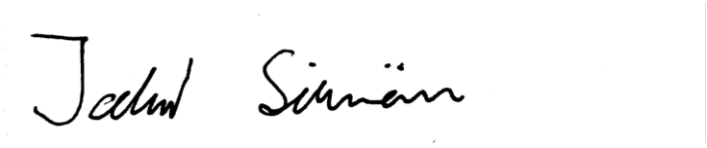
Preface

This master's thesis was written at the Department of Technology Management and Economics at Chalmers University of Technology. This study is the result of a collaboration with Volvo Cars and we want to thank them for their support throughout the entire process. We also want to express our gratitude to all the interviewees that were willing to participate, without them this study would never have been possible. Lastly, we want to thank our two supervisors Magnus Lindh from Volvo Cars and Professor Lars Trygg from Chalmers University of Technology, for their aid and guidance throughout the spring of 2022.

We want to extend our deepest gratitude to everyone who helped us make this thesis possible.

THANK YOU



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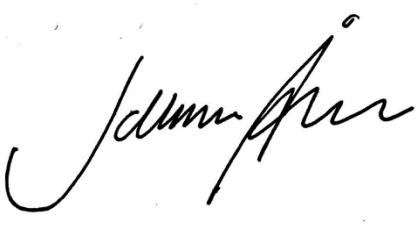

Johanna Åberg

Abstract

The importance of quick improvements of products and processes is growing more important as markets move faster each year. In order to ensure that product offerings are competitive, improvements of products and processes need to be launched quickly, which requires fast development and resolute decision-making. Development projects with respect to products and processes need to proceed fast to provide decision-makers with enough basis to bolster managers' risk-taking regarding given decisions. In autumn 2020 Volvo Cars began looking into a radical new process for constructing body structures. The new manufacturing process entailed casting large parts of the body in aluminum instead of traditional stamped and joined steel sheets. This project was named "Mega casting" and had the potential to improve both manufacturing efficiency and cost significantly. The mega casting project quickly developed and reached the stage of board of directors' decision significantly faster than comparable development projects. The aim of this study was to explain how investment decisions in development projects can be taken quickly from examining how the mega casting investment decision could be taken so quickly in comparison to other development projects of similar impact at Volvo Cars.

A three-stage method was employed starting with an initial data collection of formal documentation and initial interviews. This was followed by a survey to quantify the importance of the initial findings. Lastly, a secondary round of interviews was conducted to deepen understanding in key areas regarding speed.

31 success factors enabling the speed of the mega casting investment decision were identified from initial interviews. Based on the survey result eight of these were further investigated in secondary interviews. The results showed that the mega casting quickness was a result of many interrelated individual, organizational, economic, and strategic factors. From the mega casting project, the most impactful success factors enabling the speed of development projects' investment decisions were:

- Project gave advantages to all essential departments
- Project aligned with strategic ambitions
- Large size and impact of the project
- Newsworthiness and innovativity of the project
- Continuous and transparent communication with management
- Well-constructed development team
- Supportive managers
- Fast follower project of industry influencer

Beyond these findings it also emerged that the mega casting project differed from other development projects at Volvo Cars. Differences were found in the workflow, both of foregoing frameworks and devoting full-time to a single project, as well as the investment decision relying on longer-term factors. Lastly, agile workflow within the mega casting project was examined, however, no conclusive evidence for agile workflow affecting the speed of the mega casting project was found.

Keywords: investment decisions, development project, process development, product development, development project speed, decision making, strategic decisions, mega casting, giga casting.

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1. Introduction

In the modern economy, companies must continuously become more efficient and technically sophisticated at a faster rate than ever before. The automotive sector has long been a global leader in pushing organizational boundaries and has been responsible for the development of many management theories. Pressured by ruthless competition for ever improving quality and cost cutting, actors in the automotive industry are in dire need of quick and decisive decision-making. This is particularly relevant today as electrification and self-driving cars have resulted in several new actors from China and the rest of the world e.g., Tesla. Despite this need for quick innovation and improvement, many long standing actors have become conservative with radical innovation plagued by bureaucracy and organizational inefficiency. This study will analyze and try to explain how development projects' investment decisions can be taken quickly in practice through a case study of one particular actor.

1.1 Background

Tesla, in their "Battery Day" 2020, presented how the company had started to cast a large part of the body structure in a single aluminum piece, instead of the traditional stamped and joined steel sheets (Tesla, 2020). Volvo Cars promptly investigated this change in manufacturing and started a project named "Mega casting" to evaluate the feasibility and advantages of also performing these kinds of mega castings of aluminum (M. Fermér, personal communication, 2022). The mega casting project is a joint product and process development project. This since the project involved a new rear floor product as aluminum mega cast and required a new manufacturing process of automotive body structures. The mega casting project required several stages to actualize. First it had to be evaluated to see if the idea had any merit, and if it was found to be lucrative then the individuals working on it had to decide if they wanted to try actualizing the project. The mega casting project required major investments in new machines and tools, therefore senior managers had to agree to such an investment decision which required convincing such managers. The investment decision was crucial, or the process could never be implemented, nor the product produced. After the investment was approved by the board of directors, the mega casting project continued into the implementation stage. The mega casting project is a tremendously impactful change in manufacturing affecting many departments such as manufacturing, research and development (R&D), procurement etc.

1.1.1 Mega casting in practice

Automotive body structures globally, as well as for Volvo Cars, have traditionally been constructed into complex geometry out of many stamped and joined sheets out of steel or aluminum (M. Fermér, personal communication, 2022). Mega casting is a high pressure die casting operation where molten aluminum is quickly injected into a mold under high pressure. Casting large body parts is a revolutionary new means of manufacturing in the automotive

industry. The proposal is to cast the rear floor for future Volvo models. Volvo Cars has during the last decades become experts and industry leaders in high strength steel alloys, which makes the switch to malleable aluminum a significant disruption in industry trends.

The main financial advantage in such a development is the reduction of many individual parts, all which must be purchased, stockpiled, transported, joined, and assessed for quality which can all be replaced with one large cast part (Volvo Cars, 2021). This causes a major simplification of manufacturing and assembly as fewer tools, steps, and less labor is needed, leading to an overall cost saving. Casting technology also presents new possibilities in design freedom as casting enables more complex geometry and individualized optimization as restraints of re-using stocked smaller parts is eliminated. Upsides also include a simplification of the supply chain since raw material is the only needed input eliminating many unnecessary suppliers and their associated transaction costs and allows for better oversight further upstream. The switch to aluminum also enables significantly higher material utilization since cutoffs and other material waste can be recycled through re-melting. Lastly, the switch also has positive potential to reduce environmental impacts and improve sustainability of production, through using recycled aluminum as source material (Volvo Cars, 2021).

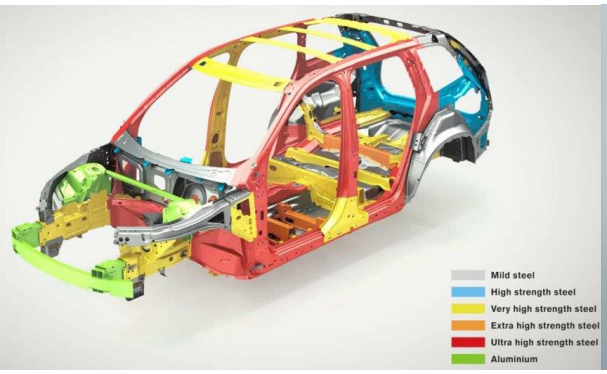

Figure 1. Traditional body structure built up by primarily stamped steel parts steel frame.

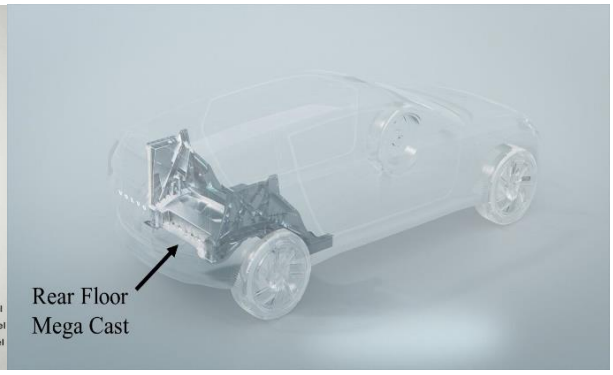

Figure 2. Example of mega cast rear floor structure

While casting metal objects in molds, such as aluminum, is a well-known and studied subject, the novelty of mega casting is the sheer size of the cast object. This large scale casting aims to cast rear floors upwards of $2m^3$ weighing approximately 60kg which poses new challenges in pre- and post-treatment as well as tooling (Volvo Cars, 2020 B). Casting the rear floor as one aluminum part will replace approximately 100 steel parts and lowers the rear floor weight by about 10-15% (Volvo Cars, 2020 A). Big enough casting machines have, until recently, been the limiting factor and were unexplored before Tesla's announcement.

1.1.2 Volvo Cars' workflow

The case company, Volvo Cars, is a Swedish original equipment manufacturer with a long history of producing high quality products since the mid-early 1900s. The company has a global

presence with around 38 000 employees globally where of 21 000 in Sweden. The company has a revenue of around 263 billion sek per year (Volvo Cars Group, 2020). Volvo Cars produces premium cars with a focus on safety and comfort and is one of the world's best known automotive brands. Volvo Cars pride themselves on producing the safest cars in the world and has often considered safety their top priority.

Formal guidelines for how development projects at Volvo Cars should be performed are governed by a specific stage-gate framework called Global Technology Development System (GTDS) where certain milestones must be achieved. GTDS brings ideas for new developments from the first stages to ready concepts in order to start implementing them in automobiles, over a normal timespan of two to three years (P. Nyström, personal communication, 2022).

The investment framework at Volvo Cars exists to govern different types of investments in the plant, aimed at providing a model of what stages are required for an efficient investment process. The framework is divided into two different types of investments: Product investments, which are directly attributable to a specific product, and Non-product investments. There are several differences between the two investment types e.g., non-product investments are not associated with any direct revenue and product investments often have a predetermined end of life. Larger non-product investments often require more time for convincing managers, anchoring the idea and getting funding, since it normally does not generate a positive business case (U. Sarge, personal communication, 2022). The time duration for the anchoring stage in weeks is an estimate based on senior experience from the authors of the framework, however, the total required time duration for both product and non-product investments are uncertain. The anchoring process is performed through a series of communication and development cycles where the idea is slowly accepted and understood by senior management.

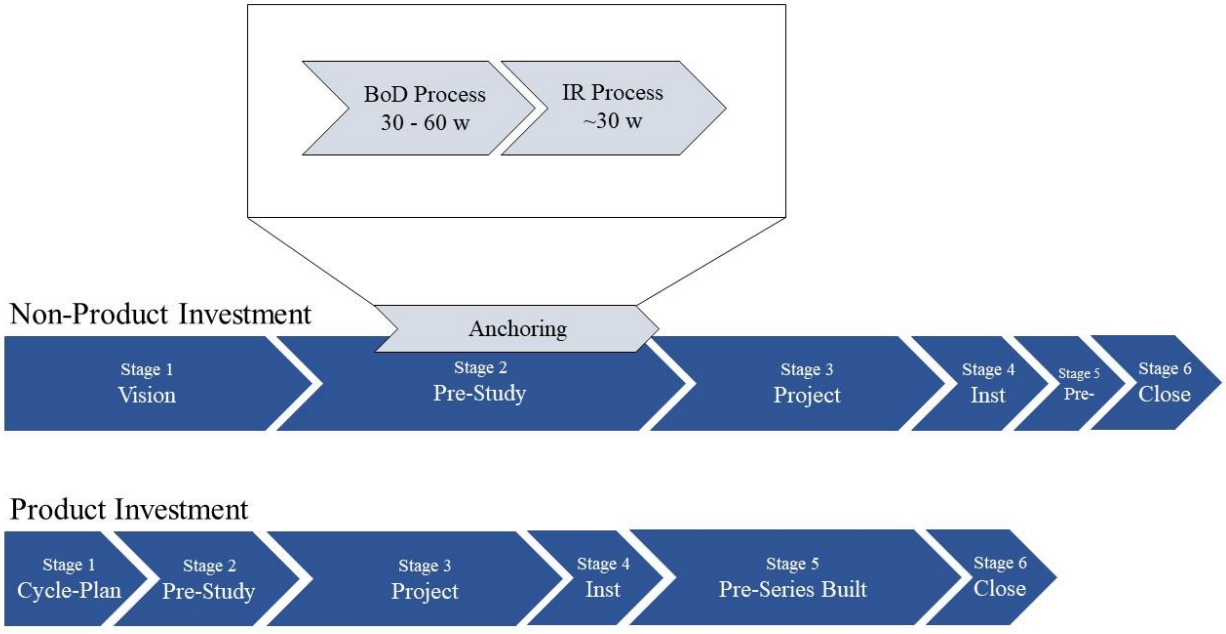

Figure 3. Typical example of process steps for non-product and product investments.

During the last couple of years, Volvo Cars' workflow has undergone an agile transformation with speed being a driving force to increase the company's innovative capabilities (M. Lindh, personal communication, 2022). In the transformation, Volvo Cars utilized the framework "SAFe" to scale the agile approach throughout the entire organization and to create their own framework called Volvo Cars Agile Framework (VCAF). VCAF is based on SAFe and is adapted step by step to fit Volvo Cars' needs and contains the four levels: Portfolio, Solution, Agile Release Train (ART), and Team.

The Team level highlights that work should be done in teams composed of three roles. Each Team consists of a Product Owner (PO), a Scrum Master (ScM) and the development team members and the Teams are supposed to work after the SCRUM principle. The development team members of a SCRUM team are the most common role which are responsible for completing work tasks. ScM serves to guide the Team as a leader and should alleviate the Team from distractions (Mountaingoatsoftware, n.d.). Lastly the PO is the person responsible for the result and delivery of the product and handles prioritizing stories and the backlog.

An ART consists of a number of Teams and has a Product Manager (PM), a Release Train Engineer (RTE) and a system architect. The roles on the ART are a scaled version of the roles on the Team level where the PM can be compared to the PO, RTE to the ScM and the system architect to a development team member. In the same way as several Teams belong to an ART, several ARTs belong to a Solution. The roles on the Solution follow the same principles as the lower levels where the roles are Solution Manager (SM), Solution Train Engineer (STE) and solution architect. The top of the VCAF framework consists of Epic Owners and the Lean Portfolio Management and the level is responsible for the exploration and implementation of business opportunities (Volvo Cars, 2022).

The Portfolio level is responsible for creating epics which are strategic tasks that the company should work towards. Based on the epics, capabilities which are needed to fulfill the epic are created at Solution level. The capabilities are later the baseline for the features, which need to be developed to achieve the capability, created on ART level. The features become the basis for the stories, small work tasks, created and performed by the Teams. It is important that each story can be directed to a feature, each feature can be traced to a capability and that each capability is associated to an epic. This creates alignment in the company and makes sure that higher levels and lower levels are working towards the same goal.

To exemplify the four levels in one part of R&D, Portfolio level handles the entire car on an abstract level. Solution level handles one large part of the car e.g., one Solution is called Vehicle Platform and includes: Body structure, Chassis, and Climate system. All of these constitute their own ART, e.g., one ART is climate system. Lastly, on Team level under the ART for climate systems one Team is responsible for the cooling compressor.

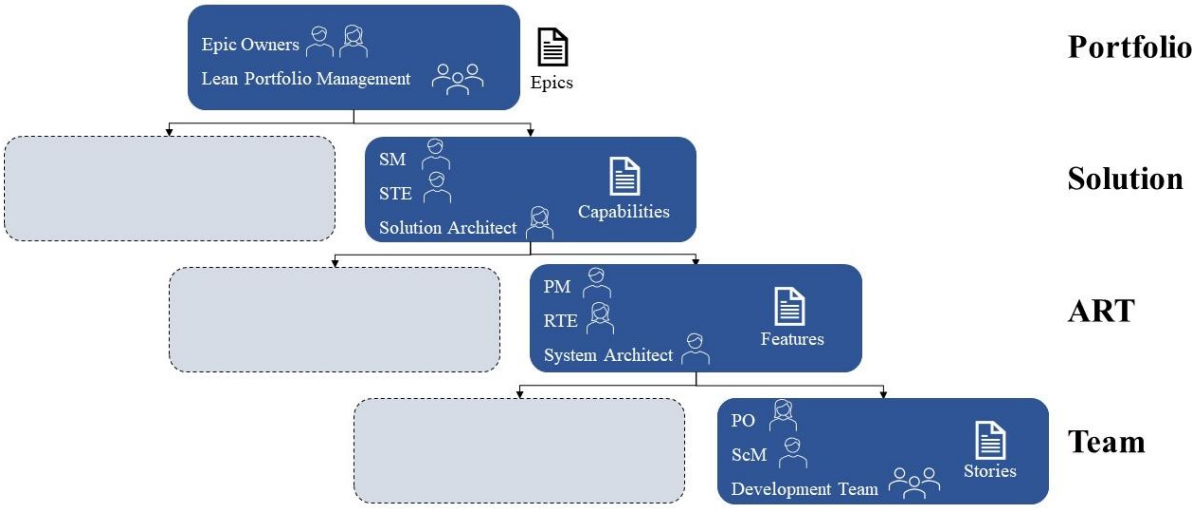

Figure 4. VCAF framework showcasing the four levels.

How traditional frameworks, such as GTDS and the investment framework, are used in practice, and how they have been utilized in mega casting project will be researched. Further, on what level in the VCAF framework the mega casting project has been handled and what part agile workflow has played in the speed of the mega casting project will be investigated.

1.1.3 Mega casting at Volvo Cars

The development project, including an investment decision, was named Mega casting and a small cross-functional project team was formed within Volvo Cars. Initial stages assessed the feasibility of both technical and economic aspects with help from value stream experts, engineers, and vehicle architects (M. Fermér, personal communication, 2022). After promising early results, the project was divided into three pre-studies to structure the work, and to prepare for such a big change. This included aspects such as alloy selection, joining methods, crash performance, strengths, durability, corrosion, weight, aftermarket, logistics, manufacturing complexity, design flexibly, investment cost, landed cost and more (M. Fermér, personal communication, 2022). As the project developed and showed satisfactory performance in such important aspects more expertise was introduced.

The first pre-study was a support study with the aim of evaluating different alloys for casting and assessing the sustainability of the project. The second study, named pre-study A, was to make a smaller aluminum casting for Volvo Cars to learn the intricacies of this new field. The third study, called pre-study B, was to perform mega casting in-house with the end goal of using it in production. The studies were in practice performed in parallel with each other (Volvo Cars, 2020 B). Several demonstrations were held for anyone at Volvo Cars who would like to listen, highlighting the progress of each pre-study along the way. A demonstration is a meeting arranged by the project team where current progress of the project is presented. E.g., in the mega casting project, results from material testing, production layout examples, and the latest calculations for cost and sustainability were presented during the demonstrations.

A year after the pre-studies were formed, investigations of mega casting were presented to the board of directors and the investment decision was approved. Based on the initial interviews, it is clear that Volvo Cars is astonished by how quickly such a large and complex investment decision was reached since development projects of similar impact commonly take longer to conclude. The impact of the mega casting project is a result of the cascading impact to many different departments. Going from pressed steel sheets to cast parts requires new design capabilities, different manufacturing skills and tools, entirely new system architecture, new sourcing strategies, new means of quality control etc. The mega casting implementation will therefore require a tremendous investment of resources from the company.

Volvo Cars would like to understand the internal workings of the company and details which made this investment decision process so fast compared to similar development projects. Volvo Cars has recognized the need for faster innovation and decisive decision-making to keep up with the newly established actors in the automotive market. These new actors are less risk adverse, take bold decisions quickly, and members from Volvo Cars believe this new market pressure has emboldened their decision-making. The efficiency of the mega casting investment decision is unprecedented as the wide impact requires the sign-off from many important individuals. This specific case is of particular interest since the automotive industry is generally quite conservative, and large architectural changes with impact of this scale are rare.

1.2 Aim

The aim is to explain how investment decisions in development projects can be taken quickly from examining how the mega casting investment decision could be taken so quickly in comparison to other development projects of similar impact at Volvo Cars.

1.3 Limitations

The mega casting project will affect Volvo Cars globally, however, this thesis chooses to limit its scope only to Volvo Cars in Gothenburg. This may have caused conclusions to be geographically biased and not as generalizable as if a more diverse approach were employed.

Obtained knowledge and information were mostly based on the internal information available at Volvo Cars and may have caused a positive bias towards the project. However, due to the sensitive and protected nature of the information this project involves, external actors had insufficient insight to provide valid data.

All initial interviews were conducted through Microsoft Teams online meetings, which may have caused an increased risk of misinterpretation and lost subjective expressions from body-language. The second round of interviews were conducted both in person and through online meetings. The online method was utilized due to Covid-19 and the interviewee subjects were given both options for the secondary interviews.

Lastly, when investigating how agile affected the speed of the mega casting project a decision was taken to limit the research to only take workflow related factors into account. Other related contributors such as agile culture or "mindset" were not considered. This since these other intangible aspects of agile methodology would require additional time and research methods which were not within the scope of this thesis.

1.4 Specification of issue under investigation

To fulfill the aim of this thesis three research questions were formulated to further specify what the research would revolve around:

1. What have been the success factors enabling the speed of the mega casting investment decision?
2. How did the mega casting project differ from other development projects at Volvo Cars?
3. How has Volvo Cars' agile workflow affected the speed of the mega casting project?

2. Methodology

The methodology chapter of this thesis consists of seven sections: Research design, Initial interviews, Survey, Secondary interviews, Literature review, Data analysis, and Research quality. Research design presents the selected methods and provides an outline for the following sections. Initial interviews, survey, secondary interviews, and literature review present the four sources of data and how it was collected. Data analysis presents the method of how data was broken down and analyzed. Lastly, research quality outlines the aspects which have been considered to ensure the quality of the research.

2.1 Research design

This study was carried out in collaboration with Volvo Cars, therefore the topic of the report and investigation were co-developed to provide practical value and research a relevant issue. Data for the thesis was based on formal documentation, literature, a survey and interviews. Documentation was utilized when available, however, when a lack of documentation was encountered, interviews were conducted to collect information.

The scope of the topic was not clarified in advance. In order to define the scope and increase the understanding about the mega casting development project an initial data collection consisting of reviewing documentation and a first round of semi-structured interviews was conducted, together with a narrative literature review. The initial data was then used to construct an online self-completion survey to verify the early findings and narrow down the scope of the research. Secondary semi-structured interviews were then performed to collect underlying data and allow for a deeper level of analysis of the most prominent findings. The narrative literature review was simultaneously continued to supplement the new findings with academic knowledge. Grounded theory data analysis was later conducted to each individual data source and later across them, to look for patterns and similarities.

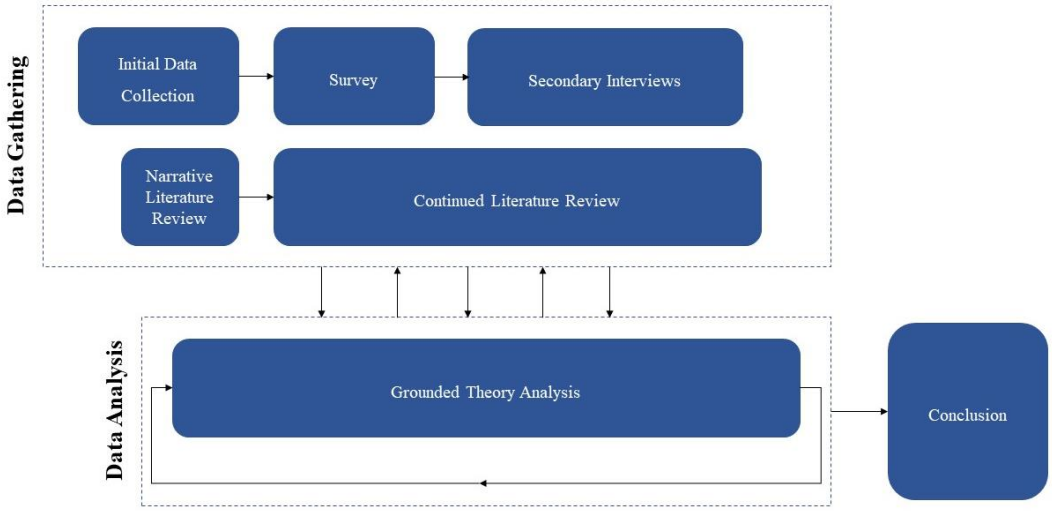

Figure 5. Summary of methodology.

2.2 Initial data collection

The initial data collection consisted of collecting information from formal documentation at Volvo Cars and conducting a first round of interviews. First an initial documentation collection was performed in order to increase the understanding of the mega casting development project. Secondly, when documentation was lacking, interviews were conducted with people involved in the mega casting project. This was done to gather more data and get a deeper understanding of the project.

2.2.1 Initial documentation collection

To start the initial data collection any documentation to investigate the research questions was gathered. First, documents regarding the mega casting project were collected and reviewed. The formal documentation of the project was shared and available through access to the mega casting project's Microsoft Teams workspace. The relevant documentation was defined with aid from the supervisor from Volvo Cars and the project leader of the mega casting project. Documented findings regarding the project's agile workflow were collected from a certain internal IT-system and reviewed after recommendation by the project leader. Relevant documents and access to the databases were given by request and from suggestions by involved actors in the mega casting project.

2.2.2 Initial interviews

To be able to understand and get insights about the mega casting project, when documentation was lacking, an analysis of internal stakeholders' views and perceptions about the project was needed. Stated by Kothari (2004), qualitative research can be used to get a subjective assessment of attitudes and insights. Hence, a qualitative approach seemed appropriate and was selected. Semi-structured interviews are a flexible method for collecting qualitative data and the emphasis is to seek out how the interviewee frames and understands issues and events (Bell et al., 2019). Based on this, semi-structured interviews with participants in the mega casting project at Volvo Cars were conducted to understand the work that has been done and the current work in the mega casting project. During a semi-structured interview, an interview guide is used but the interviewee has the possibility to elaborate on certain topics, which can provide further insights. Bell et al. (2019) describes semi-structured interviews as a combination of open/closed-ended questions. Furthermore, the approach allows for some flexibility during the interview, including spontaneous follow-up questions, and changing the order or the questions asked. The method of using semi-structured interviews was also selected since it ensures a degree of comparability between interviews (Bell et al. 2019).

The interviews were conducted online through Microsoft Teams during the first weeks of the thesis process. 16 interviews were conducted with different individuals with an average time of ~45 minutes. The interviews were outlined by a set of basic questions about the mega casting

project, based on early documentation and introduction from the supervisor from Volvo Cars, extended by following-up questions during the interview. The initial interviews emerged into a list of success factors enabling the speed of the mega casting investment decision formalized into attributes as well as findings regarding the agile workflow.

