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Coordination Challenges in Scaled Agile

A case study of collaboration between teams across organisational interfaces within Volvo Cars

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

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Abstract

The automotive industry is experiencing increased pressure for speed and flexibility while also seeing exponential growth of software influence in their products. To manage these challenges, many actors turn their attention to the software industry's ways of working. The adoption of agile methods has the potential to deliver significant value, but coordination challenges remain when scaling agile. This thesis assists in the struggle by identifying and describing coordination issues experienced between teams across organisational boundaries within companies facing agile transformations.

A case study investigating coordination between teams across an organisational interface at Volvo Cars was conducted concurrently with a literature review of agile coordination challenges and potential solutions to these. The literature review revealed research young in its tracks and an absence of conceptual frameworks to analyse coordination challenges. To facilitate analysis of the empirical findings, a segmentation of described challenges was made together with a synthesised list of mechanisms that could potentially be used to overcome these challenges.

The case study uncovered seven types of coordination challenges at Volvo Cars. These challenges were not unique to Volvo Cars specific context and could, to a varying extent, be connected to the coordination challenges identified in the literature. Furthermore, it was concluded that most of the challenges extend *beyond* the scaled agile domain. In some cases, challenges were remnants from before the agile transformation or results of the transformation itself rather than being linked to agile ways of working.

The thesis presents an overview of different agile mechanisms and solution ideas that can potentially mitigate the coordination challenges identified. However, more research is warranted for more concrete guidelines on the classification of issues and implementation of solutions. Finally, simply transforming an organisation to follow agile ways of working will not automatically solve coordination – agile provides a toolbox of mechanisms for coordination across interfaces, but practitioners need to choose, combine, and adapt these mechanisms to fit their unique context.

Keywords: Scaling Agile, Coordination in Agile, Agile Coordination, Coordination Challenges, Agile in Automotive, Agile for OEMs, Agile in Industry, Agile Enterprise.

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Terminology

ART – Agile Release Train. An organisational layer in an agile organisational structure.

Confluence – Wiki software used by Volvo Cars.

Department – Volvo Cars chosen term for sub-entity of internal organisations that are not considered ARTs – e.g. MESW.

ECU – The general abbreviation for Engine Control Unit that refers to the computer technology that controls the engine in a car.

GDPR – General Data Protection Regulation, the EU law governing data handling within and for entities conducting business within the EU.

Kanban – A lean process methodology.

MEHW – Manufacturing Engineering departments excluding MESW are collectively abbreviated as MEHW.

MESW – Manufacturing Engineering Software Download & Final Test is in the report abbreviated as MESW.

NVivo – Software used to code gathered data, both empirical data and data from the literature review.

OEM – The general abbreviation for Original Equipment Manufacturer is used throughout this report.

Organisation – Volvo Cars term of company large company entity – e.g. Manufacturing Engineering and P&Q.

P&Q – Product and Quality, the internal Volvo name for the R&D department at Volvo Cars.

SAFe – Scaling Agile Framework. The general name for a popular framework used to scale agile at larger organisation.

SCRUM – An agile team structure. Widely popular in smaller software development teams.

SOGI – Society, organisation, group, and individual.

VCAF – Volvo Cars Agile Framework. The internal name for the framework used to scale and implement agile at Volvo Cars.

VIRA – Software used for backlog management at Volvo Cars.

1
Introduction

The automotive industry is transforming. More complexity, uncertainty, ever-changing regulations, environmental requirements and increasing customer expectations are just some of the challenges that Original Equipment Manufacturers within the automotive industry – henceforth referred to as OEMs – are facing during this transformation. OEMs have to become more flexible and faster while keeping production costs as low as possible to meet these demands and stay competitive. One way to achieve this is through agile transformations that adapts and scales agile practices to fit the OEM context.

1.1 Background

Traditionally, companies are organised and structured based on their unique characteristics and the context in which they operate. Factors such as size, type of environment, product, production systems, age, and more have all been influential in configuring organisational parameters and deciding which coordination mechanisms to use. Three main coordination mechanisms have traditionally been used, according to Mintzberg (1989).

- **Mutual adjustment**: Coordination is achieved through ad hoc and informal communication channels. This form of coordination is typically found in smaller companies. Coordination through mutual adjustments allows organisations to be flexible and adapt to changing circumstances (Mintzberg, 1989).
- **Direct supervision**: One person is assigned as a leader over a smaller team and is responsible for facilitating coordination within the team and with other teams. As the organisation grows, coordination through direct supervision has traditionally been considered essential (Mintzberg, 1989).
- **Standardisation**: Work processes, outputs, skills and norms are standardised as a means of achieving coordination. This form of coordination has typically been used in large organisations, with many sub-departments that need coordinating (Mintzberg, 1989).

As for the automotive industry, large OEMs have traditionally been organised in a matrix organisation structure, following stage-gate models for product development processes with coordination through standardisation across the company (Persson & Åhlström, 2013; Sy et al., 2005; Wuest et al., 2014). If the different organisations

within an OEM are considered on a spectrum, with manufacturing on one end and new concept generation on the other end, more standardisation has typically been sought after the closer a department is to the manufacturing end where volumes are higher and variety lower (Slack & Lewis, 2020).

As product life cycles have traditionally been relatively long and customer preference variability low, even product development departments have been coordinated through standardisation (Poth & Wolf, 2017). However, as the automotive industry is changing, so are the requirements on the organisational structures. Customers are becoming more dynamic, putting pressure on automotive OEMs to become more flexible and adapt to unexpected changes (Elkins et al., 2004). Coordination purely by standardised mechanisms becomes less viable across the entire organisation spectrum. While standardised processes in manufacturing will remain to keep costs low, increasing flexibility through informal coordination mechanisms becomes critical in organisations such as product development and manufacturing engineering (Elkins et al., 2004; Poth & Wolf, 2017). One way to achieve this is by implementing large-scale agile ways of working, drawing upon coordination mechanisms closer to mutual adjustment.

The transformation to agile development is a complex process that requires significant resources – both time and money. Additionally, as agile practices on such a large scale in a manufacturing context is a relatively new phenomenon (Hohl et al., 2016), the transformation path is relatively unknown, and it is unclear what results can be expected. Volvo Cars are among the pioneers within the manufacturing industry in this journey towards agile implementation on a large scale (Hohl et al., 2016), referred to as agile transformation (Barroca et al., 2019).

In order to achieve a company-wide implementation of agile practices, Volvo Cars have developed their own agile framework called Volvo Cars Agile Framework (VCAF) that is to be used in every organisation, department and team. VCAF is based on the Scaled Agile Framework (SAFe) but is tweaked to fit Volvo Cars' specific circumstances. SAFe is a commonly used framework; 30% of respondents surveyed in 2017 were cited as using it to scale agile in their company (VersionOne, 2017). While SAFe is often considered complex to implement, it tailors well to large companies. SAFe incorporates different process templates to different levels/parts of a company, for instance utilising both Scrum and Kanban practices (Ebert & Paasivaara, 2017). While implementation of agile practices on team levels have been used for some time (Dingsøyr & Moe, 2014), SAFe has allowed agile to be scaled to the entire company (Ebert & Paasivaara, 2017).

With their agile transformation, Volvo Cars aims to improve their flexibility and speed in the product development and production line conversion processes, while maintaining efficient and low-cost production processes. Due to this split focus and the company's size, different organisations and departments are seemingly adopting agile at different paces and in formats. In some teams, such as teams focused on software development, agile comes natural and is easily implemented whilst other

teams face the implementation with more resistance. The different formats of the agile implementation across different organisations and departments can inhibit coordination and cause inefficiencies. Traditional coordination issues become apparent once again, and companies now face the challenge of solving them without transitioning too far towards standardisation.

1.2 Purpose and Research Questions

This section outlines the purpose of the study, its aim and provides context for the research questions posed.

1.2.1 Purpose

The purpose of this thesis is to identify and describe potential problems related to coordination between teams across organisational interfaces in scaled agile contexts and analyse how these problems can be mitigated effectively. The aim is to identify issues experienced by Volvo Cars during their ongoing company-wide agile transformation. Specifically, the thesis is focused on issues related to the inter-organisational collaboration between teams belonging to two organisations: teams in the department Manufacturing Engineering Software Download & Final Test – henceforth MESW – and the Product & Quality Agile Release Train(s) (ART(s)) – henceforth P&Q – with which MESW interact most frequently. Furthermore, the aim is to provide an overview over potential solutions to the issues identified.

1.2.2 Research Questions

In order to understand what problems might exist in a company, one must first get an understanding of the current situation. As the agile transformation at Volvo Cars is happening at such a large scale, the current *agile status* is relatively unknown across departments that are inherently different. Hence, it is imperative to map *how* the organisations and departments within the scope of this study have chosen to implement agile ways of working and how far they have come in their implementation process.

Research Question 1: How does the adoption of agile principles differ between MESW and P&Q at Volvo Cars?

Processes for inter-organisational collaboration and coordination at Volvo Cars are considered inefficient, with delays and incorrect prototype designs cited as problems stemming from this. In order to fulfil the aim of the study an understanding of what potential problems there are in this context must first be established.

Research Question 2: What issues can arise in the interface between organisations when companies adopt agile on a large scale?

In order to help improve the coordination between the teams within the two organisations making up the scope of this study, potential solutions to the most crucial issues need to be identified. Depending on the level of specificity of the issues – i.e. how specific the issues are to the specific departments and organisations investigated – some of the solutions could potentially be generalisable to other parts of the company.

Research Question 3: How can coordination issues in the interface between organisations be mitigated?

1.3 Delimitations

The scope of the involvement from Volvo Cars was limited to the MESW team and the ART(s) from the organisation P&Q, with which the team most frequently interacts. Thus this study delimited its focus to the interface between these two parties as a means of answering the research questions. While some transferability may arise to other parts of the company or external contexts, this is not a goal of the research.

The data collection for this study focuses on Team level coordination as well as facilitation of this through the Program level.

Research Question three was answered through a theoretical discussion based on an analysis of relevant literature and empirical data collected at Volvo Cars. Answers from this discussion only include an overview of potential solutions deemed relevant for Volvo Cars, not a concrete implementation plan. To fully answer the question and determine whether these solutions mitigate the issues identified, a pilot study with an implementation of the proposed solutions would be needed. However, such a pilot study was deemed to be outside the scope of this thesis.

