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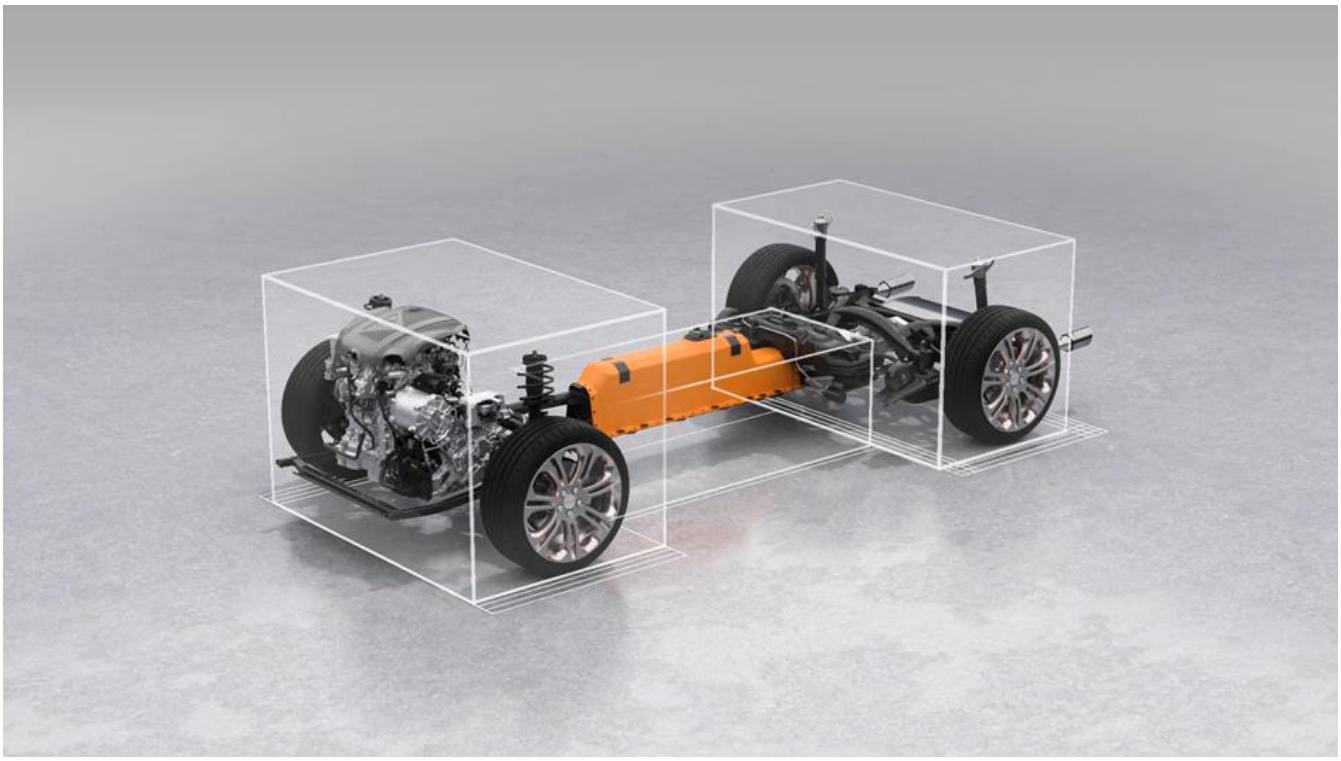

Managing Late Changes in a Global Developing and Manufacturing Organisation

A Case Study at CEVT AB

Master's Thesis in the Master's Program
Quality and Operations Management

Daniel Gyllenhammar
Nirari Yousif

Department of Technology Management and Economics
Division of Service Management and Logistics
CHALMERS UNIVERSITY OF TECHNOLOGY
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Daniel Gyllenhammar
Nirari Yousif

Tutor, Chalmers: Jan Lenning
Tutor, company CEVT: Charlie Berner
Examiner, Chalmers: Andreas Hellström

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Department of Technology Management and Economics
Division of Service Management and Logistics
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden
Telephone: + 46 (0)31-772 1000

Cover:
[The Compact Modular Architecture (CMA) developed by CEVT, which was first introduced in a vehicle 2017]

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Abstract

Our world is changing faster and faster, hence organisations have to adapt to these ever-changing circumstances. The changing environment calls for shorter development cycles which are flexible and adaptable to late changes. Furthermore, in the context of the automotive industry, the development of a vehicle is entailed with long lead-times and complex problem solving, in both the manufacturing and development process, which contradicts the market behaviour.

The thesis investigates how a developing and manufacturing organisation can respond to rapid changing customer demands. A case study was conducted at the Manufacturing Engineering department at the R&D and innovation centre CEVT, which is a company delivering technological solutions to the Geely Groups automotive manufacturers. By combining the empirical study at CEVT with the four literature areas Dynamic capabilities, Ambidexterity, Agile Methodologies, and Beyond Budgeting a deeper understanding was created for how an organisation can manage late changes. Hereby, following improvement suggestions were identified:

1) Cross-functional integration
2) Decentralised structure
3) Increased transparency
4) Linking resource allocation and planning with late changes
5) Processes and routines that fosters flexibility and are renewable
6) Planning and budgeting for late changes
7) Creating plans and budgets adopted to external and internal business cycles
8) Promoting bottom-up influences.

For CEVT to make use of the improvement suggestions further investigations regarding implementation have to be done. The research findings and a developed framework creates a foundation for future research and a starting point for organisations trying to enhance their management of late changes.

Keywords: Flexibility, Standardisation, Rapid Changing Demand, Dynamic Capabilities, Ambidexterity, Beyond Budgeting, Agile Methodologies, R&D, Innovation Centre, Manufacturing Engineering, Organisational Flexibility.

Abbreviations

BIW	Body in White
BOP	Bill of Process
CEVT	China Euro Vehicle Technology
CMA	Compact Modular Architecture
CMS	CEVT Management System
Customer	An Auto company within Geely group
eBOM	Engineering Bill of Material
ECN	Engineering Change Notice
End Customer	The end user
FDJ	Final Data Judgement
ISO	International Organization for Standardization
mBOM	Master Bill of Material
ME	Manufacturing Engineering
NPDS	New product development system
PCM	Part Change Management
PCR	Part Change Request
PLM	Product Lifecycle Management
PRI	Product Issue Tracker
QMS	Quality Management System
SPA	Scalable Platform Architecture
SPL	System Project Leader
ST	Shared Technology
TCF	Trim and Car Final
TPL	Technical Project Leader
UPL	Unit Project Leader

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Disposition

1 Introduction

Chapter 1 introduces the reader to the context of late changes, why they exist and their connection to development and manufacturing. Followed by a brief description of the case company, CEVT, the Manufacturing Engineering department, and followed by a problem description. Afterwards, the objective of the thesis, the purpose and two research questions, and finally the research scope is presented.

2 Theoretical Framework

Chapter 2 constitutes of the literature forming the theoretical framework. The chapter starts with describing Managing Late Changes from a theoretical point of view. Afterwards, four areas of literature are described, namely, Dynamic Capabilities, Ambidexterity, Agile Methodologies, and Beyond Budgeting. *This is followed a section regarding ISO 9001:2015. The last section consists of concluding remarks and relationships between the areas presented earlier in this chapter.*

3 Methodology

Chapter 3 presents the methodology used to conduct the thesis. Firstly, the choice of research strategy and design is presented. Secondly, the applied research methods are depicted. Thirdly, the data collection is described, followed by a description of how the literature was analysed. The two final sections are discussing research quality and ethical considerations.

4 Case setting

Chapter 4 presents the case setting, starting with a general description of the development and manufacturing process in the automotive industry. Followed by a more case specific section, which regards the company CEVT, its structures and processes relevant for managing late changes.

5 Result and Analysis

Chapter 5 presents the result and analysis of the gathered data. This chapter combines the data from the interviews and focus group with theoretical findings. The chapter answers both research questions and also presents a separate section that analyses the literature to facilitate the application of the findings to other, not case specific, contexts.

6 Discussion

Chapter 6 is a discussion of the results and analysis from previous chapter with the aim to problematise and create a more nuanced picture of the context.

7 Conclusion

Chapter 7 firstly presents the answer to the two research questions and ends with concluding remarks and suggestions for future research.

1 Introduction

This Chapter introduces the reader to the context of late changes, why they exist and their connection to development and manufacturing. Afterwards a brief description of the case company, CEVT, and the Manufacturing Engineering department followed by a problem description. The last sections present the objective of the thesis, the purpose and research questions, and finally the scope.

1.1 Background

Imagine to be able to match the customer demand to 100% at every point in time. Imagine an organisation with the capability to adapt to every nudge of the customer in a matter of moments. As today's market increase in both volatility and uncertainty there is an increased need for companies to develop dynamic and flexible manufacturing capabilities and processes in order to adapt to unforeseen circumstances (Ghobakhloo & Azar, 2018).

Although the paradigm of achieving dynamic manufacturing capabilities with a cost-efficient approach may have gained traction during recent time, there have always been a trade-off between how much standardisation contra flexibility an organisation should apply. The result has always been definite in one direction and as a consequence, also the organisational performance, cost, and lead time to market (Inman, Sale, Green Jr, & Whitten, 2011).

Companies have realised that understanding-, creating- and delivering value to the customer is a one-way ticket to success, and the ones that became the most skilled at it, are the ones that enjoy the leading position (Matzler, Hinterhuber, Bailom, & Sauerwein, 1996). As the demand is continuously changing, there is an increased need of continuous innovation and change (Steiber & Alänge, 2013). Furthermore, we are also on the verge where digitalisation and new manufacturing capabilities, such as 3D-printing, will come into force, which leads to a situation where companies that cannot develop the ability to change and meet the new demands may not be here tomorrow (Behrendt, Müller, Odenwälder, & Christoph Schmitz, 2017). This will re-engineer how companies, people and the structure interact with each other. Hence, the ones that learn how to adapt to the fast-changing customer-, market- and technology demands and the management of late changes are more likely survive (Birkinshaw, Zimmermann, & Raisch, 2016).

China Euro Vehicle Technology (CEVT) is an innovation center and R&D company owned by Geely group which focuses on developing automotive technology for the automotive subsidiaries in the group, such as Volvo Cars, Geely Auto, and Lynk & Co etc. CEVT has a centralised role in the group where they develop modular architectures, platforms, and new technology which is later used by the automotive companies in the group. The central role of developing technology results in high integration and collaboration with the automotive companies engineering departments. Since the company has grown rapidly since the start in 2013, the processes have not been able to conform to the changing organisation both in the headquarters at Lindholmen, Gothenburg, and in China. Regarding the deliverance to the automotive companies in the Geely group, CEVT mainly focuses on developing the technology to a sufficient readiness level where it later can be handed over. The technology is later derived and implemented in the new automotive projects. CEVT has since founded, developed an architecture for the smaller vehicles segment called Compact Modular Architecture (CMA) which is used in Volvo XC40, and two complete vehicles namely Lynk & Co 01 and 02 which was fully developed by themselves (Personal Communication, 2018).

Regarding late changes, these can be occurring anywhere in the process timeline. The definition of *late* in this context is that the change should have been done earlier to not create implications for any other part of the system. Furthermore, to define the late *Changes*, these are changes that should impact a broader part of the system and not only single parts.

1.2 Problem Description

Due to the short and fast expansion made at the organisation, issues have arisen concerning global project management in the aspect of alignment and cooperation with the companies in the group. These projects follow CEVT's internal development system called New Product Development System (NPDS). One of several development processes in NPDS is to ensure manufacturing feasibility, verify the producibility of parts, systems, and vehicles, and prepare the factory for assembly for the projects CEVT is involved in. These activities are done by a department called Manufacturing Engineering (ME). The ME department is involved in earlier stages of the new product development processes, assisting the engineers with manufacturing requirements, but is mostly operational during the industrialisation phase of the development projects. In this phase, the department takes the virtual 3D- models of all parts and systems and puts it into physical contexts. To exemplify, the engineers want to increase the readiness level of their parts, while the ME will try to ensure that they meet the different manufacturing requirements. The ME department is hence responsible for matching each part against set requirements and approve these to the next readiness level. When the parts have reached the final level, they are approved for manufacturing. ME at CEVT consist of 5 sub-departments; Stamping, Body in White (BIW), Painting, Trim and Car Final (TCF), and Geometry. The sub-departments are characterised by a high interactive and integrated relation. Although the work is different for each department, the requirements and deliverables entitle the same parts. Hence, if any changes are made in one sub-department, a chain reaction is initiated throughout the others. For CEVT to manage the industrialisation phase and the handover between CEVT's ME departments and the automotive subsidiaries different ME departments, the procedures are highly standardised. As aforementioned arguments, the market's demand and change in development is inevitable, and during the time of industrialisation, issues occur that result in changes. These changes are handled through a systematic process called Part Change Management with the purpose to handle product related late changes not within plan. Moreover, due to the magnitude of affected parties involve, the result is usually a cluster of problems that become harder to solve as time passes (Personal Communication, 2018). Since CEVT is to create innovative technology to the Geely group, one of their key abilities is to be able to deliver the latest solution possible. Hence, to be able to incorporate the latest features, design, or technology into a product is of great importance for CEVT.

1.3 Objective

As the ME department has to manage late changes in their processes as a response to an identified change from an external perspective or issues discovered from an internal point of view, it is of increased importance to be able to implement changes to the product at later stages of the process in a sustainable way. Therefore, by creating a foundation for how an organisation can support late changes, improvement suggestions in the ME department and its associated processes will be sought. In the extension, by also creating a more generalised version of the improvements, other contexts and other departments at CEVT, might be able to adopt the same methodology and hereby improve and prepare themselves for future opportunities.

1.4 Purpose

The purpose of this thesis is to acquire an understanding for how a developing- and manufacturing organisations can respond to rapidly changing demands and manage late changes in the ME department. To put the research in the context of CEVT, following research questions are created to guide and reach the objectives of the thesis:

1) How does late changes affect Manufacturing Engineering?

2) What improvement suggestion can be identified to support and facilitate the late changes?

1.5 Scope

The research will be conducted at CEVT´s ME department at Lindholmen and hereby limit the scope within the company to the processes closely related to this unit. The main focus will be to create an understanding for how the ME department and its associated processes interact when late changes are initiated, and hence identify related problematics. Moreover, to limit the scope of the thesis, the project will only encompass the as is state and improvement suggestions, excluding the implementation of these. Hereby, as the conclusions of the research will be limited to findings gathered, they might therefore lack supporting data to strengthen the implementation of forwarded suggestions.

2 Theoretical Framework

This chapter starts with a section called 2.1 Managing Late Changes addressing issues and depicting important aspects regarding late changes. Afterwards, four areas of literature are described, starting with Dynamic Capabilities and Ambidexterity, which are two conceptual approaches addressing the issues presented in Section 2.1. Subsequently, the two remaining areas of literature are Agile Methodologies and Beyond Budgeting*, which are approaches on a more operational level. These two approaches are followed by a section regarding ISO 9001:2015, as this standard was implemented at the case company at the same point in time as the research was conducted. The last section consists of concluding remarks and relationships between the sections presented earlier in this chapter.*

2.1 Managing Late Changes

When managing large and complex projects[1], such as those found in the automotive industries, some difficulties are issues like, technical challenges, changes in design and operational requirements, cost changes, responsibility disputes, and new regulations, which all tend to increase with the scale of the project (Davies et al., 2017). To further increase the complexity, New Product Development (NPD) projects are entailed with changes and processes for innovation through their whole development cycles. Moreover, companies are required to manage these changes and innovations late in NPD projects to be able to compete at a rapidly changing market, both regarding customer demand and technological advancements (Li & Moon, 2012). Furthermore, late changes create re-work, revised planning, increased documentation, and extensive cross-functional communication (Alblas & Wortmann, 2012; Davies et al., 2017). In Table 1 below, a list of issues occurring when managing late changes are described.

As traditional project management tends to promote control, ridged budgets and contracts, they also hamper innovation and flexibility, which in turn calls for a shift in focus to manage uncertainty and new management practices. To be able to handle late changes, it is important to understand the whole system and how the changes propagate through all its processes. Furthermore, to create a system that can be adapted to new requirements, not just the internal requirements but also external components and their interactions are necessary to foster system-wide collaboration and success (Davies et al., 2017; Reeves, Levin, Harnoss, & Ueda, 2017). The issue of different development projects is also prominent (Davies et al., 2017; Wheelwright & Clark, 1992). To be able to separate and structure the different projects is vital as the amount of change projects are increasing. Furthermore, to create both an organisational context and acquire personnel that foster flexibility and innovation is of high importance to remain competitive (Davies et al., 2017).

As well as projects are different so are changes. By categorising changes and also assessing them on a holistic perspective the change management process can be facilitated. One aspect which could categorise the change is where on a product level it is implemented, i.e. single part and incremental change, concerning multiple products and architectural change, or new solution and radical change. Furthermore, it is possible to categorise the changes based upon the impact on an organisational level as well, this by assessing if the change will affect for example a single project, a program, the organisation, or the entire industry. It is also of importance to create a decision-making process where the balance of the different impacts are assessed, and also the impact on single projects and programs versus the total product life cycle (Alblas & Wortmann, 2012).

[1] Sometimes referred to as Megaprojects, which are defined as projects with budgets exceeding 1 billion $ (Davies, Dodgson, Gann, & MacAulay, 2017)

Table 1: Problems when managing late changes (Alblas & Wortmann, 2012)

No.	Problem	Description
1	*Change propagation interaction*	As multiple changes can occur simultaneously, these can affect each other and result in even more changes
2	*Variation of the change's initiation level*	The change is initiated at different levels regarding architecture, single products, single components etc.
3	*Change impact on other projects*	As changes are initiated on different levels and in parallel, some might impact other projects, which in turn can create change issues that has to be accounted for
4	*Impact of Changes on plans*	As changes often have unclear effect and also can occur in parallel with other changes, the impact changes have on activities in work plans becomes uncertain
5	*Resource allocation problems*	As changes often requires more resources they are often asking for extra resources. These resources are often unavailable due to already designated to other projects. Furthermore, if there had been extra resources, these are often unavailable due to delays in previous projects, which have occurred due to changes.
6	*Integration problems*	When it comes to large technical changes, especially discontinuous changes, these tend to have major impact upon design and interfaces. This in turn leads to even more changes propagating in the system.
7	*Uncertain plans in terms of capacity*	When scope and targets change in projects, teams are faced with a divergence from the original intent. This is also valid for change projects, as an example *Change A* might affect *Change B* which in turn affects *Change A.* The result is that the initial change plan regarding *Change A* in the end has diverge from the reality, resulting in an uncertainty regarding capacity planning
8	*Unclear ownership of change issues*	As changes can be initiated at different levels and also effect different functions it can result in unclear ownership
9	*Uncertainty in change cycle time*	As changes tends to affect several functions within a company, the changes must be assessed by multiple parties resulting in complex planning. Furthermore, different functions might prioritise differently and an unclear ownership, all above are examples that adds to an uncertainty in the cycle time for the change.
10	*Unclear impact of the change during product development life cycle*	As the product development continues even though a change is initiated the design might change as time goes. This can result in that the proposed change solution is based on an old specification.
11	*Unclear effect on subsystems*	As changes might alter designs and other components, those that are out-sourced might already be work-in-progress. Hence creating a change propagation in the supply chain.
12	*Changes are seen as a high administrative cost*	Due to difficulties in time and cost estimations combined with extensive communication changes are often handled through strict administrative processes, which are associated with high administrative costs.
13	*Changes might impact the quality criteria and quality*	As there is an awareness that changes affect the time plan and resource allocation, there is a fear of including to high quality criteria, due to fear of not being able to meet the set demands. Which in turn can dampen quality.
14	*Complex changes foster strict process, hindering innovation*	These processes results in an in a system that is not supporting the flexibility to handle the changes.

Changes create new/revive/prolong projects, hence engineers assigned to these projects tend to accumulate more projects overtime (Alblas & Wortmann, 2012). Seen in the light of development projects, where Human Resources often are seen as one of the most critical and a resource that should be utilised as much as possible, engineers tend to receive even more projects to maximize utility. An important aspect regarding the utilisation of engineering capacity is that when a development engineer is focused on a single project, then given a second project, the productivity rises as more value adding tasks can be done per time unit. This due to that the engineer can move “back and forth” between projects when for example waiting for response in one project. However, when receiving a third, a fourth, a fifth, etc. project, the percentage spent on value adding tasks drops faster and faster. Furthermore, the now high-utilised engineer risks to become the bottleneck for all her or his involved projects and if something should happen, there is no slack to cover the needed extra resources. This in turn can create cascaded effects on other projects, resulting in higher development costs, missed deadlines, and quality issues (Wheelwright & Clark, 1992).

2.2 Dynamic Capabilities

Dynamic Capabilities is a framework which analyses the sources and paths to capture value by companies in rapidly changing environments. The creation of the framework stems partly from criticism towards the predominant strategic approaches, such as Porter's Five forces (Porter, 1980). These predominant approaches seem to ignore the source and methods to maintain competitive advantage in a more disruptive world (Teece, Pisano, & Shuen, 1997). Though Porter (1996) also argues that that operational effectiveness will only be a competitive advantage in the short-run, as many of the capabilities connected to operational effectiveness and best practices originate from tools and methods which can be copied by competitors. Furthermore, Teece (2014) describes the dynamic capabilities perspective to emphasise the environmental analysis of the business ecosystem, not just a single industry. The dynamic capabilities framework is also elaborating on the role of the organisations evolution and the previous path. This notion of path dependency and that "history matters" eradicates the otherwise rather common view in economic textbooks that a company have all the technological possibilities ahead of them (Teece & Pisano, 1994). The dynamic capabilities framework can be summarised to harness and orchestrate difficult-to-replicate assets by selecting and developing both technology and business models that enforce competitive advantages. Moreover, the framework can be described by three sub-categories, namely: *Sensing, seizing,* and *Transforming*[2] (Teece, 2007). These sub-categories are described more in detail bellow.

2.2.1 Sense

This aspect concern scanning, searching, and exploration across markets and technologies. Simply put, for a company to be able to act upon opportunity or threat it has to be aware of it. The perspectives that are mentioned in this sensing the environment goes beyond the common R&D investments and the continuous probing of customer demand. To be able to sense and predict the actions of suppliers, competitors, and the ecosystem as a whole, is a necessity. The company must also understand the structural evolution of all parties of the ecosystem, as this shapes the possibilities and actions which these parties can take. Furthermore, if a company can sense the latent demand of a customer it is possible to create a competitive edge which is hard to replicate for competition (Teece, 2007). In the context of the ecosystem, the considerations of regulators, business ethics, laws, and institutions have to be taken into account. The "Rules of the game" has to be calculated as the impact and co-evolution of the societal framework will be a prominent factor for any organisation's success (Williamson, 1998).

As sensing concerns gathering data from the environment, an important part is filtering for the right information and also create a flow to those that can have use for it (Teece, 2007). To be able to achieve this data gathering and be able to filter what is relevant Teece et al. (1997) is mentioning a decentralised

[2] Also called, reconfiguration and adaption.

organisation with more local autonomy as a possible solution. The decentralised organisation is less likely to be stuck in ridged hierarchical processes that hinders action upon the change of a market or technology. One parameter that not should be ignored in this context is that top management still has to be informed. Hence, mechanisms and procedures have to be created to facilitate this communication. The local data gathering done by the decentralised groups might be of great importance, but for the organisation to look beyond their own industry and anticipate changes in contexts that can impact their situation is likewise as important. The emergence of new technologies or business models from other industries are some examples. Above, the notion of exogenous forces has been mentioned to a large extent, but internal forces in the company has to be considered as well to enable the guidance of internal R&D and the selection of new technologies (Teece, 2007). In Figure 1: Components of Sensing, the elements for sensing the market and technological opportunities is depicted.

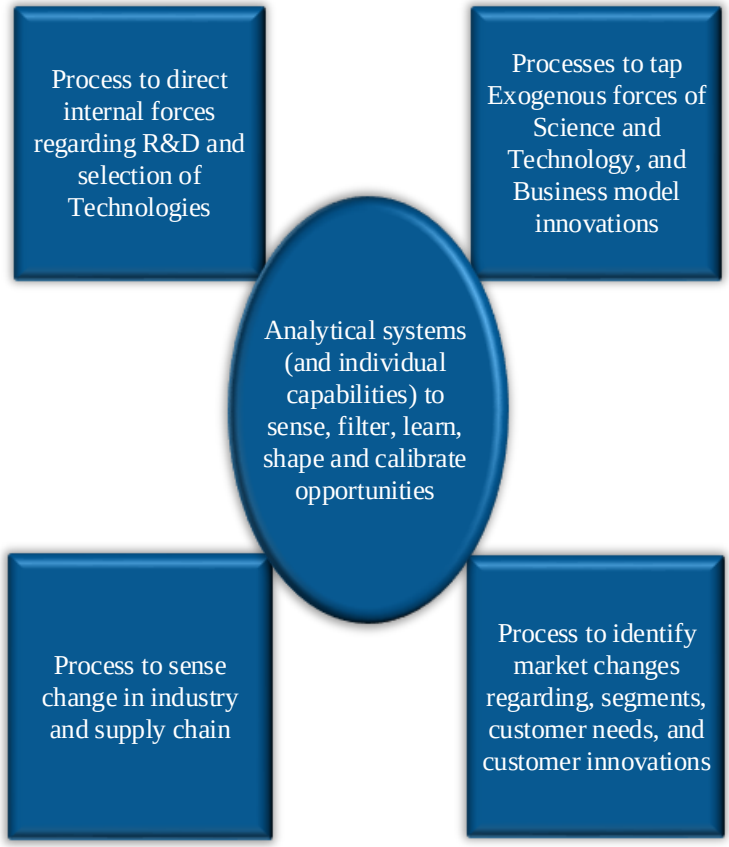

Figure 1: Components of Sensing (Teece, 2007; Teece & Pisano, 1994; Teece et al., 1997)

2.2.2 Seize

When the opportunities of markets and technologies has been sensed, *seizing* these opportunities is the next step. The enterprise has to create structures, organisational designs, procedures, and incentives for seizing these opportunities. As technologies and markets change there is also changes in dominant design and the implication of this is an uncertainty to where to put resources. In the beginning of the technological journey it might be possible to invest in multiple technologies or areas, but as time goes and the market becomes narrower, so does the investment possibilities. It is noted that for a company to stay flexible until the dominant design has emerged, the heavy investments should be postponed as long as possible (Teece, 2007).