The interviewees were selected using a snowball sampling, starting with one or more individuals in each affected department. A snowball sampling is conducted by first making initial contact with a small group of individuals, who are relevant for the research topic, which are then used to establish contacts with other people (Bell et al., 2019). To get in touch with the initial key persons, the supervisor at Volvo Cars and the project leader for the mega casting project were involved in the beginning, identifying potential interviewees to start the snowball method with. Initial interviewees were selected primarily from the mega casting core team as it provided starting points from different departments in the company and ensured knowledge and competence of the topic. According to Bell et al. (2019) one problem with snowball sampling is that it is seldom representative of the population. However, Bell et al. (2019) also states that since the concerns about the ability to generalize and external validity are not as important within qualitative research as in quantitative studies, snowball sampling is often used in qualitative research.

2.3 Survey

The findings from the initial interviews were used to construct an online self-completion survey with the purpose of validating them across interview subjects and against a larger audience. Bell et al. (2019) explains that a mixed method design is appropriate since both qualitative and quantitative methods work in collaboration. In this study an initial qualitative method was employed to generate hypotheses for the quantitative survey method. The survey was performed to quantity the subjective importance of the initially found attributes which enabled the speed of the mega casting investment decision. Each respondent was asked to rank both individual attributes and topics in order of impact to the quickness of the mega casting project. Individual attributes for quickness were grouped into functional topics and ranked only against other related attributes, e.g., attributes regarding the core team. In total the survey included five topics with four to eight attributes in each topic.

Each topic included two questions, the first asked the respondent to rank the attributes related to that topic in order of impact they played in the quickness of the mega casting project. The second question gave the respondent an option to submit any important attributes not yet captured. Lastly, survey subjects were asked to rank the topics in order of impact they played in the quickness of the mega casting project.

A survey is similar to a structured interview with the key difference of there not being an interviewer present (Bell et al., 2019). There are several advantages gained by using surveys such as: Cost, Speed, Objectivity, and Convenience for respondents. Initial interviews could not be held with every relevant internal stakeholder, due to the resource intensive nature of the

researchers and unavailability of respondents. A survey was therefore used in order to quickly validate the previous findings from initial interviews by reaching a wider audience.

The survey was conducted using Microsoft Forms and was sent through email to 57 respondents, with a response rate of 42,1%. Bell et al. (2019) mention that some difficulties with a survey method are: Difficulty in formulating unambiguous questions, Challenge in knowing who answered, and Low response rate. A convenience sampling was utilized by asking the mega casting project leader for an appropriate list of respondents. By sending out the survey to people who have been involved and interested in the mega casting project the response rate was expected to be improved. All respondents were also asked to disclose their name when answering in order to track who answered the survey. The survey subject was tested with the supervisor from Volvo Cars to improve the relevance of the questions and protect any classified information.

The survey results were presented in two diagrams for each topic. First, a stacked bar showing the ranking distribution of the attributes within the topic and their average voting score. This to present which attribute survey respondents deemed most impactful to the speed of the mega casting project within that topic. The stacked bar chart presented the entirety of the collected ranking data and was summarized in a simple format through the average voting score. The second diagram was a pie chart which displayed the percentage of number one rankings for each attribute within a topic received. The pie chart only considered a small part of the total collected data, however, was believed to have higher validity as ranking which attribute was most important was easier for respondents than ranking between e.g., third and fourth place.

The attributes proposed by respondents, collected through the second question for each topic, were carefully investigated, interpreted, and compared to existing attributes. A decision was made if the proposed attribute was novel and should be added, or if it was already captured by existing attributes and no action would be taken. These responses, interpretations and planned action were presented in a table for each topic.

Survey results were used to calculate three measures: Average voting score, Normalized average voting score (NAVS), and Weighted normalized average voting score (WNAVS). NAVS and WNAVS were calculated to be able to compare the attributes scores across the different topics. The NAVS and WNAVS scores were presented with all attributes in a joined table. These scores were used in the survey analysis as a part of selecting the most impactful attributes for the quickness of the mega casting project.

2.4 Secondary interviews

The results from the survey resulted in eight attributes which were to be investigated further with secondary interviews, with one additional attribute emerging from survey emails. The survey results were analyzed and unique questions regarding each further investigated attribute were formulated as means for the investigation. The formulated questions served as a basis for interviewee selection sampling. Interviewees from initial interviews which served a position

which enabled them to elaborate on the formulated questions were chosen as these people were deemed appropriate. In total eight individuals from initial interviews were selected for secondary interviews. Further, the sample was extended with recommended interview subjects from supervisor from Volvo Cars as well as snowball sampling during the secondary interviews. However, extensions to the sampling population were only performed when the current sample could not fully explain the phenomena and crucial explanations were lacking for the questions.

A semi-structured interview method was selected with the same motivation as for the initial interviews. A personalized semi-structured interview guide was created for each interview subject. The same respondent was asked questions regarding several different further investigated attributes when deemed appropriate. All the personalized interview guides served as tools to direct the interviews and ensure that interviews stayed on topic and answers were relevant to the formulated questions. However, follow-up questions were asked when it was deemed appropriate. 14 interviews were conducted, with an average duration of ~40 minutes. Secondary interviews were conducted both in-person and online through Microsoft Teams at the interviewee's discretion. Interview audio was recorded after permission from the interviewee. The results were presented in accordance with what each respondent answered to the common questions within each success factor.

This mixed research design, using secondary interviews after a survey, is appropriate as the quantitative survey data will be expanded upon and elaborated through a second round of interviews to fill in gaps in current data (Bell et al, 2019). The second round of interviews was conducted to deepen the understanding of the mega casting project and allowed for a dialog with the subjects on a more informed basis since the interviewers were more knowledgeable.

2.5 Literature review

According to Bell et al. (2019), a literature review can provide the basis for a qualitative study and is used for reviewing the main ideas and tendencies within a research field of interest. An initial literature review was made to discover what aspects would be interesting to investigate related to the research topic. Suspected relevant literature was discussed with the supervisor at Chalmers and Volvo Cars and was reviewed using a narrative review. A narrative review is appropriate for qualitative research designs and is used when the purpose of the literature review is to gain an initial impression of the topic that the study aims to understand better throughout the research (Bell et al., 2019). Hence, a narrative review approach was seen as appropriate since the focus of the initial literature review was to gather information about the research topic to gain a basic understanding of the research field and the problems related to it. The initial literature was collected from databases such as Google Scholar, EBSCO host, together with scientific reports. Some examples of keywords that were used are: "agile management", "agile in industry", "agile outside of software", "agile project management", and "the importance of speed". Further sources were found looking through reference lists and citations of previously found useful literature. Information about mega casting was largely provided through internal unpublished documents from Volvo Cars. Other sources were used such as the presentation from Tesla's

"Battery Day", without reflecting on the validity instead focusing on the relevance to the report.

The narrative literature review was continued during the rest of data gathering and retrospectively performed to supplement the initial literature review with relevant areas. The reviewed literature, at this stage, was preliminary based of topics from both interviews and documentation to supplement data with academic knowledge. Topics mainly addressed academic articles about: "the importance of speed", "waterfall methods", "autonomous teams", "decision-making", "investment decisions" and "internal development", "innovation diffusion", and "fast follower". Literature was collected from databases such as Google Scholar, EBSCO host and ResearchGate. Further sources were found looking through reference lists and citations of previously found useful literature. The purpose of the literature review was to compare the results to the current body of knowledge on the topic and to establish if this case study supports or contrasts previously found theory.

2.6 Data analysis

The proposed data analysis for the thesis was a grounded theory approach as outlined by Bell et al. (2019). Grounded theory includes three main tools: Coding, Theoretical saturation, and Constant comparison. As data was gathered it was continuously coded through open and axial coding. Open coding relates to scrutinizing the data for comparisons, repetitions, phrases and conceptualizing as well as categorizing data into concepts. Axial coding instead entails assembling data back again after the break down in open coding but in new formations as to find connections between concepts and categories and examining potential links between them (Bell et al., 2019).

Grounded theory is appropriate as an analysis method for qualitative data like interviews due to its iterative and inductive nature. An iterative method allows for data analysis and early coding already from initial interviews and early stages of data collection. The iterative nature also allows for saturating the categories through extensive and thorough coding until no further concepts can be found. This constant comparison results in more detailed analysis as vague and hard to detect contrasts or patterns can be found and worked through several times which improves chances of identifying and codifying them (Bell et al., 2019).

The documented findings were analyzed in comparison to the literature and how it relates to the mega casting project or Volvo Cars' workflow in general. The interview notes and impressions from initial interviews were codified by both individual researchers in a joint exercise in close proximity after the interview to gather initial concepts as first-order analysis. This to ensure that both individuals had a similar interpretation and have identified similar concepts from the interview. Initial interview findings were analyzed for content containing success factors, which were formalized into attributes, contributing to the speed of the mega casting investment decision. The attributes were then compared between the initial interviews and summarized in a table with a general description. Initial interviews were later investigated to find the number of

occurrences of each attribute. The attributes were also contrasted against each other and grouped together in functional topics which served as an important distinction for the survey stage.

The survey stage was analyzed after compiling the results in order to quantify the most impactful attributes from the initial interviews. A selection criterion was formalized to distinguish the most impactful attributes for the quickness of the mega casting project, which were further investigated during secondary interviews. The selection criterion was based on three evaluation factors: Number of occurrences in initial interviews, WNAVS score, and Percentage of number one rankings. Two of these evaluation factors had to be fulfilled in order for the attribute to be investigated further. The criteria limits for the evaluation factors were chosen to ensure a manageable amount of attributes for the secondary interviews with regards to time. To ensure that no essential attributes were excluded by the criteria limits a control was done where every attribute was checked against possible other limits.

The joint results from the different data gathering stages were used as a basis for the in-depth analysis of the mega casting project results. The analysis of the most impactful success factors enabling the speed of the mega casting investment decision were mainly based on results from the secondary interviews. The answers from the secondary interviews were codified according to one of the selected formalized attributes to be investigated from the survey. The secondary interviews were first analyzed according to first-order analysis and after those results were compared to corresponding answers from different interviewee subjects as second-order analysis. The second-order analysis was conducted for secondary interviews through scrutiny of the audio recording. A category analysis was done where themes and concepts for each further investigated attribute from many secondary interviews were compared to identify similarities, differences, and links between interviews. The different answers for one further investigated attribute were summarized and later analyzed in comparison to the literature when appropriate. The analysis was presented in different formats according to each further investigated attribute as summaries, list of successful characteristics and whether finding supports or disputes the relevant literature.

The analysis of the differences between the mega casting project from other development projects at Volvo Cars was based on both initial and secondary interviews. Interview answers regarding how the mega casting project had differed from previous experiences and the standard development procedures were interpreted through both orders of analysis. These results were also compared to the relevant literature to find similarities or differences between the mega casting project and best practices.

Lastly, the analysis regarding how Volvo Cars' agile workflow has affected the speed of the mega casting project was conducted through analyzing the documented findings and initial interviews. These findings regarding agile workflow were analyzed through the same first and second-order analysis as the other research question. The findings from the mega casting agile workflow application, both from documentation and interview answers, were compared to the literature regarding agile workflow and its intended applications and purpose. Findings were presented and a set of recommendations emerged for how Volvo Cars can re-evaluate their agile workflow for development projects.

2.7 Research quality

Several aspects were taken into consideration to ensure and assess the quality of the study. Different quality criteria are used to evaluate business and management research, and according to Bell et al. (2019) reliability and validity are important criteria when assessing the quality of qualitative research. Ethical considerations about how interview subjects and the case company were handled are also presented and how these considerations hope to quell any ethical fears. Lastly, the sustainability value of this thesis is presented and to what extent it can enhance sustainable efforts in the future.

2.7.1 Reliability

Reliability, in relation to qualitative research, can be divided into external reliability and internal reliability (Bell et al., 2019). External reliability deals with what degree the study can be repeated, which according to Bell et al. (2019) is a difficult quality criterion to meet in a qualitative study. This since it is impossible to freeze social settings and the circumstances of an initial study, which makes it less replicable. Moreover, since the knowledge and information about the mega casting project may differ in the future, the reliability of respondents and the external reliability of the data cannot be guaranteed.

Internal reliability refers to how well interpretations of the data match, meaning to what extent the researchers have interpreted what they have heard or observed when there is more than one researcher performing the study (Bell et al., 2019). To ensure internal reliability, both individual researchers were present in each interview, and in addition all secondary interviews were audio recorded to avoid missing details. Furthermore, the interviewees were given the opportunity to confirm the interpretation of the individual researchers. Results for all interviews were discussed and summarized by the researchers directly after the interviews to avoid variation of interpretations and improve the internal reliability of the data gathering.

2.7.2 Validity

According to Bell et al. (2019) validity is concerned with the conclusions generated from research and can be divided into several aspects. In relation to qualitative research, validity can be divided into external validity and internal validity. External validity deals with the degree to which conclusions of the study can be generalized across social setting (Bell et al., 2019). Since qualitive research mostly uses case studies and small samples it can be difficult to reach a high degree of external validity, such as in this research. This study was conducted only with one case company and therefore external validity cannot be guaranteed. To ensure external validity and make the results applicable in other contexts, it could have been appropriate to conduct this study with several case companies. This could be an area for research in the future, as it was not feasible for this project.

Internal validity refers to how good the researchers' findings match with the developed theories (Bell et al., 2019). To ensure that the results of this study correspond to reality, a measure of face validity was used, meaning that internal stakeholders with experience from different projects were interviewed. Internal validity was also addressed through efforts to ensure concurrent validity by interviewing individuals with different relation to the case of interest (Bell et al., 2019). This through interviewing both members within and outside the core team of the mega casting project, members from different departments and managers on a wide range of different authority levels. Lastly, findings were scrutinized by the frequency of answers, with the assumption that similar results from several independent interviews ensure greater internal validity.

2.7.3 Ethics

One of the main ethical considerations for this thesis was how the case company, Volvo Cars, was treated in the collection and publishing of data. Bell et al. (2019) outlines how it is important to consider both how data is collected and not to conduct research which violates lack of informed consent, invasion of privacy, deception, or cause harm to any participants. To avoid any physical harm to the interviewee subjects in the midst of the Covid-19 pandemic, all initial interviews were held online to avoid spreading the disease. During the second round of interviews the interviewees were given the option to assure their consent to a physical meeting.

The data collection employed several methods to avoid any ethical oversteps. Interview subjects were briefed on the subject of both the thesis and the interview beforehand to avoid any deceptive coercion. Interviewees were also informed about their right to refuse to answer any questions to uphold their right of privacy. Further, before publishing any data attributed to a particular interview subject within the organization, the interviewee was asked to validate the truthfulness and agree to its internal publication. If an interview subject was not comfortable with publishing their words, that section was removed or re-written. This was in order to protect subjects from any harmful internal repercussions, as a result of the research, and allow them to be well informed before any collected data was spread. Moreover, the attributes to be ranked from the initial interviews in the survey were presented anonymously to protect the privacy and integrity of previous respondents. These are commonly applied methods presented by Bell et al. (2019) to address similar ethical considerations.

The case company was also protected as an entity and was allowed to control any potentially protected materials from being published openly. This through sending any materials planned for publishing or spreading to the supervisor at Volvo Cars before publishing and allowing for revisions and removals of any protected material. This was to protect the case company from any potentially unforeseen harm being done and ensure nothing was published without explicit consent.

2.7.4 Sustainability

The thesis has environmental value in two distinct ways. First, the case study of mega casting involves a material swap which has positive environmental prospects. Second, climate change is a time sensitive issue with many so called “points of no return” and improvements must be made quickly (Henson, 2021). This thesis aims to find out how investment decisions in development projects can be taken quickly, which can be applied to further changes regarding sustainable development and improvements.

The material swap from steel to aluminum has three main advantages in sustainability. Aluminum will be purchased as a raw material, drastically simplifying the supply chain and allowing Volvo Cars for much better oversight of the supply chain upstream all the way to mineral extraction (Volvo Cars, 2020 A). This allows Volvo Cars to ensure that better processes are used in e.g., clean energy generation and that humanitarian challenges are combated. The change from steel to aluminum also allows for a drastically improved rate of material utilization going from 50~60% to almost 100% at Volvo Cars (Volvo Cars, 2020 A). This is possible due to the availability of remelting aluminum in a casting process in-house, which has not been possible with the prior steel sheet frames. These two factors in conjunction also eliminate a significant amount of transport of both small metal sheet parts and transporting scrap metal from production away to be recycled. Lastly, aluminum alloys are possible to construct using previously recycled material which drastically lowers the CO_2 used in production, and enabling significant improvements to sustainability. These factors provide insight into how an investment decision with sustainable improvements was taken, and if or how much these factors played a role in the final resolution of such an investment decision.

3. Literature Review

The literature review chapter outlines the theory for the thesis. The first section presents different rationales and schools of thought for strategic decision-making. The second section reviews literature describing the importance of speed in product and process development. Subsequently, a presentation of the waterfall model is presented and how it is used in development processes. The fourth section describes the ideas of autonomous teams and brings up both advantages and challenges. The last section presents the agile workflow and the most essential parts of the methodology.

3.1 Strategic decision-making

Management Study Guide (MSG) (2022) outlines strategic decisions as one of three major decision types among administrative and operational decisions. Strategic decisions are characterized by several factors:

- Complex in nature
- Involve major investments and significant amount of resources
- Affect many different parts of the organization
- Are handled at the top of the organization
- Deals with a lot of uncertainty and a great deal of risk

Strategic decisions are handled differently than administrative and operational decisions and deal with differing challenges (MSG, 2022). Strategic decisions are crucial to the long-term future success of the organization whilst other decisions have a shorter time span. The strategic decisions handle the growth of the organization as a whole and are taken in alignment with the overall mission and goals of the organization. Strategic decisions are therefore left to the highest management, such as the board of directors, and are handled infrequently (MSG, 2022).

Not all development projects require strategic decisions from the top of the organization. Wheelwright and Clark (1992) present four different types of development project which are useful when selecting which projects to pursuit. The four types differ in the degree of change they require in product and process technology. The different types are:

- Enhancements, Hybrids, and Derivatives
- Next Generation or Platform
- Radical Breakthroughs
- Research and Advanced Development

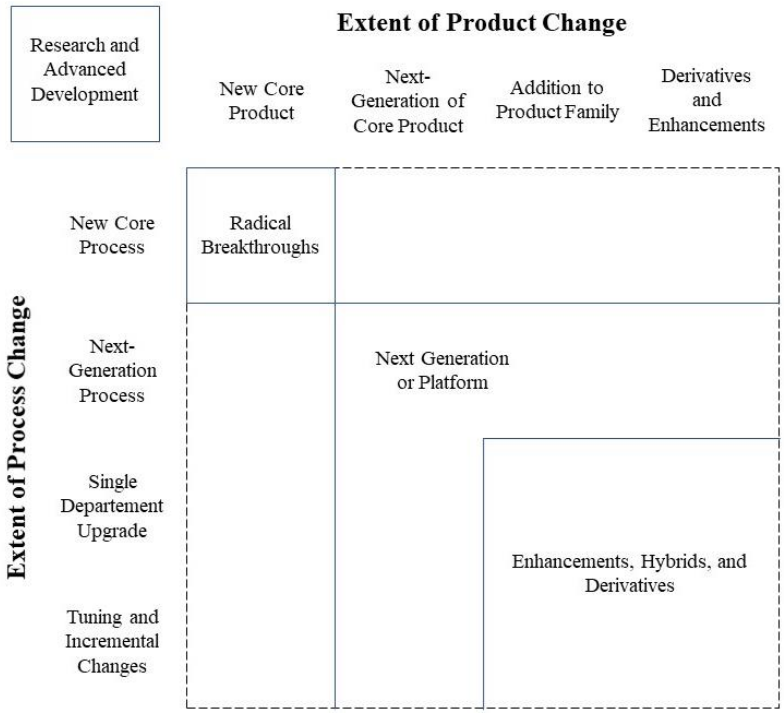

Figure 6. Four types of development projects, inspired by Wheelwright and Clark (1992).

Virlics (2013) presents investment decisions as a consequence of risk management and decisions are taken on the basis that the improvements outweigh the risks. A variety of different risk assessments theories and rationales for risks are outlined based on both economic and behavioural factors. In essence, if the financial gain outweighs the financial risk, the decision is financially sound, however, perfectly quantifying either the gain or risk is impossible, and a level of uncertainty is always present. This uncertainty causes decisions to be based upon subjective behavioural basis which is explained by Virlics (2013). Such behavioural basis can be aversion to risk based on personally type or past experiences. Risk is assessed by decision makers in both rational and emotional terms and may differ in practice from the value maximizing financial theory. Methods to manage risk is presented such as valuing flexibility in investment decisions to minimize the consequence of uncertainty. Virlics (2013) concludes that it is important to analyze investment decisions from both a economic and behavioural perspective as it may capture psychological and emotional factors of decision-making.

Zehir and Özşahin (2008) researched large-scale Turkish firms for the relationship between strategic decision-making speed and performance. Two factors were analyzed: Organizational and Environmental. Organizational factors have two major affecting measures, first one being participation which entails to which extent lower tier managers are involved in decision-making (Andersen, 2001). The second one is autonomy, which measures how much individual influence lower tier managers have and to what extent they can take decisions on their own (Andersen,

2001). Vroom and Yetton (1973) and Eisenhardt (1989) present the case that centralized decision-making with low levels of participation and autonomy is faster since involving more individuals extends and slows down the decision-making process. With fewer individuals to inform and gain consensus from, decisions can be taken faster. Eisenhardt (1989) also argues that putting too much decision-making pressure on few managers may cause anxiety making them hesitant to take important decisions quickly. Wheelright and Clark (1992) also underline the importance for managers to be involved and show interest early in a development project. This since management ability to influence diminishes as the development project progresses. Management needs to be involved from the beginning and be proactive in problem prevention instead of only reacting to it (Wheelwright & Clark, 1992).

Environmental factors, which were considered by Zehir and Özşahin (2008), were technological sophistication and industrial competition. With more technologically advanced products and developments, more information needs to be considered and decision stakes are often higher as costs and time scales are often larger. With a turbulent business environment of advanced processes and significant competition, decisions become more difficult and more diligence and time is needed for strategic decisions (Haleblian & Finkelstein, 1993). On the other hand, Eisenhardt and Bourgeois (1988) also present the fact that such environments also demand rapid decision-making to a greater extent with more to gain from faster processes. Which could result in faster decisions as a response from the environmental factors as well.

Zehir and Özşahin (2008) in their analysis of their survey study found that participation of managers does help enable faster decision-making and innovation results. Further, they found that faster strategic decision-making in general leads to better innovative performance from the firm. However, no clear statistical support was concluded regarding autonomy, technological sophistication or industrial competition, for whether they speed up or slow down strategic decisions.

Elbanna (2006) reviews strategic decision-making through different perspectives with different contributing ideas of importance: Political, Rational, or Intuitive. The rationalist perspective views strategic decisions from an idealised state, only involving the basic facts of the decisions. Political or intuitive perspective instead tried to concretize the perspective into a more applicable realistic view of how decision processes function in practice. Political perspective is based on individuals differing interests, and how to achieve them through the decision-making process. Political behaviour in decision-making may include: Coalition formation, Political tactics and timing, Use of external expertise, Use or power, Controlling information, or Manipulation. The intuitive perspective is instead a form of synthesising the available limited information into a "best guess" from the individual's perspective and experience. Intuition can aid in expediting decisions and help in formulating flexible and creating strategies and may provide more value in high-velocity situations (Elbanna, 2006).

Elbanna (2006) concludes that decisions need to be taken with multiple perspectives in mind and best practice employs even intuitive perspective in turn e.g., after a screening of rational criteria. Managers also need to be wary of the political behaviours which impact the decisions and inhibit political actors' power in decision-making which otherwise can lead to unsuccessful decisions and poor company performance.

The strategic decision-making literature helps define strategic decisions and Wheelright and Clark (1992) provides a framework of development projects for positioning the mega casting project. The literature regarding strategic decision-making also provides the thesis with three different schools of thought which to analyze the results regarding the mega casting project. Virlics (2013) proposes viewing decisions from a risk management perspective. Zehir and Özsahin (2008) presents decision-making speed and performance as a result of environmental and organisational factors. Lastly, Elbanna (2006) provides the nuance of multi-perspective analysis with political, rational and intuitive views to strategic decisions.

3.2 The importance of speed

Today's market is characterized as a global, intense, dynamic, and competitive environment. Information technology and communication has made the need for mastering fast strategic decision-making in order to stay competitive and gain an advantage even more important (Baum & Wally, 2003). Support for organizational factors from Zehir and Özsahin (2008) and the impact of fast strategic decision-making is continually found in more recent studies for modern businesses such as Campos et al. (2015). The importance of speed has been known for a long time and according to Wheelwright and Clark (1992), this turbulent environment increases the need for excellent product and process development in order to be competitive and get advantages. It is important to be both fast and efficient. Organizations that are slow to market with products that neither match their competitors' products nor customer expectations are expected to experience their market position erode and financial performance to stagnate or decrease.

Wheelwright and Clark (1992) state that the auto industry is an example of a turbulent environment. This due to the growing international competition, exploding product variety, and diversity in technology. Previously, businesses could get a competitive advantage by producing products with high levels of quality, but in today's new turbulent environment high product quality is seen as a minimum requirement (Wheelwright & Clark, 1992). The changes in markets and technologies have increased the importance of speed and variety in product and process development. The expansion of different market segments, increase in international competition, and accelerating technological change put higher pressure on all actors in the market. To succeed, organizations need to be responsive to the moves of their competitors and to changes in customer demands. According to Wheelwright and Clark (1992) there are three development imperatives: Speed, Efficiency, and Quality. Firms need to be fast and responsive, have high development productivity and produce products with distinction and integrity.

There are specific capabilities that contribute to rapid and efficient development of high-quality products and processes. Wheelwright and Clark (1992) state these as:

- "Clarity of objectives
- Focus on time to market
- Integrations inside and out
- High quality prototypes
- Strong leadership".

Moreover, Wheelwright and Clark (1992) explain that there are other capabilities needed to move quickly and efficiently to the market. These development capabilities are rooted in: "People and their skills, Organizational structure and procedures, Strategies and tactics, Tools and methodologies, and Managerial processes".

Organizations that manage to have fast-cycle development can gain more advantages over time due to the technological gap (Wheelwright & Clark, 1992). A significant performance gap is created between the actors that manage to have fast development cycles and those who have a slow development cycle. The fast-cycle competitors have a short time to market, allowing these firms to introduce the product or process before their competitors. The fast cycle of development also gives firms more time to gather knowledge about the market. Better market information increases the organization's chance to develop products or processes that match the demanding market requirements. Introducing products before competitors can lead to a significant increase in lifetime profit for the product, conversely, a late launch due to development delays can undermine profits. Wheelwright and Clark (1992) further exemplify how these advantages compound if sustained over a longer period, causing the faster innovation competitor to leap several innovation cycles ahead in the same period. One way companies can improve the speed of development is through what Schnaars (1994) defines as a "technological leapfrog", which is a subcategory of the fast-follower strategy. A technological leapfrog can imitate an innovator's technology and catch-up or even surpass them, through adopting the technology and better adapting it to the current environment (Schnaars, 1994).