1.4 Report Disposition

The report is divided into six main chapters, starting with an introduction. The introduction will include a background section, giving the reader some basic understanding of the purpose and research questions of the study. After the introduction, a literature review is presented, drawing upon relevant literature from academia to answer the research questions. The third chapter describes the methodology used in the research. Chapters four through six present the study's findings, a synthesis of these findings in a conclusion and finally a discussion about said findings in relation to both practical implication and academia.

2
Theory

This chapter outlines relevant literature based on previous research to provide context to the study and help answer the research questions. First, a brief description of agile ways of working is presented, followed by an overview of the Scaled Agile Framework. Third, previous research on coordination in scaled agile settings is reviewed and presented.

2.1 Agile Principles

Agile development originated in the software development industry since the beginning of the 21st century (Dingsøyr & Moe, 2014). Initially presented in the Agile Manifesto, agile development emphasises flexibility and adaptability, customer involvement in the development process, less standardisation of processes and tools, increased interaction amongst individuals, and functioning products are valued over comprehensive documentation (Cohen et al., 2004). While agile has become the golden standard for small teams developing software since the release of the Agile Manifesto, implementing agile on a larger scale is considered more challenging. Nonetheless, due to the perceived benefits and quickly evolving industries, more and more companies are trying to implement agile at a large scale (Dingsøyr & Moe, 2014).

2.1.1 Scaling Agile

Large companies are trying to reap the benefits of a company-wide implementation of agile ways of working, such as operating profitably in unpredictable environments where customer demands are constantly changing by efficiently re-allocating production capacity and launching new products that meet customer demands (Elkins et al., 2004). However, there are challenges to consider with such implementations in order for an organisation to scale agile successfully.

One of the fundamental principles of agile is having self-organised teams that effectively utilise every team members capacity and promotes individual interactions (Cohen et al., 2004). Relating this to the coordination mechanisms outlined by Mintzberg (1989), this type of organisation is coordinated through mutual adjustment, motivating the team members, and facilitating problem-solving and knowledge sharing (Fowler, Highsmith, et al., 2001; Mintzberg, 1989).

As agile and self-organised teams are implemented at scale, coordination issues emerge, especially related to inter-team coordination. In addition, large scale development projects often require knowledge sharing and collaboration with experts from multiple teams, creating a need for a comprehensive knowledge management system (Dingsøyr & Moe, 2014; Ebert & Paasivaara, 2017). Traditionally, this form of large scale coordination would be handled through direct supervision of teams and standardised norms, ways of working, skills and outputs (Mintzberg, 1989) – directly contradicting some of the core agile principles. Furthermore, agile transformations are more about a change of culture and a mindset within the organisation than the change of practices (Ebert & Paasivaara, 2017). This change of mindset can be considered one of the chief obstacles for an organisation to overcome (Ebert & Paasivaara, 2017).

However, core agile principles can be adapted to fit a scaled setting. Dingsøyr and Moe (2014) outline some key measures that facilitate large scale agile implementation:

- Development architects are vital in coordinating larger development projects (Dingsøyr & Moe, 2014).
- It is crucial to facilitate inter-team coordination and knowledge sharing through establishing norms and defining the language to be used across teams. Furthermore, implementing an efficient knowledge network is essential (Dingsøyr & Moe, 2014).
- Continuous, two-way dialogue between portfolio and project level planning is needed. The voices of individual team members should be heard at the Portfolio level, creating an opportunity to continuously optimise the Portfolio level planning (Dingsøyr & Moe, 2014).
- What is meant by scaling should adequately be defined, whether in regards to the number of teams, systems or activities. Ideally, scaling should include all of these parameters (Dingsøyr & Moe, 2014).

Multiple frameworks aiming to facilitate the implementation of agile at scale have also emerged. By utilising and adapting these frameworks across the entire organisation, the barriers to an agile implementation can be significantly reduced – regardless of the context and specifics of an organisation (Ebert & Paasivaara, 2017; Hohl et al., 2016). The key, however, to a successful transformation using a scaled agile framework is to make sure that there is an organisation-wide mindset shift and that the agile culture reaches *everyone* in the organisation (Ebert & Paasivaara, 2017; Hohl et al., 2016).

SAFe

The Scaled Agile Framework, was developed to help companies cope with agile ways of working on a large, often organisation-wide scale. It is one of the most frequently used frameworks for large scale agile implementations and is mainly used due to its exhaustive and clear role definitions (Ebert & Paasivaara, 2017). The exhaustive and complex list of roles, artefacts and guidelines is the critical differentiator and

benefit of SAFe compared to other frameworks – but is also often perceived as the main drawback (Ebert & Paasivaara, 2017). Sometimes, SAFe is even perceived as adding more bureaucracy to an organisation and removing some of the agile benefits (Ebert & Paasivaara, 2017). Furthermore, there are suggestions that SAFe describes some of the best practices, roles and artefacts without actually suggesting any concrete implementation strategy, making it difficult for companies to understand what to prioritise and where to focus their effort (Turetken et al., 2017). Nonetheless, if tweaked and adapted to a specific context of an organisation – such as the VCAF at Volvo Cars – SAFe can successfully be used to facilitate an organisation-wide agile implementation (Ebert & Paasivaara, 2017). Some of the benefits achieved by organisations successfully implementing agile using SAFe are accelerated time to market, increased productivity and quality, decreased project costs, and reduced overall project risks (Turetken et al., 2017).

SAFe utilises practices from other agile ways of working, such as Scrum and Extreme Programming (XP) (Turetken et al., 2017). Additionally, elements from Product Development Flow and Lean are incorporated in SAFe (Turetken et al., 2017). SAFe separates the organisation into three layers, where each layer has a different scope and scale (Vaidya, 2014). All three layers utilise agile and lean practices (Vaidya, 2014):

- **Team level**: The most narrow level in terms of scope with the smallest scale (Turetken et al., 2017). It follows a typical agile scrum team structure, albeit with some adjustments (Vaidya, 2014). The team has a Scrum Master, a Product Owner and a Development Team with five to nine members (Vaidya, 2014). The team utilises both XP and Scrum practices, such as User Stories, Daily Stand-Ups, Sprint planning, and more (Turetken et al., 2017). The Product Owner coordinates with the Product Manager on the Program level to plan and prioritise the Program Backlog, striving to optimise the delivery of features (Vaidya, 2014). The Team level works in Sprints, hoping to deliver Product Increments at the end of each Sprint. SAFe advocates for synchronised Sprints across teams, facilitating coordination across teams (Vaidya, 2014).
- **Program level**: Higher scope and larger scale compared to the Team level, aimed at organising several teams at a large scale to deliver value at the Program level (Turetken et al., 2017). Between five and twelve agile teams typically constitute one Program (Vaidya, 2014). Features/increments at the Program level are delivered in Agile Release Trains (ARTs), which are typically between 60 and 120 days long (Turetken et al., 2017; Vaidya, 2014). Several agile teams are dedicated to an ART and release Product Increments within a fixed time interval (Vaidya, 2014). Similar to the Team level, a Program has a Product Manager and a Release Train Engineer – comparable to the Product Owner and Scrum Master on the Team level (Vaidya, 2014). The Product Manager is responsible for the Program Backlog, and coordinates/directs the different Product Owners, while the Release Train Engineer drives continuous improvement, manages risks and helps facilitate execution on a Program level (Vaidya, 2014). The Program Level also has a dedicated System Architect,

responsible for guiding the architecture for all teams in the Program (Vaidya, 2014).
- **Portfolio level**: The highest level of the organisation, with the broadest scope. Portfolios are coordinated to be aligned with the organisation's overall strategy (Turetken et al., 2017). At the Portfolio level, a team of business executives are responsible for determining the overall vision, strategy and investments of the entire organisation (Vaidya, 2014). Through measures at the Portfolio level, ARTs across a Program are aligned along Value Streams – ensuring value is delivered to the customers (Vaidya, 2014). Essentially, investments are made in ARTs by Portfolio level executives that reflect the goals of the company and the Value Streams, either in terms of business goals – i.e. investing in customer-facing initiatives that aim to realise business benefits – or architectural goals – i.e. investing in technology initiatives to develop the portfolio to remain competitive in the future (Vaidya, 2014).

2.2 Agile Development in Non-Software Companies

Most reports on agile implementation stem from the IT industry or software-related entities (Conforto et al., 2014; Gustavsson, 2016). However, many argue that agile principles and methods apply to a beneficial end in other contexts (Berger & Eklund, 2015; Conforto et al., 2014). These authors argue that implementation outside the context in which agile methods emerged can be challenging but beneficial despite the differences between software and physical products and project (Berger & Eklund, 2015; Conforto et al., 2014; Gustavsson, 2016; Thamhain, 2014).

Several of these authors and other authors state that it is essential to keep in mind that agile principles are best implemented as guidelines with adaptations to the specific context (Beaumont et al., 2017; Conforto et al., 2014; Thamhain, 2014; Totten, 2017). A common theme among authors in their research on this topic seems to be a discussion around what factors or variables affect the applicability of agile.

What factors are investigated and deemed most influential varies somewhat between the studies conducted. Berger and Eklund (2015) investigate 21 different factors and conclude that the two main challenges to agile implementation in non-software contexts are:

- Inflexibility of testing resulting in barriers to fast feedback and product changes
- Existing organisational structures and mindsets inhibiting the agile transformation

There are multiple other examples of studies investigating important factors for the applicability of agile – e.g. Conforto et al. (2014), Beaumont et al. (2017), Totten (2017). What these have in common can be analysed in terms of overlaps in their conclusion of important factors to consider – e.g. team dedication and location

(Conforto et al., 2014; Totten, 2017). However, even more interesting is the common element of absence, that is, the nature of the product. Whether the development is of a physical product does not seem to be a prominent enabler for agile practices to the development organisation and process (Beaumont et al., 2017; Conforto et al., 2014; Thamhain, 2014). This suggests that the nature of the product itself is not a determinant for the applicability of agile. Instead, in the context of physical product development, there is a suggestion of an emphasis on factors such as product complexity and project size when customising the agile adoption, and specifically, some authors suggest merging agile with conventional practices (Beaumont et al., 2017; Conforto et al., 2014; Thamhain, 2014).