As well as monetary recourses has to be allocated, so has the internal resources and capabilities of the organisation. Employee knowledge and time, facilities, and management decision frameworks are just some parameters which has be taken into account. To be able to handle the data gathered from the

surrounding, and seize the opportunity, the right knowledge within the company is essential (Teece & Pisano, 1994). To also comprise teams that consist of diverse knowledge is an important factor for enabling knowledge to be spread across the organisation (Eisenhardt & Martin, 2000). As well as knowledge can be an important asset, it can also be a lock-in, due to that learning tends to be focused upon the knowledge already gathered (Leonard-Barton, 1992). Furthermore, the organisational design and structure also has to promote seizing the opportunities that has been sensed. As bureaucracy and hierarchical processes tends to slow down decision making as top management requires reports and justifications for any major change or issue, the allocation of resources can take considerable time (Eisenhardt & Martin, 2000; Teece, 2007). Moreover, it is not just about making decisions, the right decisions have to be made. Even though the statement is obvious it is more than simple to achieve in a context of rapid change. For a matter of fact, decision making is often compromised in several ways. For example, when investments should be divided between projects, the projects that are certain, or at least seen as certain, of success are favoured before those of less certainty. This implies that projects which are of a more radical nature, and with this often less certain, will not get the allocated resources which are needed. The promotion of security is even more enforced due to bureaucratic structures such as budgets which supports investments in secure cash-flows that aids in reaching the budget. In a stable and predictable world, this is not a problem, but as the organisational context is rapidly changing, these structures become more obsolete every day. To solve this issue, dysfunctional structures that do not generate value anymore, must be possible to disintegrate. The disintegration of non-value adding assets is also an issue that has to be addressed, this due to that the resources tied up in the old assets can add value in new ones, furthermore, old routines and constraints can also disappear with the old asset (Teece, 2007).

Another aspect of importance is that all hierarchical levels of the organisation should dare to contribute and to have an opinion, as this enables both shorter response time within the organisation and facilitates the process of decision making by minimising potential bias from higher levels of the hierarchy. Furthermore, the target setting, and incentive systems has to be aligned throughout the company to encourage risk-taking, creativity, and innovation. Hereby, the incentive structure must also be created so that neutrality is achieved when assessing new projects against older ones, which also rimes well with the above-mentioned issue about new versus old project financing (Teece, 2007). Decisions regarding resource allocation has a tendency to be bias or taken upon the wrong premises and is entrenched with multiple strategic paradoxes (Schoemaker & Tetlock, 2016; Smith, Lewis, & Tushman, 2016; Teece, 2007). Two issues which should be considered to enhance decision making are information asymmetries and incentives for decision-makers, but through obtaining outside perspectives, testing for logical errors, and involvement of different hierarchical levels, these factors can be reduced. As an extension, it is emphasised to have an organisation where honest opinions can be offered without further hesitation (Teece, 2007).

Moreover, the business model chosen by the company is of great importance as this creates the outline for the value proposition, selection of technologies and features, identification of market segments, cost structure, and structure of the value chain (Teece, 2007). In the context of Dynamic Capabilities, the business model must be of a constant renewal to be able to seize the opportunities from the rapidly changing market. Hence, detailed information of customer needs, market behaviour, sales and procurement cycles, and other features affecting the business are required. As well as depicting the choice for the business trajectory, the business model also has to enable the gathering of evidence to support the decision. Teece (2007) is presenting four factors to become more successful when designing a business model; firstly, analysing several alternatives; secondly, deep understanding of customer demands and needs; thirdly, deep understanding of the value chain for a cost-efficient and timely deliverance according to what the customer actually wants; Fourthly, embrace a neutral approach to outsourcing where tools like market research and transaction cost economics are supporting the decision. In Figure 2, an overview of the components for seizing is depicted.

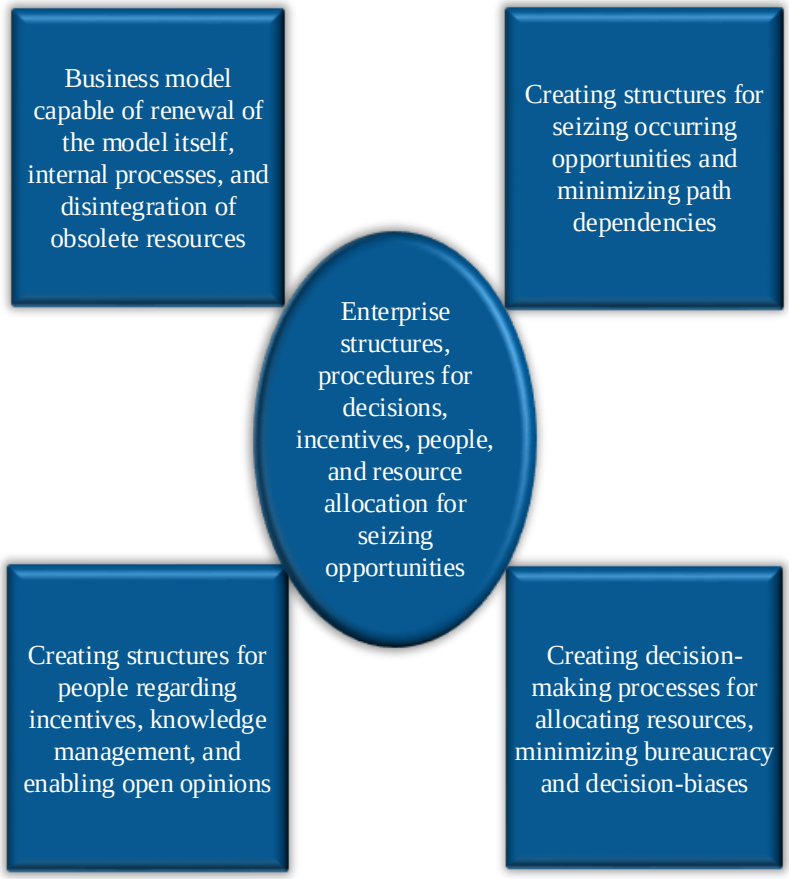

Figure 2: Components of Seizing (Teece, 2007; Teece & Pisano, 1994; Teece et al., 1997)

2.2.3 Transformation

The aspect of transformation is also referred to as reconfiguration or adaption in literature, but is here called transformation. As the company has sensed and seized opportunities, a key ability is to transform the organisation to suit what have been sensed and seized, or with other words, manage growth (Helfat & Peteraf, 2015). The goal for this aspect is to enable the organisation to escape from previous path without damaging the organisation severely and simultaneously harness the full potential of the new path. Issues arising within this area are costs occurring when changing routines, both as this is a time consuming and anxiety heightening activity within the organisation (Teece, 2007; Teece et al., 1997). Furthermore, the reconfiguration of fixed assets can be a problematic issue since these assets might be obsolete beyond recall, but nevertheless essential for success. With growth, systems and procedures are often implemented to support quality and protect against misalignment. These procedures tend to increase the hierarchical structures and bureaucracy of the organisation, making it more ridged and less flexible. What should be noticed is that in stable or slow-moving environment, this is not a problem, but when the environment is rapidly changing these rules and procedures has to constantly change as well. The previously mentioned hierarchy is often problematic as the top management tends to be isolated from the market place but still is managing the rules and procedures for those actually responding to customer and technological change (Teece, 2007). For the Dynamic Capabilities aspect, the possibility to constantly be able to renew and redesigning routines and procedures is essential (Teece & Pisano, 1994). As decision making usually becomes centralised when organisation grows, decentralisation is a vital factor to not erode the flexibility and responsiveness of the company. In the context of decentralisation, it should though be mentioned that if done improperly, there is a risk of compromising the integration of each sub-division (Teece, 2007).

Furthermore, when acting within a rapidly changing environment it is not just the internal perspective that must be considered. The transformational aspect must take the whole ecosystem into account. As well as innovation and competitive edges can stem from single technologies they can also come from cumulative aspects. This implies that management's ability to identify, develop, combine, and utilize cospecialized[3] assets is an important aspect regarding dynamic capabilities (Eisenhardt & Martin, 2000; Teece & Pisano, 1994). The cospecialised assets are of particular interest as they tend to be harder for competitors to copy and therefore is considered as a more sustainable competitive advantage. The implications for the cospecialised assets are that they often require coordination of alliances to a high extent, such as between R&D and supply chain (Teece, 2007). In Figure 3 an overview of the three categories regarding Dynamic Capabilities is shown.

[3] Cospecialisation is a class of asset where the value is a function of several assets used in combination with other assets.

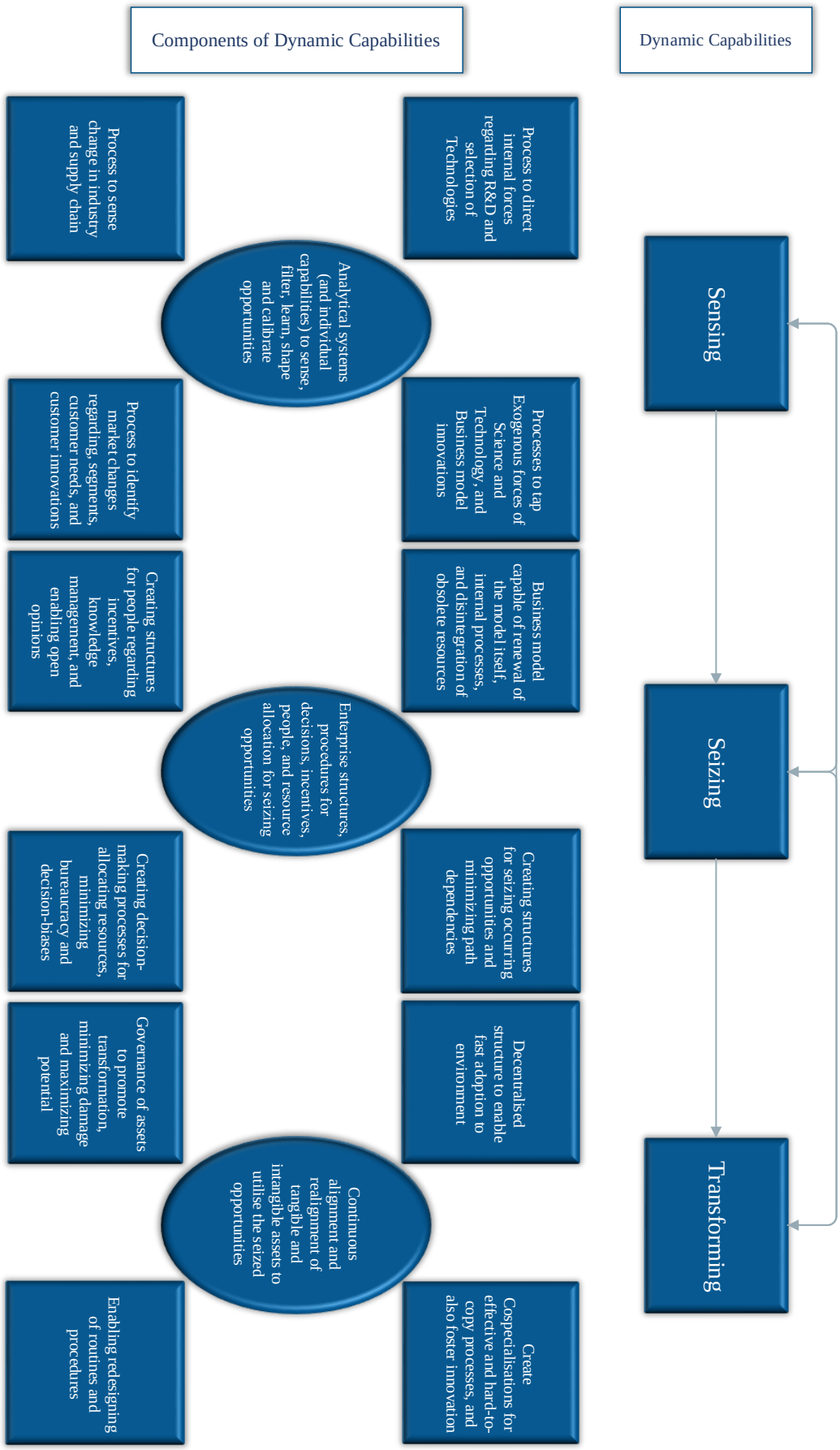

Figure 3: Components of Dynamic Capabilities (Teece, 2007; Teece & Pisano, 1994; Teece et al., 1997)

2.3 Ambidexterity

Ambidexterity in the context of organisations is referred to as the ability to both exploit and explore, i.e. enhance utilisation of current assets as well as finding new opportunities (O'Reilly & Tushman, 2013). Furthermore, organisational ambidexterity can be categorised into three different modes, namely *Behavioural integration*, *Sequential alternation*, or *Structural separation* (Birkinshaw et al., 2016). Below each mode is described separately.

Structural separation is described as a way to balance the organisation regarding exploitation and exploration activities by creating separate subunits. These subunits are not just separate in the organisational aspect, but differ in competences, culture, systems, and processes (O'Reilly & Tushman, 2011; O'Reilly & Tushman, 2008). What is common between these subunits is the strategic intent, values, and linkages to leverage assets. Furthermore, autonomy of the subunits is important, but the leadership has to be capable of resolving the inevitable tension associated with multiple organisations and their alignment. Structural separation also includes separate structures formed by alliances and partnerships in order to enhance the capacity to exploit and explore. However, the intra-organisational approach should not be seen as substitute to the inter-organisational approach, but rather as complement. Furthermore, external partners require other coordination skills and abilities from the mangers of the organisation and hereby puts other requirements for success (O'Reilly & Tushman, 2013).

Sequential Alternation is a mode which emphasises the organisations capability to switch from exploit to explore, and revers, when it is needed. It can both be performed as a reactive method based on environmental change or as a "rhythmic switching" more based upon predetermined factors or time. Arguments for this mode is that organisations tend to have easier to change formal structures and processes rather than culture and informal organisation. Furthermore, the sequential mode might be more suitable in slower moving environment than the structural separation is. Moreover, the sequential mode is seen to be more appropriate when resources are scares (O'Reilly & Tushman, 2013).

Behavioural Integration concerns the individual in contrast with both the structural and sequential mode, which concerns the organisational-level. The tension and decisions regarding exploit and explore are here delegated closer to the individual instead of at a managerial level. What though has to be done at the managerial level is setting a structure enabling the individual to make these kind of decisions, such as processes, incentives, and time distribution. One example is Toyota which encourages their routine performing (exploitation) employees to constantly change their way of working (exploration) to be more effective. The Behavioural integration emphasises that the organisational structure and culture has to encourage autonomy, the individual flexibility, and possibility to alternate to be successful. Furthermore, the organisation should be characterised by high levels of interaction and trust. Moreover, an issue addressed regarding this mode is that it does not consider how radical innovation will be achieved simultaneously as the current business is exploited. As a result this approach might be more useful in the context of incremental changes (O'Reilly & Tushman, 2013).

Furthermore, Birkinshaw, et al. (2016) are discussing that a firm is more likely to choose a certain mode depending on its legacy. On the same topic, different modes are said to be more or less suitable depending on the organisations environment and what changes that are emerging on the market (O'Reilly & Tushman, 2013). Also, worth mentioning, is that neither of the modes is said to be better than the other, rather that the strategy, culture, structure, and processes of the company are parameters which affects the adequacy of the mode. Even though the ambidextrous organisation often is depicted as a managerial issue and a change occurring top-down, the ambidextrous ability has been found to be developed from a bottom-up approach from the front-line employees and managers (Birkinshaw et al., 2016).

2.4 Agile Methodologies

Agile development has been adopted into the software world to increase both speed and quality (Salo & Abrahamsson, 2008). The concept can in short be said to be based on autonomous teams and short feedback loops, enabling faster and more accurate decisions (Bosch, 2017) The background to the Agile concept was a response to the traditional development process often referred to as the waterfall or phase gate model. This procedure is characterised by a strict sequential order where the product developed is handed over to the next phase when the current is completed (Bosch, 2017). The backbone of Agile concept can be described by the Agile Manifesto, which contains four values and 12 principles created to improve the traditional waterfall development model in software (Rigby, Sutherland, & Takeuchi, 2016). Below a condensed version of the Agile manifesto is described.

By focusing on people over tools and processes, projects should be built upon motivated individuals supported and trusted by management to get the job done. Close collaboration across the organisation and within self-organising teams is an essential component for the agile methodology (Cockburn & Highsmith, 2001). The work should engage the project team and keep a sustainable pace for everybody involved. Continuous improvement should be facilitated by regular reflections and communication to and within the development teams, which should be done face-to-face, since this is the most effective method (Beck et al., 2001; Rigby et al., 2016). Furthermore, by monitoring the results from actual performance on the market, innovators will learn faster, adapt more rapidly, be more motivated, and do more valuable work. If enabling interaction with customers and markets regarding small features and components, feedback can be received in early stages to enable decisions whether the feature or component should be kept. Moreover, arguments and issues should be resolved through experiments, not debates without facts or appeals to authorities (Beck et al., 2001; Rigby et al., 2016).

As customer demand will most likely have changed from the beginning of the project to the final release, it is a necessity to adapt product of specifications. This adaptation, and also the final value creation, is facilitated by methods such as rapid prototyping, frequent market tests, and constant collaboration (Beck et al., 2001; Rigby et al., 2016). Furthermore, as conventional project management's plans and predictions most often becomes obsolete, due to internal and external changes over time, the team should only plan those tasks that will not be changed. If changes occur, the team should embrace it and enjoy the learning and the possibility to adapt to the customer (Beck et al., 2001; Rigby et al., 2016; Williams & Cockburn, 2003).

2.4.1 When to Implement Agile

Agile methodologies are no universal antidote for increasing product development success. The methodology is more applicable in some contexts than others and will require behavioural change, training costs, and new systems. In Table 2, the applicability of Agile Methodologies are described and is emphasising the right condition regarding market environment, the customer relationship, innovation and problem type, partitioning of work tasks, and impact of development mistakes (Rigby et al., 2016). What is worth mentioning is that our world is changing, and what was accurate yesterday might not be correct tomorrow, this is relevant in the context that market stability, data gathering and feedback, and production methods might change with time (Bosch, 2017).

Table 2: Conditions for implementing Agile Methodologies (Rigby et al., 2016)

Condition	Favourable	Unfavourable
Market environment	Rapidly changing preferences, demand, and required solutions	Stable and predictable markets
Customer relationship	Possible to work closely to customers to gather feedback	Stable and clear requirements where customers not might be available for constant collaboration
Innovation and problem type	Complex innovations, unknow solutions. Change in or unclear scope. Specifications might change. Time to market and creative solutions are of high importance. Cross-functional work is essential.	The task is not new, the development is relatively clear at the start of the project. Specifications and plans can be forecasted with confidence. Functional silos can be used to solve the problem at hand sequentially.
Partitioning of work tasks	The development and customers can benefit from incremental releases. The inherent tasks of the project can be broken down into smaller tasks supporting iterative cycles. Late changes are manageable.	The product cannot be tested before all parts are complete. Late changes are impossible or expensive.
Impact of development mistakes	Mistakes provide learnings and smaller costs	Mistakes might be catastrophic

2.5 Beyond Budgeting

Beyond budgeting is a concept addressing the environmental issues of companies in a VUCA[4] world (Bogsnes, 2016). Some typical topics as company alignment, decentralisation and autonomy is addressed, and it is emphasised that systems and processes, such as the budget and annual planning, often hinders succeeding with autonomous initiatives or similar self-management principles. Furthermore, Beyond Budgeting enforces to view the organisation as an internal market, where each operating unit could be seen as a customer whom to serve and satisfy (Hope & Fraser, 2000). The concept is not just about budgets but addresses issues about overall regulatory systems in companies. With this in mind, Beyond Budgeting is operative in the area of management and steering models, even though its name has a financial emphasis (Bogsnes, 2016).

2.5.1 Beyond Budgeting Principles

Beyond budgeting is based upon 12 principles classified into two groups, six *Leadership principles* and six *Management Processes.* Bogsnes (2016) are describing them as follows:

Leadership principles

1) Purpose – engage and inspire people around bold and noble causes, ***not*** *around short-term financial targets.*

2) Values – Govern through shared values and sound judgment, ***not*** *through detailed rules and regulations.*

3) Transparency – Make information open for self-regulation, innovation, learning, and control; ***don't*** *restrict it.*

4) Organization – Cultivate a strong sense of belonging and organize around agile and accountable teams; ***avoid*** *hierarchical controls and bureaucracy.*

[4] Volatile, Uncertain, Complex, Ambiguous

5) Autonomy – Trust people with freedom to act; ***don't*** *punish everyone if someone should abuse it.*

6) Customers – Connect everyone's work with customer needs; ***avoid*** *conflicts of interest.*

Management Processes

1) Rhythm – Organize management processes dynamically around business rhythms and events; ***not*** *around the calendar year only.*

2) Targets – Set directional, ambitious, and relative goals; ***avoid*** *fixed and cascaded targets.*

3) Plans and forecasts – make planning and forecasting lean and unbiased processes; ***not*** *ridgid and political exercises.*

4) Resource allocation – Foster a cost-conscious mindset and make resources available as needed, ***not*** *through detailed annual budget allocations.*

5) Performance evaluation – Evaluate performance holistically and with peer feedback for learning and development, ***not*** *based on measurement only and not for rewards only.*

6) Rewards – Reward shared success against competition, ***not*** *against fixed performance contracts.* (p. 69-71)

The beyond budgeting concept is criticising the traditional budgeting and management model for being too ridged and limiting the organisation rather than supporting it (Heupel & Schmitz, 2015). Even though the budget can be a useful management tool, it can create severe organisational dysfunctionalities (Argyris, 1953). In Figure 4 The Budgeting Model is depicted aside with the core of the Beyond Budgeting principles. As seen in the traditional Budgeting model, the flow is going into ridged stages and implementing feedback to the annual budget, which responds with the parameters set upon an earlier environmental situation. In contrast, the Beyond Budgeting model is setting overall boundaries for the organisation and is using adaptive management tools connected to changing external factors.

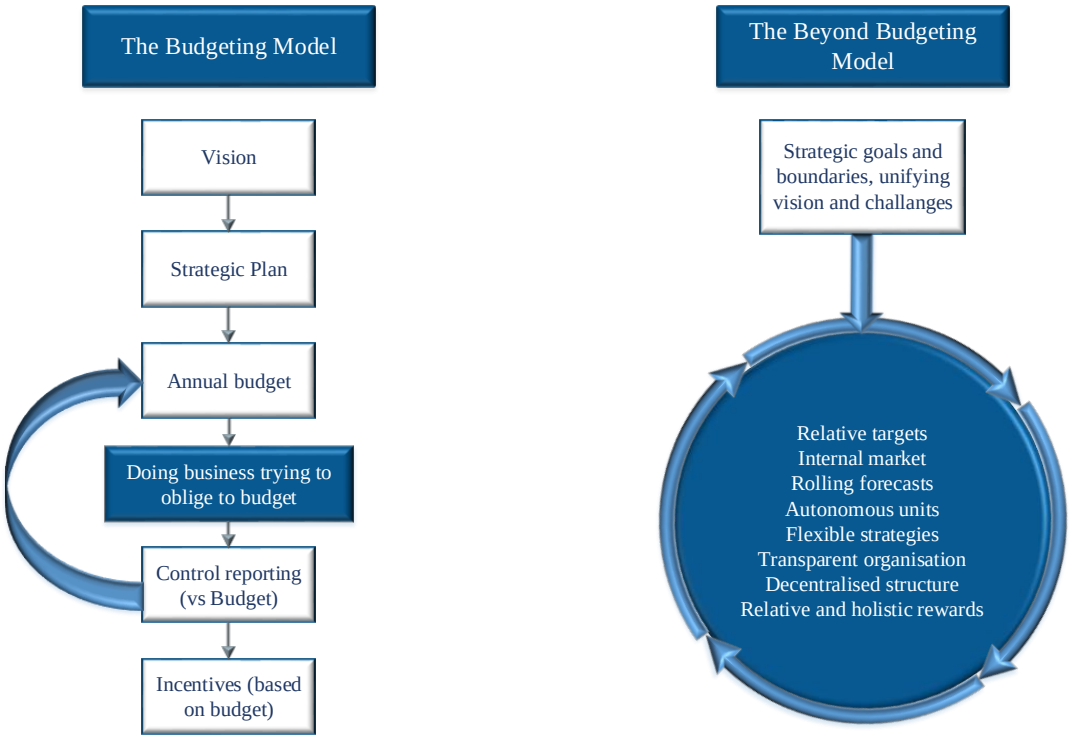

Figure 4: Traditional Budgeting vs. Beyond Budgeting (Bogsnes, 2016; Hope & Fraser, 2000)

However, as with most management systems the change process can be extensive. For beyond budgeting it is shown that implementing just a few of the principles can enhance the performance of a company and depending on the current state of the organization, the implementation will encounter different degrees of difficulty. Hence, to assess the current state of the company towards the principles can aid the implementation of Beyond Budgeting (De Waal, 2005).

2.6 ISO 9001:2015

The ISO 9001:2015, from here on referred to as ISO 9001, is a Quality Management System Standard which enables organisations to demonstrate that the firm can produce products and services which meet the customer's and legal requirements, but also aims to improve customer satisfaction through implementation of the Quality Management System (QMS) (ISO, 2015).

Furthermore, the Standard is built upon the seven Quality Management Principles (ISO, 2015):

- Customer Focus
- Leadership
- Engagement of People
- Process approach
- Improvements
- Evidence-based decision making
- Relationship management

Regarding process management, following requirements are applicable for an organisation that applies the ISO 9001 can be described as follows (ISO, 2015).

> a) determine the inputs required and the outputs expected from these processes
> b) determine the sequence and interaction of these processes;
> c) determine and apply the criteria and methods (including monitoring, measurements and related performance indicators) needed to ensure the effective operation and control of these processes;
> d) determine the resources needed for these processes and ensure their availability;
> e) assign the responsibilities and authorities for these processes;
> f) address the risks and opportunities as determined in accordance with the requirements of 6.1;
> g) evaluate these processes and implement any changes needed to ensure that these processes achieve their intended result
> h) improve the process and the quality management system (p. 2-3)

What should be mentioned in the context of the ISO 9001 is that the abovementioned requirements should be applied into the organisation to the extent which supports the operations of the processes and also create a documentation which supports the trustworthiness in that the processes are carried out as intended (ISO, 2015).

2.7 Concluding Remarks and Relationships

The discussion regarding the trade-off between standardisation and flexibility is not a new phenomenon within the management literature. Standardisation has been used as a method to achieve quality and volume of a product or service to maintain competitive on the market (Slack & Lewis, 2015). Furthermore, as well as standardisation and economies of scale can increase competitiveness, it can also diminish the company's ability to achieve a flexible organisation capable of managing issues such as new demands and innovation (Skinner, 1969). Moreover, the implementation of management practices connected to ISO 9001 has been seen to dampen the responsiveness for innovative solutions. As pre-set

processes promote working in the same way as before, there are a bias towards producing similar products, which will not disturb the existing processes (Benner, 2009).