Baptista (1999) presents models for how technology is diffused between actors called "inter-firm diffusion". Many factors affect the diffusion of technology and it depends on: Specific technology or industry, Market concentration, Firm size, Distribution of benefits, Geography, Networking, and Knowledge spillover. A bandwagon effect on diffusion can be seen as one actor innovates and competitors quickly adopt the new technology to "stay in the game" (Baptista, 1999).

Kessler et al. (2000) also highlight that speed is important in development as a source of competitive advantage. Their study research how speed, cost, and competitive advantage are affected by the source of learning, either internal or external. Quinn (1992) states that external learning in development will result in faster development time as internal resources are spent on their areas of expertise and projects are able to avoid slow bureaucratic controls. In contrast Jorde and Teece (1990) argue that internal learning and development is faster, in particular, when external knowledge is implicit and sophisticated.

Kessler et al. (2000) hypothesize that internal learning as a source for development is faster due to three distinct challenges. First one being that external knowledge is difficult to integrate since the external learning may ground itself on differing measures, references, standards, codes etc. The second reason is that development personnel tend to be less committed to externally sources projects due to a lack of passion, understanding and ownership (Kessler et al., 2000). Lastly, external projects have a lower chance of gaining support from a development leader which is needed to create internal pressure and support for the project.

Support is found for the hypothesis that internal learning results in faster development time by Kessler et al. (2000). Outsourcing development and learning tend to cause a lack of association with the project for development members and create unfamiliar context for internal development teams to work with. In conclusion Kessler et al. (2000) finds that internal development projects are advantageous in terms of both development speed and sustained competitive advantage.

This literature chapter explains the importance of fast development and outlines the reasoning for this. The literature helps underline the value of the thesis and why the findings may be relevant for other development projects. The mega casting project is said to have progressed unusually quickly which makes it an interesting case example to study and compare to the literature above.

3.3 Waterfall model

The waterfall model is a linear process framework for arranging tasks and controls in product or process development, it also goes by the names: Phase-gate model or Stage-Gate™ model. The Stage-Gate™ model is often applied as a project management tool for bringing improvement projects from concept to reality. Employing and adapting the Stage-Gate™ model can lower risks and improve performance of projects through speeding up the process (Edgett, n.d.). A method like this is often used because of its documented improvements presented by Edgett (n.d., pg 3):

- “Accelerated speed-to-market
- Increased new product success rates
- Decreased new product failure
- Increased organizational discipline and focus on the right projects
- Fewer errors, waste and re-work within projects, less scope creep
- Improved alignment across business leaders
- Efficient and effective allocation of scarce resources
- Improved visibility of all projects in the pipeline
- Improved cross-functional engagement and collaboration
- Improved communication and coordination with external stakeholders”.

The value of a stage-gate process comes from clearly defining a framework which can be applied to many future projects. This both saves organizational rework and establishes a known culture and workflow for improvement projects within the company which helps improve

communication and efficiency. The Stage-Gate™ model structures the project workflow into distinct phases, called stages and gates. During stages a number of activities are performed which must be completed for the continuation of the project. After the stage-phase a "gate" activity ensures that all necessary results are achieved, and the project scrutinized before it continues into the next stage-phase. This ensures that certain activities which may be costly are not done before essential checks have been performed which otherwise could result in rework or unnecessary costs.

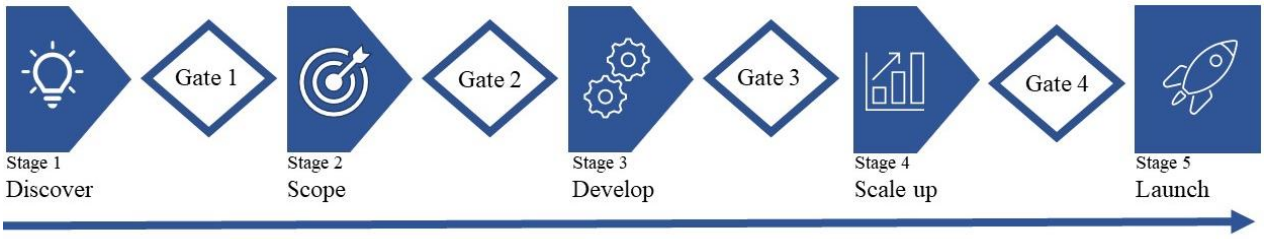

Figure 7. A generic Stage-Gate™ model, inspired by Edgett (n.d.).

The success of a project is affected by many different factors, however, certain success factors have been discovered in conjunction with Stage-Gate™ models. Such factors are:" Customer driven focus, Upfront activities, Though Go/Kill decision points, Truly cross-functional teams, and Top management involvement" (Edgett, n.d., pg 1).

There is a large variety in the different stages of a specific framework, however, Wheelwright and Clark (1992) present four major phases which all should be covered by the framework. The phases are: Concept development, Product planning, Product/Process engineering, and Pilot production/Ramp-Up. The difference in implementation of these phases comes both from individual industry needs, company culture but also from what stages the development starts and is hoping to reach. Meaning that how many stages and gates to include differs depending on if it is a process development or new product development as well as if the technology is brand new.

The traditional Stage-Gate™ model has encountered criticism of late, of it being too slow, rigid, linear, poor at handling innovative or dynamic projects which are crucial attributes in today's economy (Cooper, 2014). Other critiques are that stage-gate systems are not able to handle diverse projects and that diverse projects should not be restricted to a common mold. Further, gates might be too partial to certain metrics such as financial while ignoring others, and that they are a source of bureaucracy which slows projects down. It should be said that some proponents of the Stage-Gate™ model claim these issues are due to poor implementation of the framework. The criticism caused a re-evaluation of the method which emerged in new important factors of how stages and gates are treated. Cooper (2014) presents three new important principles for modern stage-gating: Adaptive and flexible, Agile, and Accelerated.

Accelerated aims to make the lead-time of projects faster through ensuring that projects are equipped with sufficient resources and staffed with dedicated cross-functional team members (Cooper, 2014). Further acceleration can be achieved by overlapping activities within a stage which traditionally were performed sequentially, as well as employing IT support to reduce

workload and make communication more efficient. Agile simply refers to adopting principles and tools from agile development such as sprints or scrums to a stage-gate system. Lastly, Adaptive and flexible is meant to address the rigidity of the traditional models and become more iterative in nature. Phases are performed iteratively to prototype quickly and in collaboration with customers. Products or processes no longer have to be well defined before starting development, but instead let specifics develop flexibly and introduce them as gates or stage-requirements during the process. Further, the model is proposed to become much more context-dependent resulting in smaller adaptation of the entire framework to be applied when appropriate (Cooper, 2014). For low risk or projects with low complexity, going through all stages and gates causes friction and delays in otherwise simple projects, which instead could be handled by such a simplified version.

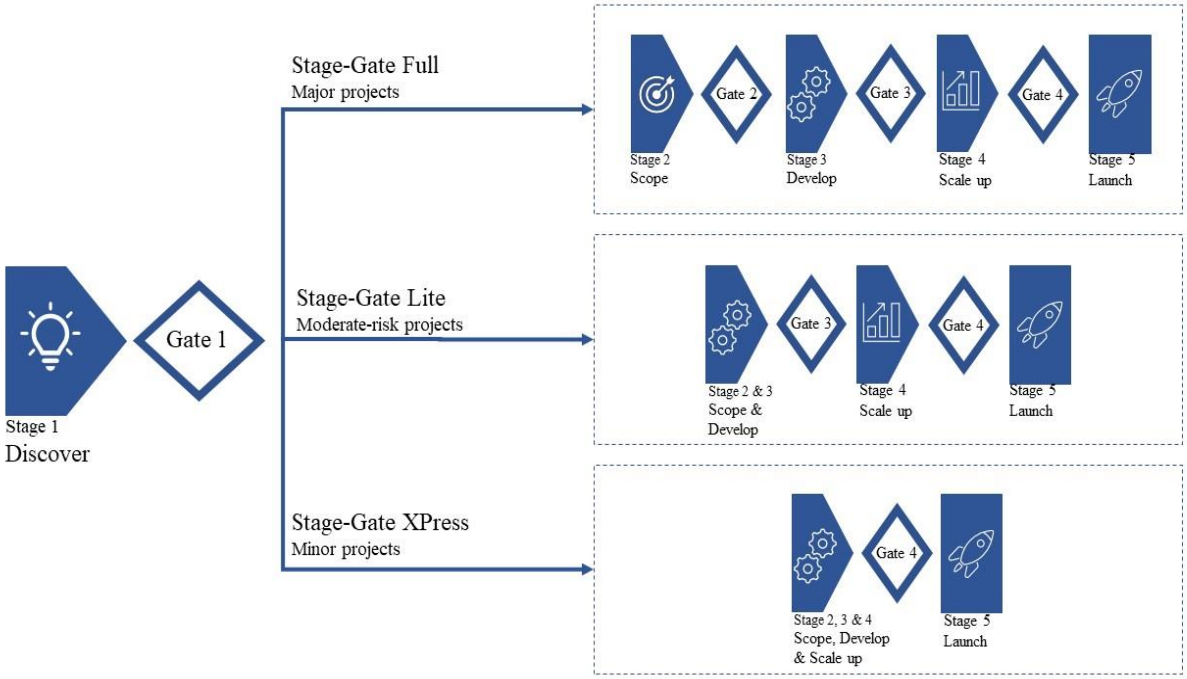

Figure 8. A generic risk adaptive Stage-Gate™ model, inspired by Edgett (n.d.).

The literature regarding the waterfall model aims to outline how standard development procedures are structured and what steps have been taken to formalize a development project. The Stage-Gate™ model is a commonly used way to structure development projects and its multiple advantages are presented. However, these types of models have been critiqued for their rigidness and ability to slow projects down. Waterfall models are traditionally used within Volvo Cars, however, how the mega casting project has used waterfall models and what advantages, or downsides waterfall models bring in practice are going to be explored.

3.4 Autonomous team

Autonomous teams, also referred to as tiger teams, are an organizational structure for new product development that is being explored in many different types of industries today (Patanakul et al., 2012). The formation and utilization of cross-functional tiger teams is an approach to sustain in the competitive and fast-moving market since these teams are targeted at bringing up innovative products and services. Tiger teams' strengths are suggested to lie in creative characteristics, such as flexibility and fast responses to changes (Lee & Ahn, 2018).

Lee and Ahn (2018) describe that a cross-functional team consists of employees from different departments such as R&D, production, and marketing. Cross-functional teams are a project-based internal way of organizing a team, and this explanation matches Wheelwright and Clark's (1992) description about autonomous teams. Wheelwright and Clark (1992) explain that in autonomous teams, individuals from different functional areas are formally assigned, co-located and dedicated full-time to the project team. All people involved in the autonomous team only focusing on one single project. According to Wheelwright and Clark (1992), there are different organizational structures in which project activities can be organized and each option is associated with a specific project leadership. Autonomous teams are an organizational structure with a very senior project leader who has full control over the resources required from different functional areas (Wheelwright & Clark, 1992).

Tiger teams are characterized with their high degree of autonomy and independence (Patanakul et al., 2012). This was already known in 1992 when Wheelwright and Clark (1992) stated that autonomous teams are not required to follow practices and procedures existing in the organization. Instead, the teams are allowed to create their own way of working which includes establishing their own practices, procedures, incentives, reward systems and norm for behavior (Wheelwright & Clark, 1992). The senior project leader of an autonomous team is involved in what the team does, but not how, which contributes to the teams having more control and responsibility. All the individual team members of the team are fully responsible for the final results of the project (Wheelwright & Clark, 1992).

There are some best practices for a cross-functional team mentioned by (L. Trygg, personal communication, 2021):

- Less than ten members in the core team
- Team members volunteer to the project
- Project members work full-time in the project
- Team members are located within discussion distance
- Team members stay in the project during the entire project span
- Team members report to the project leader, not to department managers
- All important functions are represented in the team from the beginning

Due to a high degree of autonomy, independence, leadership, dedication, and co-location, tiger teams can accomplish a high degree of innovativeness. Therefore, tiger teams are a commonly used tool for driving radical and strategic innovations (Patanakul et al., 2012). This coincides

with Wheelwright and Clark's (1992) statement that different organizational structures are suitable for different types of development projects, where autonomous teams are suitable for breakthrough or major platform projects. Autonomous teams keep a high focus on making the project successful, which often contributes to rapid and efficient project development. Furthermore, by involving individuals from different functional areas, autonomous teams can attract and select team members very freely, which is an effective way of handling cross-functional integration. All the advantages of autonomous teams make them useful when the need is to work rapidly and develop completely new solutions.

Organizational structures do not only come with advantages. According to Wheelwright and Clark (1992), autonomous teams unusually investigate opportunities in the organization, instead the teams tend to re-design or develop something entirely new. Moreover, since autonomous teams create their own culture, practices and procedures, and develop unique solutions it can be difficult to re-integrate both the team and their developed solutions into the organization again. This contributes to the fact that many autonomous teams evolve into new business units. Lastly, autonomous teams have much responsibility and control, and without clear guidelines from the start of the project it is very difficult for the senior management to make corrections during the project without disturbing the team.

The mega casting project has been performed by a core team which resembles an autonomous team. This literature chapter will serve as a point of comparison to analyze if the mega casting core team has been structured as an autonomous team or if there have been any key differences. Further, this chapter provides commonly achieved advantages which autonomous teams benefit from and challenges autonomous teams' encounter. This could serve as a guide for when autonomous teams are appropriate for Volvo Cars in the future.

3.5 Agile workflow

Agile is a methodology for organizing and structuring workflows and customer interactions which has its origin in software development (Fowler & Highsmith, 2001). Agile is meant to re-think how normal workflows are done, with an iterative process rationalizing tasks such as documentation or modeling with a healthy balance of moderation. Agile has the purpose of "... uncovering better ways of developing software by doing it and helping others do it" (Fowler & Highsmith, 2001, pg. 2). Agile was created by 17 software engineers who created the "Agile Software Development Alliance" (Fowler & Highsmith, 2001), which the same year of 2001 released the "Manifesto for Agile Software Development" (Beck et al., 2001).

Agile has the four following values as presented by Fowler and Highsmith (2001, pg. 2):

- "Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan"

The original manifesto presented twelve principles to follow as the main content of the new methodology (Beck et al., 2001). These range from focusing on satisfying customers and changing requirements even late into a project, to self-organizing teams and prioritizing simplicity (Beck et al., 2001). These are to fulfill the purpose and live up to the aim of the manifesto.

Agile has started to spread to new industries beyond software in later years as the success of the iterative model is something many companies want to capitalize on (Lindlöf & Furuhjelm, 2018). Manufacturing firms stand to gain speed and efficiency by utilizing adapted agile principles in contrast to traditional management or workflow methods. Lindlöf and Furuhjelm (2018) showcase how another Swedish large original equipment manufacturing is utilizing agile methodology in practice to great effect. Further, examples are presented by Alenmyr and Nilsson (2016) in their case study as they look at a credit agency's agile transformation as a case study of agile applications beyond software development.

Further, Bazigos et al. (2015) has come to define agile companies as those who combine speed and stability in how managers and leaders adapted to challenges and new requirements. Through a large-scale survey of decision makers throughout a variety of industries it was found that companies which could operate stably whilst taking quick and decisive action had the best financial performance and health.

There are several popular adaptations of the agile principles to applicable scenarios, where SCRUM is one of the most popular and was much like agile itself developed for software. SCRUM is a way of structuring work in short iterative cycles called "sprints" to provide clear focus on what each team member needs to work on as well as ensuring that highest priority tasks are handled first (Kniberg, 2015). The workflow is managed by a tool called "product backlog" on which each task is subdivided into smaller components until small manageable concrete assignments emerge. These small backlog items are referred to as "stories" and should be completed within a brief period, and several stories are often completed in a sprint. When formulating stories commonly an estimate of its importance, the time needed to complete it, a description of the task, and a set of acceptance criteria are included (Kniberg, 2015).

The sprints are often short, no more than a month, and start with a "sprint backlog" where several stories with the highest priority from the product backlog are committed to being completed during the individual sprint (Mountaingoatsoftware, n.d.). From this sprint backlog, members complete stories according to their designated priority and mark them as completed on the backlog tool. At the end of a sprint a short demonstration or "demo" of the new progress is presented to any relevant stakeholders. Any items not completed in the sprint backlog are re-evaluated in importance and returned to the product backlog or brought to the next sprint.

SCRUM is further organized through three main roles. The team members of a scrum team are the most common role, and individuals should often volunteer and align themselves cross-functionally. The second role is the scrum master which serves to guide the team through as a leader and should alleviate the team from distractions (Mountaingoatsoftware, n.d.). Lastly the

product owner (PO) is the person responsible for the result and delivery of the project and handles prioritizing stories and the backlog.

Further, there are many different variations on the agile methodology with their own additions or changes, where Scaled Agile Framework (SAFe) is a framework for scaling agile operations to an enterprise with its inception in 2011 (Leffingwell, 2020). SAFe, as a framework, combines agile and lean principles as a way for companies to organize. SAFe builds upon the work of SCRUM and provides an applicable implementation for larger companies to organize according to the teachings of SCRUM, with the combination of lean. SAFe organizes the company into four levels: Portfolio, Solution, Agile Release Train (ART) and Team. On a Portfolio level company strategic alignment is worked upon and high-level decision-making with long-term goals often handled by large investment objects with specific goals and implementations called "epics." Epics should outline the minimum viable product and provide a business case and are handled by a "portfolio kanban" similar to a backlog. On Solution level large projects are managed which include many instances of ARTs in a SAFe Solution train. These projects are too large for singular ARTs and the entire solution is governed by a system architect partially through their own backlog system. On ART level, teams of teams collaborate as a larger collection of team members collaborating for a joint greater purpose in their individual and team contributions. ARTs are bound by common schedule, same two-week sprints, set sprint velocity and other joint agile factors (Leffingwell, 2020). Lastly, on Team level small teams of a couple of members organize similar to a scrum team, with the PO having responsibility of communicating progress and accepting tasks from the ART that the team is a part of.

In recent years attempts have been made to combine the efficiency and structure from waterfall models with the flexibility and ability to adapt with changing markets from agile. Cooper and Sommer (2016) investigated the possibility of combining agile with traditional stage-gate waterfall methods and found that it provides the greatest value for innovation processes with large uncertainty and need for experimentation. Even more value can be found from the combination of both systems as quick iterative innovations cycles and often revised prototypes. However, two large uncertainties in the combination of agile and stage gating were: How to define a "done sprint" and Resource allocation. Adaption of agile methods outside of software development is sometimes called agile project management and has been found in several companies outside of software industry (Conforto et al., 2016). The presence of such principles may be applied without the knowledge of agile management or being called by that name.

This literature regarding agile can serve as a basis for analyzing how Volvo Cars' agile workflow in the mega casting project coincides with the literature. Further, Fowler and Highsmith (2001) can help evaluate if Volvo Cars has been able to apply the agile principles to hardware automotive development and gained the values presented. The literature can also aid in assessing if the Volvo Cars' implementation of SCRUM through SAFe has contributed to the speed of the mega casting project. Lastly, the agile literature can serve as a point of comparison if agile has been combined effectively with waterfall models in practice at Volvo Cars and if it has affected the speed of the mega casting project.

4. Results and analysis

The following sections present the results from the three stages of data gathering: Initial data collection, Survey, and Secondary interviews. In the first section a summary of relevant documentation and findings from initial interviews are presented. The first section also includes a table of the formalized attributes which enabled the speed of the mega casting investment decision. The second section presents the results and analysis of the survey. Lastly, a summary of the results from the secondary interviews are presented divided into the further investigated attributes.

4.1 Initial data collection results and analysis

In this chapter a summary of relevant documentation and initial interviews are presented. The first section presents a summary of formal documentation from the mega casting demonstrations and the IT-system called VIRA. In the second section, findings from the initial interviews are presented.

4.1.1 Documented findings

In September 2020 Tesla held a press conference where the company presented their new means of producing rear floors for their car models, through aluminum casting, called “Giga casting” (Tesla, 2020). A small team did some initial research and calculations and after positive results quickly contacted managers in both R&D and manufacturing. The mega casting project was quickly divided into three separate pre-studies to develop in parallel. The project also presented its progress throughout the company with a set of demonstrations approximately every six to eight weeks.

The demonstrations are part of the documented timeline and progress of the mega casting project and were used as part of the data gathering. Further, a software called VIRA used to handle agile workflow for Volvo Cars, was looked through to find data related to the mega casting project and how agile workflow has been used and affected the speed of the project.

4.1.1.1 Demonstration documentation

The first demonstration was presented on October 30th, 2020, and by then the core team had grown from three members to twelve members divided into: Design, Cost, Manufacturing, and Sustainability and materials. Pre-studies had not yet been formalized, instead it was structured around individually assigned areas of responsibility. In the first demonstration the initial findings and feasibility were presented to other members of the organization. It also showcased the advantages mega casting entails: Cash flow, Design freedom, Decreased cost, and Simplified assembly with fewer parts. The demonstration further presented several logistical considerations

such as a potential layout and location for mega casting implementation and concluded with a SWOT analysis, including several challenges.

The second demo was held 27th of November, 2020, and the core team had grown to 17 people now divided into the three pre-studies. Pre-study A had the purpose of quickly trialing and developing in-house aluminum casting, to get experience. Pre-study B was the rear floor casting project, with the goal to launch in a future car model. Lastly, the support study aimed to investigate what alloy to use, the sustainability impact and find available Computer Aided Engineering (CAE) tools. An estimated timeline for the mega casting project was presented counting dates for future demos and important dates for the possible implementation window.

After this, another six demonstrations of the mega casting project were held. In these the progress of each pre-study was presented. The individuals involved in each pre-study also changed several times during the progress of the mega casting project, for many different reasons. The time-plan also changed as the project continued with both new activities being added and some postponements. The mega casting project, and pre-studies, did not set their own time-plan to structure their work. Instead, the time-plan for the possible implementation window, in which mega casting is going to be part of, was used as an outline. This included ensuring that necessary steps were completed in phases they needed for the overarching vehicle project. These activities are shown as demos and project releases in figure 9. A project release is an internal or external publication of project CAD models/drawings/software or other progress for the overarching vehicle project. During a release, the current progress of the project was checked and presented to all stakeholders. These demos and project releases set the pace for the mega casting project and were the milestones that the project and pre-studies worked according to during the project.

The mega casting project took 15 months from initiation to approval from the board of directors.

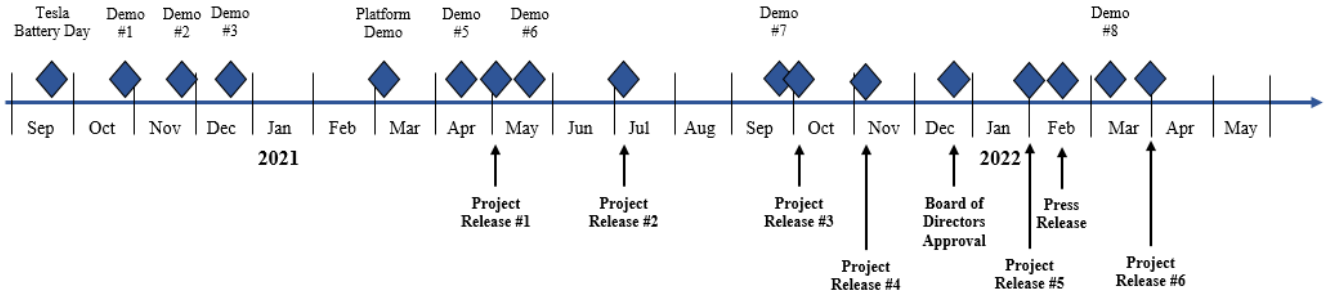

Figure 9. Schematic time-plan of the mega casting project from Sep 2020 to May 2022.

4.1.1.2 VIRA documentation

The project was first initiated in VIRA by the project leader when a capability called "Mega-castings for Vehicle Platform" was created November 9th, 2020. This capability was in turn broken down into four features. One of these features was for pre-study A and another for pre-study B, both created the same day as the capability. The two further ones were outside of the scope for this thesis. Pre-study A was in turn broken down into 85 stories and pre-study B into 64 stories. For both pre-studies, the first story was added and finished soon after the creation of the feature, and since then stories had continually been created and completed. The logged duration for each story had a large variation, ranging from two weeks up to about a year. The features had a clear set of acceptance criteria, to showcase what needed to be completed before the features were done. Looking through the individuals who had added stories or were assigned to stories, they all belonged to the same ART within R&D. This also meant that no individuals from other departments could be found on VIRA.

In order to investigate how stories were used during pre-study A, a systematic sampling was used, and every 8th story was controlled for the following four criteria: Does it contain extensive description? Does it contain extensive acceptance criteria? Does it contain a priority? How long was the duration? These criteria were selected as a method of evaluating how diligently agile stories have been used as part of a backlog. A diligent implementation of agile stories should contain an extensive description, acceptance criteria and a numeric priority. The result of this investigation is presented in table 1 below.

Story	*Description (Yes/No)*	*Acceptance criteria (Yes/No)*	*Priority (Yes/No)*	*Duration (Weeks)*
A-Story 1	Yes	Yes	No	11
A-Story 2	No	No	No	24
A-Story 3	No	No	No	6
A-Story 4	Yes	Yes	No	19
A-Story 5	Yes	Yes	No	12
A-Story 6	Yes	No	No	3
A-Story 7	Yes	No	No	10
A-Story 8	Yes	No	No	15
A-Story 9	No	No	Yes	3
A-Story 10	Yes	No	No	8
Result:	**7/10 Yes**	**3/10 Yes**	**1/10 yes**	**Average: 11**

Table 1. Contents of example stories in VIRA from pre-study A.

For pre-study B, a systematic sampling was used, and every 6th story was controlled for the following four criteria: Does it contain extensive description? Does it contain extensive acceptance criteria? Does it contain a priority? How long was the duration? The result of the investigation of how stories were used during pre-study B is outlined in table 2 below.

Story	*Description (Yes/No)*	*Acceptance criteria (Yes/No)*	*Priority (Yes/No)*	*Duration (Weeks)*
B-Story 1	No	No	Yes	6
B-Story 2	Yes	Yes	No	64
B-Story 3	No	Yes	No	2
B-Story 4	No	Yes	No	2
B-Story 5	No	No	Yes	4
B-Story 6	No	No	Yes	6
B-Story 7	No	No	Yes	10
B-Story 8	No	No	Yes	12
B-Story 9	No	No	No	11
B-Story 10	No	No	Yes	2
Result:	**1/10 Yes**	**3/10 Yes**	**6/10 yes**	**Average: 12**

Table 2. Contents of example stories in VIRA from pre-study B.

Looking through the example stories, there were some notable findings. Story 3 and 4 for pre-study B were identical in all criteria only with different starting and ending dates. Further story 2 and 9 from pre-study B were still ongoing and had not been resolved yet.

The results from the VIRA investigation showed that for pre-study A descriptions have been employed in the majority of the stories. However, acceptance criteria and numeric priorities have been applied haphazardly. For pre-study B descriptions and acceptance criteria were both lacking for most stories while priority was present for six out of ten of the stories. The average durations for both pre-studies were similar with eleven and twelve weeks respectively.