Studies of challenges with agile implementation and how these can be managed have previously been conducted within the automotive industry specifically (Gustavsson, 2020; Wohlrab et al., 2019). Similarly to these studies, the argument of domain independence when it comes to scaling agile stated by Kalenda et al. (2018) is used in this study. This allows for the use of agile practices and principles stemming from the software domain to be applied in this case study – albeit with consideration to the necessity of contextual consideration.

2.3 Coordination in Large Scale Agile Contexts

In this section, coordination challenges inherent and empirically uncovered in large scale agile contexts are outlined. Subsequently, an overview of existing theory on managing coordination in such contexts is presented, followed by a final description of specific solutions or mitigating factors to such challenges from the literature.

2.3.1 Coordination Challenges Across Agile Teams

While a successful implementation of agile practices on a large scale has been shown to affect the organisation positively, there is typically a wide range of challenges that need to be overcome (Badampudi et al., 2013; Berntzen et al., 2019). One important category of such issues is the topic of collaboration and coordination across multiple teams. These challenges arise as a result of the application of agile designs, first intended for small teams, to a larger setting – i.e. scaling agile – (Bjørnson et al., 2018; Evbota et al., 2016; Theobald & Diebold, 2018; Uludag et al., 2018).

Dingsøyr, Moe, and Seim (2018) state that even though agile was originally intended for autonomous teams, implementation on a large scale is common today, resulting in challenges for organisations to accomplish inter-team coordination. Other studies support this notion (Kasauli et al., 2020; Wohlrab et al., 2019). Some even emphasise inter-team coordination as the most prominent challenge to address when scaling agile (Gustavsson, 2017; Söderqvist et al., 2019). What these coordination challenges entail in more detail has been widely discussed in the literature, outlining potentially relevant problems for practitioners to heed in their agile transformation efforts.

One such issue that has been highlighted in the literature is challenges associated with communication across interfaces (Conboy & Carroll, 2019; Uludag et al., 2018) and how to achieve effective communication (Wohlrab et al., 2019). The distribution of information is inherently challenging in this context, given the amount of information and number of recipients (Evbota et al., 2016). Furthermore, inconsistencies in the language used can also be a problem (Badampudi et al., 2013; Stray & Moe, 2020). Adding to this, a lack of well-suited information channels has been reported (Evbota et al., 2016).

Agile methodologies prescribe an emphasis on direct interactions and face-to-face communication (Wohlrab et al., 2019). Some have reported this to create problems in contexts of distributed teams as it makes it difficult to schedule and conduct meetings (Stray & Moe, 2020; Wohlrab et al., 2019). However, other studies contradict these findings by reporting that having distributed teams does not pose a challenge (Gustavsson, 2020).

Meetings to facilitate face-to-face communication have been reported as problems as people perceive that too much time is spent in meetings (Gustavsson, 2020). Paradoxically, others have reported that when time is short alternative means of communication are used – e.g. emails and social media – leading to asynchronous communication, which is perceived as more inefficient than face-to-face communication (Evbota et al., 2016). Further support can be found in the literature for challenges associated with documented communication. Finding the right level of abstraction for communication contributes to the challenge of sharing information in agile organisations, according to Wohlrab et al. (2019), and balancing the trade-off between more detailed and lightweight documentation depending on organisational abstraction level is challenging (Kasauli et al., 2020). Evidence has been found that there is a tendency to neglect crucial documentation when transitioning to agile (Wohlrab et al., 2019). Regardless of the context, it does seem essential to manage communication effectively across interfaces in agile organisations.

Planning also requires consideration if one is to avoid significant issues (Badampudi et al., 2013; Evbota et al., 2016; Theobald & Diebold, 2018). Traditionally, planning methods and the outcome of them are viewed as static, whereas in agile planning methods emphasise flexibility and continuous change (Evbota et al., 2016; Theobald & Diebold, 2018). However, agile planning practices are less effective in scaled agile contexts where multiple teams often work with their own complex Backlogs and tend to prioritise their own work (Badampudi et al., 2013; Evbota et al., 2016). These isolated plannings need to be synchronised, as dependencies between Backlogs can emerge (Badampudi et al., 2013). This can result in teams losing sight of the complete picture (Gustavsson, 2020).

A lack of structured estimation discussions, both between and within teams, can result in sub-optimal estimations (Gustavsson, 2020), where some team members might be responsible for tasks that do not fit their role description (Evbota et al., 2016). This clash in planning processes is often challenging and can result in slower

reaction times and inhibited collaboration (Gustavsson, 2020; Theobald & Diebold, 2018).

Internal focus in the planning process and a lack of a big-picture perspective parallels another area posing a coordination challenge in agile transformations. Alignment has been a widely discussed challenge to achieve among agile teams (Dingsøyr et al., 2019; Wohlrab et al., 2019). Some have reported a tendency for reluctance to share knowledge with others and favouring individual work (Gustavsson, 2020; Wohlrab et al., 2019).

> "'We thought the teams would try to influence the complete product. But [they] have been focused inwards, on their deliverables. [...]' – Chief Architect" – Wohlrab et al. (2019, p. 14)

This inward focus is an issue in scaled agile contexts since it entails the cooperation of multiple teams where goal alignment becomes essential (Gustavsson, 2020). In many case studies, this challenge has been found where teams focus too much on their own goals rather than focusing their contributions to the collective efforts for mutual goal achievement (Gustavsson, 2020). Discrepancies between goals across teams tend to be significant (Bick et al., 2017), and there are many reasons for this misalignment, such as rewarding small isolated gains through the agile way of working (Gustavsson, 2020).

One of the reasons alignment of goals between teams is so important is that dependencies increase drastically when scaling agile (Badampudi et al., 2013; Evbota et al., 2016; Theobald & Diebold, 2018). Several authors argue that ineffective coordination in scaled agile contexts stems from a lack of dependency awareness (Bjørnson et al., 2018; Theobald & Diebold, 2018). Managing dependencies inherently entails being aware of their existence. Without awareness, teams will neither consider the consequences of neglecting dependencies nor pay heed to the management of dependencies (Bick et al., 2017). Therefore, a challenge necessary to overcome is the achievement of *dependency awareness* (Bick et al., 2017), which can be defined as:

> "A state of all of the system's relevant stakeholders (on both the team and inter-Team levels) having identified, recognised and established a shared understanding of the existence of inter-dependencies and potentially resulting alignment issues." – Bick et al. (2017, p. 940)

Knowing what stakeholders one has and what those stakeholders are doing is a logical necessity to achieve dependency awareness. However, this is described as an underlying challenge in empirical research, with Evbota et al. (2016) reporting that teams do not get updated on the activities of other teams due to a perceived lack of time.

Similarly to the challenge associated with awareness of dependencies, transparency and clarity of roles and their respective responsibilities has been established as a

prominent coordination challenge (Evbota et al., 2016; Gustavsson, 2020; Wohlrab et al., 2019). Gustavsson (2020) states that new roles are sometimes added for coordination purposes resulting in unclear responsibilities between people. Agile frameworks aim to clarify roles and responsibilities (Evbota et al., 2016) and prescribe more coordination responsibility to people in the teams (Gustavsson, 2020). This has led to a wide range of different interpretations and subsequent implementations of agile at scale, resulting in confusion. Evbota et al. (2016) reported a perceived elevation of the confusion of the POs' responsibilities specifically. Other studies have reported coordination difficulties between ARTs, resulting in PMs being pulled in as facilitators (Gustavsson, 2020). Furthermore, Gustavsson (2020) reports that unclear ownership of dependencies is an issue. Wohlrab et al. (2019) report responsibility challenges for managing the artefacts used to achieve coordination. Such artefacts often decay over time due to unclear responsibility and ownership over the artefacts themselves (Wohlrab et al., 2019).

Studies also show that there is an awareness amongst the people within organisations experiencing problems with responsibility and clarity of roles and that there is a need for clarification. Gustavsson (2020) reported a perception of lack of awareness, and commitment and there are multiple reports of a perceived need to capture responsibilities and ownership (Wohlrab et al., 2019) – e.g. for who takes the initiative (Gustavsson, 2020). However, it is important to note that some studies show that roles may differ in their perception of this challenge (Badampudi et al., 2013; Dingsøyr & Moe, 2014).

Closely associated with the roles and responsibility challenges found in the literature are challenges associated with reliance on relationships and individual knowledge. Studies have shown that coordination in scaled agile contexts depends to a great extent on personal relationships (Berntzen et al., 2019; Dingsøyr, Moe, & Seim, 2018). There is widespread evidence in the literature supporting that relationship dependence is present in many contexts and independent of the specific role. Specialists on the Team level contribute significantly to coordination through their knowledge of who knows what in the organisation (Theobald & Diebold, 2018). Evbota et al. (2016) found that both POs and developers depend on personal relationships and networks when coordinating across interfaces. Similarly, Wohlrab et al. (2019) state that the quality of systems engineering artefacts depends on the individuals in charge, and Stray and Moe (2020) found that relationships are an enabler for effective communication via instant messaging tools such as Slack.

This individual dependence highlights a more general problem area stemming from the customisation of agile methods. There is widespread support for the notion of inherent customisation of agile methods to fit unique contexts (Gustavsson, 2020; Kasauli et al., 2020). Coordination challenges arise between agile parts of an organisation adapting methods differently – e.g. teams or ARTs – and between agile and non-agile entities (Gustavsson, 2020; Kasauli et al., 2020; Theobald & Diebold, 2018).

Kasauli et al. (2020) conceptualises this customisation as *methodological islands* and discuss how it leads to coordination challenges. The methodological islands can occur between groups of teams – e.g. ARTs and hardware and software teams – or between individual teams and even with external entities outside of the organisation (Kasauli et al., 2020). These islands are characterised by their differences in terms of methods and practices as well as culture and mindset (Kasauli et al., 2020).

The concept of methodological islands can be viewed as an umbrella term encapsulating the prominent coordination challenges described by other authors. Communication challenges can be linked to the concept both by the previously mentioned challenge associated with appropriate abstraction level for documentation and the fact that the communication needs of agile teams are often not reciprocated by non-agile organisational entities (Theobald & Diebold, 2018).