There are bridges between the above described areas, the relationship between ISO 9001, innovativeness and response, Dynamic capabilities and Ambidexterity, and also agile methodologies and Beyond budgeting (Benner, 2009; Birkinshaw et al., 2016; Bogsnes, 2016). For example the continuous delivery, dividing tasks into smaller batches, and updating projects with the latest market information are common topics regarding Agile Methodologies and Beyond Budgeting (Bogsnes, 2016). Furthermore, Organisational Ambidexterity can be seen as a Dynamic Capability, see previous sections 2.2 and 2.3, where different modes of Ambidexterity results in different solutions for sensing, seizing, and transforming (Birkinshaw et al., 2016).

3 Methodology

The following chapter presents the methodology used to conduct the thesis. Firstly, the choice of research strategy and design is presented, see section 3.1. Secondly, section 3.2 presents what research methods have been applied. Thirdly, the data collection is described, followed by a description of how the literature was analysed. The two final sections are discussing research quality and ethical considerations.

3.1 Research Design and Strategy

The research strategy chosen is of a qualitative nature. Key functions and individuals in the organisation were selected and interviewed in depth to gather a deep understanding of the organisation's current state. The interviewees were chosen in a manner that would allow the result from the selection to be triangulated and in the best manner represent the organisation. The interviews will be discussed more extensively under section 3.3.1.

The research design of this master thesis is a case study conducted at a single company, namely CEVT. A case study is often performed to examine and conduct research of one or a few subjects with the objective to gather comprehensive information and deep understanding of the studied subjects (Eriksson & Wiedersheim-Paul, 2011).Characteristics such as close proximity to the analysing subject is seen as highly valuable to create the necessary understand of complex problems. Therefore, the main purpose of a case study is to understand the subject rather than to explain it. As a result, researchers examine and experience the real-life environment of the studied subjects, i.e. real events and getting familiar with the personnel. Furthermore, intensive examination thorough observations such as personal reactions, arguments, conflicts, and other events contributes to the detailed experience (Ejvegård, 2009). Therefore, a case study was seen as the most appropriate choice for this research, mainly due to its contribution to the researchers' knowledge of individuals, groups, organisational structures, politics and other related phenomenon. At the same time, the design could facilitate the possibility to illustrate the pragmatic issue of CEVT continuously trying to meet uncertain- and late changing customer demands. The real-life experience was therefore sought in order to create possibilities for a deeper, and more detailed analysis that later on could act as a complementary in the discussion chapter. Additionally, the research design was constructed to follow Eisenhardt (1989) suggestion on how to develop theories from case study research designs. Interviews act as an iterative and intimate bridge between the gathered empirical evidence and already existing literature and theories. This research design fosters a tension between diverging into new areas to understand empirical data, and sequentially converging and incrementally build a theoretical framework. Therefore, the nature of this research design is not limited to the strict linear orthodox research path, which is going from theory to hypothesis and to data collection in order to generate findings that contributes to theory (Bryman & Bell, 2015).

The reasoning between theory and research manifests how the research is conducted and what type of result is suspected to be generated. This reasoning view is most commonly known as Deductive or Inductive theory reasoning. Both reasonings however entails a strong linear approach which can result in limitations depending on the nature of the research. More specifically, deductive have a strict reliance on theory testing and hypothesis falsifying which can create an issue on how to select theory to be tested (Bryman & Bell, 2015). On the other hand, inductive reasoning limits its capabilities to the quantifiability of data and that once a theory has been developed it can be tested. However, the tendency to adopt to ontological realism is not always suitable for social subjective settings and contexts. Unlike Inductive and Deductive reasoning, Abductive reasoning is used to make logical inferences and build theories about the world. For that reason, Abductive reasoning allows a back and forth between theory and research in order to create a more open and adaptive approach to the "world" depending on how the research is progressing. The choice for this research will therefore apply abductive reasoning using already existing knowledge and theories to see how it correlates with the findings. In addition, the process will follow an open iterative and creative inferential based process that corallines with the aforementioned approach.

To be more specific, when current state of the organisation has been declared, incremental and radical innovation types and strategies will be investigated in the context of the current product development strategy to identify possible improvement suggestions that will allow and enhance the management of late changes. Moreover, it will be important to gather knowledge and create an understanding of the social context and settings from the workers. The Case setting i.e. Chapter 0 would symbolise the relationship and how the departments at CEVT are operating in order to interpret what effect late changes could entail. Although the result cannot be quantifiable, the approach becomes paramount for laying the foundation for reasoning and theory building.

Furthermore, the area of manufacturing standardisation versus flexibility have for many years been discussed in academia. But, an explicit approach to tackle the recent dramatic development of fast changing technology and continuous changing customer demand have not been presented. Theoretical frameworks such as Agile development, Beyond Budgeting, Dynamic Capabilities, and Ambidexterity have laid the foundation for future concepts and theories to build upon. However, since there is no explicit theory combining the advantages of both a standardized and flexible manufacturing structure, nor a framework that combines them for competitive advantages, the abductive reasoning is seen as a suitable approach (Bryman & Bell, 2015). Bryman and Bell (2015) also states that abductive reasoning and its relevance of data for developing a theory may become apparent only after the empirical data have been gathered, and therefore also be subject to findings that were produced by fortuity.

Going from the traditional way of working to adopting a model that encompass suggestions like agile principles will affect the whole organisation. As the Agile model is based on the organization as one unit works together to meet the uncertain customer demands, the result translates in a transformation that will affect all levels in the organisation. In order to manage the magnitude of the change, Bryman & Bell (2015) forward the concept of level analysis. A research can target different level for analysing the same problem. The level concept is based on the SOGI model (Societies organizations, groups and individuals) and sheds light on how a research can use the different levels to conduct the research.

Due to the nature of the research design and magnitude of the studied subject, a combination of group and organisation level analysis is seen as most appropriate. Combining the two levels will allow for a greater understanding of the problem which is seen as essential to understand the whole picture. By focusing on the group level first, a thorough understanding can be acquired through interviews which will describe the company and its current state. The process of understanding the current state is later use to continue the analysis to an organizational level. The literature presented in the previous chapter predominantly focus on the organizational level, hence, substantially the focal point of the analysis will orbit around the organisational level increasing the applicability of research findings to existing literature. Rousseau (1985) presents in her article that combining different organisational level analysis is possible. However, it is important to differentiate the levels of findings in order not to confuse the result. The process of human learning is subjective, as both individuals in single and group level interpret behaviour naturally. The organisation learning is however not subject to the same behaviour, meaning that combining a cross level analysis subjected to human behaviour may infect the higher organisation level analysis creating misinterpretation of the result.

The hermeneutic circle, depicted in Figure 5, can be seen as a metaphor used to describe the interpretation of meaningful subjective experience of a social setting into context. The idea of human experience and subjective as a part of research is seen as highly valuable to understand certain phenomena's and the coherent picture of a larger problem. To synthesis the problem each part is therefore as important to understand the whole context, and as to understand the whole contexts, it is vital to understand each part as well. By using an open dialectical approach between data, literature, and the studied subject, researcher can objectively use the result to contribute the findings of human involvement into theory. However, as humans deem to aspire interpretation as a part of their nature, the interpretation of social settings can be considered as a ubiquitous activity and therefore be subjective to whatever is seen as significant to the problem and not the objectives (Bryman & Bell, 2015).

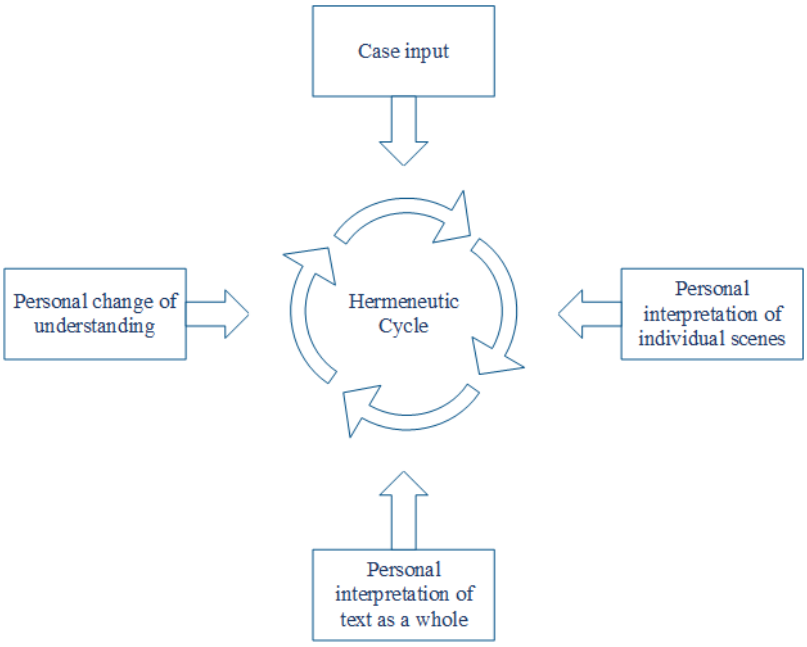

Figure 5: Hermeneutic Cycle (Bryman & Bell, 2015)

Moreover, it is also important to forward the epistemological concerns which conceptualises the issue of what is sufficient and acceptable knowledge to be justified as new knowledge. The subjective world can be interpreted in different way and therefore entail several possible trues as quantitative only has one. Following the methodology, the research can strengthen the justification of the findings.

3.2 Research Method

The research was conducted mainly using a number of steps designed to create a wide understanding in the beginning, and allow later possibilities of going back and forth as an iterative process between literature and the findings from the collected data, see Figure 6. First of all, before the scope was set, a number of unstructured interviews were conducted to create an initial understanding of CEVT's ME department. Simultaneously, literature areas were examined to acquire knowledge and complement the interviews in order to find relevant research area. When the scope was identified, research questions was shaped with purpose of both generating new knowledge to academia and create value for the company.

The next step was to conduct a comprehensive literature study in order to create a solid base and understanding of existing knowledge. Areas such as *process mapping, standardisation versus flexibility, agile development, ISO:9001, ambidexterity* and *dynamic capabilities* was studied. When a sufficient level of knowledge was reached the data collection and interview sessions were initiated. During this time, the researchers continued probing literature. The result would later become the theoretical framework. The data collection mainly consisted of going through process descriptions and related documents. Since CEVT was founded, the organisation has grown from having just a few engineers to now employing over 1800 people. Due to the exponential growth the process maps were in need to be updated in accordance to the new organisation. Hereby, the first deliverable towards CEVT was to update their process maps. Interviews were conducted based upon the SIPOC model, see Section 3.3.3. Broad and open questions under the guidance of SIPOC allowed for the interviews sessions to cover the whole process maps. Since ME consists of five sub-functions these were interviewed for each process. Using semi-structured interviews with experts in each area of ME and its sub-functions, in combination with collecting data of existing processes, in-depth knowledge could be retrieved and new process maps could be designed. This in-depth knowledge also facilitated the creation of answers to research question 1 and 2.

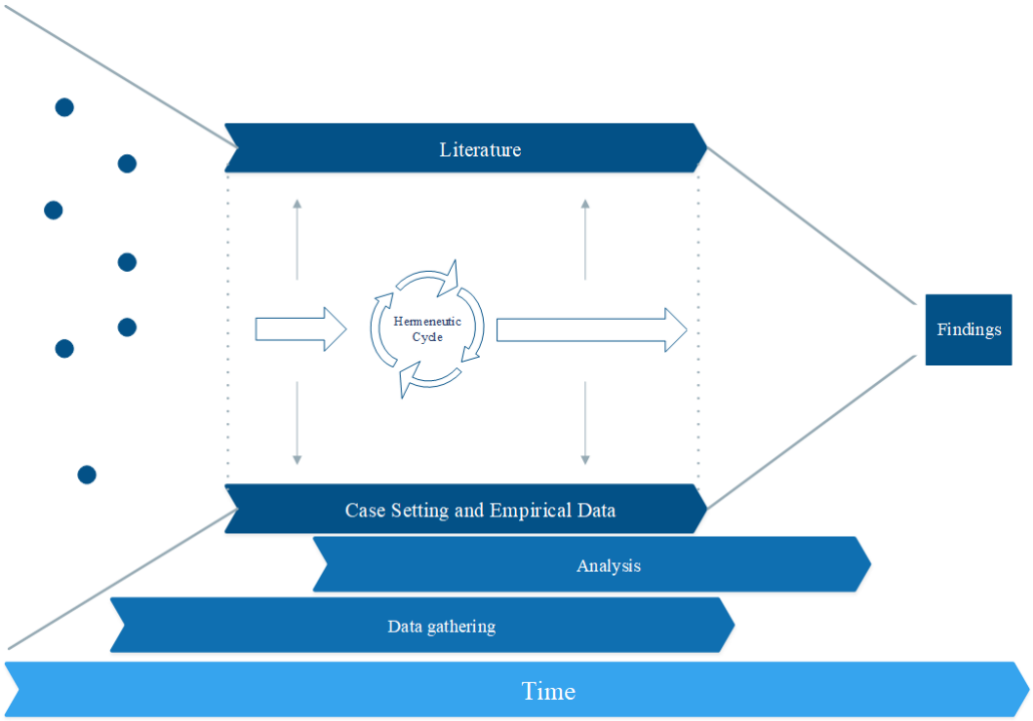

Figure 6: Research Method Relationships

Furthermore, one focus group session was conducted. The session was based on the AIM method, described in detail in Section 3.3.1.5. AIM was used as a problem-solving tool for analysing the issues and problems of managing late changes in the organisation. The session was conducted with representatives from each sub-function within ME department and orchestrated the process of narrowing down the research. The findings allowed the research to take the next step into analysis. As the AIM sessions focus on identifying root causes, the findings depict what effects managing late changes entails.

Lastly, before combining the empirical data and the literature for creating the answers for RQ1 and RQ2, the literature was analysed. To facilitate the understanding of the literature an analysis tool was created, which is described more in detail in Section 3.4.1.2..

3.3 Data Collection

The sources used for the research can be divided into two main areas, the first consisting of data collected from the company, and the second, data presented in the theoretical framework chapter. The main data collecting method used at the company consisted of a primary source from interviews, observations, and a focus group session, see Figure 7, showcasing data collection methods. Moreover, the theoretical framework mainly consists of data collected from scientific articles, research papers, and books. Additionally, company data was used to further extend the understanding of the case setting.

The following section presents the method used for gathering data. The section is divided into two sub-section namely primary data and secondary data.

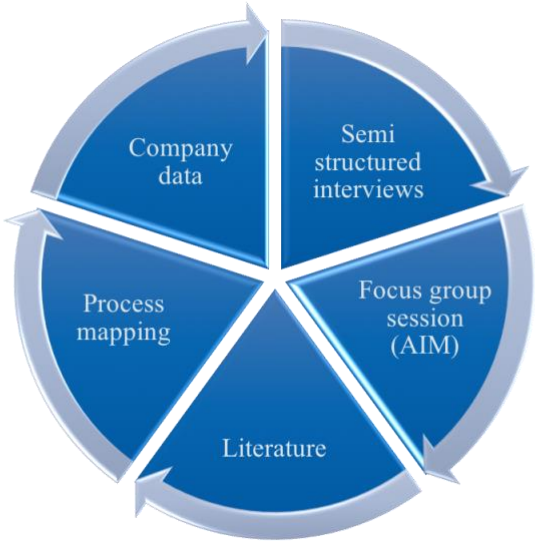

Figure 7: Data Collection Model

3.3.1 Primary Data

In following section, methods for collection of primary data is presented.

3.3.1.1 Interviews

Interviews is seen as one of the central tools used to gather information in qualitative case studies, even though the interviews in most cases are time consuming. The ability of close proximity to the knowledge carrier and flexibility provides the research with possibilities to adopt during the interview and to probe important areas and widen the window of understanding. In this research, interviews were conducted in a manner to only procure qualitative data due to the fact of detailed and in-depth knowledge desired (Bell & Nilsson, 2006).

There are mainly three types of interview structures, structured, semi-structured and unstructured. The different forms explain how controlled the interview should be, for example, a structured interview entails clear guidelines and purpose for the questions asked. Additionally, the controlled structure does not allow divergence and change in directions to emphasise on other aspects that might be important, the focus is to the fixed guidance. An unstructured interview on the other hand is mainly characterised by allowing the interviewer to direct the conversation with purpose to extract a wider range of information. Furthermore, the unstructured interview can be beneficial in the beginning of projects to get a wide and initial understanding of the subject (Bell & Nilsson, 2006).

Due to the nature of the research, it was chosen to conduct a majority of semi-structured interviews. The research process constituted the need to interview specific people in different sub-functions to create a holistic view and understanding. The semi-structured approach allowed for the possibilities to triangulate data during the interviews, but also probe into areas to create the necessary dialog to understand the process. Semi-structured interviews mainly utilise a broad set of questions used as

guidelines designed to allow the interviewee to elaborate and diverge into areas of importance to the subject. Moreover, the interviewer can also subjectively guide the trajectory and add new and follow up questions to get insight into specific areas.

When conducting interviews, it is beneficial to be at least two researchers. Bryman and Bell (2015) argues that having two researchers, one that is leading the interview and following up with question and the direction while the other one is focused on taking notes and analysing the answers, the interview process becomes more effective. The passive researcher can also interrupt and intervene the conversation to complement the leading research with question and also realign the conversation to its original guideline. During the interview sessions this approach was used combined with both a recording device and a passive researcher taking the important notes. As a result, more attention could be allocated to the interviewee and enabling a focus on the content.

An interview can be conducted in a number of different manners, however face to face interviews are seen as the most effective as it allows the interviewers to follow expressions, motions, sentiments and feelings which would be impossible to interpret in other cases (Bell & Nilsson, 2006). Moreover, it is important to keep in mind that face to face interviews are limited to a geographical location. In such cases, phone or internet interviews can be a good compliment. Throughout the research, face to face interviews were used, but in one case an unstructured interview was conducted with the ME department of Geely located in China, hence using a video conference call. Even though the research scope was limited to CEVT's ME department in Sweden, Geely's ME department can be seen as the Customer to the ME at CEVT. The interviews enabled an enhanced understanding of the organizational structure and how the global management between the two locations was structured.

3.3.1.2 Sampling

The interviewed individuals were chosen to create a sampling in which represents the different ME sub-functions and generate the correct view on the subject managing late changes (Bryman & Bell, 2015). The purpose of the sampling was to choose individuals that can represent the sub-functions opinion and problems. Each sub-function, except for ME Paint, selected an individual as a representative for the sub-function, see Table 3, interview list. Each individual was interviewed in depth once per each process map. As a result, four individuals were interviewed four times.

Table 3: Interview List

Function representative	Number of interviews
ME Stamping	4
ME BIW	4
ME TCF	4
ME Geometry	4

Additionally, representatives from each sub-function, including Paint, were summoned to a cross-functional focus group session, see
Table 4 for participatory list. As previously, the goal for the sampling was to invite individuals that represent each sub-function and can forward their voice and unify the results.

Moreover, several unstructured interviews were conducted with individuals such as the Operations Manager, Process Manager, NPDS team, Running changes team, and the PCR team in order to generate a deeper understanding of the problem. Instead of focusing on representative sampling, when choosing the individuals, it was sought to interview individuals with wider understanding of the organisation.

Table 4: AIM-session participants

Function representative	Number of sessions
ME Line Manager	1
ME Stamping	1
ME BIW	1
ME TCF	1
ME Geometry	1
ME Paint	1

3.3.1.3 Organisational Observations

During the thesis, the researchers were stationed at CEVT. Although observations have been a important factor for increasing the general understanding of the organisation and the case setting, formal observation methods was not used during this process, neither any data is presented in terms of observations.

3.3.1.4 Literature

In order to acquire comprehensive knowledge on a specific field, a literature review is a good way of learning from other researchers and creating a synthesised body of knowledge based on past research. Moreover, probing relevant knowledge field facilitate for an easier and faster learning process in the beginning of the research process (Bryman & Bell, 2015).

There are two main approaches when acquiring literature. The first is based on a methodological and systematic approach, designed to acquire a deeper knowledge on the area of interest. The second is a traditional approach which mainly consisting of creating an overview of existing knowledge (Bryman & Bell, 2015)

Since little literature have been acknowledged in the studied area, there is a fragment missing that explicitly manifest how to deal with managing late changes in a fast-paced environment. Therefore, a combination of traditional and systematic approach was used to mainly skim the literature for what have been done and what issues that had been discussed previously. The traditional approach aims to give a general overview of existing literature, whilst combining both systematic and traditional approach introduces a systematic methodological on how to investigate specific areas in depth.

Information was gathered mainly using Chalmers library and Google Scholar search engine to find relevant data on the subject. Furthermore, to identify relevant data following key phrases were used: *Managing late changes, Late customer demands, Managing New product development, New product development problematic, Lean, Agile, Global project management, Standardisation versus flexibility, VUCA, Beyond Budgeting, Innovation in uncertain markets, Scaling agile development, Waterfall model, Scrum,* and *Agile development*. Other sources were also used, namely Books, Journals, Articles, Research papers and Websites.

3.3.1.5 Focus Group (Affinity Interrelationship Method)

The Affinity Interrelationship Method (AIM) is a problem-solving tool designed for analysing qualitative data. AIM is used to understand complex problems by involving a cross functional team in a focus group session to develop a shared understanding of the problem root cause. AIM takes its heritage from the Japanese professor Shiba who first introduced the systematic step by step approach to the field of quality management (Alänge, 2009).

AIM consist of 10 steps designed to allow an open discussion in the beginning and later narrow down the identified causes to showcase the affinity and interrelationship between them (Alänge, 2009). The steps are briefly described below:

1. Formulating question - This is the main question to be answered. The facilitators had created a proposed question to facilitate the session and also focus it towards the research of the thesis. The final main question was as follows *"What is the problem when managing late changes in ME department?"*
2. Warm-up - The participants shortly presented their views of the topic.
3. Collecting data - Each participant wrote answers on notes to the main question, also known as brainwriting[5].
4. Clarifying the meaning - The facilitator checked that all participants understood each produced answer in step 3.
5. Grouping - The participants silently grouped the answers in groups consisting of 1-3 notes based upon which belonged together.
6. Higher level grouping - Headings summarising the groups created in step 5 were created. Afterwards step 5 was repeated for these groups and summarising headings were created for these new groups as well.
7. Show connections - the connection between each final heading were shown, only affecting or contradicting was allowed, i.e. two headings cannot affect each other.
8. Final Layout - The map was organised to facilitate understanding of the connections
9. Evaluation - each participant got the possibility to grade three 2nd level groupings depending on how much impact they have on the main question, this by distribute one rating of each 1,2, and 3 points, where 3 was the largest impact.
10. Concluding - When the points were counted the three areas that have received the most points were summarised in a concluding sentence.

The AIM workshop was conducted with representatives from all five ME sub-functions and the ME line manager, see
Table 4 for participants. In total, the group consisted of 6 individuals and two facilitators, i.e. the researchers, that were guiding the group throughout the session. The purpose of the AIM session was to investigate root causes regarding the issues of managing late changes in the ME department.

3.3.2 Secondary Data

In this section the sources and methods for secondary data is described.

3.3.2.1 Company Data

Company data including organisation documents, process maps, process descriptions, function information and general information was used. The documents were used as a compliment to the interviews and literature research to contextualise the case setting, but also conduct comparison with the literature framework. The data was a prominent supplement for increasing the understanding of the issue at hand and facilitate the bridge between literature and the findings. No company documents or sensitive information was disclosed.

3.3.3 Process Mapping

Process mapping can be used to achieve multiple outcomes which benefits an organisation e.g. introducing new employees, describing work flow for management, and act as tool for process improvements are just a few (Conger, 2011). Like the usage of process maps varies, so does the creation and modelling of the maps. Furthermore, process maps can be described on different hierarchical levels of an organisation, describing overall workflow and interaction, and describe specifics in a single department (Ljungberg & Larsson, 2012).As the usage varies, it is important to emphasise the customer

[5] Brain writing is a variant of brain-storming, but instead of talking, where often the most talkative person has an advantage and the quiet ones remain quiet, brainwriting is based in writing data separately (Alänge, 2009).

perspective i.e. that the process map is created towards the user, not just for documentation purposes (Bergman & Klefsjö, 2010; Ljungberg & Larsson, 2012).

3.3.3.1 SIPOC

A common framework used in process mapping is called SIPOC, which is an abbreviation for Supplier, Input, Process, Output, and Customer (Bergman & Klefsjö, 2010). Below, in Table 5, a description of the SIPOC model is given.

Table 5: SIPOC (Bergman & Klefsjö, 2010; Conger, 2011)

Function	Description
Supplier	The source of the input, can be seen as the previous process in the system. Could be a person, business function, or external supplier.
Input	Is the material, information or data required for the process, and comes from a previous process.
Process	Linked activities (consisting of repeated tasks or steps) which accomplishes a business function by transforming the input
Output	Is what has been created from the input after the transformation and is delivered to next process (or customer)
Customer	The receiver of the output, can be seen as the next process. Could be a person, business function, or external customer.

3.4 Theoretical Comparison and Analyse Tool

To facilitate the analysis of literature and empirical data, an analysis framework was developed. Furthermore, the separate analysis of the literature enabled generalised step to facilitate the application of the findings to other contexts. The framework is based on the principle of codifying, i.e. categorising data from different sources (Bryman & Bell, 2015). This method allowed for an extensive comparison between different literature areas and the case company. As a starting point the categories were based upon the star model by Galbraith (2014), which is briefly described below, followed by a description of the final analysis tool.

3.4.1.1 Star Model

This section is based upon the Star model by Galbraith (2014). The Star Model is a framework for organisational design where the organisation is described through five categories, namely, *Strategy*, *Processes*, *Structures*, *People*, and *Rewards*. These are each described below.

The *Strategy* category can be described as the organisational values, vision, goals, and objectives which guide the company towards success. The strategy is addressing overarching issues such as where the focus of the organisation lies, defining products and service segments, served market, how to produce value to customers, and aids choosing between inevitable trade-offs. The *Processes* category has two dimensions, *Vertical* and *Lateral*, regarding the processes for information and decisions. The Vertical dimension refers to issues such as how to allocate resources, how business is planned, and how budgets are decided. The Lateral dimension regards the workflow, e.g. the processes managing day-to-day activities or for developing a product. In this context, *structure* refers to the placement of power, which can further be described through the following four sub-categories; Specialisation, which is the number of different job specialities required to perform the work. Shape, which is the number of people in each

department, describing if the organisation is flat with few levels or hierarchical. Distribution of power, partly refers to the question of centralisation or decentralisation, but also how power is distributed regarding different departments, i.e. power in the lateral dimension. Departmentalisation regards the basis for how the departments are shaped, i.e. by functions, products, markets, customers, etc. *People* refers to governing of human resources, guiding policies, recruiting, training, and employee development are examples for what falls under this category. What people exists in the organisation and how they are shaped. *Rewards* regards for how the alignment between organisational and employee goals are formed. Issues such as motivation and incentives for completing the strategy and the organisations purpose are a part of this category.