4.1.2 Initial interviews

During the initial research of documentation from the mega casting project, many times a lack of information was encountered. Documentation was lacking in detail about how decisions were taken, how the pre-studies were organized with no clear time-plans or contributors, and which traditional frameworks were used. With all the documentation many questions were still left unanswered and there was a gap of knowledge around the agile workflow of the project and what caused the investment decision to be taken as fast as it did. Due to this, 16 initial interviews were conducted to try to clarify these uncertainties.

In this chapter the initial interview results are presented. In the first two sections the impact and the speed of the mega casting project are estimated based on the interviews. The following section presents general success factors contributing to the quickness of the mega casting investment decision. Subsequently, the 16 interviews are analyzed separately for general success factors and cross-analyzed to find similar notions from other respondents. These general success factors are formalized into attributes and summarized in a table. In the last section, interview answers regarding how agile workflow affected the project are presented.

4.1.2.1 The impact of the mega casting project

During the initial documentation research, the exact impact of the mega casting project was difficult to find. This required the research method to be changed and instead rely on personal insights to assess the impact of the mega casting project. During the initial interviews it was often explained how major the impact of the mega casting project is as it affects many different departments. The casting process change does not only affect the manufacturing of rear floors but also the design, procurement, safety, parts transport, assembly and all the connecting interfaces. The impact is not only widespread over departments, but also certain affected departments will undergo fundamental changes to their workflow. E.g., designing rear floors for casting requires a whole new set of skills and challenges to consider, as parts are now fitted by mold and not stamped metal sheets.

The manufacturing for body structure department, according to initial interviews, has been very conservative to substantial changes. Interviewees mentioned that stamped steel sheets have been employed in body structure construction for about 70 years causing the mega casting project to be historically impactful.

Lastly, the impact of the mega casting project can be measured by the investment needed to realize it. The mega casting implementation was approved for the Torslanda plant with a substantial enough investment to require board of directors' approval.

4.1.2.2 The speed of the mega casting project

From the initial data collection, the framework GTDS was mentioned several times as the formal way to structure development projects at Volvo Cars. This framework was brought up both as an example of how the mega casting project was fast-tracked through following the framework but skipping certain stages and gates. Other interviewees claimed that the project never utilized the framework at all which was very unusual considering the technical nature of mega casting. If the mega casting development project had followed traditional frameworks at Volvo Cars, the development would have been managed by the GTDS framework and the investment by the investment framework at Volvo Cars.

Once a GTDS project has completed, the developed findings, if approved, should be launched into a future car development project. This is the process which will result in an investment to produce the developed finding in future cars and can be considered the next stage for development. Two to three years of development is commonly needed to reach the last gate in the GTDS framework (P. Nyström, personal communication, 2022). During the initial interviews several interviewees agreed that it is common for a development project to require two to three years until the project reaches the last stage in the GTDS framework.

The last GTDS gate is what was used for comparison to the board of directors' decision for the mega casting project as this was the point when funding was approved, and mega casting was decided to be a part of future models. This comparison shows that the mega casting project

progressed significantly faster as it was able to receive board of directors' approval and funding after only 15 months, compared to the common timeframe of two to three years. However, one interviewee described that the mega casting project, on a technical level, would not yet have reached the last stage in the GTDS framework. Meaning that in GTDS terms the mega casting project has been prematurely approved, making the comparison difficult.

During the initial interviews there was unanimous agreement that the mega casting project had progressed significantly quicker than expectations and other similar development projects. E.g., one interviewee claimed that the mega casting project was one of the fastest projects the interviewee had ever worked with. Several interviewees even claimed that during certain periods the project progressed "too fast", as the progress was rarely questioned or reassured.

As documentation on precisely how fast other comparable projects were lacking, relying on personal testimonies was required to substantiate the quickness of the mega casting project. However, one interviewee, involved in investments for the manufacturing plants, presented one comparable project. The comparable project involved investments in the Torslanda plant as a strategic investment towards future needs and was comparable both in impact and cost according to the interviewee. According to the interviewee the comparable project would be classified as a non-product investment in the investment framework, whilst the mega casting project would classify somewhere between product and non-product investment. The comparable project could be divided into two stages, as seen in the investment framework, from ideation to board of directors' investment approval. The first six months were spent on the "vision" stage, followed by 15 months of "board of directors' process". The comparable project therefore required a total of 21 months, six months longer than the mega casting project for the same progress. This shows one clear example of the mega casting project progressing faster than comparable projects at Volvo Cars.

4.1.2.3 General success factors

In this sub-chapter, the initial interview findings regarding potential general success factors contributing to the speed of the mega casting investment decision are outlined in how they were presented by the interviewees.

Many respondents mentioned that the core team member's disposition and skill were crucial factors which enabled the quick progress of the mega casting project. Several individuals involved in the project attested to the positive spirit and enthusiasm around the project. Such a large project with many risks, with developing a new technology, has been greatly aided by a problem-solving mindset and excitement around the project. The excitement around the project was due to the revolutionary nature of changing production method and body structure design, something which rarely happens. This, among other factors, has led each team member to work hard in order to quickly make progress in important areas. Multiple initial interviewees also explained that the core team consisted of members who are highly skilled and experienced within their areas of expertise, as well as quickly picking up new abilities. Some respondents mentioned that the core team members' experience within Volvo Cars has brought them significant trust and

authority within the company. One example given about this was how the projects pre-studies got early initial funding partly due to the individuals involved in initializing the idea.

The mega casting project and its respective pre-studies have also been hastened due to the excellent leadership from responsible project leader, according to several interviewees. This has brought clarity to the workflow and enabled autonomous progress from individual team members. This clarity, together with trust in team members' abilities, has enabled the project leader to delegate tasks to the pre-studies. Furthermore, some interviewees also presented the "task-force" organization of the mega casting team as a significant factor in the quick progress. The task-force setup has enabled each core team member to dedicate their full attention to the mega casting project and the team set their own rules for the project. Another success factor mentioned by several interviewees was the tight-knit cross-functional collaboration of the core team, mainly between R&D and manufacturing. Through involving many departments from the start, their approval of the project was much easier to align and considered the interests of the departments early on. The cross-functional work also involved departments such as sustainability, finance, procurement and their respective managers from early stages, which certain interviewees believed sped up the project.

Another topic which arose in the initial interviews as a contributor to the speed of the mega casting project and its investment decision was the support and willingness from management. Some interviewees believed the management culture had shifted in recent time which was part of what allowed the mega casting project to progress as quickly as it did. A part of this new management culture was to seek out and pursuit disruptive change actively. Some managers themselves presented this as a reason for helping fast-track the mega casting decision and spoke of their efforts to look for new potentially revolutionary trends in the automotive market. This extended to both process and product developments and one manager explained how the novelty and impact of the mega casting project exited them greatly. Furthermore, many interview subjects believed that this new management culture entailed more willingness towards risk-taking. Interviewees spoke of new competitors around the globe which are moving faster, with shorter innovation cycles and radical risky innovation ideas. As a result, Volvo Cars' management has adapted to this new climate and accepts a greater amount of risk for development projects with significant potential. In addition, the mantra "dare-to-fail", or similar ideas also appeared in multiple interviews reflecting upon the new risk acceptance within the management culture. Interviewees emphasized that willingness towards risk extends only to certain types of risk, e.g., financial risk whilst risk affecting in areas like quality and safety are unacceptable. Beyond the maturity of risk-taking, some interview subjects also claimed that management realizes the need for flexibility and faster innovation within development projects which has allowed the mega casting project to progress faster. For example, through allowing certain early controls and checks to be skipped, not to slow the project down. Lastly, one interviewee also claimed that this management culture comes from an acute sense of survival, with managers being aware of the potentially devastating outcome of falling behind cutting edge technology.

Several interviewees also believed that the process and workflow of the mega casting project has been essential to its quick progress. During the initial interviews, many individuals highlighted the early and frequent involvement of senior management as a contributor to the quickness of the mega casting project. The continuous contact with top management, both from R&D and manufacturing, from the start of the project enabled early buy-in and interest which facilitated and sped up progress. With senior management's involvement and interest, already from the start of the project, it was possible to get faster funding and have managers' support from higher levels of the organization, which contributed to the quickness of the project. One interviewee mentioned that the workflow composed of pre-studies and predetermined deadlines created a clear time-plan from the start of the project and can be seen as one success factor. The clarity of how work was divided and what should be done and when, created a steady workflow of the project from the start. The success factor presented by the highest number of interviewees was the demonstrations that were organized during the whole project. These demonstrations provided a way to spread knowledge about the project's progress throughout the company, which created greater interest and involvement from people in the organization. The demonstrations contributed to the mega casting project receiving significant attention which hastened the project.

Furthermore, individuals mentioned that the quickness of the project and its investment decision has also been enabled due to the use of external expertise. The lack of knowledge about the new technology was highlighted as a challenge by several interviewees and by hiring experts in this area the project was able to proceed. Without external expertise, essential challenges in the project would not have been solved and the project would not have been able to proceed. Some interviewees presented the online workflow as a success factor since it increased the efficiency of the project. Working online enabled more people to participate in a single meeting and recording of meetings that could be accessed later. Moreover, one interview subject mentioned that the online workflow lowered the barriers to cross-functional work which itself was seen as a contributor to the quickness of the mega casting project. Another contributor to the speed of the project and its investment decision, mentioned by several interview subjects regarding the process and workflow, was the ability to forego traditional frameworks for development. These frameworks are thorough to ensure each aspect is considered before continuing a development or an investment, however, this also causes them to take a significant amount of time. Several interviewees claimed that the project could never have progressed as fast as it did or met the deadlines if the traditional frameworks were followed. One interviewee also mentioned that the mega casting investment calculations did not fulfill certain requirements of traditional investment guidelines. These guidelines were reconsidered for the mega casting project and the investment was instead motivated based on longer-term financial gain and strategic ambitions.

The timing of the project as it progressed was deemed by many interview subjects as an important factor which led to the project progressing faster. According to some individuals interviewed, investment in new manufacturing capability was going to be made, either in new technology or current one. Volvo Cars' investment readiness in manufacturing contributed to a curiosity to search for new technology to invest in which enabled easier and faster buy-in and funding for the mega casting project. Another success factor mentioned by some interviewees was that the technology of mega casting was already tested, developed and currently used by a

competitor. This created evidence for the realization of mega casting technology and contributed to people at Volvo Cars becoming more inclined to invest in this new technology which enabled the quickness of the project and investment. Furthermore, Tesla's "Battery Day" was presented by several individuals as a factor that sped up the project. Tesla created awareness around the mega casting technology which contributed to an increased interest in Volvo Cars' internal stakeholders. Not only did Tesla show that the technology is useful, but Tesla was also seen as a source of inspiration and therefore Volvo Cars became even more interested and wanted to quickly follow the trend.

One interviewee mentioned that Volvo Cars wants to be an innovative company that is able to respond fast to market changes, which resulted in mega casting as an impactful and quick technical improvement. This was particularly important when Volvo Cars got listed on the public stock exchange. One respondent mentioned that casting aluminum was not completely new for Volvo Cars and that the technology had already been used when casting spring towers. This technique was familiar to the company which made internal stakeholders involved in the project more confident in their choice to ramp-up the mega casting project. It contributed to quicker development of the project, and it also enabled easier and faster buy-in from management since the casting of aluminum was already proven to work. Furthermore, aluminum was already used and expanded in each new vehicle, and this was mentioned as a success factor by one interviewee. Even if the mega casting technology is a disruptive change for Volvo Cars, the extended usage of aluminum within cars is a trend the company was already pursuing. Further, some interviewees mentioned that a success factor related to the timing of the project was the availability of financial resources for new development. Volvo Cars was in a growth phase during the mega casting project, with plans to expand production, and this gave the project an advantage as funding for new projects was available within the company. The mega casting project therefore could progress faster with more resources spent on it and managers more willing to invest. Lastly, the timing of the project coincided with a possible implementation window, which created a clear stop-or-go moment. Several interviewees claimed that this critical deadline contributed greatly to the fast-tracking of the project.

Further reasons for the quick progression of the mega casting project and its investment decision were perhaps the most natural or expected ones, the improvement outcomes and investment details. Many interviewees mentioned the improvements themselves from the investment as a key reason for the quick progress. During the interviews multiple individuals shared an idea of how great the improvement of mega casting could result in. One aspect which was unique for the mega casting project was where the improvement impacted. As explained by multiple parties, R&D projects most often focus on direct customer value improvements such as a sleeker design, better noise levels or improvements in user experience. However, for the mega casting project many improvements stem from the simplification of manufacturing the rear floor. This caused the projects projection to meet many of the key performance index (KPI) ambitions of the manufacturing department such as floor space, number of joints, amount of assembly steps etc. The interviewees believed this helped the project gain cross-department support and interest from earlier stages which helped speed up the acceptance.

More traditional improvements which were brought up for the mega casting project was first sustainability. As Volvo has ambitious emission targets and sustainability is part of the company's core values and integral to their strategy, the fact that mega casting could help improve CO_2 emission was presented as a contributing factor. Some interviewees claimed that the sustainability improvements helped the project get more interest, resources and managerial acceptance since it aligned with the ambition to adopt more sustainable practices as quickly as possible. One of the major improvements expected from the mega casting project was a significant cost saving, which many respondents claimed acted both as a qualifier for the project and helped push its priority higher. The major cost improvement caused further managerial interest in the project and one respondent called the improvement "too good to ignore". Other more unique improvements from the mega casting project were the ability to more easily adjust designs for each model and the possibility to vertically integrate production of certain parts. The first is a result of the manufacturing technique where mega casting is believed to be adaptable enough to design unique moulds for each model, removing design restriction to utilize common parts for different models. This improvement was novel in design and manufacturing with some interviewees claiming this was a feature which also gave the project positive reception and led to prioritization. The ability to vertically integrate was brought up by some interviewees as an improvement in both reliance of suppliers, ability to capture profit and simplify the supply chain. These improvements were also thought to have helped accelerate the project and investment.

Lastly, two respondents claimed that the investment type of the mega casting project was a significant contributor to its acceptance and senior managers' interest. The first aspect of the mega casting investment was that it would be in "non-type bound" areas. This means that the investment could still be utilized even if the project itself fails and that the investments are not bound to a specific car model. E.g., a new building is non-type bound as it can always be reused for other purposes in the future if the initial purpose fails or changes. The mega casting investment includes expertise, new buildings, and machines such as presses. By changing the dies several different models could be made quite easily from the same infrastructure, making the presses non-type bound. The investment was also seen as being in an expandable technology which the respondents believed helped it gain traction within the company. As the mega casting technology could be expanded into other parts of the body structure or other areas entirely in the future. This gave the project significant long-term strategic value which was presented as a potential factor to why the investment decision could progress faster than others.

4.1.2.4 General success factors analysis

In this section the general success factors identified from initial interviews are analyzed and formalized into 31 attributes enabling the speed of the mega casting investment decision. The found attributes were analyzed depending on their content and grouped into functional topics. The analysis process resulted in 31 attributes divided into the following five functional topics: Core Team, Management Culture, Process and Workflow of the Project, Timing of the Project,

and Investment Specific Details and Improvements. The attributes were divided into topics in order to group them into comparable categories for the survey stage. The attributes, their classified topic and number of occurrences are presented in table 3. Number of occurrences refers to in how many unique interviews the attribute was found. Attributes are first ordered by functional topic and in descending order by number of occurrences within topics.

Topic	*Found attribute*	*Number of occurrences*
Core Team	Hard working core team with a lot of enthusiasm and with a "challenges can be overcome" mindset	7
	Small cross-functional core team with engagement from several departments	7
	Core team members are highly skilled and are experienced experts within their areas	6
	Clear leadership and clear division of labor with trust in core team members causing autonomous progress	5
	Core team has "task-force" setup with complete dedication to the project	3
	Core team members had a lot of trust and authority from management	2
Management Culture	Management being willing to take risks with new change and dare to fail	7
	Culture within management to seek out and pursuit disruptive change	3
	Management recognize a greater need for flexibility and quick improvements	2
	Management mindful of falling behind in technology	1
Process and Workflow of the Project	Demonstrations spread knowledge about the project's progress throughout the company	10
	Early and frequent contact with senior management	7
	Ability to forego traditional development frameworks and their included stages and gates	6
	Use of external expertise	5
	Online workflow has been more efficient, more participants in a single meeting and recorded meetings can be accessed later	2

	Clear time-plan from the start with pre-studies and steps to complete before deadline	1
Timing of the Project	Tesla's "Battery Day" gave widespread awareness of mega casting technology, Tesla is seen as a source of inspiration	8
	Set deadline for the possible implementation window from the beginning, which created a clear stop-or-go moment	4
	Mega casting technology was tested, developed, and currently used by a competitor	3
	Volvo Cars is in a growth phase with available resources to invest in new developments	2
	Investment in new manufacturing capacity was going to be made, either in old manufacturing technology or new one	2
	Aluminum was already being used and expanded in each new vehicle	1
	Casting aluminum was not completely new to Volvo Cars, cast spring towers are already in use	1
	Volvo Cars getting listed on the public stock exchange gave managers the courage to take impactful technical decisions	1
Investment Specific Details and Improvements	Cost savings	6
	Improvement in sustainability	3
	Improvement in manufacturing's KPIs from R&D project	3
	Investment in expandable technology, aluminum casting is applicable to other areas in the future	2
	Less reliance on suppliers by producing parts in-house	2
	Investment is non-type bound, investment infrastructure is not bound to a specific car model	2
	Better opportunities for customizing and optimizing design	1

Table 3. Found attributes enabling the speed of the mega casting investment decision from initial interviews.

4.1.2.5 Agile workflow

During the initial interviews eight respondents were asked about their insight into how Volvo Cars' agile workflow has affected the speed of the mega casting project. Only respondents from R&D with any experience and understanding of Volvo Cars' agile workflow were asked to improve the validity. Agile workflow as a contributor to the speed of the mega casting project is presented in this chapter instead of in section 4.1.2.3 about general success factors. This is due to when interviewees were asked about general success factors which contributed to the speed of the mega casting project and its investment decision, no interviewee mentioned agile workflow.

Within the mega casting project agile methodology has been applied to some degree, both in the overarching project as well as in the smaller independent pre-studies. The mega casting project was initiated as a capability on Solution level which was broken down into features for each pre-study on ART level and in turn handled by development Teams through stories. This was made clear from the initial interviews and confirmed by the initial data collection from VIRA that tools like backlogs, sprints and demos were used on these levels. Roles from the VCAF framework were responsible for the administrative part of the project with designated roles such as PO, PM and SM having partial authority over the progress of the mega casting project.

The majority of respondents, six out of eight, believed that agile had little to no effect on the speed of the mega casting project. All eight respondents could identify traces of agility within the mega casting project, mainly cross-functionality, demonstrations and backlogs, however, many were hesitant to attribute any major impact of speed to these. Cross-functional teams were something Volvo Cars employed long before the agile transformation and were not unique for this project. One respondent even claimed that the agile workflow with sprints made the cross-functional workflow between R&D and manufacturing more difficult, since manufacturing did not use agile principles such as sprints which made cross-functional planning a challenge. Backlogs and sprints have been used in each pre-study and by supporting teams to the core team but not in the core team itself, however, respondents claimed that backlogs have been used haphazardly. Backlogs have been used as a diary tool to report progress or been quickly added without important agile measures such as priority numbers. Two interviewees claimed that short sprints as agile recommends would have disrupted the workflow and potentially slowed the project down, as hardware development is different than software.

The demonstrations, on the other hand, were unique for the mega casting project, how they have been used to convey and spread information in the company. However, respondents were uncertain if demonstrations, as they were used, were in accordance with the agile way of working. Furthermore, multiple respondents presented the mega casting project as a task-force, a self-sufficient project team within Volvo Cars, noting the similarities to agile but under a different name.

A more in-depth interview with a PO was held as an extension of the initial interviews to better understand how pre-study B handled VIRA as an agile tool. It was explained that VIRA was not

used very diligently during pre-study B, this caused a lack traceability for who, when and what was done in VIRA. VIRA was more used as a formal process where each team member needed to be assigned to a story in VIRA to prove that they were working on the project. This caused individuals in pre-study B to simply create a placeholder story, without description, acceptance criteria or priority, simply to have something to assign to. Some individuals did use VIRA more thoroughly, however, others believed it consumed too much time for administration. Further, it was explained that VIRA was more used as a way to log work tasks than a true backlog from where individuals were assigned to stories and perform the work.

The stories were created by the development team for the specific functional area and not handled by the mega casting project team. The priority reporting in VIRA also had a number of limitations which caused many stories to adopt the priority of the connected feature. This made it impossible to decern which story had to be done first. It was therefore explained that the development team created their own internal priority of stories, which was not always clear in VIRA. The PO also mentioned that the development teams also avoided adding smaller tasks or details in VIRA and instead named a story e.g., “work on mega casting”, as a catch-all for their weekly tasks. Other times daily work was not added in VIRA at all.

The interviewed PO also responded that it was difficult to discern if the agile workflow had any impact on the speed or not. Remarking on the agile tools as a potential factor which could have enabled faster progress but also presenting challenges with agile in manufacturing process development such as how to clearly define a “definition of done.” Lastly, one respondent confidently claimed that agile has had a clear impact on why the mega casting could progress as fast as it did. Claiming four major enabling factors: the Demos which helped communication, Backlogs as a tool, Cross-functional planning across R&D divisions, and the Extended authority given to ARTs helping ownership.

The initial interviews regarding the agile workflow resulted in no general success factors enabling the speed from the agile workflow to be handled in the survey.

4.2 Survey results and analysis

In order to validate and quantify the 31 success factors found in the initial interviews a survey was conducted. The survey was conducted using Microsoft Forms and was sent out through email to 57 respondents, with a response rate of 42,1%. In this chapter the survey results are presented. The survey outline can be found in appendix A.

The survey consisted of eleven questions divided into six areas. The first ten questions were divided into functional topics, the same as in table 3. Each topic included two questions, the first asked the respondent to rank the attributes related to that topic in order of impact they played in the quickness of the mega casting project. The second question gave the respondent an option to submit any important attributes not yet captured. Lastly, in question 11, survey subjects were

asked to rank the topics in order of impact they played in the quickness of the mega casting project.

The results from the survey are presented in the sections below and are first presented within each topic. In each topic two graphs are presented, the first one showcasing the ranking distribution for the attributes and their corresponding average voting score. The average voting score was calculated for each attribute, but only compared within the topic. When calculating the voting score each attribute was given a score depending on its rank in the topic. A number one rank gave points equals the number of attributes within the topic, a number two rank gave one less and so on. E.g., if there were six total attributes within a topic, rank one equaled six points, rank two equaled five points and rank six equaled one point. These points were summarized and divided by the total number of respondents to get the average voting score. The second diagram showcases the percentage of number one rankings for each attribute. Both graphs are only indicative within that topic. After all topics have been presented, the ranking of the topics is presented in section 4.2.6 with a diagram showcasing the ranking distribution of the topics.

After all the survey results were presented within each topic, the survey results were transformed into a comparable format, which are presented in section 4.2.7. This to be able to compare the different attributes across the different topics. Section 4.2.8 outlines any other information related to the survey received by email. In the last section the survey results are analyzed to evaluate the most important attributes to serve as a foundation for secondary interviews.

4.2.1 Core Team

Hard working core team with a lot of enthusiasm and with a "challenges can be overcome" mindset got the highest average voting score of 4,75. *Core team has "task-force" setup with complete dedication to the project* received the lowest average voting score for all Core Team attributes. These results are presented in diagram 1 below. Diagram 1 displays the ranking distribution of the Core Team attributes and their average voting score. All the attributes are ordered after their calculated average voting score. The brown color in the diagram indicates how many times the attribute has been ranked as number one, the orange color showcases how many times the attribute has been ranked as number two etc.

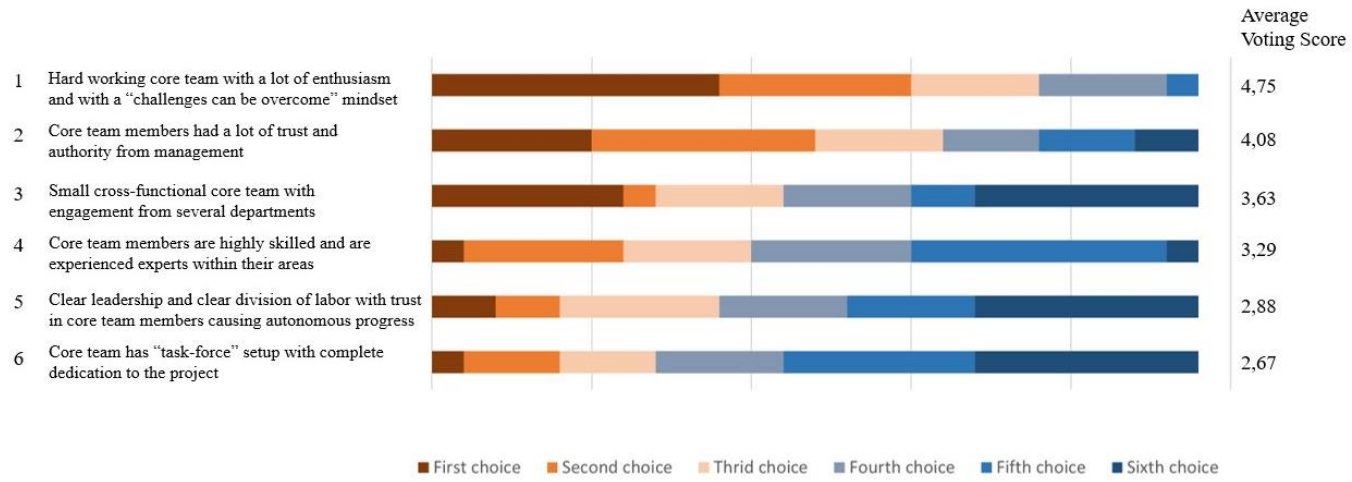

Diagram 1. Ranking distribution of Core Team attributes and their average voting score.

The attribute S*mall cross-functional core team with engagement from several departments* received more number one ranking than *Core team members had a lot of trust and authority from management* but a lower average voting score. These results are presented in diagram 2 below. The pie-chart displays the percentage of number one rankings each Core Team attribute received. This pie chart presents the results which each respondent voted as the single most important attribute as a percentage of the total population.