Similarly, previously described clashes in planning procedures and inherent maturity of different teams and their resulting ability to understand velocity and estimate correctly during planning (Evbota et al., 2016) shows the connection to planning challenges. Furthermore, the difference in planning ability results in a difference in prioritisation ability (Evbota et al., 2016), which ties the concept to the alignment challenges discussed. This link is further reinforced as Theobald and Diebold (2018) state that synchronisation and coordination are particularly challenging for organisations developing both hardware and software. The planning and misalignment challenges are perceived as overlapping and have here been segmented as one challenge category. According to Kasauli et al. (2020), companies going through agile transformations inherently need to balance a trade-off between uniformity and customisation with a tendency for more customisation the further down the agile hierarchy one looks. Wohlrab et al. (2019) state that this trade-off between alignment and autonomy is a challenge for agile transformations.

A link to lack of awareness can also be found in the literature. Berntzen et al. (2019) describe that individuals and groups working on different tasks tend to adhere to different thought worlds inhibiting coordination, similar to the notion of methodological islands having different mindsets (Kasauli et al., 2020).

It can also be argued that unclear roles and responsibilities connect to the concept, given that discrepancies between responsibility distribution constitutes customisation and thus leads to methodological islands (Kasauli et al., 2020). Similarly, the inherent uniqueness of individuals encapsulates the challenges of dependency on individuals.

2.3.2 Synthesis of Coordination Challenges from the Literature

The challenges and common issues found in the literature – see 2.3.1 – have been analysed and segmented into categories. The literature provided no conceptual frameworks for the classification of challenges and instead primarily described chal-

lenges perceived in case studies conducted. Therefore, the segmentation is based on descriptions and examples from the literature, which were codified and subsequently segmented into the categories in Table 2.1. This segmentation provides a framework for the analysis of coordination challenges.

Table 2.1: Coordination challenges in the scaled agile context deduced from descriptions in the literature and segmented into categories.

Coordination Challenges	Examples Manifesting the Challenge
Communication Issues	**Example 1:** Distributed teams constitute a potential challenge in terms of a barrier to face-to-face communication (Stray & Moe, 2020; Wohlrab et al., 2019).
	Example 2: There is a lack of appropriate channels for communication and sharing information (Evbota et al., 2016).
	Example 3: There is a paradox between too much time spent in meetings and the benefits of face-to-face communication – as opposed to asynchronous alternatives such as emails (Evbota et al., 2016).
Lack of Awareness	**Example 1:** Dependencies are prominent in scaled agile contexts, and without awareness, dependencies will neither be managed nor will their consequences be considered (Bick et al., 2017; Theobald & Diebold, 2018).
	Example 2: Teams do not get adequately updated on the activities of other teams (Evbota et al., 2016).
	Example 3: Knowledge about who knows what and the requirements enforced by interdepartmental dependencies constitutes challenges (Stray et al., 2019).
Misalignment	**Example 1:** There is a tendency to focus on the team Backlog and neglect dependencies, resulting in losing sight of the big picture (Badampudi et al., 2013; Evbota et al., 2016; Gustavsson, 2020).
	Example 2: There are tendencies of reluctance to share knowledge across interfaces and favour internal work (Gustavsson, 2020; Wohlrab et al., 2019).
	Example 3: Goals are often misaligned between teams resulting in individual teams focusing inward rather than toward mutual goal achievement (Bick et al., 2017; Gustavsson, 2020).
	Example 4: There is often a difference in estimation capabilities between teams (Evbota et al., 2016).

Table Continues on Next Page

Continuation of Table 2.1

Coordination Challenges	Examples Manifesting the Challenge
Unclear Roles and Responsibilities	**Example 1:** New roles are added for coordination purposes resulting in confusion of responsibilities (Gustavsson, 2020).
	Example 2: Agile prescribes more coordination responsibility to individual team members resulting in different local adaptions creating inter-team confusion (Evbota et al., 2016; Gustavsson, 2020).
	Example 3: There is evidence of unclear definition of ownership of both dependencies and mechanisms used to overcome coordination challenges (Gustavsson, 2020; Wohlrab et al., 2019).
Dependency on Individuals	**Example 1:** Organisations scaling agile are dependent to a great extent on individuals' relationships and network (Berntzen et al., 2019; Dingsøyr, Moe, & Seim, 2018; Evbota et al., 2016).
	Example 2: Specialists in teams are essential for coordination due to their personal knowledge of who knows what in the organisation (Theobald & Diebold, 2018).
	Example 3: The quality of system engineering artefacts depends on individuals (Stray & Moe, 2020).

2.3.3 Overlap with Coordination Challenges Outside the Agile Context

Large organisations that undergo agile transformations often do so incrementally while keeping some traditional structures in place (Theobald & Diebold, 2018; Wohlrab et al., 2019). This could mean that the customisation of agile methods incorporates inheritance from the old ways of working (Gustavsson, 2020). The pioneers in the organisation also create what Kasauli et al. (2020) referred to as pockets of agile islands in a waterfall. It is perhaps not surprising then that challenges evident in scaled agile contexts overlap to some extent with coordination challenges encountered outside the agile context.

Pernstål et al. (2012) outline some challenges within the interface between product development and manufacturing uncovered in a dual case study with two automotive companies, one of which was Volvo Cars. These challenges include: poor knowledge of other functions, late involvement of manufacturing in the development process, importance of personal relationships between the functions, engineers waiting for implementation ready solutions from development's side, and documentation ambiguities. These challenges correspond respectively with: *Lack of Awareness*, *Communication Issues*, *Dependency on Individuals*, *Unclear Roles and Responsibilities*, and *Communication Issues* again – see Table 2.1.

2.3.4 Coordination Theory

These studies consequently draw upon the well-established definition of coordination as management of dependencies first introduced by Malone and Crowston (1994) (Bick et al., 2017; Dingsøyr, Moe, & Seim, 2018; Gustavsson, 2020; Theobald & Diebold, 2018). However, what constitutes dependencies has been found to vary.

Dingsøyr et al. (2017) state that coordination is commonly understood as dependencies between tasks, resources or technology. Other studies have defined dependencies slightly different, including resources, synchronisation of activities and prerequisite activities in the definition (Dingsøyr, Moe, & Seim, 2018).

Gustavsson (2020) uses three different definitions of dependencies in his study on coordination in scaled agile contexts. First, he makes use of Okhuysen and Bechky (2009)'s division of dependencies into *static* and *emerging*, where static dependencies can be planned for whereas emerging dependencies appear unexpectedly (Gustavsson, 2020). Though not explicitly stated, Evbota et al. (2016) refer to dependencies that constitute planning constraints and hidden dependencies that cannot be planned.

Second, Gustavsson (2020) makes use of Thompson (1967)'s classification of dependencies into *Pooled*, *Sequential* and *Reciprocal* dependencies. Pooled dependencies exist where different entities draw upon the same pool of resources, e.g. knowledgeable people (Gustavsson, 2020). Sequential dependencies occur when the output of one entity constitutes input to another entity's process (Gustavsson, 2020). Reciprocal dependencies emerge when sequential dependencies occur in both directions with the same two entities (Gustavsson, 2020).

The third definition of dependencies used by Gustavsson (2020) is based on Malone and Crowston (1994)'s division of dependencies. The first category, *Task-resource dependencies*, emerge from the need to assign resources to all tasks within an organisation (Gustavsson, 2020). Second, *Producer-consumer dependencies* are a result from output of one task being the input to another (Gustavsson, 2020). Finally, *Task-subtask dependencies* occur when tasks are split and the higher abstraction task depends on the completion of the sub-task (Gustavsson, 2020).

Another study by Stray et al. (2019) classifies dependencies into three other categories: *Knowledge*, *Process* and *Resource* dependencies. These can, in turn, be subcategorised. Knowledge dependencies can adhere to expert knowledge, emphasising the importance of who knows what (Stray et al., 2019). Knowledge of requirements is the second part of knowledge dependencies, and the third is task allocation – i.e. knowledge of how knows what (Stray et al., 2019). The final part of this dependency category is historical dependencies emerging when knowledge of past decisions is needed for progress (Stray et al., 2019). Process dependencies can take the form of activity dependencies – i.e. progress in one activity is dependent on completion of another – or business processes dictating the execution order of activities (Stray et al., 2019). The resource dependencies can be either entity related – i.e. progress

of a part of the system depends on the availability of specific people or information – or technical, meaning that components require interaction with other components and thus require their readiness (Stray et al., 2019).

It is easy to see that there are significant overlaps between the different definitions. Task-subtask dependency can be viewed as a particular case of a producer-consumer dependency, which, in turn, overlaps with the sequential dependency type from Thompson (1967)'s division. Furthermore, the task-resource and pooled dependencies definitions have their basis in resources, which is one of the elements in definitions used by Dingsøyr, Moe, and Seim (2018) and Dingsøyr et al. (2017) and a main category in Stray et al. (2019)'s definition. Gustavsson (2020) suggests that producer-consumer dependencies might be a common element in all scaled agile cases. However, there is no evidence that one can or should discard consideration to the potential risk of any dependency types, regardless of definition.

The identification of dependencies is one logical step in the process of managing them, followed by how to mitigate their negative impact. A lack of efficient coordination and communication across agile teams and departments have been found to be the cause of significant issues for organisations – inconsistent results, poor estimation of progress, a lack of alignment between workstreams, absence of shared understanding, and significant quality problems are just a few examples (Badampudi et al., 2013). There are inherent challenges with coordination in scaled agile contexts given the trade-off between team autonomy and inter-team coordination (Dingsøyr, Moe, Fægri, et al., 2018; Evbota et al., 2016). However challenging it may be, there is widespread consensus that coordination is essential for success in scaled agile contexts (Berntzen et al., 2019; Dingsøyr, Bjørnson, et al., 2018; Dingsøyr et al., 2017; Kalenda et al., 2018; Stray et al., 2019). Some authors claim that inter-team coordination outweighs intra-team processes in terms of importance for system performance (Dingsøyr et al., 2017; Theobald & Diebold, 2018). This has resulted in coordination rising to the top of the agenda in research on large scale agile (Bick et al., 2017; Kasauli et al., 2020).