3.4.1.2 Analysis Tool

In Table 6, a descriptive picture of the Analysis tool is shown, for a view of the complete Analysis tool, see Appendix 1. The categories in the Star Model were then refined in an iterative manner to suit the research. Furthermore, to more easily comprehend similarities and differences, common categories within each literature area were identified and represented as Yes, No, or N/A (Not Applicable, shown as "– ") for each literature area. However, four more extensive categories were described through bullet points and text to enable elaboration of these categories upon each literature area. The more elaborated categories can be seen in
Table 7. After the Analysis tool had been used for the literature, it was used to envision the connections and what effects the identified categories would have regarding management of late changes. The final usage for the Analysis tool was to describe how CEVT related to each category.

Table 6: Descriptive table for Analysis tool

			Categories	
			Autonomy	**People and Culture**
Areas		**Dynamic Capabilities**	Yes	Bullet points describing the organisational view of people and culture, also elaborating upon how to guide the people in the organisation. Separated upon each literature area
	Ambidexterity	**Structural Separation**	N/A	
		Sequential alternation	N/A	
		Behavioural integration	Yes	
		Agile Methodologies	Yes	
		Beyond Budgeting	Yes	
		Management of Late Changes	Describing connection and effect of Autonomy when it comes to management of late changes	Describing connection and effect of *People and Culture*, when it comes to Management of Late changes
		CEVT	Describing CEVT's relation to the category Autonomy	Describing CEVT's relation to the category *People and Culture*

Table 7: Extensive Categories

Category	Description of Category
Decisions and their processes	Describing the way decisions are taken and what an organisation should bear in mind regarding decisions, also describing information flow in the organisation
Management of resources and Assets	Regards how resources should be managed and allocated, also what is important when it comes organisational assets and resources in general
People and Culture	Describing organisational view of people and culture, also elaborating upon how to guide the people in the organisation
Core of concept regarding adaptation to change	A concluding category for summarising the interpreted essence regarding adaptation to change.

3.5 Research Quality

The qualitative case study and its subjectivity to the setting have some researchers arguing to what extent it is possible to generalise and validate research findings in greater contexts. As a result, the quality of a qualitative case study becomes subjective to the particular research (Bryman & Bell, 2015). Importantly, the entailed issues of applying quality criteria, the focus should lie on forwarding the uniqueness of the case and showcasing the complex problem in-depth. Bryman & Bell (2015) uses trustworthiness and authenticity as criteria to evaluate qualitative research.

3.5.1 Trustworthiness

Trustworthiness can be divided into four sub-criteria: Credibility, Transferability, Dependability, and Confirmability. All described below in following sections.

3.5.1.1 Credibility

In order to reach internal validity and showcase credibility, a combination of triangulation and respondent validation was sought. It is important to view evidence from many different perspective and use triangulation to support the findings and not becoming subjective to the problem (Eisenhardt, 1989). Bryman and Bell (2015) also states that the nature of using single case study evidence can consequently lack criteria for generating results that are generalisable. During the research, the As-Is State was defined through internal documents and interviews. When conducting the semi-structured interviews triangulation was achieved by cross checking facts with multiple sources, ie. in this case a question was asked to each ME representatives to create a department consensus. Furthermore, as the process maps are used by all ME sub-functions, the depicted results were visually validated by each sub-function before formally presenting the results. This allowed the participants and concerned parties to secure the correct formulation and that the interpretation was in accordance to reality.

3.5.1.2 Transferability

Subjective to the setting, the act of generalising a case studied becomes harder as the findings from one case study cannot be representative for the rest. Focusing on the uniqueness and going in-depth of the case setting to understand the complex problem may allow future research to be based on the findings (Bryman & Bell, 2015). Additionally, to reach external validation the findings was compared to literature in similar areas. Due to the time limit of the thesis, no benchmarks were conducted.

3.5.1.3 Dependability

Throughout the project, both internal- and external auditing were conducted in order to ensure that the course of action was aligned to the quality criteria. Furthermore, to ensure dependability, all data from the various research phases was retained. In other words, records of the problem formulation, field notes, interviews, meetings, process map iterations, focus group, decision and analysis was stored.

3.5.1.4 Confirmability

Confirmability concerns the issue of "act of good faith" when conducting the research, and that personal values and knowledge should not interfere with the objective (Bryman & Bell, 2015). Although complete objectivity is impossible, by involving external- and internal audit parties throughout the research process a confirmability could be sought.

3.5.2 Authenticity

In addition to Trustworthiness, Authenticity should also be concerned in areas such to raise a wider range of issues concerning the political impact of the research. The five sub-criteria: Fairness, Ontological authenticity, Educative authenticity, Catalytic authenticity and Tactical authenticity are briefly described below.

3.5.2.1 Fairness

The first criteria concern the research Fairness, and sheds light on the involvement of different perspectives and viewpoint as well as putting forth findings of fairness quality. Fairness further touches on the subject of participants being equally involved and aware of what is being investigated. One issue stems from data gathered when involving and investigating a social setting. The data should fairly involve a view that represents the real-life setting including unbiasedness (Bryman & Bell, 2015).

3.5.2.2 Ontological Authenticity

Following, Ontological authenticity concerns of increasing the understanding of the involves social milieu. By introducing objective findings concerning the social setting, as a bi-product, the result would also act as a catalysator for increasing the individual's understanding of the social milieu (Bryman & Bell, 2015).

3.5.2.3 Educative Authenticity

Additionally, by increasing the understanding of the social environment, the research members could appreciate the perspective as in accordance to educative authenticity. The increased understanding could also pave way for further exploration, discussions, and meaningful construction of concepts (Bryman & Bell, 2015).

3.5.2.4 Catalytic Authenticity

As the result concluded in areas of improvements and also improvement suggestions, the Catalytic authenticity is sought through members engage in taking action to change their circumstance (Bryman & Bell, 2015).

3.5.2.5 Tactical Authenticity

The last criteria concern the necessary empowerment taken to engaging involved individuals in taking further action. As the findings explicitly highlights improvement suggestions that would enhance the organisation's market capabilities, a presentation with ME management would act as a tactical authenticity step of targeting relevant individuals that can carry through the necessary actions needed to initiate the changes (Bryman & Bell, 2015).

3.5.3 Secondary Data Quality

Quality regarding secondary data is seen as highly important. In some cases, secondary data may lay the foundation and act as building blocks for a research. Using trustworthy sources becomes therefore more important. It is vital to state that secondary data is a product of a research itself and can contain subjective

data. As secondary data can be interpreted in different ways, it can therefore also become subjective to the current research setting (Bryman & Bell, 2015; Hox & Boeije, 2005). For this research, due to the limited knowledge and explicit theories in the area on how to manage late changes, secondary data acted more as a reference rather than a leading guidance.

Secondary data was primarily focused on procuring articles from prominent researchers and original studies which later have become accepted tools in order to increase reliability. Additionally, information regarding gathered data should be forwarded. Using prominent and well-known researchers can be seen as a trustworthy choice. In many cases, the researchers spent decades on the quality of their names. To misuse their names and falsify studies or generate deceptive results would decrease their reputation. Moreover, using different sources can also be used to increase the trustworthiness. In this case, combinations of different sources of secondary data help triangulate the sources as well (Saunders et. al, 2009). In this study, triangulation is defined as two or more sources. Additionally, the secondary data for this research was synthesised into a literature framework tool in order to make an extensive comparison between the existing literature frameworks and CEVT´s state.

3.6 Ethical Consideration

Ethical considerations are considered of high importance and should be carefully considered when conducting a research. The perspective of ethics is described by four principles according to (Diener & Crandall, 1978), these are *Harm to participants*, *Lack of informed consent*, *Invasion of Privacy*, and *Deception*. Worth mentioning, is that what is ethical, and what is not ethical, can be interpreted differently and hence becomes subjective to the understanding of the researcher (Bryman & Bell, 2015). All people have the right to have their own opinion whether it is political or religious related. It is therefore of importance to respect and allow participants to answer anonymously. By taking into consideration the four principles, valuable knowledge can be extracted while still maintaining individual freedom and integrity. The principles overlap each other and together shape the ethical considerations which protects the participants, but also allows for an approach to conduct research that avoids ethical violations. Below, in Table 8, each principle is addressed in the context of the research.

Table 8: Ethical Perspectives

Ethical Perspective	**Description**
Harm to participants	Before publishing, the information was analysed and assessed by the participant to ensure that they were not in harm. The interviewees were offered to be anonymous to ensure confidentiality. An external party should not be able to track specific individuals. Therefore was the gathered data from each ME Sub-function synthesised into one unified content.
Lack of informed consent	The aim of the research, whom the researchers were, and who that would have access to the research was presented to all involved parties of the research. Moreover, during the interviews participants was also given the possibility to ask if something was unclear.
Invasion of privacy	Before each interview, the interviewers went through the overview of the research and what was expected from the session. Additionally, the interviewers asked if it was possible to record the session with purpose to verify statements and control that the interpretation was correct later. Furthermore, the results were to be approved by the interviewee to ensure no invasion of privacy. The opportunity to skip questions in interviews or not handing over data was offered to all participants.
Deception	To avoid the aspect of deception the research aim was presented before interviews and when collecting data. Following, as previously mentioned, by having a back and forth communication with the participants, the researchers ensured that all publish data was not deceptive.

4 Case Setting

This chapter starts with introducing the reader to the case setting regarding development in the automotive industry, i.e. Section 4.1. Followed by the more case specific section 4.2, which regards the company CEVT.

4.1 Case Setting: Development in the Automotive Industry

The development of a car can be said to consist of four areas, namely Architecture, Shared technology, Platform, and Top hat. These four areas will be described below in the context of manufacturing, followed by an overview of the three different factories which constituting a manufacturing plant, describing firstly Pressing and Body In White (BIW), following with the Paint shop, and lastly final assembly.

4.1.1 Architecture

The architecture of a car can be seen as the foundational pillars, in which defines the common base upon a vehicle family (Platforms and Top hat) is developed, see Figure 8 below. The architecture defines a system's functional relationships and capabilities, common layout solutions, interface standardizations and commonality of components and parts. Moreover, architecture framework development and platform partitioning also defines constrains, scalable capabilities and sets the standard core for vehicle families that will be built on the architecture.

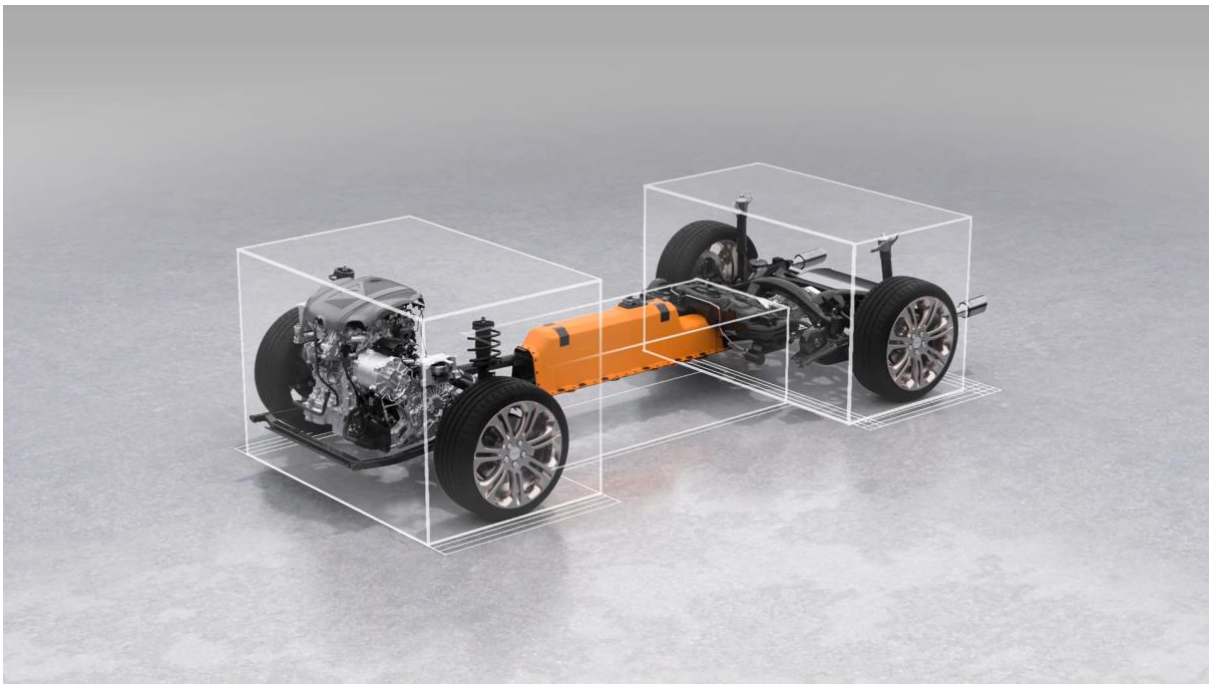

Figure 8: Vehicle Architecture

For example, the larger Volvo segments S90/V90/XC90/XC60 are based on what is called a Scalable Product Architecture (SPA), while XC40 and Lynk & Co 01 and 02 are based on the Compact Modular Architecture (CMA). The main benefits of using scalable and modular architectures is the capability of both increasing customer customization while retaining economy of scale. It is therefore important to find a balance between what technical aspects to include, and business commonality. As one of the main factor is to be as cost efficient as possible while keeping high quality, it is deemed to strive for higher communality to ensure economy of scale, leading to vehicles that have common functions also have the same solutions. Furthermore, from a manufacturing perspective, the architecture characteristics, features

and requirements define the manufacturing Bill of Process (BOP) among which platforms and family vehicles need to follow. The BOP generally defines the sequence for producing the car in the intended production facility. There are two functional limitations that need to be taken into consideration when deciding on what BOP to use for the new architecture, or vice versa when designing the architecture.

Firstly, what dimensions the vehicles will have that will be built on the architecture. This is referred to Body Window. The body window consists of dimensional limitations linked to the manufacturing process, in other terms body window explains what dimensional possibilities a vehicle can have. Therefore, it is important to be aware of the limitations of architecture and each manufacturing plants capability in order to decide what dimensions to follow to produce the new vehicles in the planned production facilities and in accordance to the BOP. If the architecture is designed and designated for smaller vehicle segments, the BOP will be designed around smaller vehicle dimensions and in accordance to the derivative models which need to be within specifications. Similar applies for an architecture which is developed for larger vehicle segments.

Secondly, the BOP not only entails dimensional limitations, but also manufacturing sequence complexity. As the manufacturing plants are designed to follow a logical order for assembling the car, the assembly steps can vary. When a manufacturing plant is developed it is designed to be as efficient as possible for certain types of platforms and Top hats. Hereby, not having BOP and manufacturing sequence in mind while designing vehicles can create issues. For example, if the design engineers neglect the specific manufacturing sequences this can result in a part preventing other parts from fitting, resulting in compromises. The compromises can be linked to re-work or decrease in manufacturing efficiency. Therefore, to share a plant it is beneficial to share the same architecture. Manufacturing plants can be redesigned to fit new sequences and allow for increased capability to include new vehicles. If the architecture is planned to be developed in multiple global locations, the problem becomes more complex. The engineers need to align with several manufacturing locations in order to find common denominators and avoid costly adaptations of manufacturing facilities.

When updating the architecture, there are two possible directions, see Figure 9. The first consist of making modifications to existing architecture, hence giving possibilities to include new feature and attributes. If the new modifications fall into the existing architecture bandwidth the development starts form program strategy intent. The second approach consists of developing a new architecture, when the need for larger and more extensive changes is necessary that is not applicable within current BOP or architecture bandwidth. CEVT´s first architecture development was CMA and was first introduced in a vehicle 2016. The development as initiated already during 2013 and followed new architecture cycle plan, which can be seen in Figure 9: Architecture development. CMA was developed with multi vehicle capability. As it is scalable to a certain degree, it can feature both Volvos 40- series vehicles and Lynk & Co corresponding sized vehicles. Furthermore, it has the capability to be integrated with the other auto companies in Geely group for increased economical of scale.

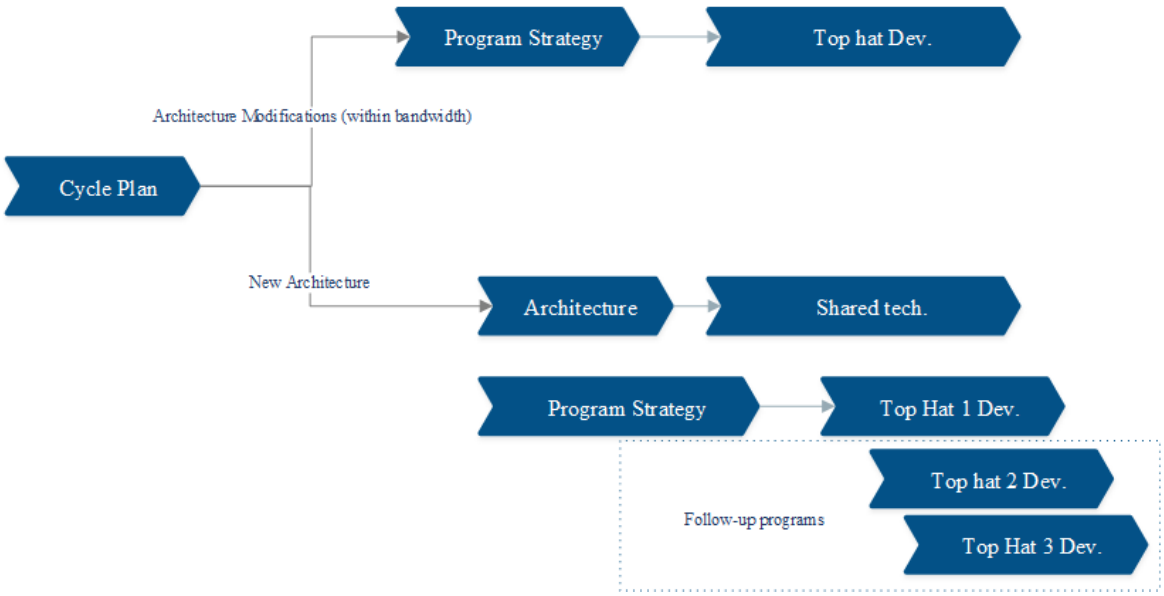

Figure 9: Architecture development cycle

4.1.2 Shared Technology

When the architecture concept has been developed, the development of shared technology (ST) is initiated. ST mainly focuses on parts and system commonality to achieve economy of scale throughout the vehicles that are planned to be built on the architecture. ST is developed concurrently with the first vehicle development. However, ST is excluded from the unique vehicle specific features and parts that distinguish the different vehicle models and brands in the group from each other. By doing so, high economies of scale whilst keeping customization and avoiding cannibalization of having too similar vehicles can be reached. Since Architecture development reaches maturity before both ST and Top hat development, and due to the nature of Top hat development having a late offset see Figure 10, ST cycle starts one phase prior to the Top hat development.

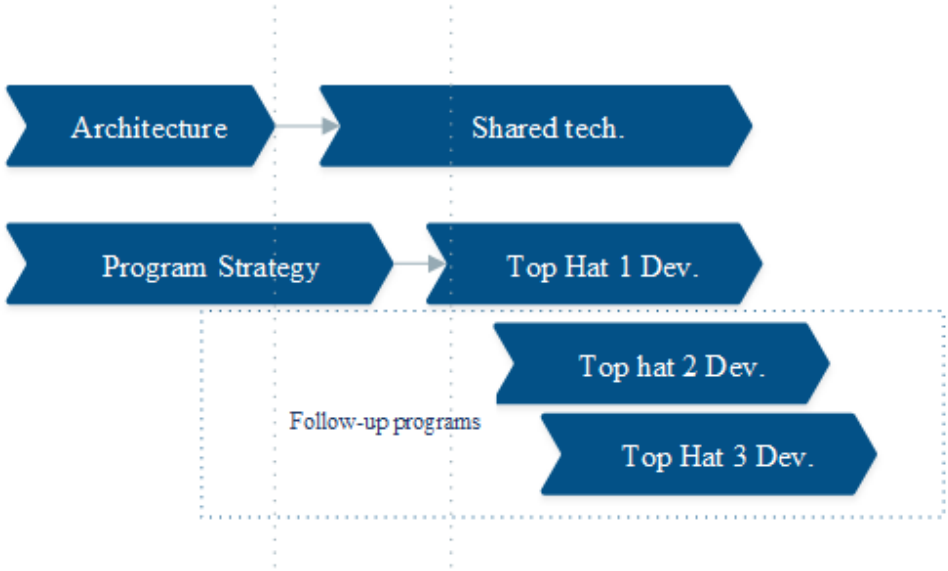

Figure 10: Automotive Development Offset

When the Architecture scope is developed and set, ST have to follow its framework and limitations. However, extrapolating customer value in the beginning of the product development phase is seen as highly ineffective, hence, allowing ST to follow the vehicle development process facilitates the

possibilities to introduce later changes in the development process. Moreover, as the next following vehicle developments occur outside the architecture development cycle, each vehicle development program encloses a shared technology development cycle allowing for further minor ST adaptations, and in some cases if fitting to the bandwidth, even architecture changes, see Figure 9: Architecture development showcasing Architecture modification cycle.

When developing the BOP, the decision of what should be in- and outsourced needs to be taken. A vehicle is divided into different splits and systems, e.g. Door panel, Instrumental Panel, Tunnel console, Floor Console, Compartment Luggage, Engine Bay etc. If the systems are to be manufactured in-house the setup needs to have a different approach from outsourcing the systems and having it delivered to the assembly line. If a system is outsourced to a Tier 1-supplier, the responsibility for developing a BOP for a system is shifted to them. The OEM[6] sets system requirements and expected quality demands. The supplier can therefore choose how to manufacture the systems, as long as it meets the requirements. As previously mentioned, managing multiple global manufacturing locations at the same time can have a complex implication in the development and manufacturing process. However, the organisation will also need to manage a supplier network for each manufacturing location. The choice of supplier and the business setup can vary depending on the manufacturing location. In some cases, different suppliers provide the same parts depending on the manufacturing location. The OEM needs to ensure that even though the vehicles are manufactured in a different location, the quality and expected output need to be the same.

4.1.3 Platform

Concurrently to the architecture development, the undercarriage or also named platform, is established and formed in accordance with the organisation strategy, commercial targets and set requirements. The strategy implies how many and what type of vehicles and platforms will be build, and the interrelationship between them. A platform is a derived system based on the architecture and consists of the underbody, seat framing, and powertrain systems that are developed and designed to be common between a set of cars. As seen in the Figure 11 below, a platform is divided into two axis consisting of seating level and cost attribute standards. For example, S/V 90 have the same architecture as XC 90/60, the difference is the seating level i.e. creating two different platforms High and Low seating. Moreover, S/V 90 share the same architecture as the new S/V 60, but the attributes are different resulting in another platform.

[6] Original Equipment Manufacturer

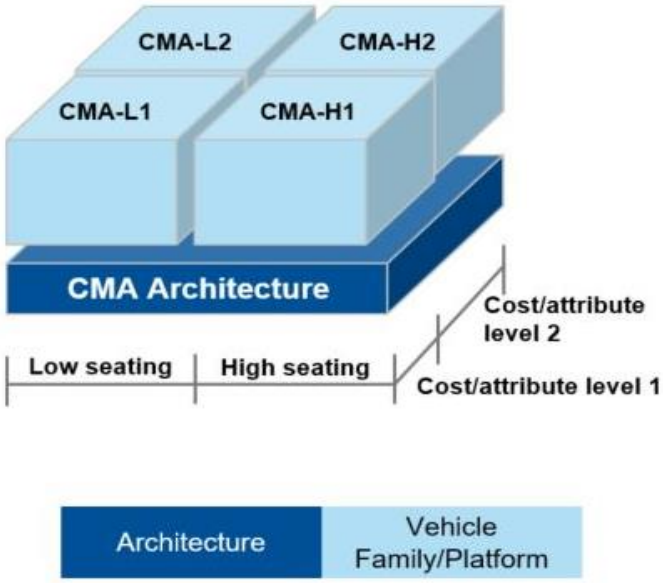

Figure 11: CMA Architecture and Platform

As all latter mentioned vehicles models constitutes an architecture, the commonality between the platform allow them to share the features that are related to high development costs. By increasing the degree of commonality, the time for return on assets is reduced and higher profit levels can be achieved.

Increasing commonality can also create standardised solutions and reduce the capability to meet fast changing demands. For example, electric vehicles have become vastly popular during the last years but have structural differences to the traditional combustion engines. Trying to combine them on the same architecture would create trade-offs. Both systems have structural limitation to one each other creating lesser engineering and design space, hence resulting in sub-optimisation. In other words, if using internal combustion engine as the primary architecture base, the battery propulsion system and battery package would need be compromised to fit. Moreover, the combination would initiate complex assembly solutions and decrease the overall production capacity. Therefore, such combinations are usually sought to be separated in both development and manufacturing.

The architecture will therefore define what types of vehicles that will be introduced to the market and the strategy will need to be aligned with customer demand. The architecture scope can therefore be extended and active for many years. For example, the development of CMA was initiated late in 2013. The development and strategy of the architecture needed to cover the demand and project plan for the next coming years. The architecture development took approximately 2.5 years. Concurrently to the architecture the first Top hats were developed and finalised in 2017. Both Lynk & Co 01 and the XC40 were first introduce for sales to the market in 2017. Following, both Lynk & Co and Volvo have planned to release a set of new cars on CMA throughout 2018, 2019 and 2020. The life cycle of each vehicle is 7 years of production. In total, the architecture strategy needs to take into consideration and convert demand for necessary change between 2013 - 2027. Although there are room for some changes, the essentials feature of the architecture and platform limitations will be same.

4.1.4 Top Hat

Since the development of both architecture and platform is related to the platform of a vehicle and usually generic for a set of cars, the possibilities for differentiation comes with modularisations of powertrain size and type, and chassis. However, the shell of the vehicle together with the interior and exterior is defined as the Top hat. The Top hat is customized for each vehicle brand and vehicle model, specifically designed to follow the advocated guideline and values of the brand. The platform is hidden and unseen to the normal crowd, but the Top hat becomes the part that end customers relate to. The Top hat also entails aesthetic and artistic design, which is part of the perceived quality and the customer experience. Even though the platform is a vital part for developing a good vehicle, the customer focus on the interaction with the visible parts. A Top hat with a common platform therefore needs specific and unique features to distinguish from the other vehicles to avoid internal cannibalisation. As depicted in Figure 12, CETV is developing platforms upon which the different car brands put their specific Top hat.