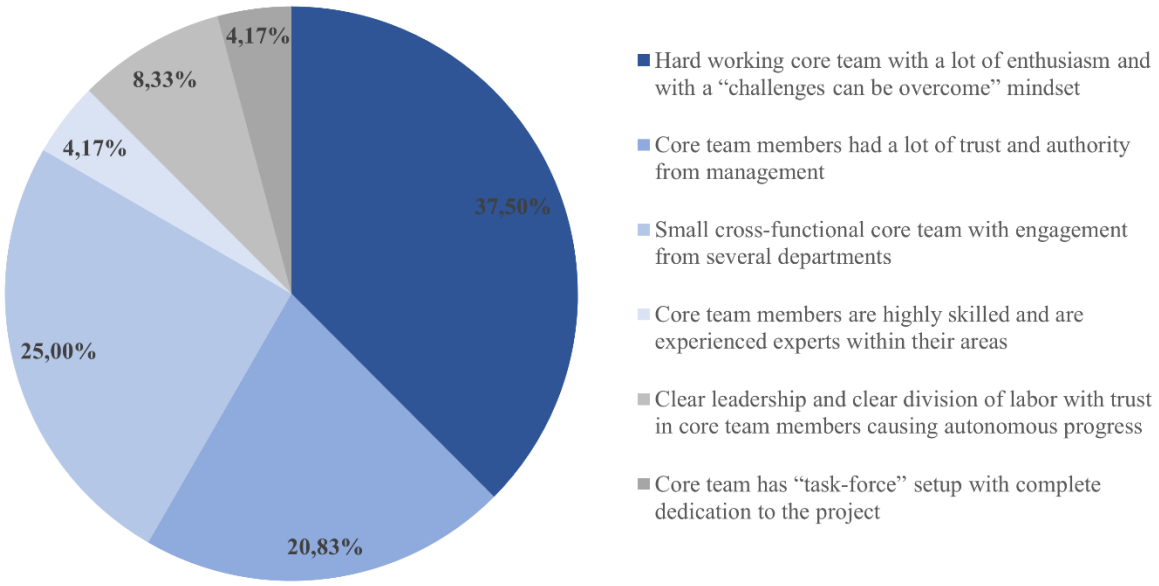

Diagram 2. Percentage of number one rankings for each Core Team attribute.

Seven respondents submitted optional answers to the question of whether any important attributes regarding Core Team were lacking. Each answer from the different respondent was interpreted and analyzed regarding if it should be added as an attribute or if it was already included in other attributes. After the analysis, a decision was taken whether the new attribute

would be added or not. All the submitted optional responses, the interpretation and planned action are presented in table 4 below.

Name	*Response*	*Interpretation and planned action*
Respondent 1	1. Core team with participants that serve as ME and R&D task leaders for sub projects. 2. Core team setting up regular Demos to share status of project 3. Core team setting up sync meetings with top ME and R&D management to get STOP/GO decision	1. Similar to *Small cross-functional core team with engagement from several departments.* No action taken. 2. Similar to the attribute *Demonstrations spread knowledge about the project's progress throughout the company* in Process and Workflow topic. No action taken. 3. Included in *Early and frequent contact with senior management* under the Process and Workflow topic. No action taken.
Respondent 2	Collaboration	The answer is too vague. No action taken.
Respondent 3	The way the project leader drive the project and the contribution of some key specialist's has been important. The way DEMO's has been performed has been great.	Included in the attributes *Clear project leadership and clear division of labor with trust in core team members causing autonomous progress* under Core Team and *Demonstrations spread knowledge about the project's progress throughout the company* under Progress and Workflow. No action taken.

Respondent 4	This response included confidential information and could not be published.	Feedback does not include any potential new attribute. No action taken.
Respondent 5	This response included confidential information and could not be published.	Included in the attribute *Ability to forego traditional development frameworks and their included stages and gates* in Process and Workflow topic. No action taken.
Respondent 6	Good team spirit and open cooperation. Easy to bring in new team members, and supportive environment.	Similar to *Hard working core team with a lot of enthusiasm and with a "challenges can be overcome" mindset.* No action taken.
Respondent 7	Transparency from the core team => demos on regular basis. This created a common understanding of status and challenges ahead as well as necessary "sense of urgency".	Similar to the attribute *Demonstrations spread knowledge about the project's progress throughout the company* in Process and Workflow topic. No action taken.

Table 4. Presenting feedback for potentially missed Core Team attributes from the survey.

Two responses included confidential information which could not be published, but their interpretations and planned action were still included. No new attribute was added to the Core Team topic as a result of the survey answers.

4.2.2 Management Culture

The attribute *Management recognize a great need for flexibility and quick improvements* got the highest Management Culture average voting score with 3,25 points. Whilst *Management mindful of falling behind in technology* only resulted in 1,63 points, making it the lowest.

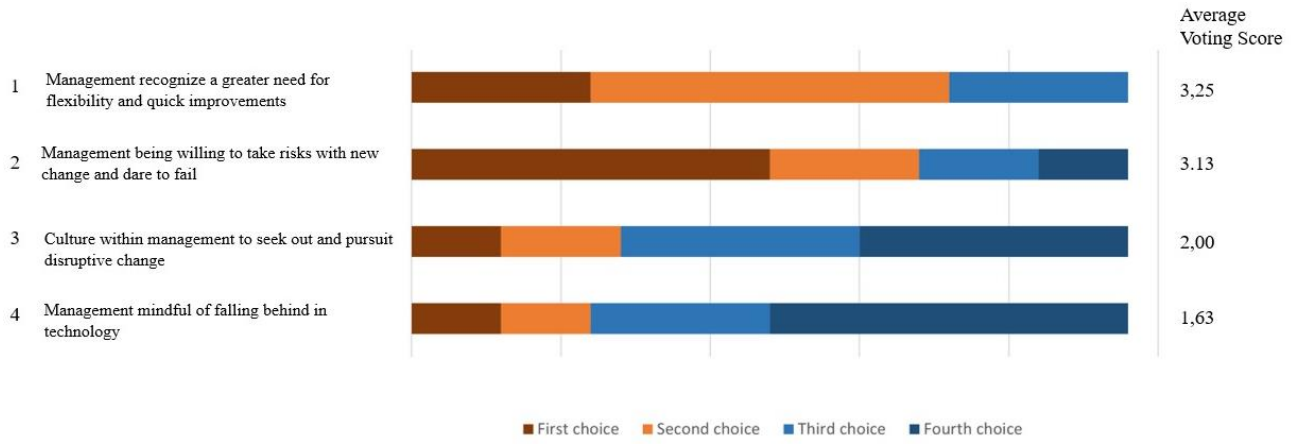

Diagram 3. Ranking distribution of Management Culture attributes and their average voting score.

50% of all respondents ranked *Management being willing to take risks with new change and dare to fail* as number one, making it the most number one ranked Management Culture attribute by a significant margin. Both *Culture within management to seek out and pursuit disruptive change* and *Management mindful of falling behind in technology* received the same amount of first rankings but had different average voting scores.

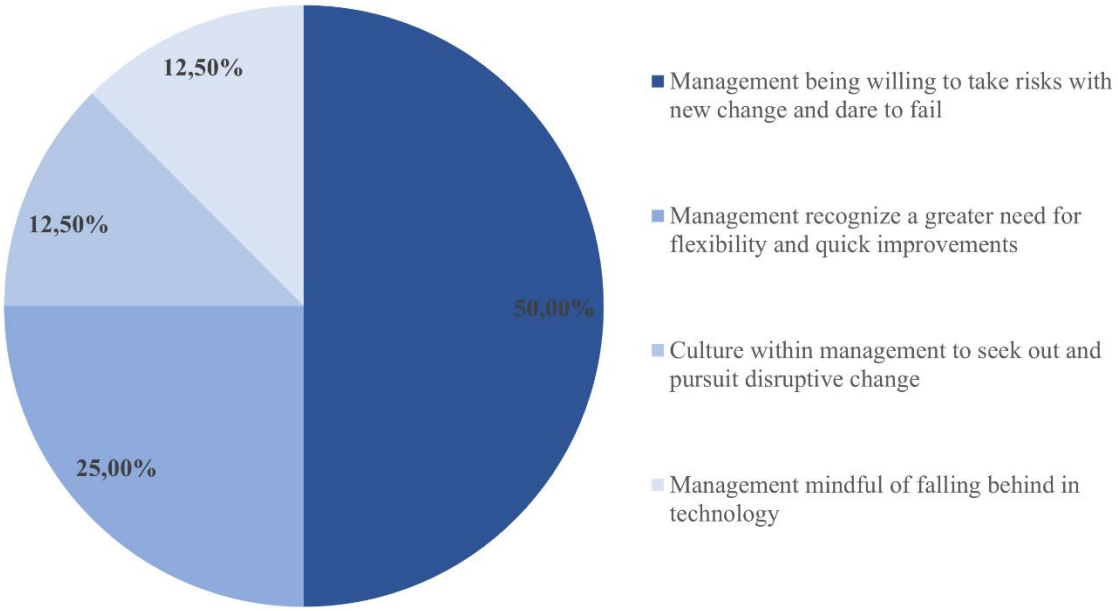

Diagram 4. Percentage of number one rankings for each Management Culture attribute.

In the Management Culture topic one respondent submitted another related attribute important to the quickness of the mega casting project not included in the survey. This answer was analyzed and the response, interpretation and planned action of it is presented in table 5 below.

Name	*Response*	*Interpretation and planned action*
Respondent 1	Higher management very supportive, targeting solutions and success.	Similar to *Core team members had a lot of trust and authority from management* under Core Team and a precursor to other Management Culture attributes. No action taken.

Table 5. Presenting feedback for potentially missed Management Culture attributes from the survey.

No new attributes were added to the Management Culture topic.

4.2.3 Process and Workflow of the Project

Early and frequent contact with senior management obtained a score of 4,50 which makes it the highest ranked attribute according to average voting score. The attribute *Online workflow has been more efficient, more participants in a single meeting and recorded meetings can be accessed later* got the lowest Process and Workflow average voting score.

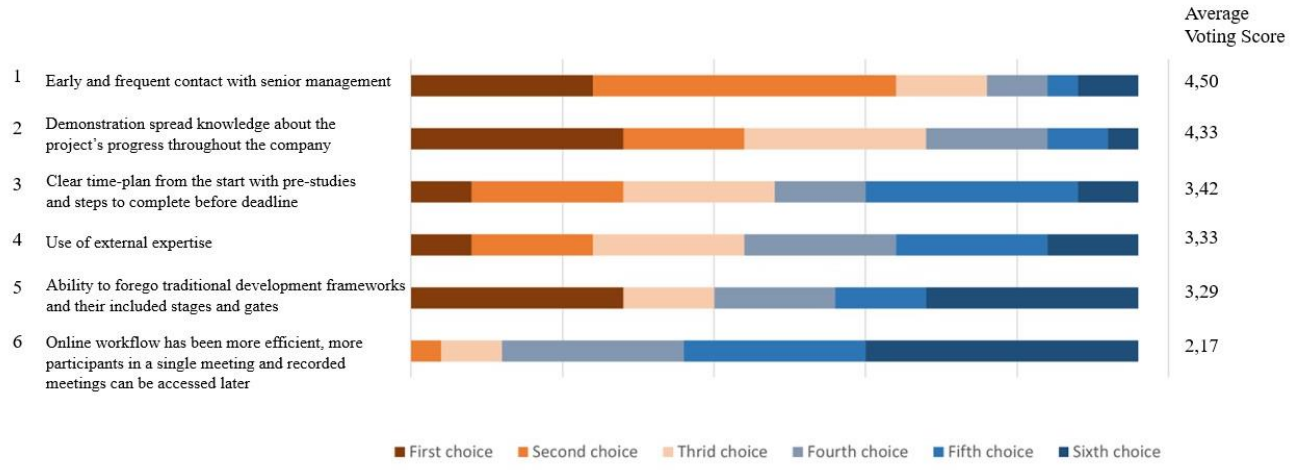

Diagram 5. Ranking distribution of Process and Workflow attributes and their average voting score.

The attribute *Early and frequent contact with senior management* got the third most number one rankings despite having the highest average voting score. The attributes with the most amount of number one rankings for Process and Workflow were both *Demonstrations spread knowledge about the project's progress throughout the company* and *Ability to forego traditional*

development frameworks and their included stages and gates. The latter, however, received the second lowest average voting score even though it got many first rankings. *Online workflow has been more efficient, more participants in a single meeting and recorded meetings can be accessed later* did not get ranked first by any respondent and is absent from the pie-chart below.

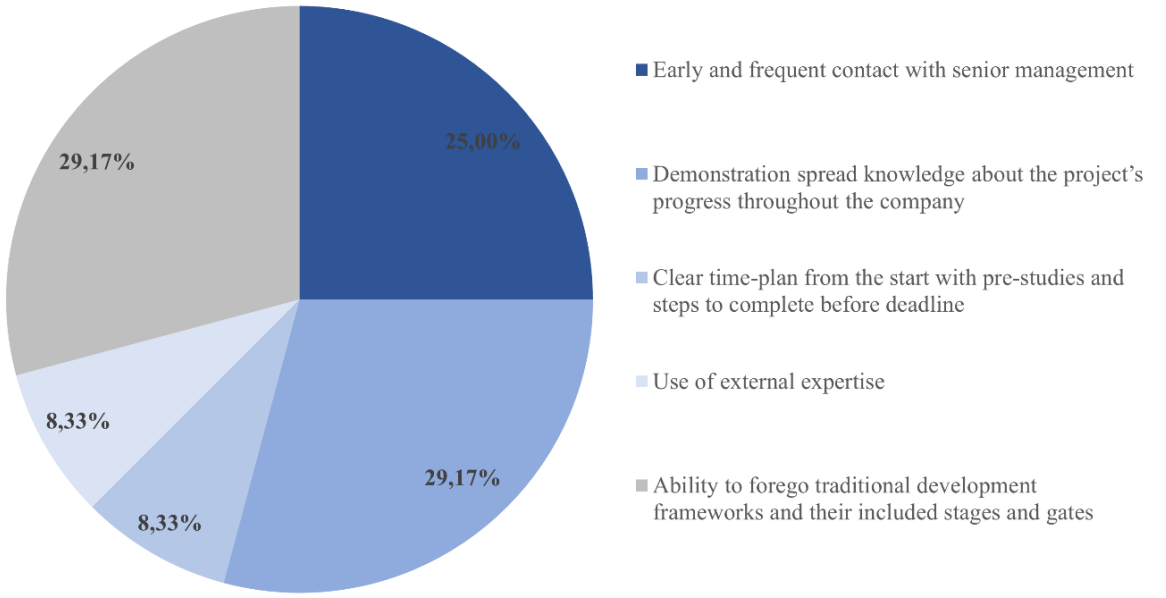

Diagram 6. Percentage of number one rankings for each Process and Workflow attribute.

Two respondents answered optional attributes to the question of whether any important attributes regarding Process and Workflow were lacking. These responses were analyzed and the responses, interpretation and planned action of them are presented in table 6 below.

Name	*Response*	*Interpretation and planned action*
Respondent 1	First comment needs to be consider.	Answer too vague and contains no new attributes. No action taken.
Respondent 2	Attention from higher management and successful Demo with high amount of attendees.	Similar to attribute *Demonstrations spread knowledge about the project's progress throughout the company*. No action taken.

Table 6. Presenting feedback for potentially missed Process and Workflow attributes from the survey.

No new attributes were added to the Process and Workflow topic as a result of the survey answers.

4.2.4 Timing of the Project

Tesla's "Battery Day" gave widespread awareness of mega casting technology, Tesla is seen as a source of inspiration received the highest average voting score of 6,46 points. *Volvo cars is in a growth phase with available resources to invest in new developments* got the lowest average voting score. Both *Investment in new manufacturing capacity was going to be made, either in old manufacturing technology or in new one* and *Mega casting technology was tested, developed, and currently used by a competitor* resulted in the same average voting score, as a shared third place.

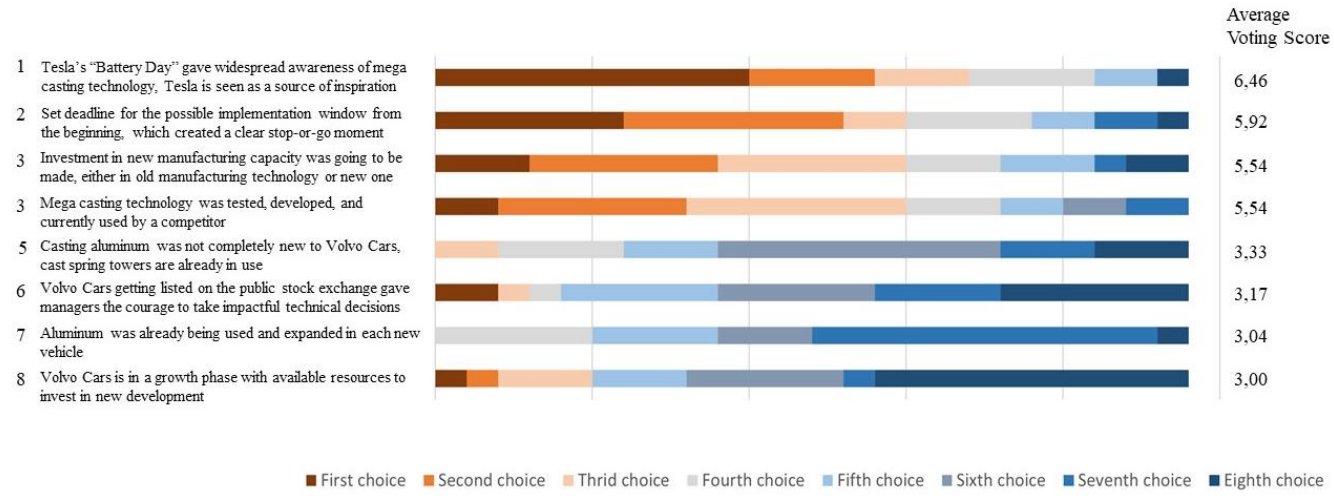

Diagram 7. Ranking distribution of Timing attributes and their average voting score.

The four attributes which got the highest voting score also got the most amount of number one rankings in the same ascending order. Two attributes received no number one ranking which were *Casting aluminum was not completely new to Volvo Cars, cast spring towers are already in use* and *Aluminum was already being used and expanded in each new vehicle.*

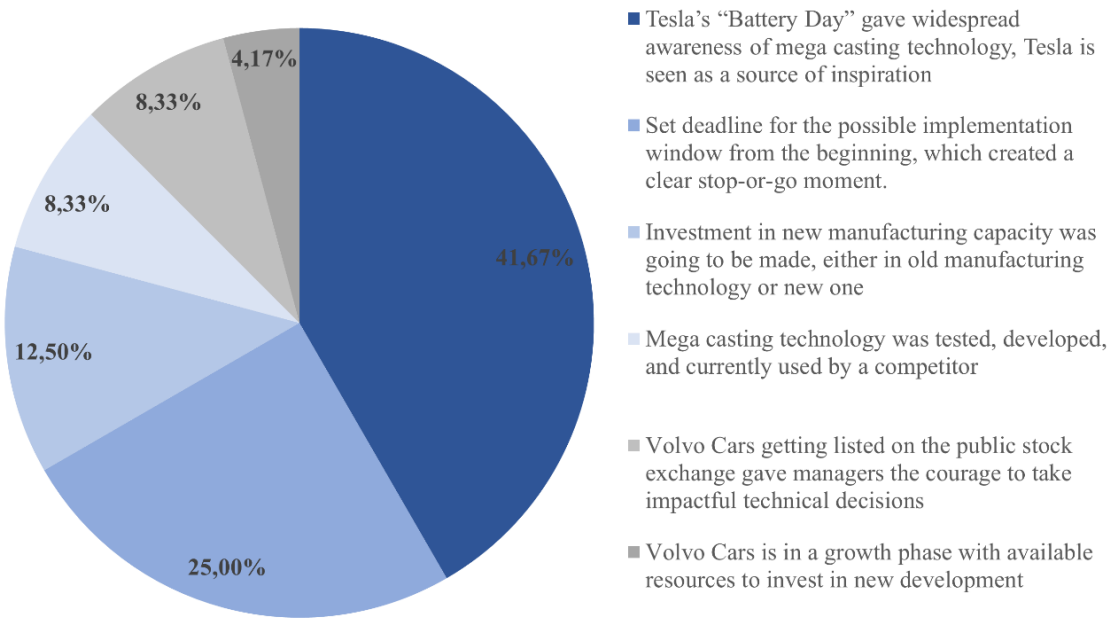

Diagram 8. Percentage of number one rankings for each Timing attribute.

Two optional answers were given from respondents for new Timing attributes not yet captured in the survey rankings. These responses were analyzed and the responses, interpretation and planned action of them are presented in table 7 below.

Name	*Response*	*Interpretation and planned action*
Respondent 1	The development of prototype tool was key to get data.	Similar to *Clear time-plan from the start with pre-studies and steps to complete before deadline* under the Process and Workflow topic. No action taken.
Respondent 2	Tesla information was used as base, and the impossible being possible	Answer too similar to the attribute *Mega casting technology was tested, developed, and currently used by a competitor*. No action taken.

Table 7. Presenting feedback for potentially missed Timing attributes from the survey.

As a result of the survey no new attributes were added to the Timing topic.

4.2.5 Investment Specific Details and Improvements

For Investment Specific Details and Improvements *Investment in expandable technology, aluminum casting is applicable to other areas in the future* received the lowest average voting score. The attribute with the highest score was *Improvements in sustainability*.

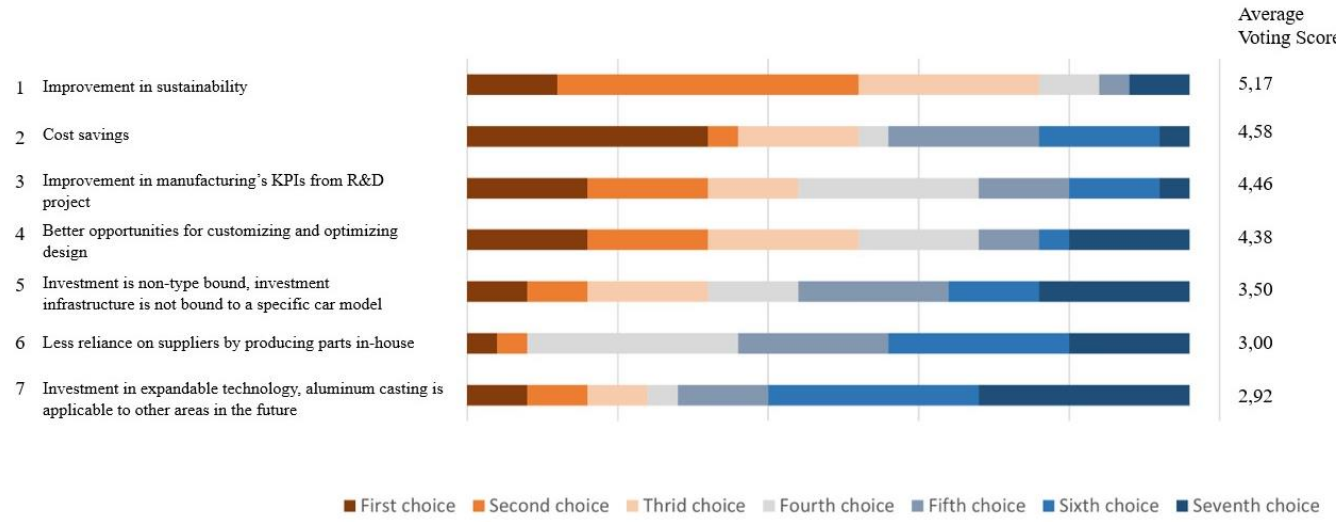

Diagram 9. Ranking distribution of Investment Specific Details and Improvements attributes and their average voting score.

Cost savings obtained the most amount of number one rankings, getting one third of total first rankings. *Improvement in manufacturing's KPIs from R&D project* and *Better opportunities for customizing and optimizing design* both placed second on the most amount of first rankings. This results in that *Improvements in sustainability* received the fourth highest amount of number one rankings despite having the highest average voting score.

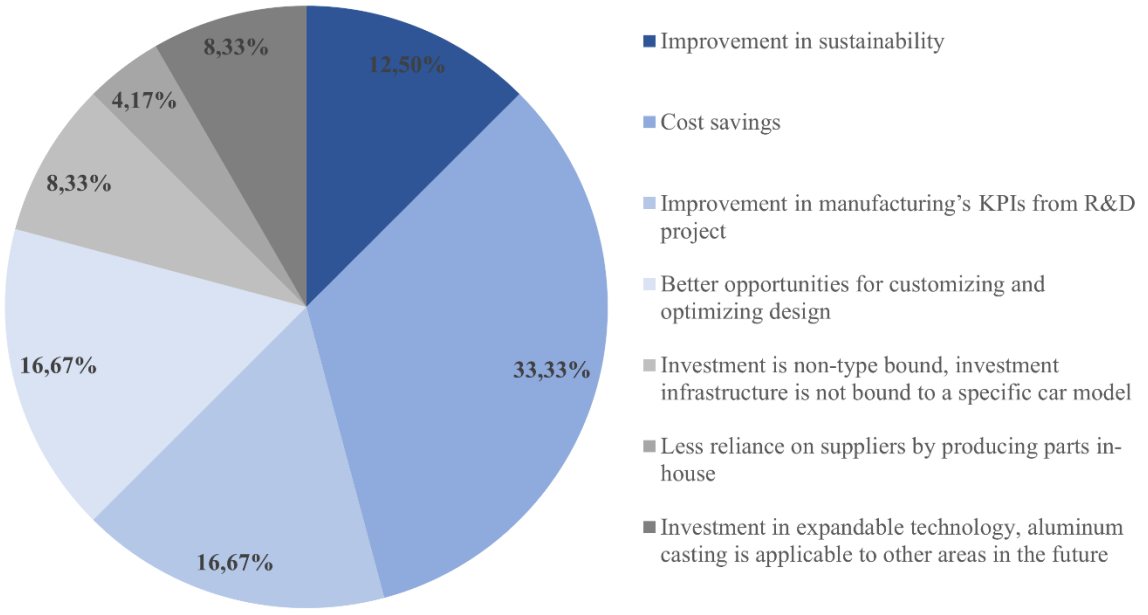

Diagram 10. Percentage of number one rankings for each Investment Specific Details and Improvements attribute.

In the Investment Specific Details and Improvements topic three respondents submitted other related attributes important to the quickness of the mega casting project not included in the survey. These responses were analyzed and the responses, interpretation and planned action of them are presented in table 8 below.

Name	*Response*	*Interpretation and planned action*
Respondent 1	This response included confidential information and could not be published.	Included in the attribute *Better opportunities for customizing and optimizing design.* No action taken.
Respondent 2	Integrate many component in one was key.	Precursor to *Cost savings*. No action taken.
Respondent 3	The principle, is high start cost and lower future investments.	Similar to *Cost savings*. No action taken.

Table 8. Presenting feedback for potentially missed Investment Specific Details and Improvements attributes from the survey.

One answer included confidential information and was not published, however, the interpretation and planned action were still included. No new attribute was added as a result of survey feedback for Investment Specific Details and Improvements.

4.2.6 Ranking of topics

The topic Core Team received both the highest average voting score. The second highest average voting score topic was Management Culture with 3,17. Investment Specific Details and Improvements got the lowest average voting score.