Coordination through personal communication, with the aim of building relationships within the organisation, has been found to be a successful way to enhance collaboration (Bjørnson et al., 2018), but this is not always possible in a large setting. Organisations need to find the right balance between standardisation of processes while maintaining agility (Pernstål et al., 2012). Finding this balance between agile principles, such as team autonomy and coordination to achieve alignment across interfaces, can be challenging (Berntzen et al., 2019; Wohlrab et al., 2019). It can lead to confusion in the organisations as people perceive that coordination efforts undermine agility and effectively inhibits the transformation (Gustavsson, 2020). At the same time, Gustavsson (2020) shows that some people in transforming organisations are aware of the necessity for the trade-off when managing dependencies, which is supported by other studies (Bass & Haxby, 2019).

Finding a balance between agile methods and traditional becomes essential (Theobald

& Diebold, 2018; Wohlrab et al., 2019). Some standardisation and documentation, for instance, will be required for compliance reasons in the automotive industry (Wohlrab et al., 2019). Different level of the organisation will have differing balancing needs (Evbota et al., 2016). However, all the way down to the Team level, there will be a need for conventional coordination mechanisms (Moe et al., 2019) as standard agile practices have been found insufficient (Evbota et al., 2016; Söderqvist et al., 2019).

Several research papers have reported on studies of conventional coordination theories in the scaled agile context. Scheerer et al. (2014) propose that research from a wide range of fields contributing to the body of coordination knowledge can assist in the understanding of scaled agile coordination. Dingsøyr, Bjørnson, et al. (2018) and Theobald and Diebold (2018) adhered to this proposition and used the three coordination mechanisms conceptualised by Salas et al. (2005) – i.e. *shared mental model*, *closed-loop communication*, and *trust* – in the agile research domain. A shared mental model entails a common understanding of the work process, its tasks, and the capabilities of other people and teams (Theobald & Diebold, 2018). Misaligned mental models can cause conflicts and are particularly important in scaled agile contexts where separate teams work towards common goals (Theobald & Diebold, 2018). Closed-loop communication entails anchoring information distributed and ensuring the correct interpretation of it with the recipients. It is vital for achieving synchronisation and keeping the shared mental model updated – ensuring they divide their focus internally and externally appropriately (Theobald & Diebold, 2018). Trust is based on a shared belief that co-workers will protect each others' interests and that others will perform their responsibilities (Theobald & Diebold, 2018). It is difficult to obtain across interfaces but crucial to performance (Theobald & Diebold, 2018).

Similar to Salas et al. (2005)'s conceptualisation of coordination is relational coordination theory (RCT) (Gittell et al., 2006) which emphasises coordination through *shared knowledge*, *shared goals* and *mutual respect*. Shared knowledge involves the extent to which others know about the work one does, and shared goals the extent to which goals are shared across interfaces (Gittell, 2011). Both facilitate the coordination of knowledge – a dependency labelled as important by Stray et al. (2019). Mutual respect revolves around whether people respect the work conducted by others across interfaces (Gittell, 2011). RCT has been argued to suit the topic of coordination in scaled agile contexts well due to the characteristics of dependencies being prominent, uncertainty high, speed important, and autonomy a cornerstone (Berntzen et al., 2019). Berntzen et al. (2019) argue that effective coordination in scaled agile contexts depends on relationships between employees built upon the elements of RCT and presents evidence of their existence among POs. Similarly, Theobald and Diebold (2018) found that personal relationships across interfaces are perceived by many as a means of achieving successful collaboration.

The elements of RCT are reinforced by high-quality communication (Berntzen et al., 2019), achievement of which has been a topic within coordination research for

quite some time. The use of boundary objects to facilitate communication across interfaces leading to improved coordination originates from the late 1980s (Lindlöf, 2014), long before the origin of agile development methods. Nevertheless, boundary objects are used frequently in research on coordination within the scaled agile context (Kasauli et al., 2020; Wohlrab et al., 2019).

Perhaps the most commonly referred to coordination framework is Mintzberg (1989)'s three principles of mutual adjustment, direct supervision and standardisation. In agile contexts, mutual adjustment principles have been widely emphasised (Dingsøyr, Bjørnson, et al., 2018; Dingsøyr, Moe, & Seim, 2018). Mutual adjustment has been labelled as a mechanism for dealing with emerging dependencies, which are prominent in the agile context (Gustavsson, 2020) – although not necessarily the only dependency type. As previously mentioned, scaled agile entails more coordination responsibility being accorded to the individual team members. Coordination across team interfaces relies heavily on mutual adjustment (Gustavsson, 2017) and informal coordination methods (Dingsøyr, Moe, Fægri, et al., 2018). Perhaps this is because mutual adjustment facilitates coordination of all three dependency types – knowledge, process and resources (Stray et al., 2019). There is also a connection between mutual adjustment through ad hoc informal coordination and closed-loop communication previously described. Theobald and Diebold (2018) describe how information conveyed in formal, standardised procedures for communication – e.g. Scrum of Scrums – is subsequently reviewed for closing the loop of the communication via mutual adjustment mechanisms. For higher-level coordination, the term layered mutual adjustment has been coined as a means of coordinating across interfaces using the same principles of informal and ad hoc interactions (Söderqvist et al., 2019).

Then there are coordination concepts that weave some of the previously mentioned theories together in new conceptualisations. Bick et al. (2017) quote Espinosa et al. (2010)'s division of coordination into *explicit* and *implicit* coordination. Explicit being further divisible into mechanistic elements – e.g. plans, rules, routines, which overlaps with Mintzberg (1989)'s standardisation – and organic elements – e.g. mutual adjustment and feedback, which overlaps with both Mintzberg (1989) and closed-loop communication. Implicit coordination elements consists of "shared mental models, team expertise, and transactive memory systems" according to Bick et al. (2017, p. 936) and thus overlap with Salas et al. (2005)'s widely used theory. Others have also been quoting the organic and cognitive elements of coordination in research on scaled agile coordination (Stray et al., 2019).

Dingsøyr, Moe, and Seim (2018) describe theoretical *modes* of coordination, each mode being manifested by its characteristic underlying mechanisms. The first mode is *group mode of personal coordination*, which manifested by scheduled and unscheduled meetings for group-to-group coordination (Dingsøyr, Moe, & Seim, 2018) – e.g. Scrum of Scrum. Second, *individual mode of personal coordination* characterised by informal coordination using – e.g. rotation of team members and direct communication (Dingsøyr, Moe, & Seim, 2018). Last, *impersonal mode of coordination*

manifested by plans, guidelines, checklists, etc. (Dingsøyr, Moe, & Seim, 2018). Dingsøyr, Moe, and Seim (2018) state that mutual adjustment or feedback – which can be assimilated to closed-loop communication – should be conducted informally.

2.3.5 How to Overcome Coordination Challenges in a Large-Scale Agile Context

The different theories frame and emphasise different concepts for achieving effective and efficient coordination. Furthermore, how to achieve the different concepts may differ to some extent and overlap to some. Some have labelled the underlying mechanisms for achieving the concepts as such – i.e. *mechanisms* e.g. (Stray et al., 2019) – and by others as routines (Gustavsson, 2020), arenas (Dingsøyr, Moe, Fægri, et al., 2018) and boundary objects (Kasauli et al., 2020; Wohlrab et al., 2019). Some authors have used these labels seemingly interchangeably – e.g. (Gustavsson, 2020) – and their manifestations indeed contain overlaps. For instance, Scrum of Scrums has been labelled as an arena, a mechanism and a routine (Dingsøyr, Moe, Fægri, et al., 2018; Gustavsson, 2020; Stray et al., 2019). Similarly, the Backlog is interchangeably labelled by different authors (Gustavsson, 2020; Kasauli et al., 2020; Stray et al., 2019). In this thesis, the term mechanism is used to universally cover manifestations of the coordination concepts described in the previous section.

The mechanisms are intended to solve dependencies between interfaces (Moe et al., 2018), and they are therefore vital since coordination is of great significance in large scaled agile contexts as previously shown. The mechanisms discussed in the literature are sometimes generally acknowledged to improve coordination overall – e.g. Community of Practice as discussed by Evbota et al. (2016) and Gustavsson (2017). Other times more directly focused on the management of specific types of dependencies and achieving a specific coordination concept – e.g. (Okhuysen & Bechky, 2009)'s five-element framework consisting of plans and rules, objects and representations, routines, roles, and proximity for managing emerging dependencies through mutual adjustment (Gustavsson, 2020). Scrum of Scrums is one mechanism discussed as a means of managing specific dependencies. Stray et al. (2019) claim that it helps manage three knowledge dependency types and is especially prominent in mitigating activity dependencies. Informal coordination as a concept has been discussed as enabled by having an open office space facilitating ad hoc direct interactions (Dingsøyr, Moe, Fægri, et al., 2018).

Turning the perspective around, a wide range of mechanisms are described as targeting specific challenges relating to specific coordination concepts. Stray et al. (2019) outlines 20 different mechanisms corresponding to the dependency types, knowledge, process, and resource – as well as their sub-types – see Table 2.2. Furthermore, Stray et al. (2019) highlight the mechanisms that target four or more different dependencies – Scrum of Scrums, Team leader meetings, Daily Stand-ups, Ad hoc conversations, Communication tools, Kanban board and Open Work area.

Table 2.2: Coordination mechanisms and the respective dependency type they help mitigate Stray et al. (2019).

	Dependencies							
	Knowledge				**Process**		**Resource**	
Mechanism	Expertise	Requirement	Task allocation	Historical |	Activity	Business process |	Entity	Technical
Scrum of Scrums	X	X	X		X			
Team Leader Meeting	X			X		X	X	
Daily Stand-Up	X		X		X	X	X	X
Retrospective	X			X				
Software Release								X
Workshops	X	X						
Sprint Planning Meetings	X	X	X					
Ad-hoc Conversations	X	X	X		X	X		X
Project Meetings	X		X					
Preparation for Product Demo	X			X				
Product Demo to Customer		X						
Wiki		X						
Task			X					
Product Backlog			X		X			
Communication Tools	X	X	X	X	X		X	
Project Management Tools		X	X	X				
Priority List	X		X					
Kanban Board	X	X	X		X		X	
Whiteboard		X						
Open Work Area		X	X		X		X	

Furthermore, there is a wide range of mechanisms to overcome the awareness challenge – perceived by many agile organisations – by creating of a shared mental model or shared knowledge and goals. Meetings and roles are mechanisms that play an integral part in accomplishing this (Theobald & Diebold, 2018). Berntzen et al. (2019) argue that the PO plays an essential role in achieving shared knowledge and goals across interfaces and is supported by previous research (Paasivaara et al., 2012). One essential function of the PO for coordination is prioritising inter-team requirements (Berntzen et al., 2019; Kasauli et al., 2020). Mechanisms such as implementing a goal hierarchy and managing goals through demo meetings and Backlog grooming have also been found to facilitate the alignment of goals and distribution of knowledge (Berntzen et al., 2019). Combining meetings and the PO role is also important, with weekly PO coordination meetings. The key to creating shared knowledge and goals and obtaining the RCT elements can be facilitated by regular PO workshops (Berntzen et al., 2019). The awareness challenge has also been found mitigated by alignment of planning activities focused on specification, prioritisation, estimation and allocation (Bick et al., 2017). Finally, requirement documentation on the ap-

propriate level of abstraction can help overcome the awareness challenge and create shared understanding (Wohlrab et al., 2019).