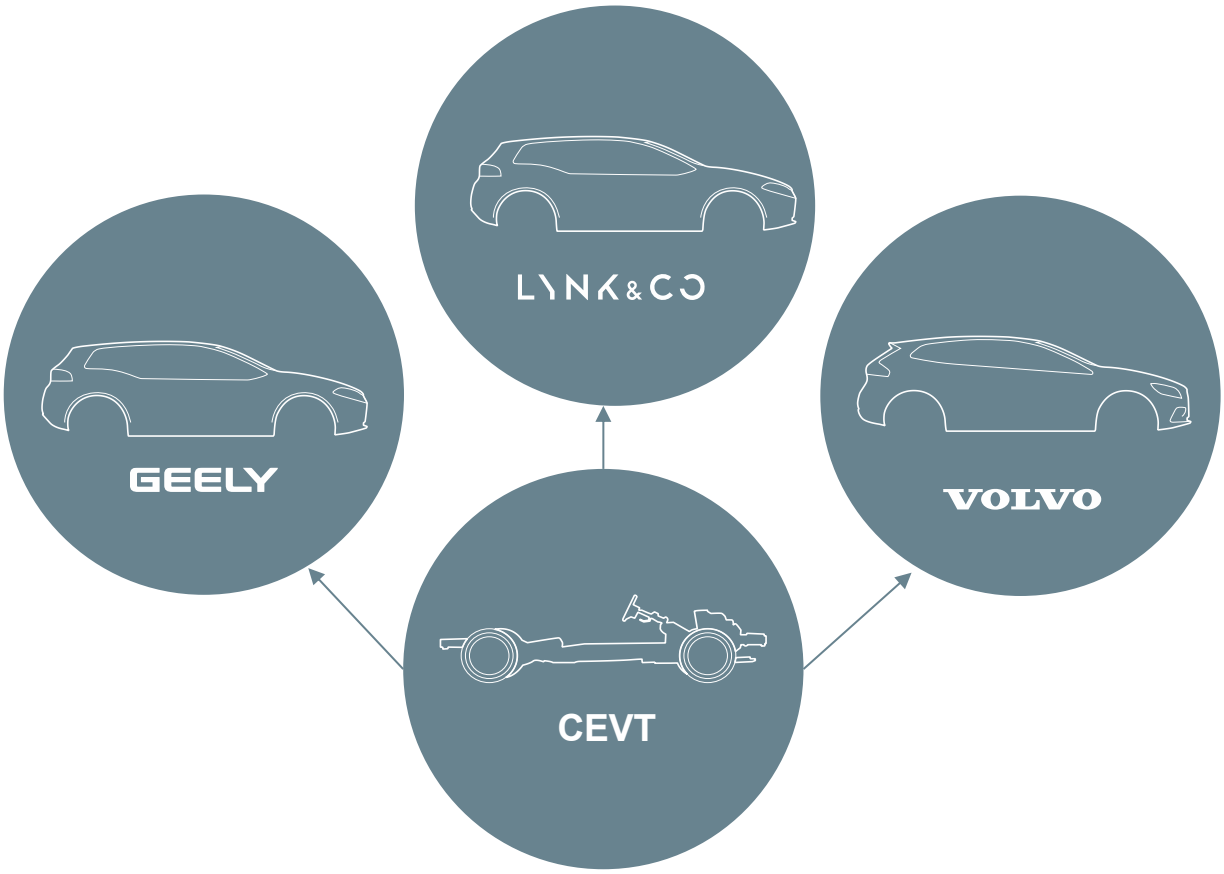

Figure 12: Top Hats and Platform

A vehicle Top hat consists of door panels, roof top, tailgate, tunnel console, bumpers, uni-harness, instrument panel, wheelhouse etc. Each of these parts are to a degree Top hat specific, however even here there is a need to finding commonalities. As the architecture and platform is being developed, the first Top hat essentials are simultaneously developed. At the beginning of the development process of the architecture and platform there is a delay in Top hat development, the development must follow the requirements set from ST. ST is therefore directing the development trajectory up until last point of order or Final data judgment (FDJ). FDJ can also be seen as the focal point were the virtual world, i.e. all data regarding the parts, now have to be transformed to physical action. This is also called the industrialisation phase. As a rule of thumb, at FDJ there should be no more changes, all parts and drawings should be frozen. Furthermore, all parts of the vehicle and tools need to be ordered form the suppliers to meet the first build event. After FDJ, both Top hat and ST development converge to follow the same time line. It is after FDJ when changes emerge that they become harder to manage. As all parts

are frozen and ordered, introducing larger system level changes at this stage triggers chain reactions that needs re-work and further validation. Additionally, as FDJ is set as he last focal point for ordering parts and tools, delaying this process usually has a direct relation to the delay of start of production.

4.1.5 Body in White, Paint, and Final Assembly

A vehicle is manufactured using a sequence of build events and assembly stations. These events and stations are divided into three different factories, namely Body in White (BIW), Paint, and Final assembly, forming a manufacturing plant capable of producing a full car.

The first factory in the build sequence is BIW. It is in this factory that the vehicle takes shape and the structure is born. The manufacturing process is highly automated and mainly consists of large stamping tools and robots. The stamping process forms sheet metal to become different parts of the vehicles. Parts such as front structure, front and rear floor, body sides etc. The stamping process is also directly related to vehicle architecture and the body window. The design of the tools sets the max bandwidth and body window of the vehicles. The vehicle body is formed in five stamping steps and the process is characterised by large tools that have long and fixed lead-times for manufacturing. Therefore, there is a lot of effort going in to ensure that Stamping process can order tools in advance for the project not to be delayed. Although the stamping process strictly follows the set design and project strategy, anchored in top management, there is a risk of late changes which can be costly if not managed appropriately. These parts are later joined together to form the vehicle metal structure, also called BIW, see Figure 13: Joining of Body in white.

Figure 13: Joining of Body in white

The next factory in the build sequence is called Paint. Here is where the vehicles are coated with various surface treatments to protect from rust, see Figure 14. Moreover, it is in this factory were the paint is applied on the vehicles. As the first factory, the Paint factory is to a larger extent automated. Hence,

creating dimensions for a certain Body window defined in the BOP. Throughout this factory's process the vehicles are transported in skids and hangers. These are also limited to the vehicle dimension and weight which need to be overlooked when developing a new vehicle.

Following, the last step before the vehicle is transfer to the next factory is sealing. The sealings isolate and protects the vehicles from external noise, vibration and water. The sealing is also a factor that determines the vehicle comfort due to the noise factor. Different vehicles have different requirements when it comes to sealing levels. Additionally, as Top hat shapes differ from each other, the process of sealing the vehicles can become difficult for the robots. In some cases, the robots cannot reach certain areas, and therefore manual labour might be needed.

Figure 14: Paint Factory

After the coating, painting, and sealing process the vehicles are transported to the last factory, Final assembly. This factory is the most comprehensive in terms of amount of activities and working stations. Final assembly is where the vehicle goes from being a metal structure to becoming a finished product. Here, the vehicle's metal structure is merged with all assembly parts and systems.

Compared to Body in white and Paint, final assembly have more workers and the processes constitutes of both manual, semi-automated and automated processes. However, most of the processes are either manual or semi-automated stations. As the assembly stations are predetermined and fixed, each part that is to be assembled needs to be assembled in the right sequence, otherwise there is a risk that the part will not fit, or damage will be done to the end product.

The difficulty level rises when introducing new Top hats to final assembly. The new Top hat usually brings new features that need to be planned into the assembly sequence. As the BOP is never Top hat specific, but instead, the assembly lines are balanced and generalised to manage a limited number of

platforms. By combining different vehicles in final assembly, the entail predetermined limitations of already running platforms usually creates an offset to the new ones. Additionally, introducing these changes can become complex and costly to manage as changes need to be made in running production. However, the degree of manual labour in final assembly allows for a certain degree of flexibility, but should not be seen as an instance for increasing the variety without carefully planned. The variations will affect manufacturing efficiency and increase the risk for poor cost of quality.

4.2 CEVT

CEVT is the innovation centre for The Geely Group, delivering automotive technology and solutions to the other auto companies in the group. The aim for CEVT is to meet the demand of tomorrow's global markets by utilising advanced virtual engineering and modular development strategies. Furthermore, as CEVT delivers technology, the assignment can vary, going from providing know-how and expertise in some areas of the latest technological innovation to delivering a complete vehicle.

As seen in the figure below, Figure 15, there are several companies in the Geely group. Formally, CEVT is owned by Zhejiang Geely Holding Group but operates under Geely Auto Group and develops technology to all automotive brands for example Geely Auto, Lynk & CO, and Volvo Cars, which are defined as CEVT's *customers* from here on. The final user of the vehicles is defined as the *end customer*.

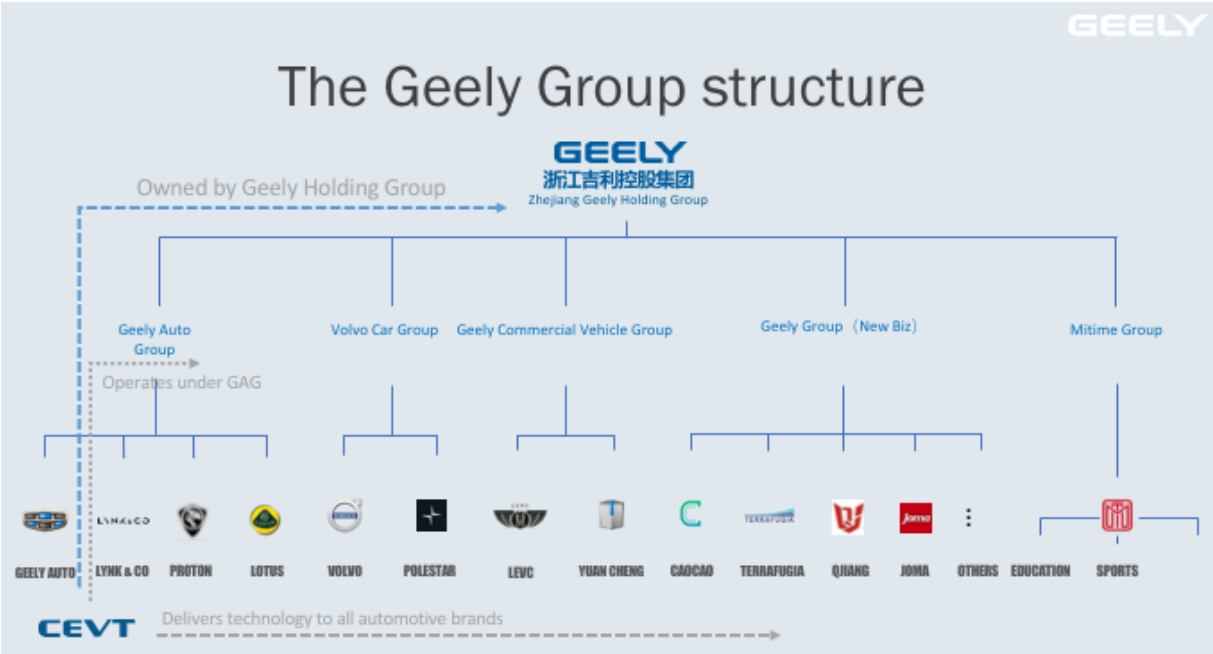

Figure 15: Geely Group Structure

CEVT as any other automotive related company needs to strive to meet certain commercial targets. However, in contrast to other automotive companies, CEVT is a non-profitable organisation. This means that their commercial targets are not related to financial means, but of those set by its customers. In other terms, CEVT receives projects form the customer with product related targets. In CEVT´s case the commercial targets concern areas such of Emission, legislation, regulation, safety requirements, and those subjective to the vehicle development as perceived ride quality, performance etc.

Moreover, since CEVT is an R&D unit in The Geely Group, their role varies for each project. The responsibility is therefore different depending on what the customer is requesting. For example, CEVT carried out the full development of Lynk & CO 01 and had the responsibility 3 month in after start of

production. Then the project was handed over to Lynk & CO China which took over the responsibility. CEVT´s relationship to the other companies always consists of:

1. The initial involvement in projects
2. A clear cut and hand over process of the projects.

This means that CEVT first needs to receive a development request. For example, developing a new platform such as the CMA. The request is then answered with a quotation based on what financial support and resources are needed. It is up to the customer to decide if the quotation is competitive enough and proceed with the deal.

4.2.1 Organisational and Process Structure

As CEVT is mixture of Sweden and China, so is the organisational structure and context, but as the overarching structure is from Geely, the hierarchical structure of the Chinese culture is manifested in the Swedish organisation as well. Furthermore, CEVT's organisational structure is based on functions and even though their joined QMS[7] with Geely, NPDS[8], is based on processes that illustrate a cross-functional integration, the physical structure and organisational behaviour is separated between functions. From the perspective of ME, the department is separated physically from the other functions as they are located in a separate building, and this is also how they work on a day-to-day basis. ME is hereby separated from the upstream functions in the process, like design and engineering, as well as the downstream functions performing the processes after ME, i.e. Geely ME and Production Plant. There is one exception regarding the separation of development and ME, which is the sub-function Paint within the ME-department, which is performing both research and development and ME tasks. Furthermore, within ME there are five sub-functions, namely Paint, TCF[9], BIW[10], Geometry, and stamping. These sub-functions are located in the same building, grouped separately. The sizes of each sub-function of ME varies, TCF is the largest about 45 employees, Paint is the smallest reaching a head count of about 5 employees. Bellow, in Table 9, the size of each function within ME are shown. In the following sections each sub-function and the management structure of ME is described.

Table 9: ME Function sizes

Function	Number of Employees
TCF	45
Paint	5
Geometry	10
Body in White	20
Stamping	10

4.2.1.1 Stamping

The Stamping function is in charge assuring that the stamping of the vehicle body is correctly conducted. Stamping also set the general requirements to which the engineering departments needs to follow. These requirements can be related to body tolerances, shape restrictions and physical limitations existing in today's manufacturing technology. As previously mentions, the stamping process is characterised by high tooling cost and long lead time. As a result, Stamping becomes a time-critical function for the development process were the function needs to start collaborating with the suppliers before any other process.

[7] Quality Management System
[8] New Product Development System
[9] Trim and Car Final
[10] Body in White

4.2.1.2 Body in white

Body in white (BIW) mainly focuses on assuring the process of joining the different vehicle metal structure frames together into one unit, see Figure 16. When the different parts have been produced, the joining process takes place. During the joining process, BIW needs to state in what sequence the different parts are going to be joined and by what manufacturing method. Additionally, the function needs to take into consideration the manufacturing plants capability and the requirements towards the engineering department. BIW is also in charge of evaluating new joining techniques and validate if the process is stable enough to be use as a serial solution.

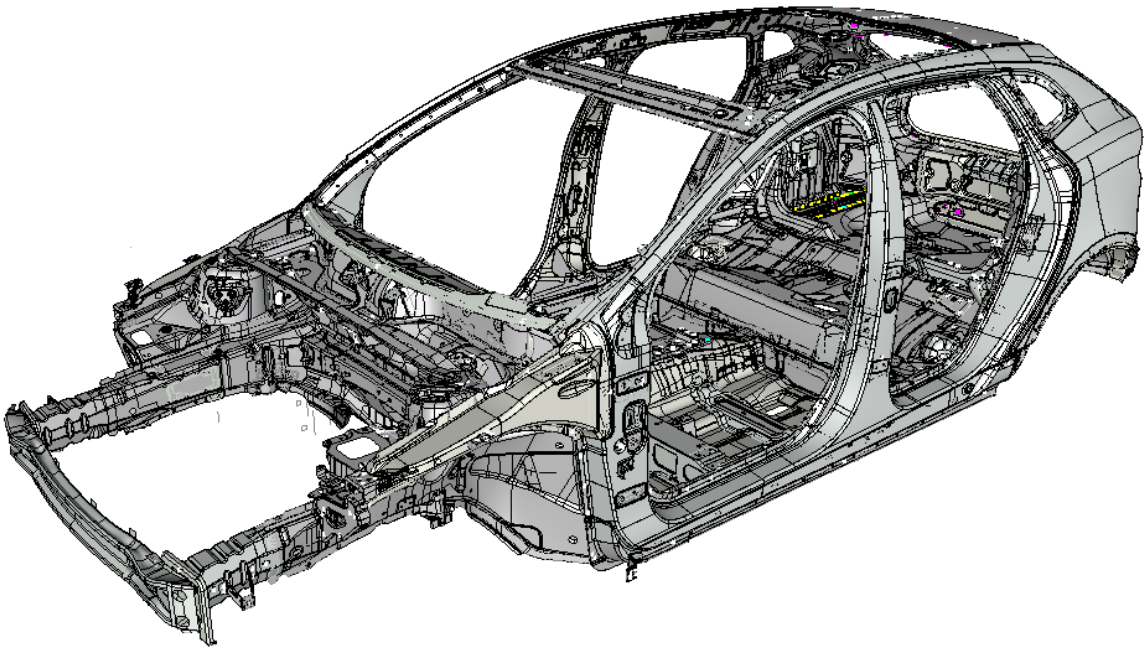

Figure 16: Illustration of Body in White

4.2.1.3 Paint

The sub-function Paint assures the manufacturability in the second factory. As previous functions, Paint sets the general requirement of current manufacturing limitations and restriction. Their job is to ensure that the surface treatment, paint and sealing process is quality assured and in accordance to the set requirements. However, as mentioned earlier, Paint also conducts the research and development themselves. Hereby, not only do they have to ensure the build quality, they also conduct development of new surface treatments, paint and sealings.

4.2.1.4 TCF

Trim and car final (TCF) has the most comprehensive and extensive role in ME. As they are both superior in terms of members and factory activity, they are in charges of assuring the manufacturing process of all assembly parts. Compared to the other functions which either have a few activates or some part to oversee, TCF's roles is more complicated. All assembly parts need to be verified both in the assembly process, but also as a system. Hence, since TCF operates in the last factory, the responsibility of having the last touch of the vehicles results in them being involved in various of tasks.

TCF also have to verify the manufacturability for the different build events leading up to serial production. In addition, TCF needs to oversee and lay the foundation and assure the physical

verifications. The assuring process also includes detailed description of the assembly sequence, method and tools used.

4.2.1.5 Geometry

Geometry can be seen as a support functions to the other sub-functions within ME. As the geometry function do not have any physical responsibilities, the purpose is to secure geometric quality in both the products and processes. The geometry function can also be of assistance when there are tolerance deviations in the manufacturing or assembly process. By involving Geometry, the team can look for possible changes in tolerances to tackle the problems instead of having to change larger tools which are connected to heavier financial investment.

4.2.1.6 ME Management Structure

CEVT's ME department is structured as a Matrix organisation and is depicted in Figure 17. The first part of the matrix can be seen through the solid lines, and is the line organisation. The line organisation is function based, i.e. separated upon *Geometry, TCF, Paint, BIW, Stamping,* and *ME Project*, all reporting to the Vice President (VP) of ME. As CEVT continuously manages several projects at the same time, the second matrix is based upon the projects and can be seen through the dotted lines. Here each function has an SPL reporting to the Unit Project Leader (UPL).

The ME VP is responsible for the whole ME division and assures that each project is aligned with the rest of the organisation. The Director of ME Project role is to make sure that all projects are in accordance to the project timeline and align that all UPLs are meeting the deliverables. Furthermore, at beginning of each project the time scope and resources are decided, which should be aligned with the global project management. Each project receives a certain amount of resources from top management which is later allocated to each sub division within ME. The UPLs are responsible for respective sub-function within ME and reports the progress of the unit to top management and is the representative of ME when strategic decisions are made. A UPL is assigned for each project, meaning that a sub-function can have different UPLs depending on which project. Furthermore, each sub-function within ME has a System Project Leader (SPL) which represents the different systems in the function. The SPLs role is to govern the function and make sure that the team is delivering in accordance with the defined milestones and deliverables.

Within the engineering level of Figure 17 there is a Senior System Manager (SSM) which is not shown in the figure. The SSM is the team leader within the sub-function and a part of the line organisation. Their role is to provide technical support to the engineers, but also to assist SPLs in various decisions such as complexity, difficulty level, and amount of resources and time needed to conduct the projects. Hence there is one more hierarchical level than that is depicted above the engineer. Moreover, the number of engineers following the directives of SSMs and SPLs are varying, the number in Figure 17 is only to exemplify.

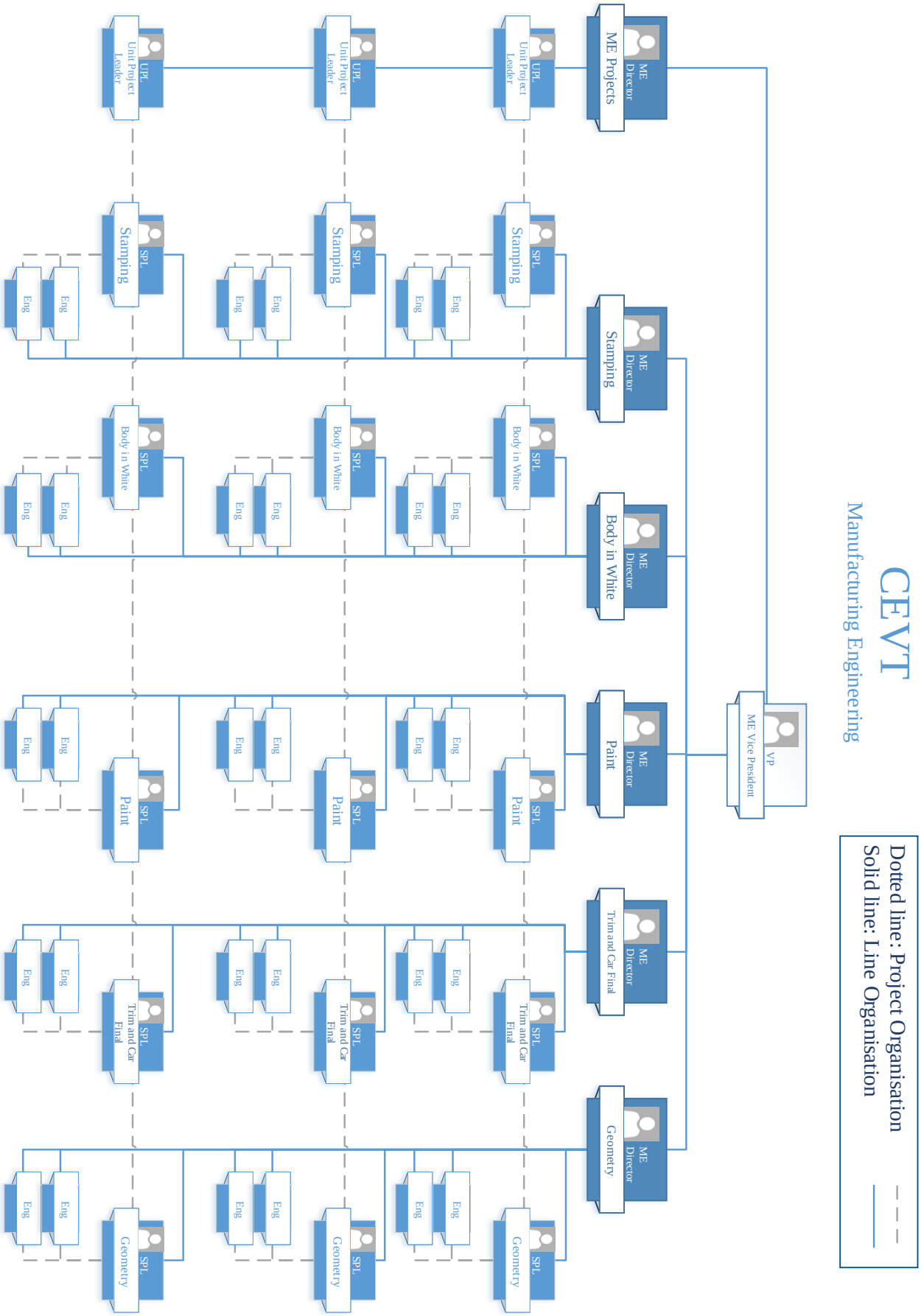

Figure 17: ME Matrix Organisation

4.2.2 Management Systems and Processes

Following sections describes the managements systems of CEVT, their Product Lifecycle Management system (PLM), Milestones and Gateways, and the process for change management and requests.

4.2.2.1 NPDS & CEVT Management System

NPDS is CEVT´s and Geely´s product development system. The purpose of NPDS is to guide and support navigation throughout a development project and provide project awareness to the involved. NPDS states in what order the development project should be carried out and what processes and deliverables to follow at time. NPDS is a system that allows different workflows, organisations and systems to simultaneously tangent and interact throughout the development of vehicle projects. It defines the master logic of gateways, milestones, deliverables, tools, and interactions between processes. Furthermore, NPDS is created as an interactive system to support global development projects. Therefore, NPDS requires well defined and accurate processes that can be comprehended globally, even though cultural differences amongst its users.

As a system, NPDS has four hierarchical levels, each level increasing in detail. Even though the fourth level of NPDS is the most detailed, specific meetings and activities are not shown here. The reason for this level of detail is to enable more general descriptions where detailed processes can be performed differently but achieving the same result depending on where they are conducted. This is to allow a global acceptance and governance for the systems. Hence, inputs, outputs, and the different processes are clearly defined in each level, and as long as they meet the set requirements, the exact working procedure can be locally decided.

CEVT Management System (CMS) is CEVT internal QMS, which compared to NPDS is a system that provides a systematic guidance with more detailed documentation and processes. Where NPDS describes project timings and higher-level processes or group process in the development project process, CMS focus lies on what is supposed to be done and when in the development project it is supposed to be carried out. In contrast to NPDS, CMS is created to convey clear directives and descriptions for work procedures. Hereby, CMS is created with the purpose to support NPDS in areas where it lacks clear directives for how CEVT is to conduct the processes. All processes in NPDS performed by CEVT are a part of CMS, but should be described in more detail than NPDS. As a result, the systems complement each other to provide a full governance throughout the development process. By creating an overarching system with general but defined deliverables, i.e. NPDS, all companies can follow a clear trajectory of their development project, even though multiple companies are involved. Furthermore, the two-system solution allows all companies to have their own tailored QMS, like CMS for CEVT, but still be globally aligned through NPDS. Moreover, CMS is also targeted to a wider audience within the organisation compared to NPDS. As NPDS only regards new product development projects, CMS contains directives and guidance for the whole company including HR, Finance, After Market Service to Knowledge Management and Internal Audit processes.

4.2.2.2 Team Center

CEVT uses a PLM system as an information management system called Team Center. The system is provided by Siemens which describes it as a PLM system that connects people and processes, by digital means across functional silos. The system efficiently integrates collaboration of data, documentation, processes, systems, simulations, visualisation and other computer aided functions to facilitate and manage the product development, product lifecycle, and information management of products from its creation and throughout its lifetime. Furthermore, the PLM system is used by both Volvo and Geely, but as they previously have had their own customised solutions the interaction has been problematic.