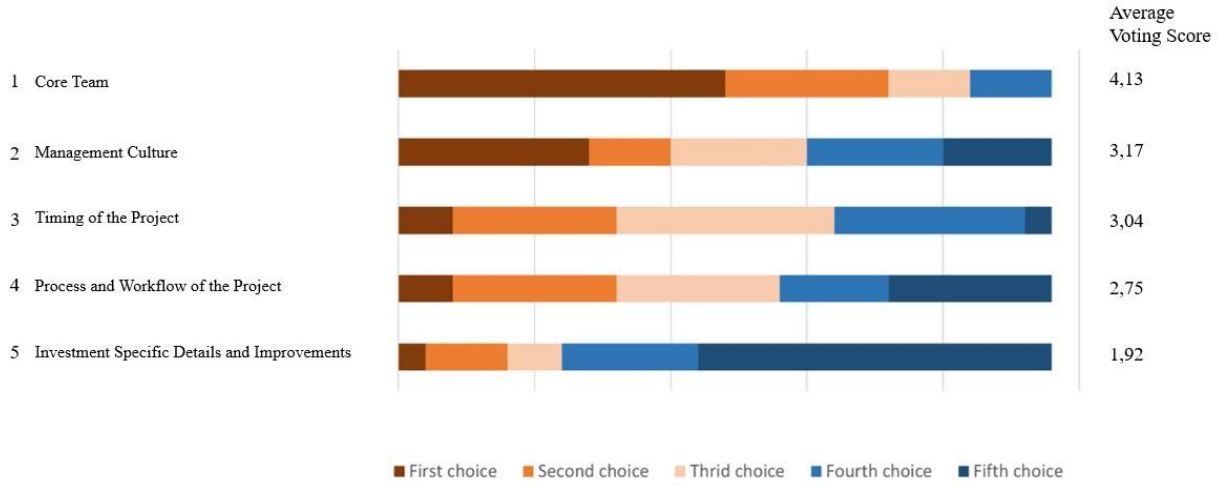

Diagram 11. Ranking distribution of functional topics and their average voting score.

4.2.7 Comparison of attributes

In order to compare all the attributes between the different topics a normalized average voting score (NAVS) and a weighted normalized average voting score (WNAVS) were calculated. NAVS was calculated by dividing the average voting score with the amount of attributes within the corresponding topic. Lastly, these NAVS were weighed by the results from question 11, the perceived importance of each topic from the survey resulting in WNAVS.

These scores, for each attribute, are presented in table 10 below. The attributes in table 10 are structured according to ascending order according to their WNAVS and colored depending on their corresponding topic. The color coding for the different topics is presented in table 9.

Core Team	*Management Culture*	*Process and Workflow in the Project*	*Timing of the Project*	*Investment Specific details and Improvements*

Table 9. Color coding for the topics in table 10.

Found attribute	*NAVS*	*WNAVS*
Hard working core team with a lot of enthusiasm and with a “challenges can be overcome” mindset	0,79	3,27
Core team members had a lot of trust and authority from management	0,68	2,81
Management recognize a greater need for flexibility and quick improvements	0,81	2,57
Small cross-functional core team with engagement from several departments	0,60	2,49
Management being willing to take risks with new change and dare to fail	0,78	2,47
Tesla’s “Battery Day” gave widespread awareness of mega casting technology, Tesla is seen as a source of inspiration	0,81	2,46
Core team members are highly skilled and are experienced experts within their areas	0,55	2,26
Set deadline for the possible implementation window from the beginning, which created a clear stop-or-go moment	0,74	2,25
Investment in new manufacturing capacity was going to be made, either in old manufacturing technology or new one	0,69	2,11
Mega casting technology was tested, developed, and currently used by a competitor	0,69	2,11
Early and frequent contact with senior management	0,75	2,06
Demonstrations spread knowledge about the project’s progress throughout the company	0,72	1,99
Clear leadership and clear division of labor with trust in core team members causing autonomous progress	0,48	1,98
Core team has “task-force” setup with complete dedication to the project	0,44	1,83

Culture within management to seek out and pursuit disruptive change	0,50	1,58
Clear time-plan from the start with pre-studies and steps to complete before deadline	0,57	1,57
Use of external expertise	0,56	1,53
Ability to forego traditional development frameworks and their included stages and gates	0,55	1,51
Improvement in sustainability	0,74	1,41
Management mindful of falling behind in technology	0,41	1,29
Casting aluminum was not completely new to Volvo Cars, cast spring towers are already in use	0,42	1,27
Cost savings	0,65	1,25
Improvement in manufacturing's KPIs from R&D project	0,64	1,22
Volvo Cars getting listed on the public stock exchange gave managers the courage to take impactful technical decisions	0,40	1,20
Better opportunities for customizing and optimizing design	0,63	1,20
Aluminum was already being used and expanded in each new vehicle	0,38	1,16
Volvo Cars is in a growth phase with available resources to invest in new developments	0,38	1,14
Online workflow has been more efficient, more participants in a single meeting and recorded meetings can be accessed later	0,36	0,99
Investment is non-type bound, investment infrastructure is not bound to a specific car model	0,50	0,96
Less reliance on suppliers by producing parts in-house	0,43	0,82
Investment in expandable technology, aluminum casting is applicable to other areas in the future	0,42	0,80

Table 10. Presenting normalized average voting score (NAVS) and weighted normalized average voting score (WNAVS) for each attribute in the different topics.

Management recognize a greater need for flexibility and quick improvements and *Tesla's "Battery Day" gave widespread awareness of mega casting technology, Tesla is seen as a source of inspiration* both ties for the highest NAVS score with 0,81 whilst only having the third and sixth highest WNAVS score respectively. *Improvements in sustainability* received a high NAVS score of 0,74 but scored 1,41 in WNAVS which is in the lower half. This shows that the attribute *Improvements in sustainability* was ranked very impactful within its topic, however, the topic Investment Specific Details and Improvements was ranked low.

Furthermore, the attributes *Core team members had a lot of trust and authority from management* and *Small cross-functional core team with engagement from several departments* received a NAVS of 0,68 and 0,60 respectively which is lower than many other attributes. Despite this they ranked as the second and fourth highest in WNAVS showing that the topic Core Team was ranked as very impactful.

4.2.8 Survey emails

During the survey two respondents contacted the researchers via email to add their own feedback. First, one respondent believed that the attributes within the Core Team topic were too difficult to decern between and rank, and the respondent withdrew from the survey due to this. The second respondent wanted to give feedback on a potential new attribute which the respondent forgot to write during the survey. Translated from Swedish it read: "That the involved are accustomed only to 100% vertical integration, in all dimensions, construction, preparation, manufacturing, procurement, etc. We are staffed already from the start to both construct and manufacture by ourselves, meaning that this type of competence was already available". This aspect was investigated further during the secondary interviews, as it was not captured by any current attribute.

4.2.9 Survey results analysis

The survey results were analyzed in order to select the most impactful attributes for the quickness of the mega casting investment decision. A selection of attributes had to be made in the interest of time as there were not available resources to further investigate all attributes. The selection criterion was chosen to capture the most important attributes based on three evaluation factors. The criteria limits for these evaluation factors were chosen to result in an appropriate amount of attributes for further investigation. The chosen evaluation factors were: Number of occurrences from initial interviews, WNAVS score, and Percentage of number one rankings within the topic.

The criteria limits for the evaluation factors were: Greater than 6 occurrences in initial interviews, WNAVS score higher than 2,4, or Greater or equal to 25% of number one rankings within the topic. Attributes had to fulfill at least two out of three criteria to be selected for further investigation. The selected attributes and their evaluation factor values are presented in table 11 below, with the fulfilled selection criteria marked green.

Attribute	*Number of occurrences > 6*	*WNAVS > 2,4*	*Number one rankings ≥ 25%*
Hard working core team with a lot of enthusiasm and with a "challenges can be overcome" mindset	7	3,27	37,50%
Core team members had a lot of trust and authority from management	2	2,81	25,00%
Small cross-functional core team with engagement from several departments	7	2,49	20,83%
Management recognize a greater need for flexibility and quick improvements	2	2,57	25,00%
Management being willing to take risks with new change and dare to fail	7	2,47	50,00%
Demonstrations spread knowledge about the project's progress throughout the company	10	1,99	29,17%
Early and frequent contact with senior management	7	2,06	25,00%
Tesla's "Battery Day" gave widespread awareness of mega casting technology, Tesla is seen as a source of inspiration	8	2,46	41,67%

Table 11. Selected attributes for further investigation and their evaluation factor values. Fulfilled criteria are marked in green.

The survey analysis resulted in eight attributes to be investigated further during secondary interviews. In addition, the new proposed attribute from the survey emails regarding vertical integration and available knowledge resulted in a total of nine attributes which were investigated during secondary interviews.

4.3 Secondary interview results

This section presents a summary of the results from the secondary interviews. 14 interviews were conducted, spanning all nine attributes from the survey results and emails. Interviewee subjects included five core team members, five managers and four other individuals knowledgeable about the attributes. Interviewee subjects which were deemed appropriate to answer any uncertainty and elaborate for a comprehensive explanation surrounding each attribute were chosen. The

findings from the secondary interviews are presented for each attribute as the insight was provided during the interview.

4.3.1 Hard working core team with a lot of enthusiasm and with a "challenges can be overcome" mindset

Five core team members were asked about their enthusiasm, why the mega casting project had received such hard work and dedication and where the positive mindset towards challenges came from. All the interviewed core team members unanimously agreed that themselves and other core team members had been particularly motivated and that this had been a key reason which sped up the mega casting project.

The core team members themselves theorized that they were perceived as hard working due to a couple of different reasons. One reason which was given was that the demonstrations kept the momentum of the project which caused a continually high pace of work. Another reason was the simple fact that deliveries were completed on time and that the managers' expectations were met. Furthermore, the fact that the core team consisted of only a couple of members, especially in the beginning, and were able to accomplish as much work as they did in the timespan reflected their hard work. One explanation given for the productive team was that the division of responsibilities was very clear in the project and team members did not disturb each other, instead each of the core team members could progress autonomously.

Subsequentially, the interviewed core team members were asked about why they believed the core team had displayed such enthusiasm towards the mega casting project. Interviewees mentioned many different reasons for why the core team members were motivated. The fact that the individuals, who volunteered and were part of the mega casting project, were motivated people with a positive outlook on mega casting helped keep the team motivated. These individuals' enthusiasm spread to the team as a whole and raised the team's performance. Interviewees also described it as motivating to participate in a team with such skilled and experienced co-workers and with an excellent project leader. Further, one interviewee mentioned that there were no "losers" in the mega casting project and that both manufacturing and R&D were winners. This is rare as commonly these two departments have to compromise innovation against manufacturability. The fact that both departments could gain from the same project and the project had support from both sides was mentioned as a motivating factor. This fact, among others, led to very little critique from management and rarely received negative feedback, which made it easier to stay enthusiastic.

Another reason several interviewees mentioned was the fact that the opportunity to fully devote themselves to the mega casting project full-time made them motivated to perform their best. This reason was also given to explain why the core team members were able to keep a positive mindset towards challenges. Working full-time made individuals feel that they had the resources to handle problems and not make trade-offs between multiple simultaneous projects. This positive mindset was also explained as a prerequisite for joining the project, as the ones selected to the core team already believed in the underlying technology. Furthermore, the fact that there

was a clear deadline for the possible implementation window created time pressure for which problems had to be solved, which required the team to stay positive and left little room for doubters in the core team. The mindset that challenges can be overcome was also strengthened by management as the core team members felt that they were supported when challenges arose. E.g., one interviewee explained how funding for overcoming a challenge could quickly and easily be approved making the project proceed seamlessly. Another interviewee also mentioned how the possibility to avoid otherwise bureaucratic processes made them feel significantly more motivated towards the project.

The two most mentioned reasons contributing to the enthusiasm in the core team were the fact that the mega casting technology was something completely new and entailed a radical change for Volvo Cars. All the interviewees mentioned that the mega casting project was seen as a new and exciting development where team members would be working with cutting edge process development and given the opportunity to learn new skills. Mega casting large aluminum parts for a vehicle was seen as a giant leap in technology and core team members explained how motivating it has been to be part of a development like this. The mega casting project was even more radical as it affects a part of the company which has not seen any major changes with this impact in decades. One interviewee also mentioned how exciting it was to be able to launch a new automotive technology and be the first in Europe to have it, which caused further motivation to realize that ambition. This radical change was also something interviewed core team members viewed as a milestone event both in the company's history and their careers which made them work their hardest. The interviewees also explained how enjoyable it has been to work with a large, unexplored highly innovative project as most other projects had been minor iterative incremental improvements. Moreover, the mega casting project was seen by the interviewees as something very motivating to be a part of since it was such a large investment and change for Volvo Cars, which made core team members feel like they were a part of something important.

Lastly, multiple core team members interviewed mentioned that their enthusiasm around the project evolved from being part of a development project which had a good chance of becoming reality. Since the mega casting project had such managerial support and good cost benefits, the odds of it being in future cars felt high which made core team members feel like their work mattered. The technology had many advantages and future possibilities which made core team members appreciate the opportunity and wanted to rise to the occasion.

Based on the survey results, the enthusiasm from the core team has been seen by several employees at Volvo Cars. The core team members interviewed were asked how this motivation and enthusiasm have translated into increased progress and speed of the mega casting project, however, interviewees found it hard to describe in detail. The enthusiasm was more of a feeling and culture of the core team, but a couple of concrete examples were given as a reflection of the hard work and enthusiasm. Several interviewees claimed that they themselves, or other members of the core team, had worked in the late evening or during weekends to ensure that deliveries were finished on time. Otherwise, unfavorable tasks, such as international travel, were met with volunteers and a willingness to do what was needed, this described by the interviewees. The enthusiasm around the mega casting project was also seen outside the core team as many

individuals wanted to volunteer to be a part of the core team. Interviewees also explained that this contributed to increased motivation in the core team as they felt selected and delighted to be a part of the mega casting project.

4.3.2 Core team members had a lot of trust and authority from management

Both core team members and managers were interviewed regarding this attribute in order to get both perspectives. All interviewed core team members believed that they had a lot of trust from management both from the start of the project, but also gained more as it progressed. Some interviewees also claimed that this project received more trust from management compared to other development projects they had been a part of.

First all interviewees were asked how this level of trust was achieved, what actions were taken to gain trust, and what was different about the mega casting project compared to other development projects. Several interviewees, both core team members and managers, expressed that the core team of the mega casting project consisted of particular individuals which made the team trusted by management. Several individuals involved in the core team have had long careers within Volvo Cars and were already trusted by management before the project. These senior team members extended to both R&D and manufacturing which ensured trust from management within both departments. The interviewed managers also explained that they already knew that core team members were highly skilled in their respective areas of expertise, which made management trust that they would take the right decisions. Multiple interviewees also explained how the addition of casting experts, which were hired externally, enhanced management trust in core team's ability to handle the complexity of mega casting. The core team members also proved themselves very capable by quickly developing the skills needed for understanding the intricacies of mega casting technology, which according to managers made the core team trustworthy.

As explained by both managers and the core team itself, several successful actions were taken by the core team which gave them trust. The first reason the interviewed managers described, which made them trust the core team members, was that the core team always ensured to complete their deliveries on time and kept their promises to management. The fact that the core team members were also able to take responsibility for the progress of the mega casting project and continued work autonomously led managers to give them extended authority of the project. The core team members lived up to management expectations which caused them to have trust in the core team. One interviewee also mentioned that the division of work and ability to progress autonomously is a part of agile methodology.

The fact that the core team members endeavored to always present a unified message to management, from every single individual from the core team, gave the project a lot of trust. The core team members explained how they had internal alignment meetings to ensure that they all conveyed the same message about the current progress and goals. One interviewed manager explained how this was appreciated and made the team trustworthy. A core team member

explained how important they believed this was as alignment meetings arranged by managers were not needed, which saved the project time.

Another key measure which the core team performed excellently was their communication with management. The core team members' presentations and pitches to management were described by the interviewed managers as very transparent, honest, and professional, which made managers trust the core team. The core team members explained how a lot of effort had been put into a variety of management presentations to gain management support. Through these presentations the core team members were able to showcase both their hard work and that promises to management were kept. One major tool for this type of communication was demonstrations. The transparent and pragmatic information presented in the demonstrations gave managers confidence and trust in the core team.

The mega casting technology itself intrigued managers and one interviewed core team member described how this made managers act in a supporting role instead of a controlling one. Management participated in supplier negotiations and supported the initiatives from the core team instead of micromanaging them. However, one manager did not agree that the subject of the project influenced the amount of support or trust the core team received. Furthermore, both core team members and management explained that managers were not knowledgeable about mega casting technology and its intricacies. Management's lack of knowledge led them to rely on the core team and trust their judgement as the core team possessed more knowledge about mega casting.

Lastly, both managers and core team members proclaimed that the mega casting project promising improvements in cost, sustainability, flexibility etc., led to increased authority for the core team. These improvements made management willing to entrust control over the mega casting project to the core team members in order to implement the improvements as quickly as possible. One interviewed manager explained how the mega casting technology was a "game changer" and implementing it quickly was paramount.

Interviewees were also asked about how this trust from management contributed to the speed of the mega casting project and investment. The first aspect of trust which sped up the mega casting project was the ability to avoid some management meetings otherwise needed to convince managers. This also extended to a faster approval of funding for certain activities which one core team member explained could take months. The mega casting project was able to progress seamlessly and more quickly as the core team themselves had the authority to take many decisions themselves without asking management. Normally, projects also require alignment meetings between the different departments involved, however, these meetings could also be avoided due to the core team's cross-functionally aligned members. Management also had a less controlling role and lacked the knowledge to outline formal strict requirements for the mega casting project and its deliveries. This led to that management rarely questioned the decisions of the core team and their competence which removed possible stop blocks commonly slowing the project down.

4.3.3 Small cross-functional core team with engagement from several departments

Five core team members were interviewed about their experiences within the core team and the cross-functional structure as it emerged as an important factor, contributing to the speed of the project, from the survey. All interviewed members agreed that the cross-functional structure had worked well in the mega casting project and most claimed it had worked better than other teams they had been a part of. One interviewee, however, claimed that there was still room for improvement in the communication of the core team, whilst it worked well with the available resources and time.

The first unique factor for the core team's cross-functional collaboration, which emerged from the interviews, was the fact that core team members worked full-time on the mega casting project. The full dedication to the project led to team members developing a feeling of ownership for the project, where core team members felt a stronger sense of belonging to the project than to their own department. Working full-time also led to that the team quickly could develop a team spirit, getting to know their colleagues, developing trust and open communication. Issues and disagreements within the core team were not left to fester as the open and frequent communication resolved them quickly. The communication was simplified due to the online workflow according to one interviewee. Working full-time also made it possible to save time since catching up was rarely needed between co-workers, which is otherwise needed.

The second unique factor of the mega casting project which interviewees mentioned helped the cross-functional collaboration between R&D and manufacturing was that both departments received advantages from the project. Commonly R&D and manufacturing have to compromise as they have different goals with developments, however, the mega casting project was able to bridge this gap since the project was advantageous for both departments. The fact that the project had no "losers" made collaboration between departments work better as they shared a common goal.

The core team members and their project leader were mentioned as success factors for the cross-functional work. The core team had strong leadership which held the cross-functional team together and helped steer the focus on the most important tasks. The strong leadership helped ensure that team members knew what their responsibilities were, which aided the team's workflow. The individuals and their characteristics were also explained to have played a large role in the cross-functional collaboration. Individuals' background, experience, knowledge and personalities were all important factors in how well the collaboration of the core team worked. Team members were described to balance each other's strengths and weaknesses and had great respect for each other. This breadth of knowledge sped the project up since the team already possessed the most necessary knowledge, saving time spent finding knowledgeable individuals outside the team. Moreover, the team members' experience with working in cross-functional teams and with vague tasks was presented as a more important aspect than their technical expertise.

The mega casting core team was also able to work cross-functionally since all members, despite coming from different departments, were aligned in what the project should result in. This was

achieved by holding alignment meetings and that the project leader was adamant in presenting a unified message. Alignment was also possible since core team members were largely co-located.

Lastly, an aspect brought up by an interviewee was how rare it was for cross-functional teams to be used so early in a development project, in this case already in the pre-studies. The cross-functional collaboration between manufacturing and R&D was perceived to have been enhanced by this early disposition, helping the mega casting project proceed as fast as it has. Interestingly, another interviewee claimed that the exclusion of non-essential departments involvement early on aided the mega casting progress as focus could be on understanding the technology and developing a basic prototype. The interviewee explained that if other departments' interests were to be considered from the start, the project would have required more time.

4.3.4 Management recognize a greater need for flexibility and quick improvements

Four managers were interviewed to investigate if they recognize a greater need for flexibility and quick improvements and why this is recognized now. All the managers claimed that the need for rapid improvements and flexibility has increased during the last year. One manager explained that this has been a change during the last two years, while another manager described that this mindset has been changing over five years.

From the interviews two major factors were outlined as contributors to the need for flexibility and quick improvements. The first one was the changing market pressure, which is a result of more competitors, faster innovation cycles and the introduction of new technologies. This was presented as an external force that Volvo Cars recognizes a need to adapt to in order to stay competitive in the market. One interviewee mentioned Tesla as one of these competitors that has contributed to this increased pressure, due to their innovative nature and establishing of new market trends. Volvo Cars realizes the need to adapt to this heightened market pressure through increased flexibility and faster innovations. Another interviewee explained how the automotive market traditionally has been slow with radical innovations, but that this has shifted in recent years.

The second major factor towards Volvo Cars' pursuit of greater flexibility and faster improvements was through their internal strategy. During the last few years Volvo Cars has shifted in what market segment they aim for, wanting to position themselves as an industry leader in technology and innovation. Two managers explained how manufacturing at Volvo Cars traditionally has only invested in "of the shelf" proven technologies with a focus on reliance and risk minimization. However, the mega casting project was explained as a clear deviation from this standard as it is a new and unproven technology and entails a greater risk, highlighting how Volvo Cars is valuing flexibility and quick improvements.

All the managers interviewed agreed that they recognize a need for faster development of new technologies. Management has become more aware of the risk of "standing still" and that doing nothing is riskier than investing in certain new technologies. Further, one manager stressed the importance of launching new developments faster and speeding up the implementation. Another

interviewee also claimed that innovative individuals at Volvo Cars create pressure on the company to be innovative and that these people make quick improvements happen. Individuals with a lot of new ideas and ambition to actualize them, inadvertently pressure Volvo Cars to become innovative.

Additionally, one factor which was presented as a reason for the mega casting project's success and managers willingness was the realization of the long-term benefits e.g., flexibility. Mega casting was seen as a long-term investment and therefore the otherwise risky choice will still pay off in the long-term. Another factor interviewees brought up was the current state of Volvo Cars, meaning that the current size, growth ambitions and liquidity create the possibility for valuing flexibility and performing quick improvements. Meaning that if Volvo Cars was much larger, the investment decision could not be taken as quickly since it would risk greater consequences, but if Volvo Cars was smaller, they might lack the funding needed for a project like mega casting.

This greater need for flexibility and quick improvements has affected the mega casting project as managers have been more resolute in their decision-making. The management saw the mega casting project and its investment as an important step for both staying competitive in the changing market and fulfilling their strategic ambitions. This has also caused the project to speed up as both of these factors are time sensitive, which played a part in the quickness of the mega casting project and its investment decision.

4.3.5 Management willing to take risks with change and dare to fail

Out of the four interviewed managers during the secondary interviews, three outright agreed that the willingness towards risk was greater in the mega casting project than other development projects at Volvo Cars. Two managers believed the most significant factor for this willingness towards risk-taking for the mega casting project was how it aligned with Volvo Cars' strategic ambitions. Volvo Cars is aiming to compete as a premier automotive manufacturer when it comes to innovation and technology and managers saw mega casting as a way to fulfill this. The mega casting project was a concrete way for managers to achieve their communicated strategy, making the mega casting decision makers more willing to bear the risk. The increased willingness towards risk was a recent phenomenon, in particular within manufacturing, where traditionally low risk well tested technologies were favored. One manager explained that to achieve Volvo Cars' strategic ambitions and become a premier automotive manufacturer, Volvo Cars needs to be more aggressive in their pursuit of new technologies and in their risk-taking. Managers need to internalize these steps as the only way to achieve this strategy and getting accustomed to greater uncertainty and risk is a part of it. The ambition of technological sophistication was paraphrased by two managers as Volvo Cars wants to be number one, not number four any longer, and Volvo Cars wants to beat Tesla and other competitors in certain segments.

Based on the interviews there were many factors which affected managers to take the risk with the mega casting project. One interviewee mentioned that Tesla created pressure for Volvo Cars to quickly adopt the technology and paved the way in terms of feasibility which gave managers

the courage to take the risk. Tesla as a competitor was deemed important as another competitor would not have had the same impact. Three managers agreed that the risk was simply weighed against the rewards and for the mega casting project the rewards were far greater. The mega casting project had a positive business case with potential for significant cost reduction, with other improvements such as flexibility as well. One manager even explained it as a "game changer" and the magnitude of these improvements made the risk worth taking and the project had significant incentive to be implemented quickly. Interviewees explained how the improvements are expected to provide a significant competitive advantage if implemented before competitors, which made the risk lucrative and led to willingness amongst managers.

Another factor which made managers more willing to take the risk with the mega casting project was the transparency from the core team. One manager explained how the transparency gave managers insight into the project during the process which made managers calm regarding uncertainties and less risk adverse. Lastly, this manager explained how shorter innovation cycles have created the pressure for risk acceptance as a way to speed up development projects. Shorter innovation cycles were also explained as a reason for this risk willing behavior continuing in the future.

4.3.6 Demonstrations spread knowledge about the project's progress throughout the company

First, the project leader who conceived the idea about demonstrations and has orchestrated the demonstrations since the project launch was interviewed about their impact on the speed of the mega casting project. The project leader explained that the demonstrations as an idea were not inspired by agile and did not adopt any structure from agile. However, the project leader does acknowledge that agile does include demonstrations. The project leader believed demonstrations came naturally as a way to quickly and easily inform stakeholders from many different departments in a joint meeting about the progress of the mega casting project. The interviewee also stressed the transparency which was presented during the demonstrations as both successes and challenges were shared at every demonstration. The demos also made sure to include what the next steps of the project were for each pre-study. Further, during the early stages, when mega casting was hoping to be launched into the possible implementation window, the demonstrations were an effective tool to early communicate important dates for stop or go decisions. The demonstrations were mostly presented by the core team members who performed the work. The project leader thinks that the demonstrations were very helpful as they gave the core team significantly more control over the knowledge sharing about the mega casting project. The core team was able to choose their own schedule for the demonstrations and could invite different stakeholders to the same meeting. The use of demonstrations gave the core team extended control which allowed them to present the project on their own terms. Moreover, demonstrations served as a tool to let the core team evaluate their progress and realign their message to ensure that all core team members were on the same page and convey the same message to managers. The demonstrations also gained a lot of interest from different members of the organization as they were novel.

The demonstrations were able to speed the project up according to the project leader as the core team was able to present important facts and gain managerial attention much earlier than normal development projects. This ensured that managers were informed about when important decisions had to be taken with better notice and had much greater insight into the project. The transparency from the demonstrations gave the project significant trust among management. This was aided by the steady progress reports which showed management that when challenges were faced in the past these were able to be overcome by the core team. The fact that the demonstrations were mainly presented by the core team members instead of only the project leader also built trust and authority for the individuals involved. The project leader explained that it was important and took it for granted that the core team members who performed the work would present it at the demonstration. This since the team member who performed the work should get credit for it.