The communication challenge widely perceived in the context of scaled agile coordination can be overcome through high-quality communication – which is the enabler of the RCT elements (Berntzen et al., 2019) – and closed-loop communication (Theobald & Diebold, 2018). What defines high-quality communication is frequent, accurate, timely, and problem-solving communication (Berntzen et al., 2019). Both high-quality and closed-loop communication include frequency as a determinant (Berntzen et al., 2019; Theobald & Diebold, 2018). Furthermore, the problem-solving element of high-quality education (Berntzen et al., 2019) can be linked to closed-loop communication using Wheelwright and Clark (1992)'s definition of integrated problem-solving, in which two-way communication is an enabler. Thus, the two communication concepts – i.e. closed-loop and high-quality – can therefore be argued to overlap. Thus, an assumption can be made that mechanisms that reinforce the one impact the other positively.

Introducing more frequent common demos across interfaces is one mechanism found to improved closed-loop communication (Theobald & Diebold, 2018). There is also support for the use of informal communication to overcome the communication challenge. Informal communication can, in turn, be achieved through open workspaces and co-location of teams across interfaces (Theobald & Diebold, 2018) or unscheduled meetings (Berntzen et al., 2019). At the same time, others argue for the combination of the formal and informal for improved communication (Dingsøyr, Moe, Fægri, et al., 2018). Standardising, and thereby formalising communication mechanisms can also facilitate the informal day-to-day communication between individuals (Berntzen et al., 2019). Standardisation through Slack as a communication platform proved in one case to enable both timely and frequent communication, according to Berntzen et al. (2019). Furthermore, increasing cross-interface representation in meetings also improves communication and thus coordination (Berntzen et al., 2019). Gustavsson (2020) found that increased frequency of Scrum of Scrums and including more external people in these and the PI-meetings enabled improvements to communication.

For a complete overview of the examples found in the literature on mechanisms – or otherwise labelled – that help overcome challenges and dependencies and enable the fulfilment of coordination concepts, see Table 2.3. However, findings suggest that mechanisms need to be tailored – sometimes longer meetings are preferable – and supplemented by other inter-team coordination mechanisms. For instance, Scrum of Scrums has been held as a prominent mechanism by many, as previously mentioned, but many have claimed a need for supplementing Scrum of Scrums with other mechanisms such as plannings meetings, reviews and retrospectives (Bick et al., 2017; Paasivaara et al., 2012; Stray et al., 2019). Similarly, Dingsøyr, Moe, Fægri, et al. (2018) state that several mechanisms are needed to facilitate knowledge sharing and coordination, and Gustavsson (2020) found that the Program Boards benefited from the support of mid-sprint reviews.

> "The main implication of our study is, therefore, that project management needs to combine many coordination practices to be able to handle all the dependencies in large-scale agile projects." – Stray et al. (2019, p. 7014)

Just as mechanisms need to supplement and support one another to achieve the best possible coordination effect, the same mechanisms need to be managed and allowed to evolve over time. Theobald and Diebold (2018) found that overcoming the awareness challenge and establishing shared knowledge depended initially on formal mechanisms and – as the project studied progressed – subsequently on informal mechanisms to an increasing extent. Experimentation and change of these mechanisms as time passed was also emphasised by (Theobald & Diebold, 2018). Many others have supported this dynamic view on coordination mechanisms – e.g. (Berntzen et al., 2019; Bick et al., 2017; Dingsøyr, Bjørnson, et al., 2018; Dingsøyr, Moe, Fægri, et al., 2018; Dingsøyr, Moe, & Seim, 2018; Evbota et al., 2016; Gustavsson, 2020; Wohlrab et al., 2019) – and it is, therefore, essential to evaluate and reevaluate the mechanisms used regularly (Berntzen et al., 2019; Wohlrab et al., 2019).

Table 2.3: Coordination mechanisms described in the literature

Mechanism	Description of Mechanism's Effect
Scrum of Scrums	Meeting between Scrum Masters with the purpose of managing dependencies (Dingsøyr, Moe, Fægri, et al., 2018; Stray et al., 2019) and commonly used as a synchronisation mechanism (Kalenda et al., 2018). Mitigates three out of four knowledge dependencies – expertise, requirement, task allocation – and the activity type process dependency (Stray et al., 2019) and has also been mentioned as a mechanism for managing emerging dependencies (Gustavsson, 2020; Sjøberg, 2018). The frequency of meetings and roles attending can be adapted to optimise when needed (Gustavsson, 2020). Scrum of Scrums facilitates face-to-face communication (Kuusinen et al., 2017) and knowledge sharing leading to improved communication across teams (Gustavsson, 2020). Gustavsson (2020) also found evidence that Scrum of Scrums can make teams less dependent upon specific individuals. However, one should keep in mind that Scrum of Scrums can be challenging as the number of teams grows larger (Evbota et al., 2016; Gustavsson, 2019).

Table Continues on Next Page

Continuation of Table 2.3

Mechanism	Description of Mechanism's Effect
Team Leader Meeting	A weekly scheduled meeting – with team leaders and managers present – found to mitigate dependencies across all three main types – expertise, historical, business process, and entity (Stray et al., 2019). The role of the team leader is often manifested as Scrum Master (Bick et al., 2017; Sjøberg, 2018; Stray et al., 2019). Scheduled meetings have been found to increase the frequency of inter-team exchanges (Stray & Moe, 2020).
Communication Tools	Can be of different kinds – e.g. emails, slack, Skype, Teams (Gregory et al., 2020; Stray et al., 2019). Stray et al. (2019) found that instant messaging tools mitigate all knowledge dependencies, activity process dependencies and entity resource dependencies (Stray et al., 2019). Instant messaging tools can be used for both technical questions and social interactions (Stray et al., 2019). Furthermore, Stray and Moe (2020) found that slack improved awareness and facilitated increased speed of feedback and communication in general.
Project Management Tools	Can, for instance, be in the form of tools for managing a Backlog – e.g. JIRA (Diebold et al., 2015; Dingsøyr, Moe, Fægri, et al., 2018; Stray et al., 2019). Such tools can mitigate requirement, task allocation, and historical knowledge dependencies (Stray et al., 2019).
Daily Stand-Up	Sometimes labelled *daily scrum* is a team meeting for presenting progress, coordinate work and solve problems (Gustavsson, 2020), improves team collaboration (Brooke & Allswang, 2015) and can be perceived as the team's Scrum of Scrums equivalent (Bick et al., 2017). (Schön et al., 2020; Stray et al., 2018). Nevertheless, it has sometimes been found useful as an inter-team mechanism where challenges of scale can be overcome by having pre-meetings. Subsequently, representatives in the actual meeting speak for the sub-teams (Santos et al., 2015). Daily stand-ups have been determined as a critical success factor for agile projects by improving team commitment and dynamics (Totten, 2017). The mechanism can also improve problem-solving communication (Stray et al., 2018) and mitigates all process and resource dependency types as well as historical and expertise knowledge dependencies (Stray et al., 2019). Stray et al. (2018) also state that awareness can be improved through this mechanism and suggest adaptions to the implementation of the mechanism to better reap the benefits – e.g. skip the question of what has been done since last time, rotate the role of meeting facilitator and schedule meeting right before lunch.

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Mechanism	Description of Mechanism's Effect
Retrospective	A regular meeting that embodies one of the core agile principles of reflection and adjustment (Andriyani et al., 2017; Gustavsson, 2020) focused on improving processes (Dingsøyr, Moe, & Seim, 2018; Moe, 2013; Paez et al., 2018). Retrospectives are most commonly held internally within the team but can be used across team interfaces (Dingsøyr, Moe, Fægri, et al., 2018; Dingsøyr et al., 2017; Kalenda et al., 2018). The retrospective mechanism has been found to help with dependency management (Andriyani et al., 2017) and has been held by some as the most important agile practice (Paez et al., 2018). Stray et al. (2019) found that it mitigates two knowledge dependencies – expertise and historical. Retrospectives have also been found to help develop shared understanding, help build trust, and increase communication and add feedback to it (Paez et al., 2018). Furthermore, retrospectives improve group mode coordination (Stray & Moe, 2020). However, not all teams manage to find root causes during retrospectives but merely identify symptoms of problems (Kalenda et al., 2018).
Software Release	Mitigates the technical resource dependency type (Stray et al., 2019).
Workshops	Workshops can be manifested in many ways. PI-planning workshops have been suggested as meaningful for coordination (Hendler, 2021). PO workshops held semi-quarterly were found by Berntzen et al. (2019) to facilitate knowledge sharing and alignment of goals. Other authors support the impact on knowledge by this mechanism. Stray et al. (2019) states that workshops mitigate expertise and requirement knowledge dependencies and Kalenda et al. (2018) argue that workshops can be used to facilitate knowledge sharing.
Sprint Planning Meeting	A meeting held at the start of each sprint to decide what items from the Product Backlog goes into the sprint Backlog for completion within the upcoming sprint (Diebold et al., 2015; Garzaniti et al., 2019; Gustavsson, 2020). The meetings are primarily focused on intra-team coordination (Kalenda et al., 2018) and were found by Stray et al. (2019) to mitigate expertise, requirement and task allocation knowledge dependencies. The mechanism has also been found to facilitate dependency awareness (Bick et al., 2017) which can be tracked in a dependency map used in these meetings (Diebold et al., 2015). However, in order to manage these dependencies appropriately, inter-team meetings are required to supplement the sprint planning meetings (Bick et al., 2017). Furthermore, sprint planning meetings have been found to improve planning, team communication and management of emerging dependencies (Hendler, 2021; Stray et al., 2019).