However, both Volvo and Geely are now migrating their systems into the same version as CEVT, to facilitate the collaboration. This as all new collaborative projects will use the version of CEVT.

The data included in Team Center is shared throughout the company and used as a collaboration tool. The engineers that design the parts use Engineering Bill of Material (eBOM) and Master Bill of Material (mBOM) to release and share part design and data including the technical specification with other departments to use. The release includes lists with 3D model of vehicle components and parts that together makes up for a vehicle. Each part is separately unique, for example, if it is used in a certain manufacturing plant, the information is showcased and entailed in the 3D model. By allowing the responsible engineer to manage the PLM system, the functions know at any moment what version is valid and what technical specifications to use. The PLM system also provides the possibilities to see if change have been made or even if there is an active change request regarding a part. Furthermore, information such as part number, material, surface treatment, dimensions and special requirements etc. are also showcased.

4.2.2.3 Milestones and Gateways

Milestones are decision meetings for top management where project data should be available to support decision to proceed into the next development phase. The time for milestones are not fixed and is therefore not used for project timing. These milestones are go/no-go decisions assessing the project towards e.g. strategic, business, technical, and marketing targets. Furthermore, resource allocations are approved and plans for future processes, e.g. ramp-up or sourcing agreements with suppliers, are set based on the data available at the current point in time. Some major milestones include decisions like, approved Pilot Production, approved start of Mass Production, approved delivery from Mass Production of vehicles to external customers, decision to close program.

Following, the Gateways are key events during the development process and are checkpoints where the development team is assessing achieved product maturity against planned maturity. The gateways mark the chain of events and timing needed to finish the development project. Some important gateways are, securing that component design is fully compatible, maturity level to enable purchasing of manufacturing tools, cross-functional approval that business requirements are achieved, verifying that tools produce products meeting set targets, confirm process capability for mass production, and start of mass production and ramp-up.

4.2.2.4 Change Management Process

CEVT has a process called Part Change Management (PCM), which purpose is to be a centralised point for managing product related issue reporting regarding late changes. The PCM involves cross-functional collaboration, engineers, and suppliers to support the change. Furthermore, the PCM process manage usage changes, change variant conditions, and Part changes, i.e. geometry, attribute, and function.

Within the PCM process, several tools and workstreams are utilised, see Figure 18. Five phases can be distinguished. Firstly, Problem identification phase, securing facts about the issue. Secondly, Investigation and Concept Development Phase, developing concept and acquiring delta information requirements. Thirdly, Solution Development, establishing the facts about the solution including the impact analysis and approval of detailed solution. Fourthly, Solution impact phase, which entails securing the implementation, including introducing timing, supplier negotiation, and the delta impact review. Lastly, Solution Verification phase, which verifies the solutions.

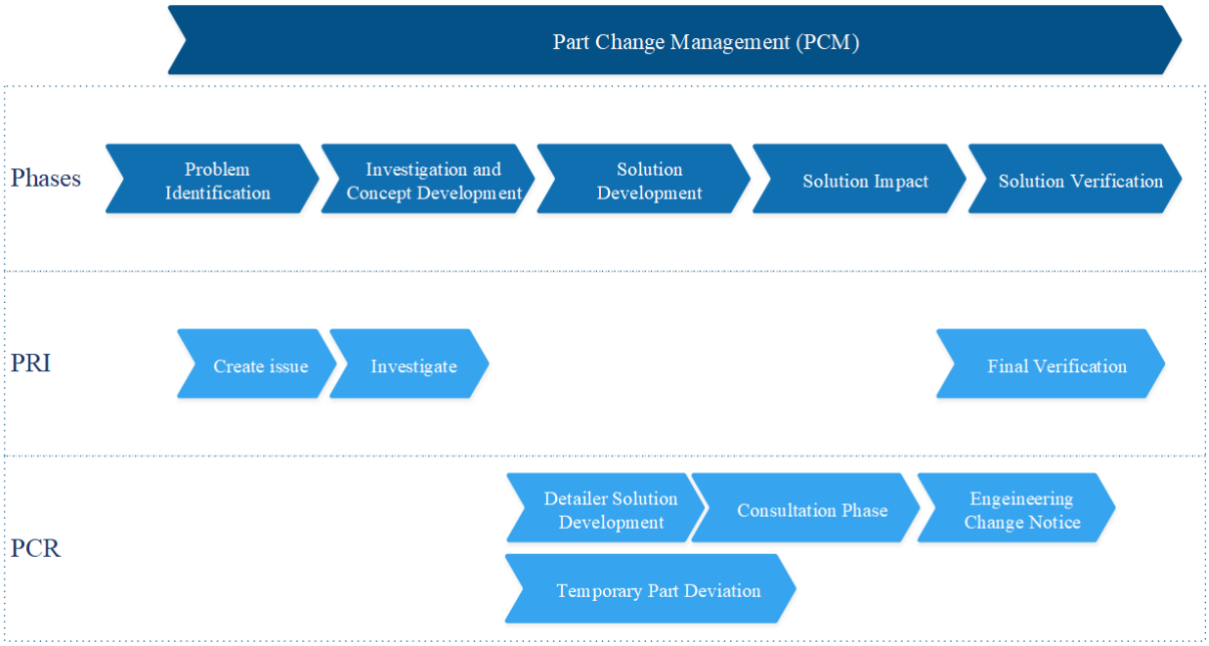

Figure 18: Part Change Management Process

These Phases are linked to other tools to facilitate the process, the tools are briefly described below. The Product Issue Tracker (PRI), describes issues related to hardware parts, enable approval for resources to be spent upon the change, enable concept approval for the change, and manage the verification of the issue solution. Furthermore, each issue that is created is graded on a scale from 1-5 by risk severity, where 5 is the highest severity. The PRIs have meetings to facilitate the coordination where the number of roles can vary. However, five roles are mandatory to attend and four depends on the context. The roles can be seen in Table 10.

Table 10: Roles of PRI meeting

Role	Comment
Technical Project leader (TPL)	Mandatory
PCM Coordinator	Organiser
Issue Owner	Represented
Issuer	Requirement owner, Mandatory
Module Team Director	Mandatory
Vehicle Integration	Mandatory
Manufacturing Engineering	Mandatory
Purchasing	Mandatory
Project Finance	-

Moreover, Part Change Request (PCR) is a process used to reach a decision regarding a part change. The change request must contain complete specifications, i.e. CAD data, specifying documents etc., this to enable a well-informed approval from the project manager and the creation of an Engineering Change Notice (ECN) to permit the part to be changed in the Bill of Material. Hence, the specification must not be altered when a PCR is started. If altered the PCR has to be reset and approved another time.

As CEVT delivers solutions to several other automobile companies, changes create cascade effects into their products. Hence, in some cases requiring input from these companies, this input is often set to be received within ten days. However, in some cases CEVT have shared responsibility or even act as a

support function. In these cases, their role becomes more of an advisor rather than the final decision maker.

Furthermore, if changes are to be implemented into a product that is already in production it is called a *Running Change*, which entails another level of complexity as methods and procedures has to be changed in existing factories and products. As an example, in some cases, the part needs to physically be produced and undergo a line trial. Line trail is an exercise were the new parts are used in running manufacturing plants to complete the verification of the change.

4.2.3 Manufacturing Engineering

CEVT's manufacturing engineering department, which purpose is to validate all preparatory design and engineering work, and secure the producibility of the vehicles, is represented in NPDS by 20 high-level processes. The sub-functions have the same process interface and the same process maps for each process throughout a development project. Moreover, the gateway description is also the same, i.e. the deliverables are generalised for ME as an entity and not separated by sub-function, resulting in a ME-deliverable at each gateway. However, the tasks and deliverables s different for each sub-function. This implies that even though different tasks, the sub-functions have the same overarching description for each process. Each gateway deliverable constitutes of specific deliverables from each sub functions. ME deliverable is therefore depended on each sub-function meeting its deliverable to avoid delays.

Even though each sub-function is separated both in work, location, and deliverables, they are all included under the same management structure. This allows for homogeneous result by having the same governance throughout the development process. All sub-functions' UPLs meet regularly with ME Directors in a cross-functional meeting. The purpose of the meeting is to ensure that all sub-functions are aligned with each other, discuss issues, present project development progress, and agree on how to proceed. Furthermore, another objective for the ME-process is to ensure a smooth ramp-up for production. Amongst these processes, some lies under ME-CEVT's responsibility, some under Geely-ME. The responsibility can vary from project to project which emphasises the importance that NPDS is well documented and defined to enable clear guidelines for what to do in different vehicle projects

4.2.4 Culture and Communication

As mentioned earlier, CEVT is a multinational company with the main combination of Chinese and Swedish culture, there are of course issues concerning cultural differences. Both at managerial levels as well as at a more operational. An example is the Swedish culture for decisions where everybody should both be able to get their voice heard and take part in the decision, a decision which preferably is taken in consensus. Whether as in China, the leader/manager takes the decision, no questions are asked. This aspect manifests itself when, for example, departments from both Sweden and China collaborate to solve an issue. The Swedish department might send a proposal for how to solve the problem, expecting the Chinese department to give them feedback. The receiving Chinese department might though take this as a decision/order, instead of a suggestion and a call for input. Furthermore, the Chinese culture tends to work in silos, and only when ready, present the final solution. As CEVT in many instances are working with quality criteria and requirements, it is a common procedure to hand over lists, such as the eBOM, mentioned above. These lists are often managed through software such as Team Center, to facilitate the global communication. The IT-platforms are used to enable continuous information sharing. In some cases, whole lists are published to convey the information. In other instances, single items are uploaded to existing lists as fast as they are ready, to update the list for the next process.

As a development project starts, ME gives input to the program strategy creation done by top-management, which consolidates input parameters such as strategic intent, technology plans, prerequisites, e.g. program scope, and vehicle project plan draft. The project is then progressing to design and engineering, which are creating the components for the project. Design and engineering are mainly communicating with ME through iterative processes, like pre-determined check-up meetings, and lists, such as the eBOM. ME is verifying the component compatibility and if there is a problem, alerting the previous step that there is an issue to be resolved, i.e. a PRI is created. When the parts are verified, OK, by ME according to the set requirements, the next step is ME-Geely. As mentioned before, the point in time which the communication between ME-CEVT and ME-Geely starts is different between projects as these are handed over at different stages from project to project. Furthermore, the majority of communication from ME is made either to design, engineering or to ME-Geely (China). Regarding the communication between ME-CEVT/Geely this is more complicated than between ME-CEVT and the design and engineering departments, due to the geographical distance. This as design and engineering are located in Gothenburg close to ME CEVT. However, the foundation of the communication is the same, lists and meetings, often with the help of video or phone calls, but the employees are also traveling multiple times a year to meet in person. The step after ME-Geely is the production plant, if an issue is discovered the communication goes backwards through all previous steps. Passing through ME-Geely, ME-CEVT, and back to Design/engineering depending on the nature of the issue. Furthermore, there might be input from other levels of the organisation igniting communication processes or change requests. As an example, there could be identified issues discovered at the market, which sometimes goes back to the top management levels to trickle down through all sub-functions yet again to reach ME and restart the process of the identified issue. In Figure 19 the external communication with ME during a development project is depicted, where the grey arrows are the first communication loop and the red arrows are feedback/updates.

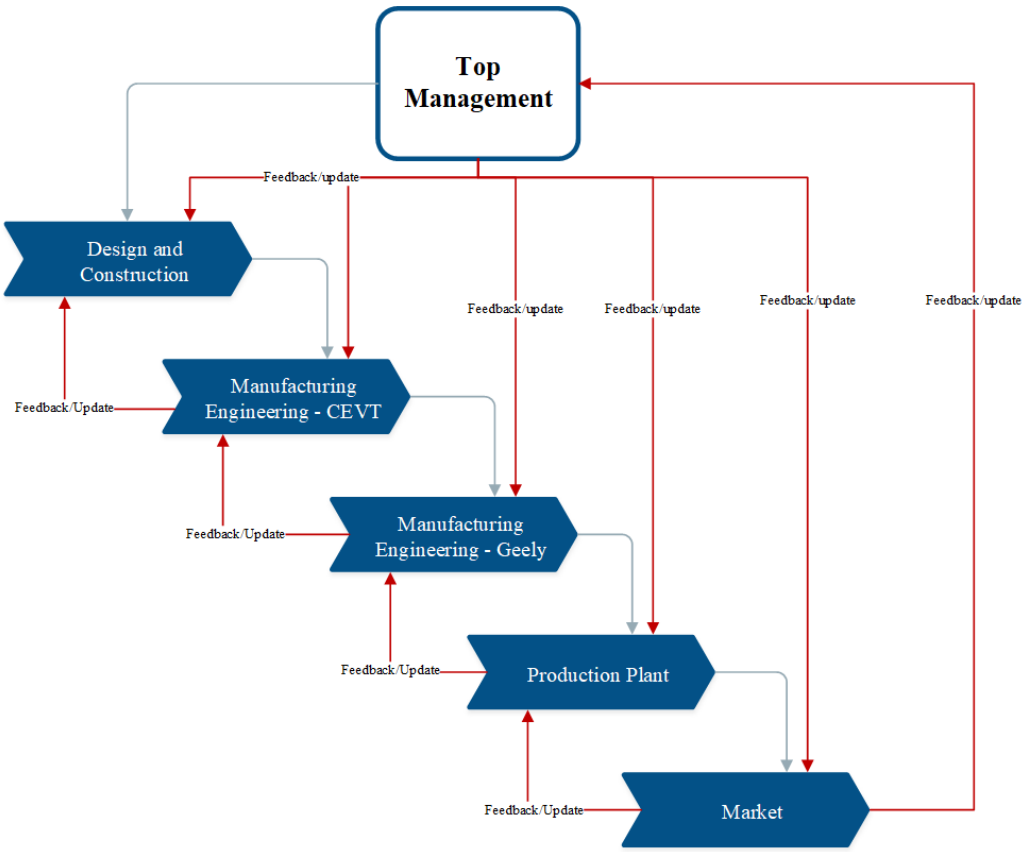

Figure 19: ME and External Communication

Regarding the communication within the ME-department this varies from project to project, process to process, and even regarding parts within projects. What can be mentioned is that during many processes the communication is done by predetermined meetings to enable cross-functional communication. These meetings can in many occasions be rather extensive and hereby be time-demanding. Therefore, the meetings are at times considered unnecessary use of time even though they are adding value to the process as a whole. Furthermore, as mentioned above in Section 4.2.1, the ME-department is located in the same building and the majority of the employees are sitting in an open office landscape which facilitates the day-to-day communication.

4.2.5 Organisational Guidance: Values and Motivation

The first message that is conveyed when entering CEVT's homepage[11] is the text *Developing cars for a different tomorrow,* and then in a smaller font *We redefine automotive engineering.* These sentences can be seen as guidelines and goals which are supported by their three company values, namely *Think Big, Find a Way,* and *Get Inspired.* Furthermore, these guidelines promote the production of "future proofed" products. The first of CEVT's values, *Think Big*, aims to foster innovation and think outside of the box. This has a conflict in that CEVT mostly work on ordered projects, an example is the Terrafugia project[12] which is another Geely company that wants CEVT to develop their concept, even though an innovative project, the source is external, and it is not CEVT's idea. The second, *Find a Way*, is about testing and not give in for any problem, it aims to encourage complex problem solving, not giving in to the big ideas. The third value, *Get Inspired*, is about gaining input from other sources and cultures, working together to enable multiple perspectives to join and create the best of solutions.

As the organisation is separated upon units, the units can have different methods to motivate the employees. An overarching principle is though the development and learning of employees, which can both be enforced by each manager, but also through the central learning function, CEVT Academy organising courses, workshops etc. Furthermore, personal development is one of the parameters that is evaluated regarding employees, other examples of evaluation parameters are innovativeness and collaborative capability, but as similar as about motivation, each unit can have other methods for evaluating employees.

4.2.6 Decisions and Governance

When it comes to decisions regarding changes, this is described more in detail in Section 4.2.2. However, depending on what change that is to be done, different instances of decisions are required. For example, if it regards electrical components it might regard TCF but not Paint. What is common between these changes is that they require decisions from several functions/persons to be able to progress. As of today, it is not possible to see how far a function has come regarding evaluation of approval for a change, if not using direct communication.

For some decisions just requiring single persons to respond, the decision process for changes does not have to go through a certain process, which enables direct contact and a quick response, depending on the person's availability. For larger changes and more complex changes, like work method changes, and especially new projects, the decision process is more extensive. Multiple functions have to approve the change and multiple new verifications might have to be done.

[11] http://www.cevt.se/
[12] A Flying car

4.2.7 Strategy, Plans, Forecasts, and Budgets

As the start of CEVT was to create the CMA platform, the goal in the early years was clear and defined. With the launch of the first platform, the company lost their direction to some extent. During the start of CEVT, all members worked unified to create the first platform, CMA. The goal was therefore clear and the workers were aligned. Today, CEVT have increased its product portfolio and is involved in multiple projects globally. Instead of having all workers using their full capacity to develop the one architecture, the workers have several ongoing projects at the same time.

Regarding budgets, as of now these are created with a top-down approach and the units are assigned resources, which in turn the units can dispose upon each project. It can be described as the unit is giving the project a "loan". However, the organisation tries to turn this unit based top-down approach to a project-based bottom-up approach. Furthermore, the main budget is created once a year, but revised one or two times a year to a larger extent, minor adjustments are also made each month, based on the latest forecast. In between these updates the budget is though locked. Moreover, a quote from a ME employee regarding the budget depicts the view of the budget:

> *"The budget is often seen as too far from reality to be of any use, but everybody is relating and tries to follow it." – ME Employee*

What should be mentioned is that the size is of the projects is not seen as the main issue, but rather the number of projects and change of scope during budget periods.

Regarding how CEVT is planning, the organisation is always tied to larger projects. Which implies that even though CEVT has the ability to affect projects, they very seldom have their own. The planning is set upon estimations from product planning and production plant, which results in a time plan and a resource allocation plan. Furthermore, the time plan is updated as the ME department works towards product launch, but the resource allocation plan is much more static, even though the content of the project can vary significantly. Worth mentioning is that when there is some sort of change, the time for each phase in the time plan is shortened. Hence, the initial response is that the time is too short, but with hindsight the deliverance of the project is occurring according to the new time plan. There are though suspicions within the organisation that there is a trade-off between this shortened time plan and quality, i.e. time to market versus quality of the project.

When it comes to forecasts it is the finance department that ties it all together, based on input from other departments. Furthermore, each unit and project deliver estimations for required man power, also estimations regarding the project content but these are seldom accurate. The forecasts are updated each month but revised more extensively one or two times a year before the large budget updates mentioned earlier. Moreover, in terms of updates the unit perspective is more vivid than the project. Another parameter to consider is that the forecast as of now depicts available resources but not the demanded resources.

5 Result and Analysis

In this chapter, gathered data that have been put forth throughout the thesis is synthesised and analysed. The analysis is a result of reflections made through comparing data gathered from the interviews and focus group with theoretical framework. As a result, the chapter will answer both research questions, stating the effects of managing late changes and conclude in improvement suggestions on how to manage the issues. Firstly, the result from the focus group is presented in section 5.1, followed by section 5.2, answering the first research question. Secondly, in section 5.3, a literature analysis is depicted, comparing the literature to facilitate the combination with the results and creating a not case specific foundation to facilitate the usage in other contexts. Lastly, in section 5.4, the second research question is sought to be answered by fusing theory and the findings from the result and first research question.

5.1 Organisational Issues Regarding Late Changes

In this context the late changes are defined as issues that affect the system on a wider perspective, i.e. it is not just a single part that has to be changed, but the effect of the change propagates to other levels of the system. Furthermore, there is an awareness of the problematics regarding late changes in the organisation, below the result from the focus group is presented in a synthesised manner. For a complete description of the method used for the focus group see Section 3.3.1. The final result from the focus groups session is portrayed in Figure 20: AIM - Master Map. The question used for the focus group session was *"What is the problem when managing late changes in Manufacturing Engineering."* which can be seen in Figure 20 in the red box located in top left corner.

Six main issues have been identified when it comes to managing late changes in CEVT, these are shown in Table 11. Furthermore, there are sub-issues describing the problem at a finer granular level. As seen in Table 11, there are three levels of the issues, where three of the six main areas are the 1st and highest, two belongs to the 2nd level, and one belongs to the 3rd level. All issues at 2nd level, plus the" Lone wolf" Issue 3 at the 3rd level, are graded to depict the interpreted importance for affecting the management of late changes. Here, three 2nd level issues received the highest severity, namely "Change scopes are not defined clearly", "The solution is sub-optimized", and "Processes are not made for managing late changes". As an example, Issue 1 "Late Changes lack definition and Communication" has two 2nd level sub-headings "Change scopes are not defined clearly" and "Late changes are poorly communicated and lack transparency in the organization", receiving 7p and 6p each. Here, the 1st level is a joint heading of the 2nd level, which in turn represents the 3rd level statements. E.g. "Change scope are not defined clearly" represents the statements "The information about the changes are not defined clearly to be able to act on the changes" and "It is sometimes difficult to know what is included in the change".

The issues are also interacting and affecting each other, this interaction can be seen in Table 12, where reading in the horizontal direction, the affected issues by the row are shown, e.g. Issue 1 affects 2, 4, and 5. While reading in the vertical direction, shows which affects the column, e.g. Issue 2 is affected by Issue 1. As seen from Table 12, the 4th issue is a result of all the other problems, as all other issues affects this one. Furthermore, the 1st and the 2nd issues are the ones affecting most other issues, hereby these are the ones propagating most through the system. The summary of the issues and session was formulated into following sentence: *Lack of communication and definitions, combined with unsuitable processes and tools for managing late changes, create sub-optimized solutions*. For a visual representation of the interactions and full result, see Figure 20.

Table 11: Issues Regarding late changes

1st level	Issue 1 Late Changes lack definition and Communication				
2nd level	Change scope is not defined clearly **-7p**		Late changes are poorly communicated and lack transparency in the organization - **6p**		
3rd level	The information about the changes are not defined clearly to be able to act on the changes	It is sometimes difficult to know what is included in the change	The problem is that ME is not part of late change decision	Changes made in wrong order and not communicated back (i.e. No communication)	The problem is that late changes do not get decided in a transparent way

1st level	Issue 2		Issue 3	Issue 4	
2nd level	The Solution is sub-optimized - **7p**			Negative mind-set for managing late changes - **2p**	
3rd level	The problem is that ME does not have the time to do late changes professionally	The product becomes sub-optimized because other parts or processes needs to adapt to the change	The Problem is that ME Competence is measured according to late change performance - **0p**	The problem is frustration that your previous work is trash	Mentally embrace the changes as opportunities, to have jobs in Gothenburg

1st level	Issue 5 Budget and plans are not flexible enough to support Late changes						
2nd level	Lack of flexibility to allocate enough resources - **5p**		Late changes generate re-work - **0p**		Late changes drives costs - **1p**		
3rd level	The problem is issue with resources and project timing	ME TCF should increase the ability to allocate resources faster to the subjects/areas where they are needed the most	Repetitive work needs to be done - waste of resources and quality depreciation	Finished work can be undone and needs to be done again e.g. Matching	It can take long time to get the time and cost consequences	It drives cost, e.g. Finished tools	Resources (Human Capital, Money) ask for more

1st level	Issue 6 Processes and tools are not developed to manage late changes			
2nd level	Processes are not made for managing late changes - **7p**			
3rd level	It can delay verification process	Time to get approvals is limited/slow	The PLM-system used at CEVT is not optimized to cope with late changes due to the high administrative workload it requires	Assign a taskforce with authority to take decision

Table 12: Relationships between Issues regarding late changes

Issue	1 Definitions and Communication	2 Sub-optimized solutions	3 Measured upon late changes	4 Negative mind-set	5 Budget and Plans	6 Process and tools
1		X		X	X	
2			X	X	X	
3				X		
4						
5				X		
6				X	X	

The table is showing the relationships between the Issues regarding late changes. Reading in the horizontal direction, the affected issues by the row are shown, e.g. Issue 1 affects 2, 4, and 5. While reading in the vertical direction, shows which affects the column, e.g. Issue 2 is affected by Issue 1.

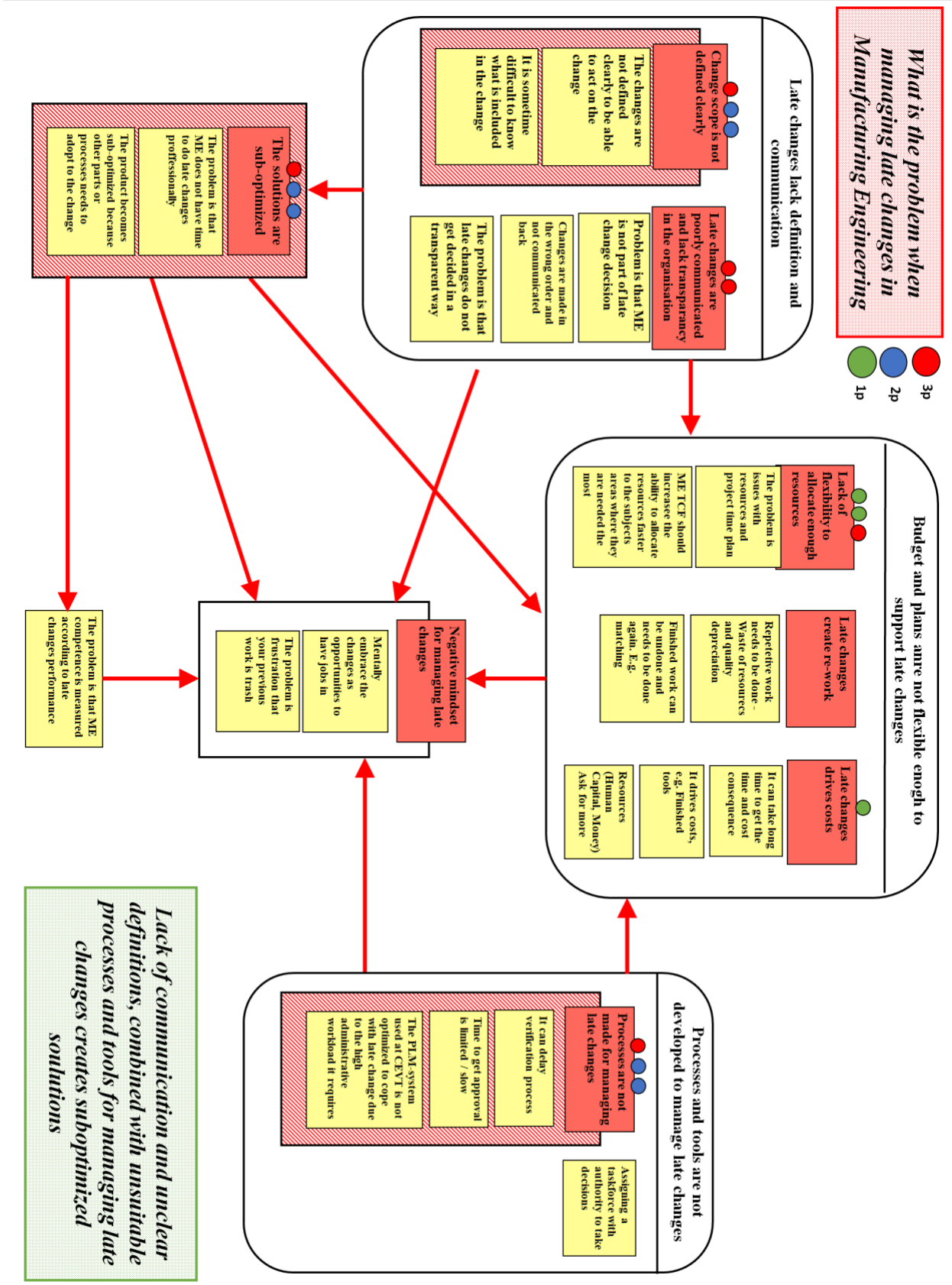

Figure 20: AIM - Master Map

5.2 RQ1: Effect of Late Changes

In this section, the first Research Question, see below, is sought to be answered.