The project leader described that the core team members, in the beginning, were hesitant about the idea of demonstrations. However, after the first couple of demonstrations the structure of the demonstration and how core team members needed to prepare became formalized and team members were comfortable with the way of working. This led to that the time needed to prepare each demonstration was reduced to only a day or two before the demonstration and team members became supportive of demonstrations. The project leader further explained that team members worked extra to ensure that they had something valuable to present at the demonstration. One way this was accomplished was by setting and publishing the demonstration agenda weeks before the date, showing what each person and pre-study was expected to present.

The project leader suggested that managers outside the mega casting project should also be interviewed to gain an outside perspective on the demonstrations. Two managers were interviewed, first a manager for cost engineering and then a product manager (PM). The cost engineering manager reiterated the claims from the product leader and stated that the demonstrations presented a holistic, honest and transparent view of the mega casting project in a professional manner. The PM also believed that the structure of the demonstrations was a key factor for their success, with a clear agenda down to the minute, without disruptions and questions handled separately. The cost engineering manager also agreed that the mega casting team had “flipped the script” of how knowledge sharing could be done at Volvo Cars. The cost engineering manager stressed the fact that team members themselves were presenting during demonstrations, which gave the core team a lot of legitimacy and trustworthiness. The PM gave three reasons why team members themselves ought to be presenting: Increased engagement in the project, Work divided into more individuals, and Better presentations as the most informed member was presenting. The cost engineering manager also identified the demonstrations as an extra deadline for which core team members worked extra hard towards to ensure something valuable could be presented. The cost engineering manager believed that one reason for demonstrations being uncommon is that they could require a significant amount of extra work.

The manager for cost engineering also highlighted how the demonstrations created a forum for managers to contribute with tips to the project. One example was how the manager gave a recommendation of a person who could be a valuable asset to the mega casting project’s current

challenges after a demonstration. Both the PM and cost engineering manager mentioned that the fact that the demonstrations were held online created an opportunity for far more participants in a single knowledge sharing meeting. The online forum also made it easier for cross-functional managers to attend the same meeting as it was easier to fit in their differing schedules and work around. The PM emphasized that the demos could not have been performed to the same extent if they were held in person. Lastly, the cost engineering manager explained how effective the demonstrations were at spreading knowledge. The PM agreed and both described that even if only one member of a department had attended the demonstration, that attendee quickly shared the information throughout the department through informal meetings. This caused significant knowledge about the project and its details to be spread which furthered the support and legitimacy from managers. The PM concluded that one of the major benefits from the demonstration was the level of transparency the demos provided the project, agreeing with the project leader.

All three interviewees were asked if they believed that the demonstrations had an audience of most managers or employees as this would result in either bottom-up or top-down attention for the project. However, none of the managers could confidently say and believed it was a mix of the two. The first demos were listened to mostly by managers, but as the demonstrations got more traction and went from 10-20 participants to over 200 in demo number 8, who listened was no longer tracked.

4.3.7 Early and frequent contact with management

Four managers as well as the project leader of the core team were interviewed regarding the contact with management during the mega casting project. Many individuals from the interviews insist on the importance of both early establishing and frequency of managerial contact for the speed of the mega casting project, as also seen in the survey. Most managers agreed that contact had been more frequent for the mega casting project than for other development projects they have been involved in, and several managers have had weekly checkoffs of the project.

When asked how contact had been conducted between management and the core team several ways were mentioned. The first tool mentioned was the demonstration which ensured that broad communication with a wide array of managers was upheld with regular intervals in the earlier stages. The demos also created managerial attention and piqued managers' curiosity regarding the mega casting project. The second tool was group reviews between core team members and their respective department managers. Thirdly, contact was established early on and upheld through informal methods such as unnuanced phone calls. Many of these communication channels were initiated and created by the core team and its members, and the traditional forums were not relied on for the mega casting project. These ad-hoc communication forums established contact earlier and speed the project and its investment decision up.

The interviewed managers were asked how come management were willing to spend so much time on supporting the mega casting project team. One clear reason was the immense benefits mega casting had identified, with early positive benchmarks and a lucrative business case. These

improvements, which would affect several departments, were communicated to management early on and in an informative manner. These improvements in turn caused management to have contact and support the project to ensure its fast and successful development and implementation. One manager believed that the competitor pressure from Tesla also made management more supportive of the mega casting project. Another factor which caused management to maintain contact with the mega casting team was that a certain senior manager within manufacturing early on showed interest which spread throughout management. One of these early adopters within management had previous experience within body structure development mentioned as a potential cause of this early support. Management engaged each other to support the mega casting team with frequent contact and brought the project up to their seniors.

One of the major differences between managerial contact and support for the mega casting project and other R&D projects was the engagement of the manufacturing department. Manufacturing quickly realized the improvements to their KPIs that the mega casting project would entail and started supporting the project and keeping frequent contact. One manager explained how without manufacturing's support the project would be unlikely to succeed as the challenges would have been too difficult to handle. The core team's cross-functional disposition was also an enabler for multi-departmental support and contact.

From the secondary interviews several success factors for this early and frequent contact were found. The first factor mentioned by several interviewees was the understanding from both management and core team members that the mega casting project needed support. Both sides understood that early and frequent contact was important and needed for the project success and prioritized such tasks. One reason for this was that the complexity of the mega casting project required frequent communication between management and core team members to facilitate their mutual understanding. Another factor explained by one interviewed manager was that the contact between management and the core team was not made in silos, which enabled and eased frequent contact. One manager mentioned how communication was improved by management and the core team being co-located in Torslanda.

One manager interviewed also pointed out that the individuals involved in the core team have been a contributing factor to the early and frequent contact and that it was the core team members which ensured that the contact was established. The core team members took the initiative to contact management both early on and frequently throughout the project. The members involved also had a good reputation within Volvo Cars which made managers more willing to hear them out. The core team members were also experienced enough within the company to have their own network within management, which made establishing contact through unconventional methods possible.

The direct communication between senior managers and technicians from the core team was unusual but worked in the mega casting project's favor according to the interviewees. The direct line of contact ensured that management's questions could be answered more quickly by the most qualified individual, causing the mega casting project to be able to proceed faster.

4.3.8 Tesla's "Battery Day" gave widespread awareness of mega casting technology, Tesla is seen as a source of inspiration

The validity of this phenomenon was first brought up to an employee working with scouting and evaluating innovations by competitors. This interviewee recognized the importance of what they called an "influencer" both in the mega casting project and other development projects at Volvo Cars. The interviewee described an influencer as a company inspiring others and which companies strive towards replicating. Further, the respondent explained that having a competitor influencer can increase the speed of a development project due to many factors. The first reason was that the influencer can be seen as a threat to Volvo Cars' market position, potentially causing a loss in brand value, sales, profit etc. To minimize this threat managers will attempt to develop competitive new capabilities, similar to the influencers, as fast as possible. This interviewee outlined three actions managers can take to speed up a development project: Allocating more resources, Forego bureaucratic control frameworks, and Accepting more risk. A second factor was when an influencer made something first, this creates a prepared market of potential supplier from which the development project can be sourced from. This also extends to available knowledge sources to universities, licensing from the influencer as well as investigating new patents or teardowns for benchmarking. These available sources of knowledge help speed the development project up significantly as less time is spent on trial and error and already proven ideas can be pursued. Lastly, the interviewee explained that an influencer can prove the market value and technical implementation and therefore convincing managers is easier as the development project is perceived as less risky. The project will develop faster as less time is spent on convincing managers in meetings and needless controlling behaviors from managers to manage the risk can be suppressed.

Further interviews were conducted, one with an essential member of the core team and one working with base product development, both with extensive knowledge of Tesla's importance to the mega casting project.

The core team member and the innovation scout explained that Tesla was seen as an influencer broadly at Volvo Cars due to their innovative nature and many individuals, from different departments and managerial levels, saw Tesla as an inspiration. Tesla as an influencer was very important as if a similar innovation had been discovered by another competitor, the interviewees believe it would not have gained as much traction. However, the two interview subjects explained that the mega casting project gained further traction within Volvo Cars as Tesla had successfully improved two key measures that Volvo Cars values: Cost and Weight. As explained by all interviewees, Tesla as an influencer significantly sped up the development of the mega casting project. This was further elaborated on by the core team member, stating that if Tesla had not acted as an influencer the investment decision regarding mega casting would not have been taken yet.

Tesla was instrumental in the speed of the mega casting project and its investment decision as Tesla fulfilled all three factors from influencers. When Tesla held their "Battery Day", managers at Volvo Cars realized the threat Tesla posed when the company successfully had cast their rear floor. All the interviewees explained that Volvo Cars' managers wanted to know why Tesla

made such changes when faced with competitor innovation. It quickly emerged that Tesla's innovation resulted in improved cost and weight, which made managers at Volvo Cars want to catch up as fast as possible. The interview subject working with base product development explained that the mega casting development was then sped up through using external available sources of knowledge about large castings such as contacting Tesla's suppliers. All three interviewees also agreed that Tesla proved that mega casting works and can be a profitable venture which helped convince managers at Volvo Cars to take the step towards the new development.

The core team member explained how Tesla as an influencer has been used to promote the mega casting project to managers internally within Volvo Cars which has helped give the project support and legitimacy. Furthermore, the interviewee described that Tesla, and their CEO, has a lot of media attention and "hype" surrounding them which caused managers at Volvo Cars to gain a natural interest in anything related to Tesla. However, the core team member stated that Tesla has not been pushed in every meeting, instead a level of transparency and honesty where Tesla as an influencer has been presented, in particular during early meetings. The core team member also expressed that Tesla has not been in the forefront of the entire development project and believed that such action may harm the legitimacy of the project as it could be seen as simply a copy.

4.3.9 Vertical integration and available knowledge

When trying to investigate the hypothesis that the mega casting project was able to proceed as quickly as it did due to body structure production and knowledge being available in-house, three members from the core team were interviewed. Core team members were interviewed in order to evaluate the claim in the mega casting context and understand the perspective of those closest to the issue. None of the three core team members believed that the amount of available knowledge of body structure construction in-house for Volvo Cars aided the speed of the mega casting investment decision. Instead, they claimed that knowledge about the mega casting technology had been significantly lacking for large parts of the project so far, which has been resolved by utilizing external knowledge. However, two core team members thought the opposite, that the lack of available knowledge instead had aided the speed, as the lack of knowledge had made decision makers bold. This lack of knowledge created an overly optimistic view of the mega casting project where the challenges and difficulties were not yet known from early stages. The two core members believed that if every challenge was known from the start the mega casting project would have progressed slower as managers would be much more risk-adverse and hesitant. The core team members also explained how they have had to convince management on several levels with the available knowledge of mega casting. Explaining that some managers were still cautious regarding body structure developments despite Volvo Cars' extensive internal experience.

Further, to investigate the hypothesis in a wider context within Volvo Cars to establish if there is precedence, two further employees were interviewed as they were recommended by the Volvo Cars supervisor. One interviewee was part of the sunroof development, an area that is almost

completely outsourced. It was investigated if this respondent believed that improvements could be made faster if a larger part of the department of sunroof was handled in-house and if the outsourcing caused a lack of knowledge in-house. However, neither of these ideas were shared by the respondent, who believed that Volvo Cars' collaboration with suppliers for sunroofs was effective and allowed for fast developments. The interviewee explained that Volvo Cars was able to make fast improvements and reach the improvement targets quickly through the supplier relationship. The next interview subject for this hypothesis worked as an innovation scout at Volvo Cars. This interviewee was asked if any evidence had been observed for the idea that improvements within areas of greater in-house production were easier to implement and get managerial support for. However, this interview subject also disputed this claim, and had not observed evidence for any such idea in their experience within Volvo Cars.

5. Discussion

The discussion chapter is divided into three sections based on the research questions to be answered. In the first section a review of the success factors enabling the speed of the mega casting investment decision through the development project is presented. Followed by a discussion regarding how the mega casting project differs from other development projects at Volvo Cars. In the last section the agile workflow is discussed as agile relates to the speed of the mega casting project.

5.1 Success factors enabling the speed of the mega casting project

From the initial interviews 31 general success factors contributing to the speed of the mega casting project and its investment decision were found. These were formalized into attributes and further investigated through a survey. In the survey result a comparison of the attributes was made where several interesting patterns emerged, this is outlined in table 10. While attributes from most topics were distributed across the entire table, ranked according to the WNAVS score, some clusters were still easily identifiable. At the top of the WNAVS rankings, in table 10, many attributes belonging to Core Team and Management Culture were present. On the opposite end of the spectrum many Investment Specific Details and Improvements attributes were clustered. This shows that the latter topic was considered significantly less important than any other by respondents. This resulted in no attributes from the topic Investment Specific Details and Improvements being investigated further during the secondary interviews. One possible factor for this was that respondents did not consider the attributes within this topic as contributors to the speed of the mega casting project but instead qualifiers of the project itself. Support for this can be found from the initial interviews where many interviewees claimed that e.g., cost savings, which appeared in six initial interviews, was a particularly important aspect of the project despite its lack of survey results.

The selection criterion resulted in eight attributes to investigate further, however, this does not exclude any non-selected attributes being contributors to the speed of the mega casting project and investment decision. Several of the non-selected attributes may have played an important role in the success of the mega casting project and evidence for some of these superfluous attributes was found in secondary interviews. The precise interdependence of all attributes and their underlying rationale could be an area for future research.

The formulation of the attributes may have affected the validity of the survey results. One respondent emailed and explained how they could not decern between attributes and therefore chose not to participate. This same impression may have been shared by more respondents, while they, however, have continued with the survey or stopped but not contacted the researchers.

The following sub-chapters to this first section of the discussion are focused on the nine selected attributes that were further investigated during the secondary interviews. These are the attributes that were seen as the most important to the speed of the mega casting project and its investment decision of the initial interviewees and the survey respondents.

5.1.1 Hard working core team with a lot of enthusiasm and with a "challenges can be overcome" mindset

Based on the results gathered it is clear that the core team's motivation and enthusiasm has been a large contributing factor to the speed of the mega casting project. This since it has led to a positive mindset within the core team and a willingness towards otherwise unfavorable work tasks and time investments.

There are a multitude of factors which are suspected to have led to the high motivation. The first factors are ones regarding the core team members and team structure and are in line with Trygg (2021). Three of these identified factors which have contributed to the high enthusiasm in the mega casting project are: Few team members, Members volunteered, and Team member worked full-time on the project. These factors are also mentioned as success factors for cross-functional teams by Trygg (2021). Few members created an environment of ownership of the project, which contributed to high motivation. The core team members also had a clear division of responsibilities to reach their objectives, which Wheelwright and Clark (1992) claim is one capability needed for quick and efficient development. As the mega casting project progressed the ten-member limit Trygg (2021) recommends was exceeded, however, this may have been resolved through dividing the project into smaller pre-studies. Moreover, the fact that members volunteered ensured that the selected core team members were enthusiastic about the project. Core team members working full-time also led to them becoming motivated as devoting all their attention to one project. This made the project progress faster and alleviated members from making trade-offs between simultaneous projects.

Other factors contributing to the enthusiasm regarding the team formulation and structure were that both the team members and project leader were experienced and the core team's authority over their own processes. These factors are mentioned by Wheelright and Clark (1992) and Patanakul et al. (2012) as defining factors for autonomous teams. The authors explain how autonomous teams of this kind are appropriate for radical and strategic innovations which the findings from the mega casting project support. The core team in the mega casting project resembled what the literature describes as an autonomous team and based on the findings this way of structuring a team has been a positive contributing factor to the speed of the mega casting project. This is also supported by Wheelwright and Clark (1992) whom state that autonomous teams are useful when the need is to work rapidly and develop innovative solutions. Moreover, the authors claim that project speed in general is accelerated by strong leadership, as demonstrated in the mega casting project.

Furthermore, the support from management contributed to the team's enthusiasm in two ways. First, due to management's continuous support, team members did not have any worry about

receiving funding or assistance for upcoming challenges which enhanced their motivation and ability to overcome issues. Secondly, the managerial support led to a significant amount of positive feedback and less critique, and this positive feedback motivated the core team members to live up to the managers' expectations and work their hardest.

One tool which seemingly assisted the high motivation according to the interviewed core team members were the demonstrations. These provided two unique advantages. One was the ability for core team members to show off their hard work and get credit for it among their peers. The other was the deadline that the demonstrations imposed which core team members could work towards. These frequent deadlines created more actionable goals which led to the core team keeping their pace of work high, which shares its similarities with agile. Demonstrations can therefore be seen as a tool not only for knowledge sharing but also for improving team motivation.

The mega casting project also had several characteristics which made the core team members motivated to work with it:

- The project had no "losers"
- Mega casting had a good chance of being implemented
- The technology was brand new
- The project was large and impactful

The generalizability of these characteristics is in question as they are not easily pursued or introduced into development projects which do not have these characteristics natively. The characteristics are, however, identified as having a significant impact on the success and speed of the mega casting project, through improving the enthusiasm of the core team.

One theory why the mega casting core team was perceived as particularly hard working could also be a result that there was high level of transparency into all the work they were doing. This transparency was mainly achieved through the demonstrations.

5.1.2 Core team members had a lot of trust and authority from management

From the results it is made clear, according to individuals involved in the mega casting project, that the trust and authority management gave the core team was an essential part of its success. There are several clear success factors which permeated the core team which led to management trust and support:

- Clear communication from core team
- Core team put effort into professional and transparent presentations
- Core team was aligned to a unified message
- Both skilled and senior people in core team
- Core team delivered on time and lived up to managers' expectations

Trust gained from these and other factors emerged as clear contributors impacting the speed of the mega casting investment decision positively. The speed itself from the increased productivity as the core team worked hard and the results it showed led to management trusting the core team even more. There was a self-reinforcing cycle in this way where speed led to trust and trust led to speed, however, precisely how much speed or trust to attribute to such a phenomenon is unclear in the mega casting project.

The fact that managers were willing to relinquish control over the mega casting project for the purpose of speeding up the project showcases that they have internalized the importance of speed, supporting literature such as Baum and Wally (2003) and Kessler et al. (2000). Wheelright and Clark (1992) claim that "people and their skills" is a fundamental pillar of capabilities needed for rapid and efficient development. This same value was also found in the mega casting project as individuals' seniority and skill were factors of success of rapid development, in this case fulfilled through the authority from management.

The authority given to core team members and that it has been identified as a factor which helped speed the project up supports Vroom and Yetton (1973) and Eisenhardt (1989) in their ideas that decentralized decision-making can make decision-making faster. Similarly, support for Zehir and Özsahin (2008) findings that greater participation of lower managers enabling faster decision-making was found and fast decisions help speed projects up.

Lastly, how the subject of a development project affects the support, authority and trust management gives the members involved in the project was not unanimously one sided. However, more support for the idea that the project subject playing a major role was found and therefore is considered as a success factor for the mega casting project. The novelty of the mega casting technology and the inspiration from Tesla is believed to have aided the mega casting project receive further managerial support. Managements own lack of knowledge about the technology led them to trust the core team more and give them more authority. Further, the fact that the mega casting project contained significant improvements made management more inclined to trust the project and the surrounding team.

5.1.3 Small cross-functional core team with engagement from several departments

Five factors were identified as major contributors to the successful cross-functional collaboration in the mega casting project:

- Core team members worked full-time
- The project was advantageous for both R&D and manufacturing
- Strong leadership and experienced collaborative individuals
- Core team members were all aligned
- The cross-functional collaboration started in an early stage

Trygg (2021) also mentions working full-time and members co-located as success factors for cross-functional teams which the mega casting project shares. Further, Trygg (2021) identifies

team members involvement during the entire project span and team members reporting to the project leader which neither were mentioned by interviewees as important factors.

The results regarding cross-functional involvement during early stages in the project were in question, as involving essential departments emerged as important, but also excluding non-essential during early stages. Not involving certain departments at the start of a complex development helps avoid difficult objections and can give a fledgling project some breathing room. This contrasts with Trygg (2021) that all important functions should be represented in the team from the beginning, however, defining what functions classify as important might be a subjective assessment. There is a significant risk with ignoring certain departments' early input as the adjustments needed later could result in significant rework and delays. It is possible that the novelty and lack of experience regarding mega casting made this avoidance of certain departments beneficial, whilst more standardized and less novel projects could gain from wider early involvement.

The project leader role in the mega casting team resembles how Wheelright and Clark (1992) describe a leader for an autonomous team. The team leader had both significant experience within Volvo Cars and was responsible for the team's resources regarding all departments. The project leader also trusted the selected team members considerably as the project leader was only involved in what the team did, but not managing how. This trust from the project manager was likely a source of mutual trust between team members, as they relied on the project leaders' judgement. The trust in the team members was upheld since core team members were responsible for the results.

Based on the results gathered, the composed cross-functional team has been an important success factor for the quickness of the mega casting project. The mega casting core team is recognized as an autonomous team and its application coincides with Wheelright and Clark (1992) as it has been a beneficiary factor to a novel project which required rapid development. The mega casting project was able to progress fast since the cross-functional collaboration led to ownership and hard work, available knowledge within the team and alignment led to managers trust in the team. Wheelright and Clark (1992) also mention challenges with autonomous team e.g., to re-integrate the development team and the solution after the autonomous team has been allowed to develop their own workflow. Volvo Cars should consider this challenge before the mega casting development project has concluded to minimize these risks.

5.1.4 Management recognize a greater need for flexibility and quick improvements

The greater importance of flexibility and quick improvements mainly emerged from two different sources: the Shifting market pressure and the Internal strategic ambitions of Volvo Cars. The market pressure was perceived to have changed drastically by individuals interviewed at Volvo Cars, stemming from new emerging actors as well as quickly developing market trends. Trends such as autonomous driving and electrification are revolutionizing the automotive market caused by actors such as Tesla and heightened by shorter innovation cycles. The increased market pressure has led managers to value flexibility and quick improvements and to be more

willing to take higher risks. This was also verbalized through the sentiment of "risk of standing still" as the market shifts makes the risk of inaction greater. The risk of standing still has been a measuring stick for new development project ideas, such as the mega casting project, and has made new developments look less risky in comparison.

The strategic ambitions of Volvo Cars instead came from the goals of top management and with the aim of fulfilling these ambitions managers recognize the need for flexibility and fast development. In order to position Volvo Cars as a premier automotive manufacturer, for cutting edge modern cars, quick innovations and flexibility were identified as a necessity. This need for increased flexibility and quick improvements has been identified as an enabler for the mega casting project and a contributor for the project's speed. Without these two factors prompting managers to take risks, the mega casting project would have been unlikely to succeed.

Volvo Cars' financial position, growth and size can also be seen as an enabler for the mega casting project's implementation. Volvo Cars had liquidity, ambition and appropriate size to implement large scale differences to their manufacturing process. The company's current situation gave managers the opportunity to focus on radical new innovations which helped make the quickness and implementation of the mega casting project possible.

The fact that managers recognize a greater need for flexibility and quick improvements shows their awareness of the importance of speed. The need for fast strategic decision-making in modern markets, as outlined by Baum and Wally (2003) and Campos et al. (2015) is clearly present in the mega casting project. The fast-changing market and increased pressure on the actors is a common occurrence outlined by Wheelwright and Clark (1992) and result in a need for quick and efficient improvements. In response Volvo Cars are making large developments and investments in new technology such as the mega casting project, with added focus on implementing quickly.

5.1.5 Management willing to take risks with change and dare to fail

Virlics' (2013) perspective of risk versus reward in investment decisions was also presented in the secondary interviews from managers as a way to manage investment risk. Managers were convinced that the rewards of the mega casting project outweighed the risks which led to acceptance of an otherwise risky venture. The mega casting investment decision agreed with Virlics' (2013) perspective as the financial rewards was greater than the financial risks, making the decision financially sound. Uncertainty surrounding the mega casting project was minimized through transparent communication from the core team as well as relying on the flexibility of the non-type bound investment. This is also in agreement with Virlics (2013) and provides insight into a practical example of how managers might be affected by substantiating factors which affect their aversion to risk. The transparency of the core team as well as the influence of competitors such as Tesla, mentioned in the secondary interviews, showcase how managers themselves can identify external behavioural factors which affect their risk towards investment decisions.

Transparency of the mega casting project is a multifaceted success factor which seemingly also aided in reducing the perceived risk of the mega casting investment decision. As managers gained insight into sources of uncertainty regarding the project, such as team capability, future challenges, upcoming stages etc., the risk this uncertainty introduces was diminished. This showcases how transparency can reduce uncertainty and therefore risk of development projects and their associated investments.

From the secondary interviews it was also made clear that development projects which are strategically aligned have a greater acceptance of risk. This fact can be utilized by project leaders when trying to achieve managerial acceptance by promoting the development project's connection to the company strategy. Furthermore, these interview findings showcase the importance of actionably formalized business strategy and provides an example of how strategic alignment may be applied in practice.

The risk of the mega casting project has been increased in order to speed the project up. One clear example of this is how traditional development frameworks at Volvo Cars and workflows have been avoided or foregone. The acceptance of managers to allow a development project without the normal controls in place to continue development and lead to a significant investment decision shows managers' acceptance of risk. Speeding up a project is associated with an increased risk, as removing e.g., controls or checks can save significant amount of time whilst introducing risk. The trade-off between risk and speed should be formalized into investment decisions and workflows of Volvo Cars to ensure that the trade-off is made on an informed basis. The decision regarding mega casting can be seen as ad-hoc since available development processes were unable to handle such a project. The hastening of the mega casting investment decision was a result of external factors, mainly the overarching vehicle project and possible implementation window. External factors such as these will always be present, however, ensuring that investment decisions are made on an informed level can aid decision makers in the future. It should be mentioned that the introduced risk from accelerating development projects can also involve risk for delays or postponement causing the project not to be completed faster in the end. The time pressure put on a development team may be an effective tool for speeding up a project, however, to which extent this can be utilized could be an area for future research.

Based on the secondary interviews, managers' willingness to take risks has contributed to the speed of the mega casting project and its investment decision. Acceptance of taking risks leads to development projects proceeding despite the presence of uncertainties, which is needed to compete in a market with shorter innovation cycles. In addition, development projects involving less risk are more likely to proceed faster, since the trade-off between these two becomes simplified, as projects can be sped up without exceeding managers tolerance for risk. Therefore, it is of high importance to minimize the risk of development projects in order to make them proceed faster.

5.1.6 Demonstrations spread knowledge about the project's progress throughout the company

Based on the results gathered there is an agreement that the demonstrations have been a contributing factor to the quickness of the mega casting project and investment decision. When comparing the results from both initial and secondary interviews it shows that demonstrations have aided the project both for the core team and management. Demonstrations in the mega casting project have fulfilled a similar purpose as in agile literature of presenting progress in determined intervals to stakeholders, however, the mega casting project's demonstrations were not inspired by agile methodology (Mountaingoatsoftware, n.d.).