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Mechanism	Description of Mechanism's Effect
Ad Hoc Conversations	Unplanned communication between people that can take place anywhere (Stray et al., 2019) and even between distributed teams, although this puts greater pressure on relationships – which is a general drawback of the mechanism (Gustavsson, 2020) – and generally diminishes the use of the mechanism (Stray & Moe, 2020). Stray et al. (2019) found the mechanism very important since it mitigates all knowledge dependencies except historical, both process dependency types and technical resource dependencies (Stray et al., 2019). Kalenda et al. (2018) support this with findings of requirements being managed through this mechanism. Furthermore, Moe et al. (2019) found this mechanism to be particularly important in agile contexts and Stray and Moe (2020) state that this enables group mode coordination through feedback-integrated communication.
Project Meetings	Project meeting that can be manifested in different ways depending on roles participating – e.g. architect project meeting or business project meeting – found to facilitate group mode coordination (Dingsøyr, Moe, & Seim, 2018). It also mitigates expertise and task allocation dependencies (Stray et al., 2019).
Prep. for Product Demo	Preparations before demos have been found to mitigate expertise and historical knowledge dependencies (Stray et al., 2019).
Product Demo To Customer	Demos specifically to customer mitigates requirement knowledge dependencies (Stray et al., 2019)
Wiki	Can be used to document architectural guidelines, team routines, cross-team routines, system documentation, retrospective documentation, solutions descriptions, and testing documentation (Dingsøyr, Moe, Fægri, et al., 2018). The mechanism improves knowledge sharing (Kalenda et al., 2018; Santos et al., 2015) and mitigates requirement knowledge dependencies (Stray et al., 2019). Furthermore, wikis can help overcome challenges associated with distributed teams (Stray & Moe, 2020) and contribute to establishing a shared mental model (Bjørnson et al., 2018).
Task	Are artefacts manifested through different entities such as User Stories and Backlog items (Kasauli et al., 2020) and help mitigates task allocation knowledge dependencies (Stray et al., 2019).

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Mechanism	Description of Mechanism's Effect
Product Backlog	Is a mean of organising features, requirements and User Stories through which the PO can manage prioritisation (Diebold et al., 2015; Dingsøyr, Moe, Fægri, et al., 2018). Using a Product Backlog mitigates task allocation and activity dependencies (Stray et al., 2019). Backlog items can also function as high-level requirement representations used by teams to define and prioritise their own Backlogs, e.g. sprint Backlogs (Kasauli et al., 2020). A shared Product Backlog can also be used as a Master Plan (Dingsøyr, Moe, Fægri, et al., 2018) which can help overcome the otherwise single-team limitation of this mechanism (Schön et al., 2020). Using a common Backlog for inter-team coordination has been found useful (Kalenda et al., 2018). Furthermore, the Product Backlog can be used to track dependencies (Gustavsson, 2020), and if used in combination with Backlog refinement, it facilitates closed-loop communication (Bjørnson et al., 2018).
Backlog Refinement	Sometimes labelled Backlog grooming, can improve the quality of the Product Backlog and its prioritisation (Garcia et al., 2019). It can facilitate closed-loop communication (Bjørnson et al., 2018).
Priority List	Mitigates expertise and task allocation knowledge dependencies (Stray et al., 2019).
SAFe Documentation	The SAFe documentation and documentation of individual adoption can help entities understand their differences (Kasauli et al., 2020).
Kanban Board	Is a way to organise work (Suonsyrjä, 2017) and visualise to-dos, work in progress, waiting and completed work (Stray et al., 2019). Using it can help manage risks for the individual team (Schön et al., 2020). Kanban board also help mitigate requirement and task allocation knowledge dependencies as well as activity process dependencies and entity resource dependencies (Stray et al., 2019).
Whiteboard	Can be used as a Kanban board to manage work items (Hanssen et al., 2016). However, it can also be used otherwise – e.g. for team huddles and architecture discussions (Dingsøyr, Moe, Fægri, et al., 2018; Wilson, 2015) – and facilitates communication and knowledge sharing (Kropp et al., 2017). Furthermore, Gustavsson (2020) found that it can be used to visualise dependencies and Stray et al. (2019) found that whiteboards help mitigate requirement knowledge dependencies (Stray et al., 2019).

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Mechanism	Description of Mechanism's Effect
Open Work Space	All team members situated in same location (Bjørnson et al., 2018; Dingsøyr, Moe, Fægri, et al., 2018). Several authors have found this to enable coordination (Dingsøyr, Moe, & Seim, 2018; Stray et al., 2019). Dingsøyr, Moe, Fægri, et al. (2018) and Santos et al. (2015) found it contributed to improved knowledge sharing. Stray et al. (2019) state that the mechanism mitigates requirement and task allocation knowledge dependencies as well as activity process dependencies and entity resource dependencies (Stray et al., 2019). Open work space also facilitates building trust and relationships based on mutual respect (Berntzen et al., 2019; Bjørnson et al., 2018). Furthermore, it reinforces ad hoc conversations (Stray et al., 2019) and improve informal communication (Dingsøyr, Moe, & Seim, 2018) and increase the quality of communication (Berntzen et al., 2019).
User Stories	Backlog items can be formulated as User Stories (Dingsøyr, Moe, Fægri, et al., 2018; Dingsøyr, Moe, & Seim, 2018; Garzaniti et al., 2019), which helps clarify the customer value provided by a functionality (Kasauli et al., 2020). This mechanism has been found to facilitate knowledge management (Andriyani et al., 2017), create a shared understanding between teams (Kasauli et al., 2020), and help build a shared mental model (Hallmann, 2020). Furthermore, User Stories can act as facilitators of communication (Garcia et al., 2019) – e.g. communication of requirements between POs and developers (Hallmann, 2020).
Features	Features represent high-level requirements that can be broken down into manageable work pieces (Kasauli et al., 2020) – e.g. User Stories – by different teams and managed in the Product Backlog (Stray & Moe, 2020). Features can help determine inter-team dependencies and are extendable by implementing coordination ownership for specific features assigned to individuals within teams to improve inter-team coordination (Gustavsson, 2020).
Interface Requirements	Software architecture interfaces constitute requirements for all entities working with that architecture (Kasauli et al., 2020).
Technology Capabilities	Descriptions of system capabilities enable individual teams to identify reusable assets and their interfaces and requirements (Kasauli et al., 2020).

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Mechanism	Description of Mechanism's Effect
Testing	Shared testing between teams enables avoidance of regression and alignment of customer value achievement and functionality documentation (Kasauli et al., 2020). Furthermore, early and frequent testing enables feedback to the developers (Pantiuchina et al., 2017). Testing can also act as a mechanism for facilitating communication of requirements (dos Santos & Vilain, 2018), which according to Bjerke-Gulstuen et al. (2015) leads to improved shared understanding.
APIs/Interfaces	Interfaces between parts of a solution can be documented to help modularise and divide work (Kasauli et al., 2020).
Reference Architecture	Architecture descriptions help different teams to identify where features fit in the whole and ensure new solutions align with requirements (Kasauli et al., 2020).
Standards & Regulations	Standards such as ISO and regulations prescribe mechanisms that can be used – e.g. prescriptions of safety assurance cases for white/black box testing to ensure the product manages potential risks in use (Kasauli et al., 2020). Standardisation is also one of the three mechanisms prescribed for coordination by Mintzberg (1989).
Variability Model	Features and their respective constraints can be used to understand the interaction between solutions and the entire product (Kasauli et al., 2020).
Customer Documentation	External documentation can also be used internally to understand interconnections of sub-systems (Kasauli et al., 2020).
Contracts	Contracts with external organisational parties constitute constraints for all teams concerned (Kasauli et al., 2020). However, Dingsøyr, Bjørnson, et al. (2018) states that contracts are less prominent in agile contexts as a coordination mechanism.
Roadmaps	Roadmaps are often used to guide the development of Product Backlogs (Gustavsson, 2020) and contain information on what new features will be offered to customers and when (Stray & Moe, 2020). Roadmaps link products together that co-evolve over a long time and can be used to coordinate (Kasauli et al., 2020). Roadmaps are a mechanism that can help achieve impersonal coordination, which limits the need for direct communication for coordination (Dingsøyr, Moe, & Seim, 2018; Dingsøyr et al., 2017). Furthermore, roadmaps can act as a visualisation mechanism to support a common understanding of the big picture in large projects (Schön et al., 2017).
Short-Term Plans	Breaking down plans into smaller increments help coordinate work across teams (Kasauli et al., 2020).

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Mechanism	Description of Mechanism's Effect
Resource Budget	Available resources – e.g. hardware resources constraints for software development – constitutes a boundary object which helps entities understand their differences (Kasauli et al., 2020).
Trace Links	Can help clarify the relationship between other mechanisms and enable improved collaborative development of mechanisms over time (Kasauli et al., 2020; Wohlrab et al., 2019).
Demo	Demos can be held at different scales – e.g. sprint demos, mid-sprint demos, system demos – and with different stakeholders involved to show work completed during an iteration (Dingsøyr, Moe, Fægri, et al., 2018; Gustavsson, 2020; Rolland et al., 2016). This mechanism has been found to improve common understanding across interfaces (Berntzen et al., 2019; Gustavsson, 2020). Furthermore, demos enable timely feedback (Brooke & Allswang, 2015; Rolland et al., 2016). It also enables group mode of personal coordination (Dingsøyr, Moe, & Seim, 2018).
Experience Forum	Is a type of meeting for different agile roles focused on the development methods used (Dingsøyr, Moe, Fægri, et al., 2018; Šmite et al., 2019). This mechanism has been found to facilitate sharing of experiences across interfaces (Dingsøyr, Moe, & Seim, 2018; Dingsøyr et al., 2017). Furthermore, experience forums are a mechanism for achieving group mode personal coordination (Dingsøyr, Moe, & Seim, 2018).
Lunch Seminar	Can be used for presentations regarding, for instance, new architectural components (Dingsøyr, Moe, Fægri, et al., 2018). Lunch seminars are a different scheduled meeting mechanism with the same effects as experience forums – i.e. group mode personal communication and sharing experiences (Dingsøyr, Moe, & Seim, 2018; Dingsøyr et al., 2017).
Technical Corner	Meeting where architects brief the team (Dingsøyr, Moe, Fægri, et al., 2018). Similar to lunch seminars, this mechanism can be grouped together with experience forums as a scheduled meeting mechanism for group mode personal communication and sharing experiences (Dingsøyr, Moe, & Seim, 2018; Dingsøyr et al., 2017).
Metascrum	Frequent meetings between managers from different organisational entities on a higher level than Scrum of Scrums where obstacles in Programs are discussed (Dingsøyr, Moe, Fægri, et al., 2018; Dingsøyr, Moe, & Seim, 2018; Dingsøyr et al., 2017).
Open Space Technology	Is a discussion forum where topics are freely suggested, and participants can then join breakouts of their interest to discuss challenges and improvements (Dingsøyr, Moe, Fægri, et al., 2018; Šmite et al., 2019).