- *"How does late changes affect Manufacturing Engineering?"*

Below, Figure 21 illustrate the six identified factors from previous section, and has divided them into causes and effects. Figure 21 also acts as a systematic and logical approach to conduct reflections and analyse the underlying problematic factors that occur when managing late changes. Firstly, identified causes are analysed in Section 5.2.1 in order to set a foundation, which is followed by answering what effects the causes create when managing late changes in section 5.2.2.

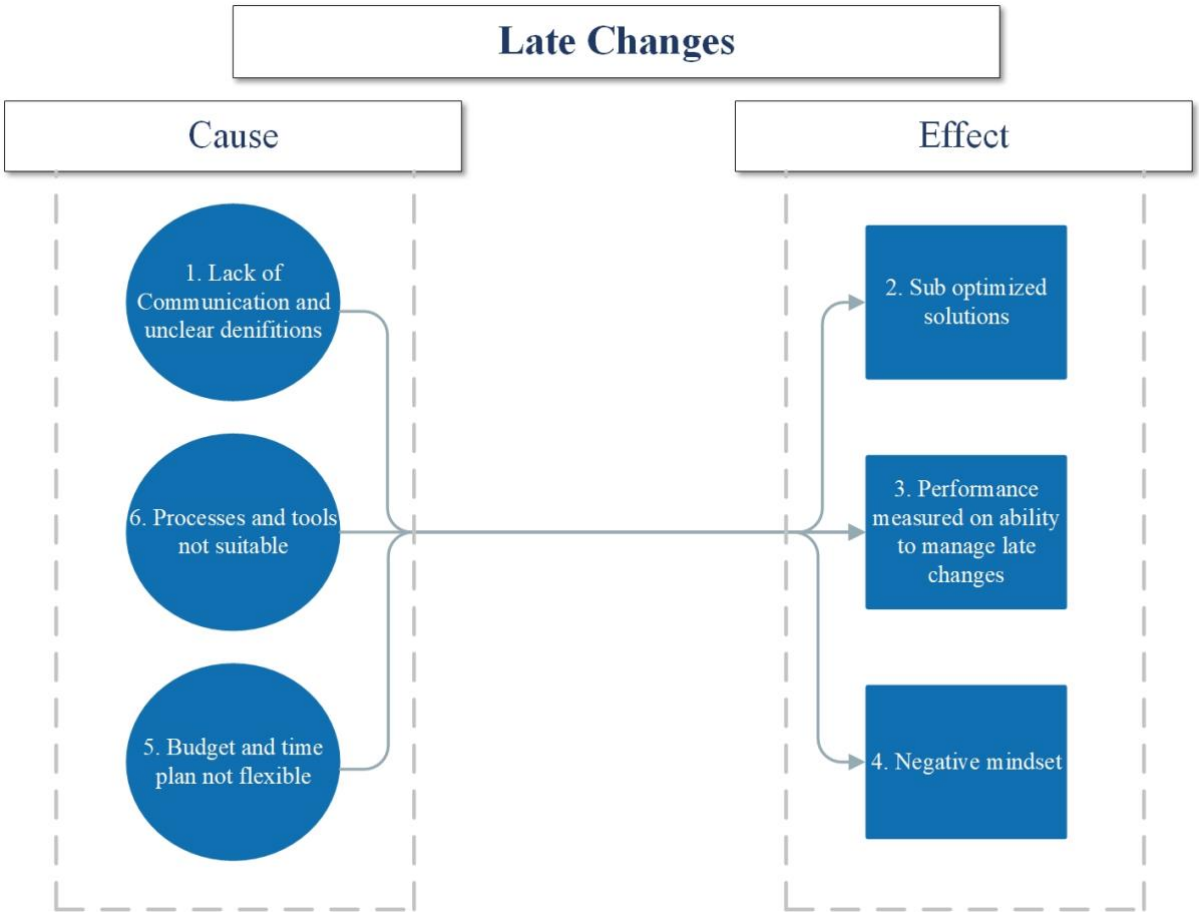

Figure 21: Late Changes - Cause and Effect

5.2.1 Causes

There are three main causes interacting with each other, namely; *Lack of communication and unclear definitions*, *Processes and tools not suitable*, and *Budget and time plan not flexible*, see section 5.1. These cases are presented and analysed in the following section.

5.2.1.1 Communication and Unclear Definitions

The first cause is *Lack of communication and unclear definitions* that occurs when late changes are initiated. Even though CEVT wants to be an agile organisation, its structure and how it operates does not support this intent. The organisation is functional based and formed according to a linear hierarchical structure as compared to, for example, an agile sprint-based structure with cross-functional and autonomous teams.

Each function and department within ME consists of people with specific competence. This type of environment fosters a one-dimensional perspective, in which each team focus on only developing their area. Consequently, when late changes occur, the management have to delegate the work in accordance to each functional group. Each group then needs to respectively solve the issues in a silo-based manner, limiting the communication bandwidth and decreasing the cross-functionality. This was also highlighted in Table 1: Problems when managing late changes (Alblas & Wortmann, 2012).

CEVT is a centralised R&D unit within Geely auto group and the business structure is based on delivering engineering solutions to order. The customer for CEVT, in this case becomes the auto companies in Geely group. Although traditional automotive OEMs[13] sell vehicles to different markets, the development is usually homogenised in one unit. The decision structure for CEVT is therefore different compared to the traditional product development unit which have direct contact with the customer. Figure 22 illustrate the communication process between CEVT, the "customer" (Auto company within Geely group), and the end customer. As shown, the communication passes through the "customer" before reaching the final End Customer. In addition, as the communication is centred around Geely, the decisions are often taken outside CEVT's designated area, creating a communication gap.

To facilitate the global project management, most of the communication is made through email, phone calls, and video conference meetings. Moreover, the engineers have several ongoing projects at the same time, and the workload is high and intense. Adding the complexity of managing changes, the communication and objectives becomes harder to manage in a global setting. Hence, as the communication is unclear down the hierarchical levels and horizontally to all involved parties, the end result is affected, or as stated in Section 5.1, the engineers need to create solutions that are sub-optimised. The result can be seen not only as a communication gap, but also a missing link between top management and the engineers.

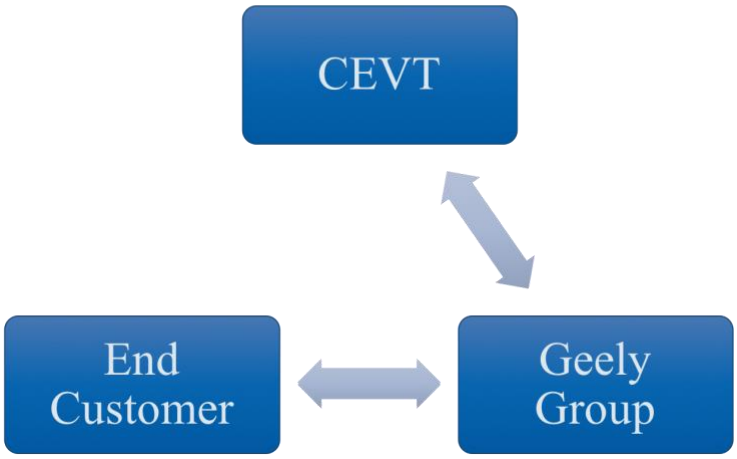

Figure 22: CEVT, Geely, and End Customer - Communication

CEVT have a system for documenting and managing changes, referred to as the Part Change Management system. However, when larger system level changes occur, the organisation lacks a procedure for how to correctly manage the effects. Moreover, directives for managing late changes in the development cycles are poorly communicated, as seen in Table 11: Issues Regarding late changes. The changes lack clear action plans, and in general, there is no structured approach to tackle larger system level changes and the complexity it entails. In contrast to a firefighter, who with precision knows exactly what to do in fire emergencies, CEVT both lack a clear action plan with clear communication channels and defined tasks, but also a formation strategy. Instead, decisions become more centralised

[13] Original Equipment Manufacturer

when undergoing a change, increasing hierarchical structures and creating inefficient processes and bottlenecks. As a result, the engineers working with the changes feel lack of transparency and sees this as an uncertain environment. Further examples of poor communication and unclear definitions can be seen in Table 13 below.

Table 13: Examples of Poor communication and unclear definitions

Number	Example
1	Cause and effect relationships are not clear. If a certain process is late, what other processes will be affected?
2	Project timelines becomes harder to control as the delay is usually hard to measure.
3	Unclear who is leading the change.
4	Unclear change scope and the magnitude of the change.
5	Might involve Geely ME and the system suppliers. Increasing communication complexity and bandwidth.

5.2.1.2 Processes and Tools are not Suitable for Managing Late Changes

The second cause identified relates to the organisations processes and tools. CEVT uses NPDS as a reference tool for the engineers to clarify what process to follow at any given moment during the different product development phases. Moreover, NPDS is a static system, and can therefore not be adopted and reflect on-going projects in detail. In other terms, as changes occur, formulations to the project plans are made in accordance to the change impact. NPDS do not support deviations in the product development structure, hence, it becomes harder for the workers to interpret and compare their day-to-day activities with NPDS.

Additionally, NPDS is a heritage from Volvo and as Volvo's operations are different to CEVT´s, the system was not fully representative of the actual work in some area. To put it differently, CEVT has inherited a management system that was designed for a different user. During the last years, CEVT have tried to update NPDS in accordance to their daily activities to reflect the reality. However, as mentioned previously, CEVT is characterised by continuous changing projects that entail complex development structures, using a static model to represent a volatile environment creates pragmatic issues. As one of the interviewees stated:

> *"We cannot use NPDS, as it both lack correct processes which reflect the work we do, and information and continuity". – ME Employee*

What should be added, is that NPDS is supposed to be a generic system and include Geely Auto as well. As Geely is a Chinese organisation, both the culture and processes are different. Using a system to reflect two different ways of working decreases the usability and the applicability. The result is that NPDS instead becomes a reference system that to a large extent is not used as a reference in the daily activities.

Moreover, as late changes emerge, the engineers need to figure out were in the product development phases to restart. Additionally, a consequence analysis needs to be made showing the affected processes. For example, if the physical verification stage is completed and a change emerge, the restart position might be in virtual creation, followed by virtual verification and then back to physical verification. Furthermore, global legislations, regulations, safety concerns and customers commercial targets may be re-assessed in accordance to the revised version. Hence, being a factor that prolongs the development process. Another aspect regards that the PLM system and computer tools are seen as inefficient when managing late changes. The engineers suffer from excessive administration from the systems when undergoing changes. In addition to the internal system inefficiency, as CEVT collaborates with its customers, the PLM system and tools needs to be capable of interacting with several different interfaces. This interaction process with customers can increase the complexity, hence both prolonging the development process and adding to the issues when undergoing the change.

5.2.1.3 Budget & Plans are not Flexible

The third cause concerns budgeting, resource allocation and time plan not being flexible enough to adopt in accordance to the effect generated by the changes. It was clearly manifested that this was a serious issue among the engineers that attended the focus group. Late changes is not only depicted as a factor affecting the overall organisation, but also the day-to-day work. The added cumulative work from the changes results in decreased work efficiency and increased stress levels. As one of the engineers said:

> *"Our human capital decreases as we have to manage these changes in these circumstances".*
> *- ME Employee*

The budget is set once a year and revised twice, after four and eight months. Still, financial resources is rarely allocated to the change processes. Moreover, there is a common view that changes have become a part of the development projects. However, top management expect to keep the initial budgets throughout the project. At the beginning, each project receives a certain amount of resources to be allocated in terms of workers and product cost. However, as the traditional budgets tries to extrapolate future value in an uncertain environment, the accuracy tend to offset, also adressed in Table 1: Problems when managing late changes (Alblas & Wortmann, 2012). The traditional way of budgeting is usually a task managed by top management, which are not as experienced with the products and processes as the engineers. It is clear that a missing link is generated from poor communication and understanding between the engineers who actually perform the work and top management that sets the requirements. Budgets also become bias from having to meet the annual financial targets and not the actual work due to the top-down approach.

5.2.2 Effect

Following section summarises all causes and issues of managing late changes, and synthesis the effect in three parts. The first, *Sub-optimized solutions*, followed by *Performance measurement*, and lastly *Negative mind set*.

5.2.2.1 Sub-optimized Solutions

Sub-optimized solutions is the result when the engineers need to make compromises on the product in order to manage the late changes in their day-to-day tasks. During the previous section 5.2.1, three causes were depicted which showcased the problematic issues that occur when managing late changes. Needless to say, all causes have effects, and the same goes for the aforementioned ones. The most vital effect is sub-optimized solutions. As a result of CEVT´s as-is-state and the current management principles when solving late changes, the engineers are forced to present sub-optimized solutions in order to manage the short time frame and surplus of work. When the changes are initiated top management does not allocate additional resources in terms of financial measure and time for the engineers to professionally manage the changes in a correct way. The engineers are fully occupied with their current work load, and as a result, with the additional work they simply do not have the time or resources to manage the changes. Hence, they create sub-optimized solutions in order to manage their day-to-day activities.

It is clear that the result of today's organisation structure, processes, management principles, lack of communication and unclear definitions, unsuitable processes and tools, and not flexible budgets and time plans have a direct connection to sub-optimized solutions. All these factors create constrains and misalignment between the different departments and functions which result in inefficiency of work. Lack of communication and unclear definitions together with processes and tools not designed to manage late changes have engineers fall into silo based problem solving which complicates the overall management. As each function starts focusing on their own systems, the complexity rises and the holistic solution is affected. The current way of managing late changes is therefore not sustainable in the long run. In addition, cost of poor quality increases as the changes occur later in the projects. If the engineers need to make larger system changes large financial investments are created at this stage. Further, allowing sub-optimized solutions also increases the risk for both future failure and recurring changes.

5.2.2.2 Performance measured on ability to manage changes

The second effect concerns the assessment of how the changes are managed and solved. Engineers state that their performance is measured by their ability to manage and solve the changes. The causes mentioned previously orchestrate an environmental setting that is not ideal for the engineers to showcase their capabilities, and as a result, the measurement becomes subjective to the setting and incorrect to the engineer's actual capabilities. As showed in Table 12: Relationships between Issues regarding late changes, Sub-optimized solutions have a direct effect on how the engineers' performance is measured. As the environmental setting fosters sub-optimized solutions, the engineers perceive that they are measured upon factors which is out of their control and the measurement becomes deceptive.

5.2.2.3 Negative Mindset

The last effect concerns the atmosphere that is created around the late change process. All identified factors have an effect on the atmosphere creating a negative mindset among the engineers, which can be seen in Table 12. In addition, the organisation has none or few external motivational factors, i.e. such as monetary or other benefits. Instead, having complex problem-solving day to day activities and an interesting environment to work in acts as a catalyst for increasing the intrinsic motivation instead of using extrinsic measures. However, as portrayed, negative mindset is a result of just that, the work at hand. Some of the engineers might find the intrinsic motivation sufficient, but if not carefully managed, the work might exceed the motivation creating a negative spiral. The magnitude of the problem is stretched throughout the organisation including majority of the individuals that in some way are involved in the change.

5.3 Literature Analysis

To enable other contexts to make use of the findings, the literature is analysed as a separate step, and is here presented in a synthesised manner that is not case specific for CEVT, but regards the management of late changes in general.

The four presented literature areas[14] are each addressing issues regarding organisational flexibility and hereby, facilitating the management of late changes. The literature areas all have their core concepts regarding managing change, these are shown in Table 14: Literature Core Concepts regarding adaptation to change. Even though different approaches, the areas have a high degree of commonality. One major difference is that Beyond Budgeting, Agile Methodologies, and Behavioural integration - Ambidexterity, is not explicitly addressing how to manage and create truly innovative solutions and ideas, i.e. radical innovations. However, Dynamic Capabilities and the two other Ambidexterity categories propose solutions to this issue.

Table 14: Literature Core Concepts regarding adaptation to change

			Core of concept regarding adaptation to change	
Literature Area		**Dynamic Capabilities**	• Sense • Seize • Transform	• Minimize hierarchy • Constant renewal • Don't lock-in, beware of path dependencies
	Ambidexterity	**Structural Separation**	Parallel exploit/explore	
		Sequential alternation	Alternating exploit/explore	
		Behavioural integration	Individual adaption and autonomy for managing exploit/explore	
		Agile Methodologies	Iterative updates based on autonomy and customer collaboration	
		Beyond Budgeting	Base business on environmental context, not predetermined statements. Guide and trust autonomous units.	

The areas of literature have several categories in common, which are shown in Table 15, for a complete view of the analysis tool see Appendix 1. As all factors are a part of a holistic system, they are also interacting with each other. In Figure 23, an interrelationship diagram is shown to visualise the interactions between the categories in Table 15. As seen, from Figure 23, autonomy is the final category where the others tie together. This autonomous unit can be seen as the final function that is actually performing the change. Hence, to facilitate the capacity of the unit to act upon changes will promote organisation flexibility. Firstly, the autonomous unit has to be able to act without waiting for go/no-go decisions, hereby a requirement is a decentralised decision structure. Secondly, to support decentralisation the unit has to be able to allocate resources, both regarding human and financial. The resources also have to be flexible in time, i.e. not have to wait until next budget or plan update, and the unit has to be able to control the amount of resources and workload. Regarding the workload it is seen that, to be efficient, the number of projects should be limited, while an over commitment leads to inefficiency and less flexibility. Thirdly, for top-management to let go of control the unit must be trusted, and to be trusted these units has to be transparent in what they intend and what they are doing. Fourthly,

[14] Dynamic Capabilities, Ambidexterity, Agile Methodologies, and Beyond Budgeting

top management has to feel secure about that the unit have all the relevant information to support both good decisions and are able to act upon them. This knowledge is in turn requiring wide organisational and functional knowledge, where the organisational knowledge, i.e. what is going on in the organisation and at other units, is supported by transparency. For the functional knowledge, the literature is suggesting integrated cross-functional collaboration and teams, emphasising that all relevant knowledge should be as close as possible to be able to respond quickly. The notion of both transparency and cross-functionality also minimizes the risk for decision-biases as it is essential that all alternatives are regarded as equal when hedging the bets for the future.

Table 15: Literature Comparison

	Areas						
			Ambidexterity				
		Dynamic Capabilities	Structural Separation	Sequential alternation	Behavioural integration	Agile Methodologies	Beyond Budgeting
Categories	Decentralisation	Yes	-	-	Yes	Yes	Yes
	Autonomy	Yes	Yes	-	Yes	Yes	Yes
	Cross-functional integration	Yes	-	Yes	Yes	Yes	Yes
	Renewal of processes, routines, structures i.e. Continuous improvement	Yes	-	Yes	Yes	Yes	Yes
	Trust people with responsibility	-	-	-	Yes	Yes	Yes
	Local power over resource allocation	Yes	-	-	Yes	Yes	Yes
	Allocate resources when needed, not based on previous decisions	Yes	-	Yes	Yes	Yes	Yes
	Transparency in organisation	Yes	-	-	-	Yes	Yes

Beside these interlinked topics mentioned above, there are two other categories of topics which influences the system, these are classified as either *Guiding* or *Supporting*. The *Guiding* regards vision, strategic intent, culture, and incentives, all steering the organisation towards a common goal, enabling top management to direct the autonomous unit but not go into operational detail. The *Supporting* category consists of organisational processes, routines, and structures that promote change but also are possible to renew when obsolete or inefficient. An example of routines for processes to handle changes in the system is to categorise changes depending on impact on where in the environmental system[15] and level of product development impact[16]. The renewal of processes is also a method to minimize the path-dependencies, hence enabling more opportunities to be grasped in the future. Needless to say, these processes, routines, and structures should not increase the bureaucracy in the organisation, like

[15] i.e. function, organisational, industry, or society
[16] i.e. part, product family, program, system, new product

unnecessary control functions, they should neither be allowed to increase hierarchy, which should be minimized. These supporting structures could be seen as means to eliminate hinders on the road to flexibility and pre-emptive measures for managing late changes.

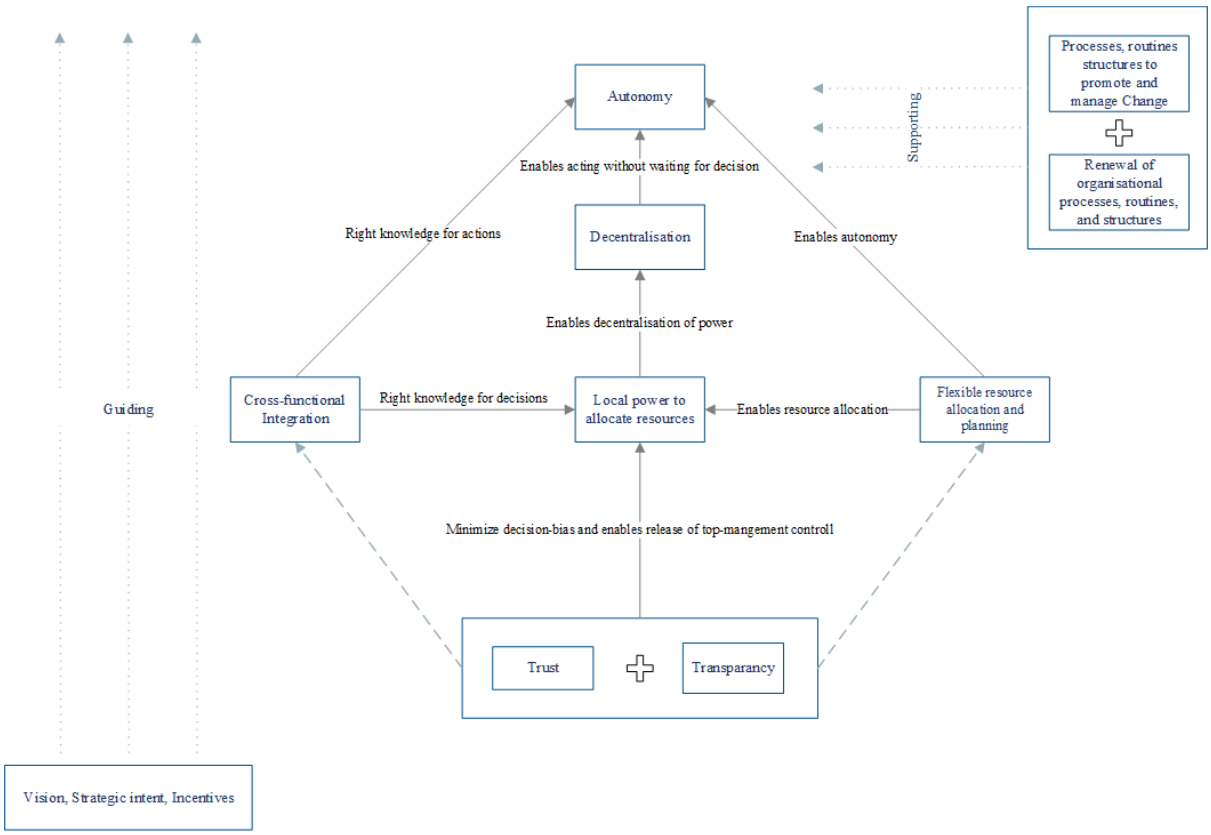

Figure 23: Category Interrelationship Diagram

5.4 RQ2: Improvement Suggestions

By addressing the causes and effects presented in previous section, i.e. 5.2., and combining these with the analysed literature, this section aims to answer Research Question 2:

- *"What improvement suggestions can be identified to support and facilitate Late Changes?"*

Below each of the presented causes are discussed under separate headings and improvements suggestions are brought forward. The explicit connection to the theoretical areas can be found Table 15: Literature Comparison.

5.4.1 Communication and Unclear Definitions

The development of a car requires cross-functional collaboration (Alblas & Wortmann, 2012; Davies et al., 2017), which is seen in CEVT as the interaction between different functions are extensive. However, even though CEVT have cross-functional collaboration, ***cross-functional integration*** is required to become more flexible. This implies team structures based on all necessary competencies to complete the task, not team structures based on functions. The Cross-functional integration will facilitate communication, enhance understanding, and make it easier to manage the workload (Cockburn & Highsmith, 2001).

Furthermore, as seen in section 5.3 Literature analysis a ***decentralised structure*** is required to achieve autonomy and flexibility. By minimizing the layers of decision hierarchy in CEVT autonomy of the cross-functional teams will be facilitated (Teece & Pisano, 1994; Teece, 2007). As the decentralised structure enables decisions closer to the problem several improvements can be achieved. Firstly, it decreases the risk of sub-optimisation due to more updated knowledge (Bogsnes, 2016; Rigby et al., 2016). Secondly, it will also enhance flexibility as actions can be done without waiting for a higher hierarchical level to respond, i.e. minimizing unnecessary communication (Eisenhardt & Martin, 2000; Teece, 2007). Thirdly, it increases engagement and ownership of the problem, decreasing the negative mindset and minimizing rework (Cockburn & Highsmith, 2001). Worth mentioning is that the decentralisation does not have to imply a complete structural change, the important factor is where decisions are taken.

Moreover, a requirement for the decentralised structure is ***transparency***, both upstream as well as downstream in the hierarchy, and also between different cross-functional teams (Bogsnes, 2016; Rigby et al., 2016). In the context of CEVT, the communication with China is vital and to be truly transparent will be a problematic issue due to both geographical distance but also due to cultural difference. However, the transparency is a necessity to achieve trust within the organisation (Rigby et al., 2016). The trust and transparency will in turn decrease the risk for decision-bias as resources has to be allocated, based on resource requests from the cross functional teams (O'Reilly & Tushman, 2011; Teece, 2007).