All the demonstrations have been presented by the core team members themselves and based on the interviewees it emerged that this has been a contributing factor to their hard work, dedication and ownership of the project. Having core team members present themselves has caused them to become more motivated, as "behinds the scenes work" has instead been displayed in front of managers and other stakeholders. The possibility to show the hard work has in the mega casting project been a factor to its success. The ability to own the project has also been emphasized as the core team members have not handed over their work to a manager who forwards it upwards. These positive effects are suspected to be caused by the fact that team members were part of the decision to perform demonstrations and counseled for scheduling. The demos have also put extra pressure on core team members to deliver important progress milestones on time as the schedule was set long in advance. The extra pressure was considered positive and not overbearing according to core team members, since they saw it as self-imposed. The demonstrations in the mega casting project also served as an effective tool for the core team members to reflect on their past progress together and align themselves to a common goal. Several interviewees explained how it can be hard to schedule time for such actions, in particular, when subjected to an urgent schedule. Moreover, the demonstrations seemingly did not require extensive extra resources or time to complete as team members formalized the workflow needed to quickly prepare and present a professional presentation.

The demonstrations have also sped the project and its investment decision up as they have helped to gain support and authority from multiple levels of management. Demos were a good tool for the mega casting core team to get more attention and "airtime" with management. Through communication channels such as demonstrations the mega casting project was able to establish top management involvement, which is one success factor of a project related to Stage-Gate™ models by Edgett (n.d.). This success factor was able to be achieved despite not employing such frameworks in contrary to Edgett (n.d.). Demonstrations helped in establishing the early involvement of management which greatly improved management's ability to impact the mega casting project as outlined by Wheelright and Clark (1992). Based on the mega casting project demonstrations seem to be an effective tool for capturing management attention in the early stages of a project.

Demonstrations presented a holistic and transparent view of the mega casting project along its course which showcased a level of honesty and maintaining steady progress. The team's progress created significant trust for the mega casting team from management as their capabilities were

proven along the way and after continually fulfilling management's expectations and communicating this effectively. Each core team member was entrusted since core members were able to present the mega casting progress themselves with their expert knowledge.

The demonstrations were very effective in communicating information both around the company and to management. Significant evidence was found supporting the fact that the demonstrations saved more time than they required to complete. The demonstrations were one important tool which provided the foundation which enabled the speed of the mega casting investment decision. There were several key aspects of the demos which led to its success in the mega casting project:

- Demonstration meetings only handled one project
- Demonstrations were held online
- Demonstrations presented a honest and transparent view of the project
- Demonstrations were planned in collaboration with team members
- Team members themselves presented the information
- Demonstrations were professionally handled
- Both managers and laborers were invited to attend
- Experienced leader with connections within the company
- Topic of mega casting had widespread interest in the company

The transparency of the mega casting demonstrations emerged from the interviews as the most important aspect which generated trust from management. One possible explanation for the transparency is that early interest and support from some senior managers, as a result of Tesla's "Battery Day", gave the core team the courage to be honest and transparent. As even if challenges were presented, the project was unlikely to be stopped without a fair process with the existing managers' support. The fact that the core team invited attendees to their own meeting on their schedule could also be an explaining factor to why they were comfortable enough to be transparent. The project received undivided managerial attention during the demonstrations, and this could also be a contributing factor to the transparency of the demonstrations. This could be an area of future research into success factors of knowledge sharing demonstrations.

5.1.7 Early and frequent contact with management

The widespread involvement of both lower and senior managers indicates that the mega casting project has had a high degree of participation as described by Eisenhardt (1989). Managers from both several levels and departments have been involved in the decision-making and even more stakeholders have been informed through the demonstrations. The success and speed of the mega casting investment decision gives support to the idea that broad manager participation can help decision-making and speed the project up. Whilst, at the same time, failing to find support for the delay's decentralization can cause stated by Vroom and Yetton (1973) and Eisenhardt (1989).

Both the interviews and survey results stress the importance of early and frequent managerial contact to gain their support and understanding for the success of a development project. The managerial contact was instrumental in establishing management trust in the core team and the

mega casting project as a whole. This trust in turn led to autonomy regarding smaller project decisions leading to speed, acceptance of new unique workflows and willingness to accept the risk of mega casting. In this way early and frequent contact led to the success of other identified success factors, causing the major impact on speed of the project from this attribute to be indirect. Moreover, the direct and frequent contact between core team members and management led to faster resolution of questions which is believed to have had a direct effect on the speed of the mega casting project and its investment decision.

The early and frequent contact can be seen as an enabler for the autonomous team setup. It is also possible that this continuous communication between the core team and management can prevent challenges with autonomous teams outlined by Wheelright and Clark (1992). E.g. re-integrating the core team back into the organization and making corrections could be easier since there has been a greater level of mutual understanding and communication.

Several key characteristics of the core team and project were identified to ease the establishment of managerial contact which can be applied by project leaders in the future:

- Invoke managers' attention through demonstrations
- Clearly communicate the improvements to management
- Take initiative to contact management
- Select at least one core team member with a personal managerial network
- Start by involving managers who are likely to support the project
- Dare to create your own communication forums / use informal ones
- Use competitor developments as a point of interest

The availability of these characteristics for any given development project is uncertain, as one or more could be challenging or impossible to introduce. However, these characteristics should serve as a guide managers should consider when trying to establish well-functioning communication with management. It should be mentioned that management's time is a limited resource, and it would be impossible to spend a significant amount of time on every development project. The importance of the mega casting project in terms of cost and impact is likely unique which have improved the project's availability to early and frequent contact with management.

5.1.8 Tesla's "Battery Day" gave widespread awareness of mega casting technology, Tesla is seen as a source of inspiration

From the results of this study a clear trend which has been foundational to the entire mega casting project has been the influence from Tesla. Their influence was mentioned in almost every interview as a contributing factor to why the mega casting project has received such managerial attention and been able to progress as fast as it did. This attention has played a role in enabling early and frequent managerial contact with managers due to a prior native interest in the project from managers. This prior interest was often explained by interviewees as stemming from the fact that mega casting was inspired and used by Tesla. Tesla as an influencer was important since Tesla is looked up to by many managers and seen as an inspiration, often explained by

interviewees due to their innovative nature, stock evaluation or eccentric media covered CEO. This interest also helped other parts of the mega casting project to succeed, such as the demonstrations, as many attendees were interested in the subject due to the Tesla influence. Without Tesla as an influencer, it is unknown how successful the demonstrations would have been and if managerial attention would have been possible to the same extent.

Three key reasons why an influencer speed up a development project was outlined by one particular interviewee and after cross-analysis with other interviews significant support for their existence in the mega casting project was found to have helped the speed of the mega casting project. First, the fact that Tesla had performed mega casting before created significant pressure for Volvo Cars to develop the same process technology as soon as possible. This pressure made managers more willing to bear the risk which the mega casting investment decision entailed. Secondly, managers were also more easily convinced to support the mega casting venture as Tesla had already proven that the process works in practice. Thirdly, Tesla, being the first with large scale aluminum casting, also created the market for important infrastructure which let Volvo Cars develop mega casting quicker as suppliers were already available.

Tesla as an influencer exemplifies how the mega casting technology was adopted by inter-firm diffusion by Volvo Cars as explained by Baptista (1999). Many similar factors for diffusion can be found such as the importance of benefits and knowledge spillover. Interviewees also spoke about how the market pressure prompted the adoption, similar to the bandwagon effect Baptista (1999) describes. Interestingly geographic proximity was not found to be an important factor, suggesting its importance may have diminished since 1999. The firm size was also discussed as an enabler, but larger size was only considered favorable to adoption to a certain point by interviewees in contrast to Baptista (1999). The success of Volvo Cars' mega casting adoption, as a result of Tesla, can be likened to what Schnaars (1994) calls a technological leapfrog. Through employing a fast-follower imitation strategy the mega casting project was able to ascertain many advantages as presented.

From the results, major support for an influencer speeding development project up was found and using influencers to promote development projects to management is likely to improve a project's chances to receive managerial support. However, caution should be employed when promoting with an influencer as overreliance can gouge the development project's own ownership and innovativeness. The mega casting core team presented Tesla as a way to legitimize the project but did not rely on their e.g., data or calculations. Exactly to what extent and how influencers should be utilized in the promotion of a development project is uncertain and could serve as a topic for future research.

Lastly, it is important to mention that influencers are only available for technological "followers" and can never be used to develop something brand new. Developing new capabilities, which are not yet explored by any competitor, can be a source of competitive advantage which should not be ignored. However, these cannot be aided by an influencer. This begs the question if influencers from e.g., other industries can be employed to similar effectiveness as direct influencer competitors. Such a subject could be an area for future research.

5.1.9 Vertical integration and available knowledge

Whilst the person who proposed the attribute of vertical integration and internal development believed this was a contributing factor to why the mega casting project progressed faster than other development projects at Volvo Cars, the results fail to find support for this in the mega casting project. First, there was a dispute regarding the degree of available knowledge regarding mega casting as it is not something Volvo Cars has handled in-house prior. Secondly, the results from the secondary interviews show that no interview subjects agree with the notion of internal development progressing faster at Volvo Cars as a result of quicker decision-making.

The findings are more in line with Quinn (1992), with interview subjects at Volvo Cars believing that external developments being an effective way of working. One possible reason for this is that Volvo Cars' extensive and long-term collaboration with suppliers has allowed them to overcome the challenges with external developments as outlined by Kessler et al. (2000). In particular, the idea that development managers are unwilling to support external developments does not seem to be true at Volvo Cars. These results are interesting as they are in partial disagreement with Jorde and Teece (1990) as the mega casting project was sophisticated whilst it can be argued that such a process development is based mostly on explicit knowledge.

The precise impact of the fact that the mega casting investment decision being based on internal development within body structure with significant internal knowledge is difficult to decern. However, results indicate that it has not been a major contributor to the speed of the mega casting invetsment decision.

5.2 The mega casting project differences

The mega casting investment decision has many similar characteristics as the ones outlined for strategic decisions stated by MSG (2022). The project's investment decision has been handled by the board of directors and from a high-level perspective which makes the process look like it followed the standards for a strategic decision. However, the differences instead emerge when examining the development process of the mega casting project which has been used as the basis for the strategic investment decision. This sub-chapter will outline the differences between the mega casting project compared to other development projects at Volvo Cars.

Positioning the mega casting project in Wheelright and Clark's (1992) framework for different types of development projects, results show that it is a radical process innovation but a next generation of rear floors as a product. The mega casting project requires new manufacturing tools, procedures, and changes both the material and technology fundamentally, therefore it is considered a new core process for producing rear floors. Further, the mega casting project will enable a new generation of rear floors, with the same core purpose but a new design and properties. According to the four development types presented by Wheelright and Clark (1992) the mega casting project resembles a next generation project.

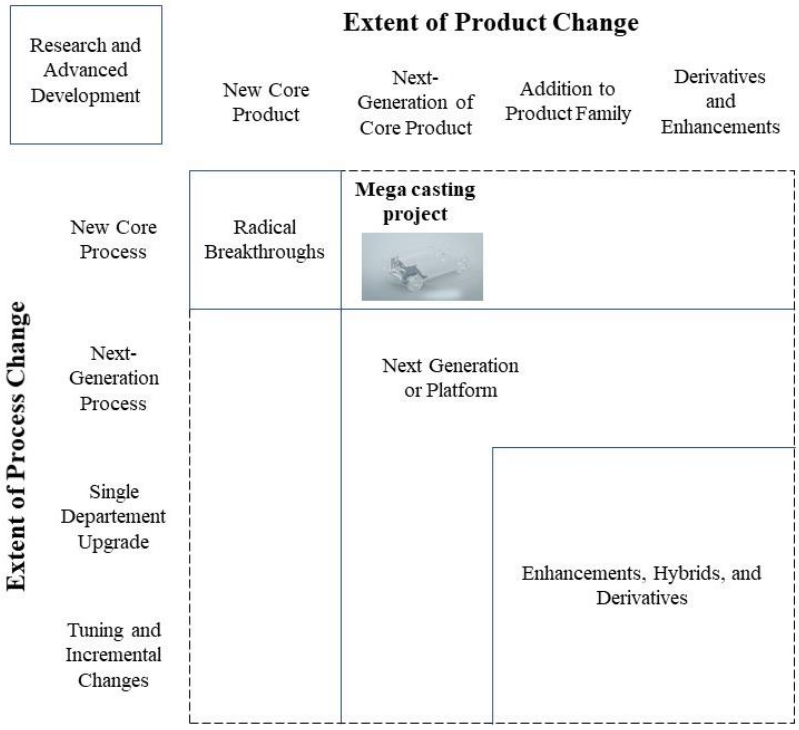

Figure 10. Positioning the mega casting project in the framework for different development projects inspired by Wheelwright and Clark (1992).

The mega casting project was compared with the other development projects at Volvo Cars. The first difference with the mega casting project was how the development, which was the basis for the investment decision, was not handled through the traditional frameworks. From both interview stages it emerged that the processes in the mega casting project were not in accordance with Volvo Cars' standard frameworks. The waterfall framework called GTDS, nor the investment framework, were employed in the mega casting project which begs to question if the mega casting project missed out on the advantages Edgett (n.d.) presents from Stage-Gate™ models. "Accelerated speed-to-market" is a measurement of speed which is interesting as the mega casting project was able to progress quickly. Truly cross-functional teams and Top management involvement was also achieved by the mega casting project despite not using Stage-Gate™ models. This shows that the advantages Edgett (n.d.) presents can still be attained even if Stage-Gate™ models are not used. The investment framework at Volvo Cars was likely avoided since the mega casting project would classify between the two investment types. From the interviews core team members purposely avoided frameworks due to their slowness and rigidity, similar to the critique outlined by Cooper (2014). The mega casting project was fast-tracked by avoiding certain stages and gates in traditional frameworks which might have been appropriate due to the project's diverse and innovative nature. This is also mentioned about stage-gate systems which can be found in Cooper (2014), and as a response the author suggests re-evaluating the current waterfall frameworks with the new principles of adaptivity, flexibility, agility and acceleration.

Similarities to principles described by Cooper (2014) can be found throughout the mega casting project. The task-force setup with assigned autonomy to the core team allowed for adaptivity and flexibility where new activities, similar to stages and gates, were introduced between demonstrations. The mega casting project also had access to sufficient resources, staffed with cross-functional members and overlapping steps, similar to the principle Accelerated. These learnings should be preserved and formalized at Volvo Cars in their frameworks. The traditional development frameworks at Volvo Cars, such as GTDS, could perhaps be expanded upon to include context-dependent stages which can be adapted to individual development project's requirements. This could help Volvo Cars handle future diverse and innovative development projects, similar to the mega casting project, successfully in the future.

Another issue with waterfall frameworks that Cooper (2014) presents is that they might be too partial to certain metrics, often financial. Explained by the author this is a source of bureaucracy and that projects are slowed down as a result. This could be one reason for foregoing certain frameworks at Volvo Cars as their avoidance was crucial to the early progress of the mega casting project, according to the interviews. The details of Volvo Cars' frameworks are not analyzed in enough detail to determine, but perhaps the frameworks lack in capturing strategic, long-term and other ambiguous metrics which are important. This since the traditional investment metrics at Volvo Cars were not fulfilled but the mega casting project was approved anyways. Usually, investment projects at Volvo Cars need to fulfill specific financial KPIs, but due to the mega casting project's strategic ambitions and long-term financial gain the KPIs results were overlooked. It is possible that the GTDS framework was avoided due to overreliance of certain financial KPIs, however, a more thorough analysis would have to be executed. The involvement of different factors in the investment decision frameworks could need re-evaluation as a result.

Based on the interviews it has emerged that the mega casting investment decision focused more on the long-term financial gain and the strategic ambitions than the standard financial KPIs for investments. Virlics (2013) likened this to a greater reliance on behavioral factors as the financial gain and risk were very uncertain. Managers involved in the mega casting investment decision did speak of significant uncertainty during the interviews as reflected in their willingness for risk-taking and have instead motivated the decision with long-term and strategic factors. Elbanna (2006) presents a similar perspective of strategic decision-making called intuitive, where managers' experience within the automotive industry have guided their decisions. The intuitive perspective was used rather than the more objective rational perspective since only relying on the rational perspective was insufficient in the mega casting investment decision due to the uncertainty involved. The reliance on intuitive, subjective and behavioral factors emerged from the interviews as several interviewees mentioned the mega casting project's focus on strategic and long-term advantages as unique for this project.

From the interviews it was clear that many levels of management have been involved in the mega casting decision, but the core team have still been able to take smaller decisions during the development themselves. Zehir and Özsahin (2008) refer to these aspects as "participation" and "autonomy". Both the high level of participation and significant degree of autonomy to the team

members were presented as unique by the interviewees. Management has showed significant interest in the mega casting project, causing many managers to participate in the decision-making. The combination of high participation and the speed of the mega casting decision supports Zehir and Özahin's (2008) conclusion that participation of managers helps enable faster decision-making. The autonomy given to the core team members was facilitated through the avoidance of controls and gates normally in place in development projects at Volvo Cars. Management's trust in the core team members gave the core team autonomy over development decisions and enabled their own way of working.

In the interviews core team members explained how they created their own communication channels that differed from traditional ways of communicating with management at Volvo Cars. Instead, communication was done through demonstrations, informal phone calls and self-arranged meetings with management. This way of communicating was seen by the interviewees as a success factor of the project. The success of the project's communication is interesting and was perhaps a necessity as the communication channels that gates in waterfall models normally bring were not available. These new ways of communicating with management could be investigated and how these could be applied in other development projects at Volvo Cars.

Lastly, the task-force setup of the mega casting project is an uncommon way to handle development projects at Volvo Cars. The task-force setup gave the core team members the possibility to work full-time on the project and create their own way of working, leading to a high level of dedication. Moreover, the task-force setup was appropriate for the mega casting project due to the core team's flexibility and fast response to change which is similar to what Lee and Ahn (2018) mention about tiger teams. The novelty of mega casting led to a significant degree of uncertainty and ambiguity regarding development steps, leading to the core team having to be flexible enough to handle such delicate situations. The task-force setup also resembles the definition provided by Wheelwright and Clark (1992) of autonomous teams, and the mega casting project supports the authors' idea that autonomous teams are suitable for radical innovations and major platform projects. Volvo Cars should continue to utilize a task-force setup when projects are expected to involve significant degrees of ambiguity and projects are large and novel to a similar degree of the mega casting project.

5.3 Agile workflow in the mega casting project

Based on the results many traces of agile workflow have been found in the mega casting project. Within the mega casting project cross-functional teams have been used to a large extent and cross-functionality has been mentioned by several interview subjects during the initial interviews. The team of the mega casting project has had a task-force setup where people have been responsible for different areas causing autonomous progress. This follows the principle of self-organizing teams stated by Beck et al. (2001), belonging to the main content of agile.

Interviewees elaborating on the agile workflow in the mega casting project claimed that each pre-study and supporting teams to the core team have been using agile tools such as "product backlogs" and the workflow has been organized in periods such as sprints. The use of backlogs

and sprints of the supporting teams to the core team can also be confirmed by the VIRA documentation. During the mega casting project stories have been created and completed, and some information about each story has been logged in VIRA. A PO described how each story is assigned to a specific individual responsible for the task. Stories have been used during the mega casting project by different supporting teams, even if not all tasks, especially smaller tasks, have been logged as their own story in VIRA. Many traces of agile were found, but the implementation of the agile tools and procedures has been haphazard and the connection to agile as a methodology was lacking.

The mega casting core team has been cross-functional with members from many parts of the organization. However, only a few Volvo Cars employees attributed this to an agile tool while others claimed that this way of working has been common for a long time. Further, the demonstrations have been an effective way to communicate the mega casting project throughout Volvo Cars, however, the individuals responsible for the demonstrations did not consider them as an agile tool. Demonstrations in agile is a way to communicate what has been achieved during the latest finished sprint (Mountaingoatsoftware, n.d.), however, as the core team has not used sprints the mega casting demonstrations were not the same. Demonstrations in the mega casting project were deadlines set in which the current progress was reported, not particular milestones reports showing yet another difference. Sprints themselves were another point of contention with agile methodology as presented by Kniberg (2015). The core team's task-force setup allowed for avoiding sprints whilst sprints were still used in the underlying pre-studies and by the supporting teams to organize the stories and workflow. The effectiveness of sprints was discussed as the cross-functional collaboration between R&D and manufacturing was disrupted by their different planning timeframes. Some interview respondents even believed that sprints in the core team would have disrupted the longer-term planning needed for hardware development.

Despite the presence of several agile tools and structures in the mega casting project, there was a gap in the implementation compared to agile theory. Whilst product backlogs were present during the division of work in the mega casting project, its usage has a lot to be desired compared to the formal description. Backlogs in the mega casting project, as described during the initial data gathering, were used as a tool to formalize work tasks and document work. This contrasts with the purpose of product backlogs according to agile theory which describes them as a tool for structuring work and aid in prioritizing. Backlogs have not been employed as a tool filled with stories where team members could pick the highest prioritized one and perform the task. Instead, stories were written short before or during the work as a way to document in VIRA what each team member was working on. This was further proven by the investigation of the VIRA tool where commonly acceptance criteria were lacking for both pre-studies as well as either extensive description or priority in stories. The VIRA investigation also shows that the duration of stories was significantly longer than theory recommends, with average durations of almost three months (Mountaingoatsoftware, n.d.). There is a possibility that the bypassing of agile tools has instead aided the speed of the mega casting project, as less time was spent on documentation. However, this was not expressed by any interview subject but could serve as a future research topic.

Moreover, Volvo Cars has used the SAFe framework to implement the work of SCRUM, and the mega casting project was not an exception. The mega casting project was initiated as a capability which shows that VCAF has been applied in the working of the project. Interview subjects during initial interviews had roles from the VCAF framework such as PO, PM, SM etc., which agrees with Leffingwell's (2020) description of SAFe. This shows that the organization governing part of the mega casting project was agile to some extent. Only one out of eight interviewees mentioned that the SAFe structure and its belonging roles affected the speed of the mega casting project claiming that it gave the agile managers more authority over the project. However, the findings indicate that this control and authority given to ARTs and core team members are a result of other factors than the SAFe structure.

After interviewing members at Volvo Cars about agile workflow many seem to view agile as a framework with a set of associated tools. Further, interviewees could recognize that cross-functional teams are supposedly agile but fail to recognize why agile prescribes these methods and what advantage it should bring. Agile is seen as a set of tools for documentation and bureaucracy and is in stark contrast with agile values presented by Fowler and Highsmith (2001). This may be a reason why few interviewees recognize that agile workflow has played a role in the speed of the mega casting project. This is further connected with the fact that Volvo Cars seem to employ an agile way of thinking, however, employees at Volvo Cars are not willing to attribute any such ideas to the term "agile". Instead, practices such as cross-functional teams have been used long before any agile transformation and therefore employees do not associate the success from these practices with agile. This can be compared to what Conforto et al. (2016) called agile project management. There is a presence of agile principles in the mega casting project but without the knowledge of being agile and being called by that name. Lastly, the mega casting project has neither followed agile nor traditional development frameworks at Volvo Cars as described by the core team. Instead, ad-hoc solutions to workflow have been used which could be one reason interviewees were hesitant to attribute any major impact of speed to agile.

Agile workflow may also have fundamental differences when applied to hardware development compared to software, as highlighted by the results. Short sprints may be difficult since hardware development entails longer lead times, physical testing and requires longer cycle times. Another challenge was raised by an interviewee similar to the uncertainty presented by Cooper and Sommer (2016) about agile with stage-gating regarding how to formulate a "definition of done". It should also be questioned if cross-functionality plays a different role in hardware development projects such as mega casting since it may instead be a requirement rather than an improvement. The fact that agile has not been recognized as a source of speed and efficiency for the mega casting project shows that this case study fails to find support for claims such as Lindlöf and Furuhjelm (2018) found regarding agile in manufacturing. The role of agile in hardware development projects could be an area for future research.

In summary, traces of Volvo Cars' agile workflow have been found in the mega casting project, but the implementation has been haphazardly compared to the diligent implementation literature advocates. Interviewees have been hesitant to attribute any quickness or success of the mega casting project to the agile workflow and many interviewees found it difficult to decern what

tools were truly agile. No conclusive evidence could be found that agile has sped up or slowed down the speed of the mega casting project.

Based on our results three potential suggestions are formulated with the aim for Volvo Cars to be able to clearly evaluate their agile workflow and use it to become both faster and more stable in their development as outlined by Bazigos et al. (2015). First, agile tools such as VIRA need to be re-evaluated to what its purpose is in comparison to how it is used in practice. The suggestion is to either work on moving closer towards true agile applications of tools like product backlogs or remove the enforcement of such tools from teams which apply VIRA as formality. If VIRA is deemed a useful tool for all teams, even if only for documentation, Volvo Cars should realize VIRA can no longer be seen as an agile tool and should not expect agile advantages. Secondly, Volvo Cars should educate the personnel on agile fundamental principles and values to gain a deeper perspective on their agile workflow. This more nuanced perspective of agile could help make users of agile practices more accepting of the term and create awareness of the fact that their traditional tools often can be seen as agile. The third and last suggestion is that Volvo Cars should reflect upon how applicable traditional agile methodology is for hardware and if adjustments need to be made.

Lastly, it should be taken into consideration that departments such as manufacturing have yet to transition to agile and that any development project involving non agile departments, such as the mega casting project, needs to be mindful on how this will affect the agile workflow.

6. Conclusion

This thesis aimed to answer how development projects' investment decisions can be taken quickly from examining how the mega casting investment decision could be taken so quickly in comparison to other development projects of similar impact at Volvo Cars. From interviews with individuals at Volvo Cars it can be concluded that the mega casting project was able to reach a board of directors' investment decision faster than similar development projects, and one comparison project shows that the mega casting investment decision was up to six months faster. From initial interviews a large amount of success factors was found and formalized into 31 attributes contributing to the speed of the mega casting project and its investment decision. Eight attributes emerged as the most impactful from a survey which were chosen to be investigated further in secondary interviews. From the mega casting project, the most impactful success factors enabling the speed of development projects' investment decisions are:

- Project gave advantages to all essential departments
- Project aligned with strategic ambitions
- Large size and impact of the project
- Newsworthiness and innovativity of the project
- Continuous and transparent communication with management
- Well-constructed development team
- Supportive managers
- Fast follower project of industry influencer

These success factors should be considered by project initiators and managers when looking to accelerate the timespan for development projects' investment decisions. Several of these factors exemplify how the mega casting project differed from other development projects. Further, the mega casting development project has deviated in other important ways. The mega casting project has employed a task-force setup where the core team members could work full-time and create their own work processes. This caused the mega casting project to forego traditional workflow frameworks for investments and development projects which otherwise are commonly used. The mega casting project also had a greater extent of managerial attention. All the differences between mega casting project and other development projects seemingly caused the mega casting investment decision by managers to be based upon longer-term financial and strategic factors to a greater degree. Many of these differences were also found to have increased the speed of the mega casting project and its investment decision.

Traces of agile workflow can be found throughout the mega casting project, however, the implementation has been haphazard. An attempt to fulfill the agile requirements in the mega casting project has been made, without achieving many of the advantages it could bring. No evidence was found for the agile workflow affecting the speed of the mega casting project.

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Appendix 1

Survey Thesis Mega Casting.pdf

Mega casting survey in its entirety as a PDF.

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