5.4.2 Processes and Tools are not Suitable for Managing Late Changes

As of now, CEVT struggles with high amount of changes, categorised as either running changes or through PCM, both through existing systems. What is missing is ***linking resource allocation and planning with late changes***. Even though resources can be allocated, regarding for example PRIs[17], these are still limited towards budgets and pre-set time plans. Hence, creating a limited flexibility when manging the changes (O'Reilly & Tushman, 2013). Furthermore, the time required to perform the change has to be allocated to the functions the change concerns (Bogsnes, 2016). If not incorporating the added task into individual time plans the workload will increase beyond suitable levels (Alblas & Wortmann, 2012; Wheelwright & Clark, 1992). As suggested by Albas & Wortmann (2012), the management of late changes is facilitated by categorisation of the changes. This is done by CEVT in their PCM process, but could further be used if linking it towards the resource allocation and planning

[17] Product Issue Tracker

mentioned above. Below, in Figure 24, a Change Severity Framework is shown, applicable for the automotive industry. By utilising the mindset of this approach, CEVT could categorise the change impact and hereby enable a better approximation of resource and planning requirements.

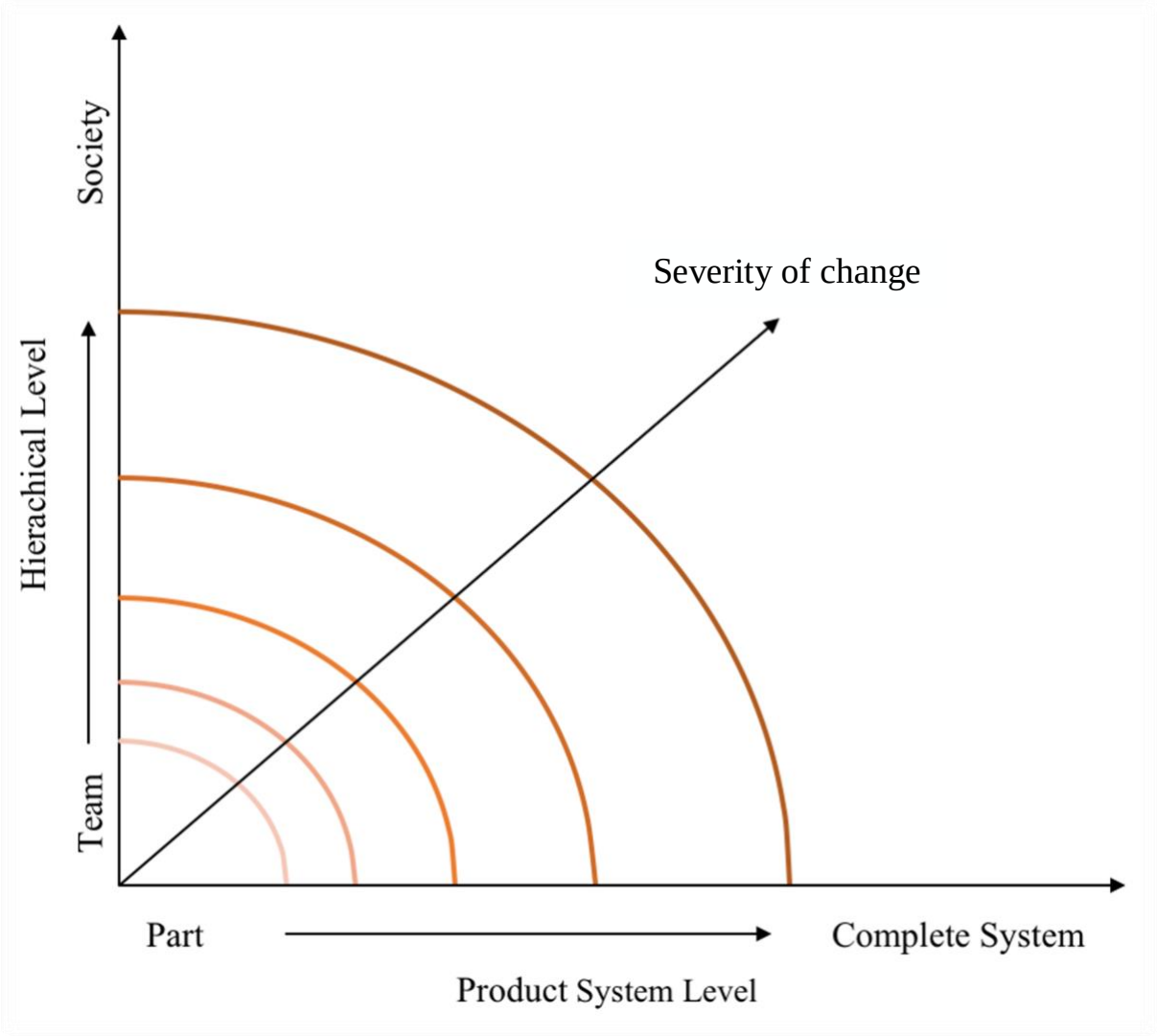

Figure 24: Change Severity Framework

The Change Severity Framework in Figure 24 classifies the changes regarding where it impacts on a hierarchical level and where it impacts on a product system level. At the x-axis, i.e. the Product System level, the categorisation concerns Part, Top hat, Shared technology, Architecture, and Complete System. The Complete system change could for example imply that the whole vehicle is changed. On the y-axis, the Hierarchical level goes from the smallest organisational unit which here is the team[18] to the largest which is the society as a whole. As seen from Figure 24, the severity of the change will increase as it moves towards the outer rims of the graph. By clearly define and categorise the changes, combined with clear directions for what this implies to the engineers, a defined approach can be taken to manage the change at hand. Hereby, the categorisation will facilitate the understanding and linkage of resource allocation and planning regarding late changes, which will be discussed further in Section 5.4.3.

As one of the notions from the literature analysis, see Section 5.3, and also emphasised by Teece (2007), addresses the issue of ***processes and routines that fosters flexibility and are renewable*** following improvement suggestion regards NPDS and CMS. As mentioned earlier in Section 5.2.1, NPDS is a static system, which limits the possibilities for flexibility (Helfat & Peteraf, 2015). Hereby, to make

[18] The individual will be the smallest unit, but if only affecting the individual it will probably not reach the system, hence excluded

CEVT more flexible their process managements systems has to be flexible and adoptable for managing late changes (O'Reilly & Tushman, 2013). An important aspect is to illustrate what happens when a process becomes interrupted by a late change (Alblas & Wortmann, 2012); What other processes will be affected? What has to be re-planned, and what has to be re-done? There are a lot of questions which has to be accounted for. Clarifying the connections and definitions for processes, tasks, and deliverables will be a path for achieving a more coherent system. Furthermore, in a constantly changing world the ability to renew the systems are essential (Teece, 2007; Teece et al., 1997). If NPDS becomes a "living system" that can be updated in parallel with the change of the surrounding world, accuracy will be increased, but also applicability and usefulness to engineers. Furthermore, even though NPDS has functions for updates, CMS might be where there will be more frequent updates. However, both management systems should have procedures to sense when to change, seize the opportunity, and transform the inherent processes, preferably in real time if it is possible. Worth mentioning is that these procedures for renewal should be of minimized bureaucracy and hierarchy (Teece, 2007), hence falling back upon previous sections about trust and transparency (Beck et al., 2001; Bogsnes, 2016).

Related to the two paragraphs above is the creation of an action plan regarding late changes. As of now, the engineers are missing a clear guidance for what to do when managing late changes. Hence, the actions are delayed due to uncertainty (Davies et al., 2017; Reeves et al., 2017). This might though be relieved as knowledge about the PCM system is spread. If not, the creation of routines, i.e. creating action plans, for managing late changes the engineers can take actions as soon as the change has been proclaimed without further ado.

The presented Change Severity Framework in Figure 24 and the improvement suggestions to CEVT's QMS in this section, aims to conform processes for managing late changes. Moreover, these suggestions will also enhance the communication and clarify definitions regarding late changes, also facilitating the accuracy of plans and budgets, which will be discussed in following section.

5.4.3 Budget & Plans not Flexible

As noticed, even though late changes are a part of CEVT's day-to-day work, late changes are neither incorporated into the plan nor budget. Hence, these management tools are doomed to be inaccurate (Bogsnes, 2016). As pointed out in the literature, change should be embraced as an opportunity, changes should be seen as a possibility to enhance the final product. Therefore, by ***planning and budgeting for late changes*** CEVT can improve their estimations regarding the future (Hope & Fraser, 2000). Moreover, the risk for over commitment amongst the engineers are also minimized (Beck et al., 2001; Rigby et al., 2016).

Furthermore, the updates of budgets and plans occurs on calendar basis, which dampens flexibility as resources are locked between these instances (Bogsnes, 2016; Hope & Fraser, 2000). If ***creating plans and budgets adopted to external and internal business cycles***, predictions and adaptability will increase (Bogsnes, 2016; Rigby et al., 2016). Depending on the situation, the renewal of budgets and plans could follow projects, processes, or other business events where updates are needed. In addition, budgets and plans should be allowed to be adjusted in a higher degree in between updates to allow for faster response (Hope & Fraser, 2000), i.e. not be locked between revisions.

As of now, CEVT is hierarchical and in many cases steered in a top-down manner, even though there are attempts to create more bottom-up influences. By ***promoting the bottom-up influences***, increased accuracy and commitment will be fostered regarding budgets and plans (Beck et al., 2001; Bogsnes, 2016; Teece, 2007). Worth mentioning, is that this both build upon and foster the previously discussed autonomy, decentralisation, transparency, and trust.

What has been said about budgets and plans above, is likewise applicable to strategy and forecasts (Bogsnes, 2016; Hope & Fraser, 2000). As these processes are interlinked, the adjustment of one process might not be enough to affect the system, but requires a complete system renewal to achieve success.

5.4.4 Sub-optimized Solutions

With the above-mentioned improvement suggestions, the minimization of sub-optimized solutions is sought. Hence, leading to higher quality products and solutions enabling a fairer evaluation of the engineers' performance. This will further improve the mind-set amongst the employees which in turn can lead to higher motivation creating a better performing organisation. In Table 16 a summary of the improvement suggestions can be seen in connection to their most related cause.

Table 16: Improvement Suggestions and Causes

Improvement Suggestions	Causes
Cross-functional integration	Communication and Unclear definitions
Decentralised structure	Communication and Unclear definitions
Increased transparency	Communication and Unclear definitions
Linking resource allocation and planning with late changes	Processes & Tools are not Suitable for managing late changes
Processes and routines that fosters flexibility and are renewable	Processes & Tools are not Suitable for managing late changes
Planning and budgeting for late changes	Budgets & Plans not flexible
Creating plans and budgets adopted to external and internal business cycles	Budgets & Plans not flexible
Promoting bottom-up influences	Budgets & Plans not flexible

Furthermore, as shown in Figure 23: Category Interrelationship Diagram, linkages exist between the identified categories, and this is also the case for the improvement suggestions. In Figure 25: Linkage diagram of Improvement Suggestions a similar diagram is shown, but here depicting the relationship between the improvement suggestions. The final goal is to enhance the management of Late Changes, which can be seen in the top of the diagram. The improvement suggestions *Creating plans and budgets adopted to external and internal business cycles*, and *Planning and Budgeting for Late Changes*, acts as supporting categories. These two improvement suggestions are combined with the already existing capability of CEVT, namely their internal education system *CEVT Academy*, which fosters learning and employee development. An important aspect mentioned by O'Reilly and Tushman (2011). Going to the Guiding categories to the left in Figure 25, CEVT has a guiding vision in *Developing Cars for a different tomorrow*, and their unifying values *Think Big*, *Get Inspired*, and *Find a Way*.

Furthermore, going from the bottom we have the trust and transparency enabling the *bottom up influences* and the *Cross-functional integration* (Beck et al., 2001; Bogsnes, 2016; Teece, 2007), as well as enabling Processes and tools that fosters flexibility and are renewable (O'Reilly & Tushman, 2011; Teece, 2007). The trust and transparency in combination with the bottom up influences is also increasing the accuracy of the supporting categories (Bogsnes, 2016) and will minimize the decision bias when creating and *linking resources allocation and with late changes* (Teece, 2007). To enable the right knowledge for decisions regarding resource allocation and plans the *Cross-functional integration* is essential, and this improvement suggestion will also enable the right knowledge for responding quickly to a late change (Cockburn & Highsmith, 2001). The improvement suggestion to have *Processes and routines that fosters flexibility and are renewable* does not only regard NPDS. It is also important that the systems set in place for, as an example, *Linking resources allocation with late changes* fosters flexibility and are renewable as well to not create more bureaucracy and ridged systems that tend to be obsolete (Teece, 2007). To reach the enhance flexibility and management of late changes, the decentralisation of power is necessary to enable decisions to be taken as quickly as an opportunity is sensed (Teece & Pisano, 1994).

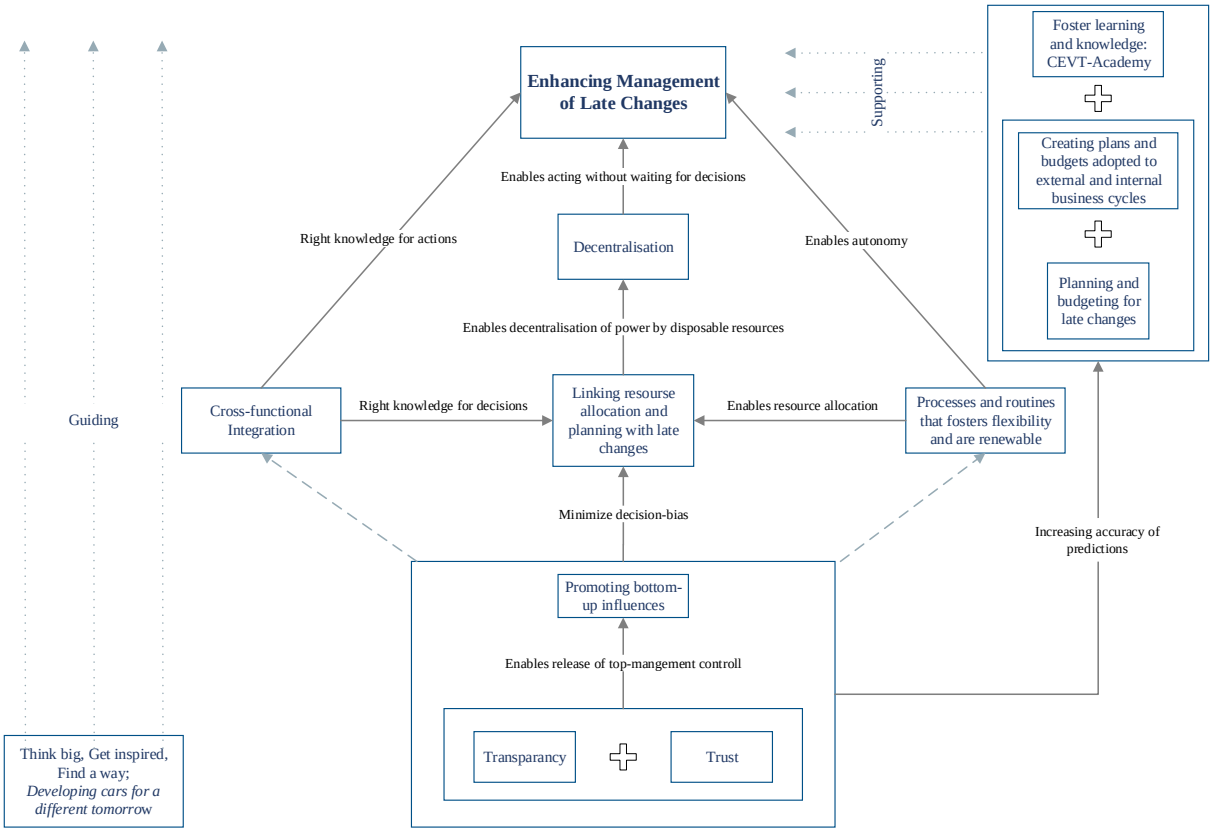

Figure 25: Linkage diagram of Improvement Suggestions

6 Discussion

This Chapter is a discussion of the results and analysis from previous chapter with the aim to problematise and create a more nuanced picture of the context. Furthermore, this chapter also discusses the usage of the findings.

The development of architecture, platform and Top hat entails long lead times, complex problem solving and uncertainties that needs to be managed throughout the new product development process. Additionally, taking into consideration the product life-time, engineers and top management need to extrapolate customer demands for many years to come. These decisions are related with large financial investments, long lead time for return on assets, and can be crucial for the organisations future. It has become a virtue for companies to sense market trends, and quickly being able to transform the organisation to meet these demands. In contrast, the customer demands are more volatile and changing faster than ever and it becomes harder for companies to anticipate, forecast, and plan. For a company like CEVT, this directly translates to having a development process that is capable of assimilating different demands and being able to change accordingly.

Since vehicles of today are gaining added features related to software, the industry is trending to become more similar to smartphones. Digitalisation, introducing connectivity to the vehicle, and also having autonomous driving demands changes to the business model compared to the traditional automotive organisation in order to survive. Not only is new competence needed, but both the management and development process of software is vastly different to hardware. In other terms, it will also affect how the development processes will look like. Comparing software and hardware development, software-based product development usually consists of smaller short development sprints that are characterised with close proximity to the customer and their feedback. By enabling a close relationship with the customers, the developer can more accurately develop products in accordance to the latest demands. However, an important factor is that the lead times are much shorter than those to developing hardware, which needs physical testing and manufacturing. Combining both software and hardware development under the same processes creates an inefficient cluster. As the two are different in factors such as time, resources, and working structures, the combination results in irregular development process and unsynchronised deliverables and milestones.

The analysis chapter answers both the first and second research question, showcasing improvement suggestions to how CEVT can enhance their ability to manage late changes and meet new customer demands. The suggestions are a result of combining both literature and results with reflections to synthesis areas of improvements. Even though there are instances in the literature reflecting upon similar cases in the industry and its close proximity, primary sources from these contexts are missing. As Bryman & Bell (2015) argue the case study should focus on forwarding the complexity of the specific case and its details. The research has therefore also forward the uniqueness of the case and its complexity.

Furthermore, as there was only one focus group session, even though consisting of multiple perspectives, additional sessions would have strengthened the research result. Each identified issue should be investigated further to; Firstly, ensure that the issues are factual to the portrayed level. Secondly, contextualise and quantify the improvements in context of the company, and thirdly, analyse the effects of implementing the changes. This would allow the organisation to better understand the root causes of the problem and how the improvement suggestions should be implemented.

Moreover, as the research was focused upon the Manufacturing Engineering department at CEVT, the findings should not be applied without considerations towards a new context in the organisation. However, the Literature Analysis in chapter 5 will facilitate the extrapolation to other contexts as this is not a case specific part of the thesis. Moreover, the concept is scalable, as the research could be seen as a pre-study for which to start and build similar research upon, both from an academic perspective as well as at CEVT. Different settings apply for the different departments, and a thorough analysis should be conducted to conclude that the same improvement suggestions could be applied.

The improvement suggestions can be seen as a symbiotic system, depended and affecting each other in multiple ways, which is discussed in Section 5.4.4 Sub-optimized Solutions. This implies that by implementing only one, might give a small effect, while implementing several will generate a much larger effect as the combination of the suggestions are stronger than each one separated. Moreover, these interactions are addressed above regarding positive synergistic effects, but the negative effects are not address to a large extent, which therefore deserves more attention.

Furthermore, hinders and difficulties for implementation should be considered as these were not included in the scope of the research. The implementations of the improvement suggestions would translate in changing vital parts of the organisation. Another perspective that has to be accounted for is that the suggestions, even though developed for the ME department, would involve the whole organisation in a transforming project. Affecting both organisational structure and behaviour. Furthermore, an effect of implementing the improvement suggestions would result in changing the power structure i.e. decentralising the decisions taken by top management to lower levels in the hierarchy. By shifting the structure, the behaviour would also need to be changed, and in organisations and cultures which are autocratic, the change can be difficult. Since CEVT is closely collaborating with organisations and cultures that are both more autocratic and passive in their power structure, implementing these reforms would mean changing culture and behaviour that is deeply imbedded in each organisation, which is seen as a difficult problem to solve. Moreover, as mentioned in section 2.4.1 When to Implement Agile, there are circumstances that are more favourable for implementing agile methodologies. Even though these circumstances for CEVT can change over time, it is of importance to bear them in mind. It is also most likely that similar circumstances can be found for presented improvement suggestions. Hereby, should the suggestions be seen as a limitation of scope for improvement, directing further research regarding the implementation of the improvements suggestions.

Regarding vison and strategic intent, CEVT has, as mentioned, these components in their organisation. What might be missing is a unifying goal that is more short-term and explicit, as these values all are beyond something concrete and the number of projects the organisation is managing are extensive. Compared to when CEVT developed the CMA platform, CEVT is now missing an explicit and unifying short-term goal for which the organisation jointly could strive to achieve.

CEVT has grown rapidly in the last years, and with new people comes new knowledge, which follows that CEVT is constantly renewing itself to improve as an organisation. CEVT academy and weekly open sessions for improving NPDS are just some examples. In fact, this thesis can be seen as gesture for willingness to change, due to the nature of the topic and how the research was formulated in collaboration with the company and academia. Moreover, CEVT already has several of the categories presented in Figure 25: Linkage diagram of Improvement Suggestions. For example, their value words are important to guide the organisation towards their vision and they motivate their employees by foster learning and creation of new, innovative solutions, for something bigger. Since CEVT has a heritage from Volvo but also other automotive companies, inherited processes and procedures has to be revised to suit the new organisation. This renewal is something CEVT is constantly doing, never standing still but working with continuous improvements of their processes.

It is suggested that the findings stretch to include companies and industries that operate under the same circumstances. Rapidly changing customer demands, and uncertain markets is changing the global playing field, adding fast changing technology, all companies that have an internal product development process should see this research findings as a base to further build upon their capabilities in order to manage late changes. The synthesised literature and analysis tool presented in previous chapters can be seen as a formation for how the improvement suggestion are interlinked. The identified factors are supported by literature on how an organisation can manage changing customer demands. However, it is strongly suggested to see the literature analysis as a base for further organisation specific analysis to put the improvement suggestions into context of the subject.

When the physical constraints of hardware manufacturing and development are relieved by technology, the possibility for an organisation to utilise this speed will be vital. The findings in this thesis hereby creates a foundation for organisations to prepare themselves for the future uncertainties to come, and respond to our world of change. Further, factors such as globalisation and increased reach to larger markets have increased the overall competitiveness, making companies strive to differentiate themselves in areas portrayed as dominant. Therefore, being able to quickly meet customer demand will put organisations at the frontier displaying their superior capability of producing what the customer wants before their competitors. If an organisation adopts the forwarded framework in Figure 23: Category Interrelationship Diagram before its competitors, they will increase the possibility to differentiate themselves by enabling the mastering of this capability, creating a competitive edge.

7 Conclusion

The purpose of this thesis is to acquire an understanding for how a developing- and manufacturing organisation can respond to rapidly changing customer demands and hereby manage late changes in their ME department.

Below the two research questions are answered to reach the purpose stated above.

7.1 RQ1: How does late changes affect the ME process?

Multiple causes affect the ME process when managing late changes, causes regarding *unclear communication and definitions, Unsuitable Processes and Tools*, and *in-flexible budgets and plans.* Furthermore, these causes result in effects such as *sub-optimised solutions* and a *negative mindset regarding late changes*. Diminishing employee motivation and product quality.

7.2 RQ2: What improvement suggestion can be identified to support and facilitate the late changes?

To improve ME:s management of late changes, eight improvement suggestions are presented, namely *Cross functional integration, Decentralised structure, Transparency, Linking resources allocations and plans to categorised changes, Processes and routines that fosters flexibility and are renewable, Planning and budgeting for late changes, Creating plans and budgets adopted to external and internal business cycles, Promoting bottom-up influences.* By implementing these improvement suggestions, the flexibility of the organisation will be enhanced, which minimizes the sub-optimised solutions that occurs in the context of managing late changes.

7.3 Future Research and Concluding Remarks

For CEVT, there is a need for investigating the possibilities to implement the presented improvement suggestions. This is a prominent factor as there is no sign of a stagnating environmental change. Furthermore, to fully utilise the improvements similar research should be conducted at other departments.

From the perspective of efficient processes and organisational structures, there is a need of addressing the conflict between QMS and flexibility. As approaches such as Agile methodologies and Beyond Budgeting calls for more flexible control systems and autonomous units within the organisation, the traditional management structures are questioned. In the extension, the impact on delivered quality to customer, when above mentioned approaches have been implemented in a traditional industry, is a relevant aspect for investigation.

Even though there are research bridging theoretical areas such as Dynamic Capabilities and Ambidexterity, and also between Agile Methodologies and Beyond Budgeting, these concepts regard different levels of the problem. Hence, leading to that Ambidexterity and Dynamic Capabilities are connected but are missing the link to the more operative approaches like Agile Methodologies and Beyond Budgeting.

The clash between flexibility and standardisation presents a pragmatic paradox, in which will continue to be of interest, especially since there is no sign of stagnation in our environment when it comes to changing customer demands. Hence, aligning the paradox will foster an organisation with the ability to achieve superior competitive advantage.

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Appendix 1

			Category			
Area			**Decentralisation**	**Autonomy**	**Cross-functional integration**	**Renewal of processes, routines, structures**
		Dynamic Capabilities				
	Ambidexterity	**Structural Separation**				
		Sequential alternation				
		Behavioural integration				
		Agile Methodologies				
		Beyond Budgeting				
		Problems when Managing Late Changes				
		CEVT				

			Category		
Area			Trust people with responsibility	Local power over resource allocation	Allocate resources when needed, not based on previous decision
		Dynamic Capabilities			
	Ambidexterity	Structural Separation			
		Sequential alternation			
		Behavioural integration			
		Agile Methodologies			
		Beyond Budgeting			
		Problems when Managing Late Changes			
		CEVT			

			Category		
Area			Allocate resources when needed, not based on previous decision	Transparency in organisation	Promoting Reactive response regarding change
		Dynamic Capabilities			
	Ambidexterity	Structural Separation			
		Sequential alternation			
		Behavioural integration			
		Agile Methodologies			
		Beyond Budgeting			
		Problems when Managing Late Changes			
		CEVT			

			Category			
Area			People	Decisions	Resources and assets	Core of concept regarding adaptation to change
		Dynamic Capabilities				
	Ambidexterity	Structural Separation				
		Sequential alternation				
		Behavioural integration				
		Agile Methodologies				
		Beyond Budgeting				
		Problems when Managing Late Changes				
		CEVT				