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Mechanism	Description of Mechanism's Effect
Team Member Rotation	Team members can shift membership between different teams (Dingsøyr, Moe, Fægri, et al., 2018). This mechanism has been reported as a systematic way of sharing knowledge across interfaces (Santos et al., 2015), facilitating face-to-face communication (Kuusinen et al., 2017). Furthermore, the mechanism helps achieve the individual mode of personal coordination (Dingsøyr, Moe, & Seim, 2018).
Dependency Map	A chart of User Story dependencies is tied to the Product Backlog, which helps teams prioritise and plan for the execution of tasks in the appropriate order for the collective good (Bjerke-Gulstuen et al., 2015).
Physical Informal Meetings	Can be manifested through dinners, trips, social events, and help create a shared understanding of direction, build relationships and improve communication (Stray & Moe, 2020).
Roles	The creation of roles for coordination purposes is common in scaled agile contexts – e.g. Product Manager and System Architect prescribed by the SAFe framework (Gustavsson, 2020). More informally, teams can also appoint coordination responsibility to specific team members to act as ambassadors and participate in meetings across specific interfaces (Stray & Moe, 2020).
Universal Language Use	By using a organisation-wide universal language, all members of the organisation can participate in and take part in communication (Stray & Moe, 2020).

3
Methodology

This chapter describes the methodology of the study as well as the rationale behind it. Different elements of the methodology such as the research strategy, design and methods are described and discussed from an ethical and quality perspective.

3.1 Research Strategy

According to Bryman and Bell (2011), there are two main research strategies – qualitative and quantitative – distinguishable by their respective orientation to business research. Qualitative business research is often, but not exclusively, inductive, meaning that it is focused on the generation of theory as opposed to testing it (Bryman & Bell, 2011). Qualitative research is associated with interpretivism (Bryman & Bell, 2011). These notions combined support the qualitative research domain's focus on understanding rather than explaining social phenomenon (Bryman & Bell, 2011). A notion supported by other authors such as Uwe Flick and Steinke (2001), who claim that this makes the strategy suitable for questions of the type addressed in this thesis.

Furthermore, Bryman and Bell (2011) describe qualitative research as a step-wise and iterative approach to research commonly following six main steps. This study will follow a process based on these main steps illustrated in the iterative process in Figure 3.1. Finally, this study followed an inductive approach, aiming to generate new theory based on empirical findings and thus, the research strategy chosen for this study is qualitative. However, some elements of the deductive approach were present in this study at an early stage as this part of the process involved studying existing theory. The notable difference from a more conventional deductive approach for the overall study adheres to the purpose of this review of theory. This literature review was conducted to provide a framework for analysis rather than generate hypotheses to be tested in the study, as in deductive research (Bryman & Bell, 2011).

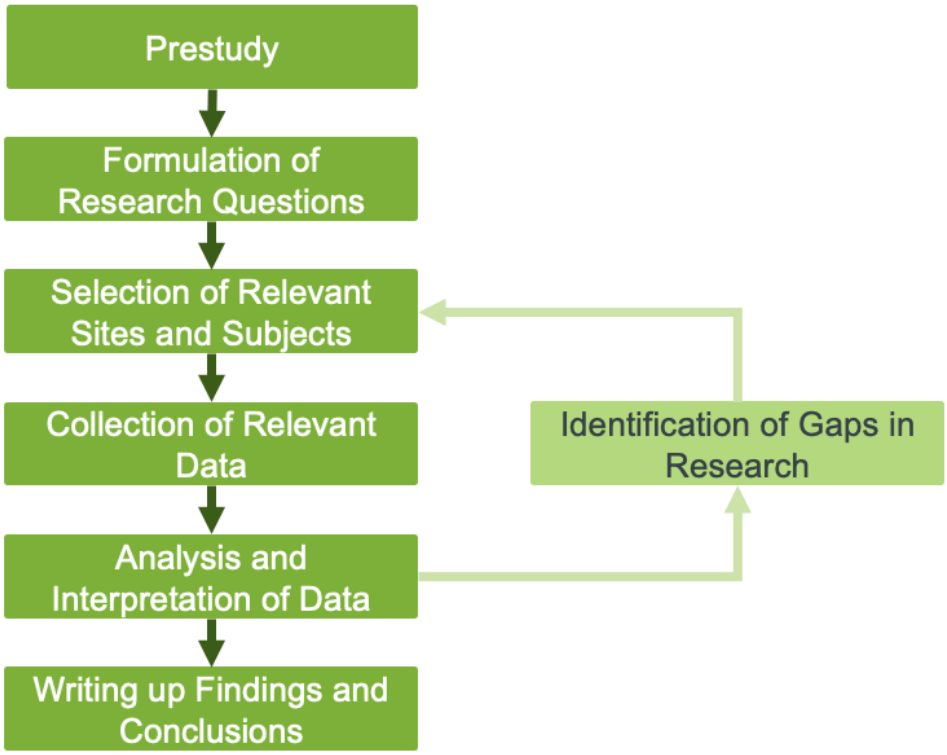

Figure 3.1: Illustration of the process for this study based on the general process for qualitative research by Bryman and Bell (2011).

3.2 Research Design

Research design and research method are two concepts often mistaken for one another (Bryman & Bell, 2011). The distinction between the two terms is on the level of abstraction. Research design composes the structure used to execute the chosen research method or methods (Bryman & Bell, 2011) and can thus be viewed as a framework for the method.

A case study is distinguished from other research designs by its bounded focus on a system or situation and the detailed analysis thereof (Bryman & Bell, 2011). It is perhaps the most commonly used design in business research, and the case can constitute different systems, groups, events, or organisations (Bryman & Bell, 2011).

> "The basic case study entails the detailed and intensive analysis of a single case." – Bryman and Bell (2011, p. 59)

The choice of research design often has to consider practical considerations, according to Bryman and Bell (2011). This study was proposed and offered the researchers by Volvo Cars as a Master's thesis opportunity. This carried practical considerations as the study depended on Volvo Cars for resources, particularly for the data collection. This dependency also influenced the choice of research design as Volvo Cars proposed a case study design with a specific entity in mind.

However, coordination in large scale agile contexts is at the forefront of the research agenda (Bjørnson et al., 2018; Evbota et al., 2016; Theobald & Diebold, 2018; Uludag et al., 2018). This, together with the increasing influence of software in automotive systems (Pernstål et al., 2012), made the case of Volvo Cars MESW and their interfaces with P&Q an attractive research setting. A few studies have been conducted in similar contexts revolving around the topic of coordination across interfaces – e.g. Gustavsson (2020)'s multi-case study and Wohlrab et al. (2019) – but research in this context is still relatively scarce. This provided an ample opportunity to conduct research exploring somewhat uncharted terrain, contribute to a relatively infant body of knowledge, and provide meaning to Volvo Cars. Thus the practical considerations and the research value perspective were relatively aligned and determined the choice of this research project for the authors. The case chosen can be defined as a group level case study on the SOGI model (Bryman & Bell, 2011), with MESW and its interfaces with P&Q constituting the system boundaries of the case.

The practical implications may have also influenced the development of research questions and strategy to suit the appropriate uses of a case study design. However, this seemed natural given that an inherent problem with case studies is the need to determine whether it is significant for the research questions posed (Flick, 2001).

3.3 Research Methods

This section outlines the data collection methods used in the study. The methods chosen can be divided into two fractions – literature review and empirical data collection methods. The literature review was conducted to provide a framework for the empirical data analysis and provide academic context to the case data. The empirical data collection concerned the case study and was, similarly to the research design, influenced by practical considerations as is often the case (Bryman & Bell, 2011). The empirical data mainly adhere to interview data collected from participants but include supplements of data from internal documentation from Volvo and ethnographic observations.

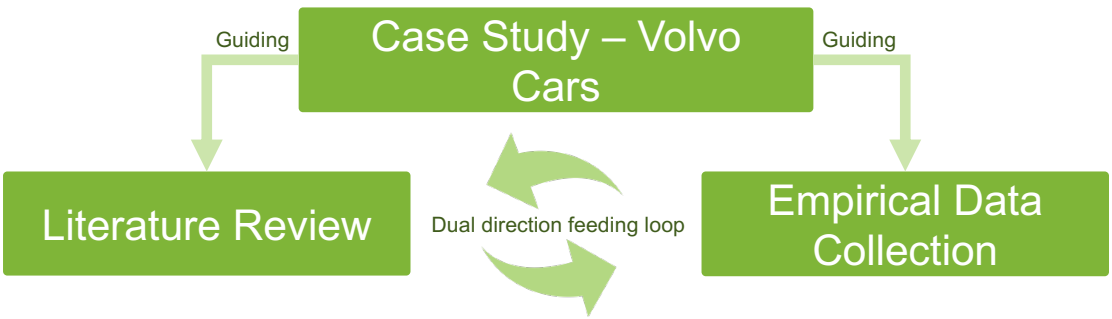

Figure 3.2: Illustration of how the research design influenced the data collection – both literature review and empirical data collection.

3.3.1 Literature Review

The purpose of the literature review was manifold. It can help define research questions, choose research design and method, and help analyse data collected (Bryman & Bell, 2011) and has done so in this study. The process for conducting a literature review includes elements of judgement in terms of determining what to include and exclude in the review (Bryman & Bell, 2011). In qualitative studies, with an interpretivistic epistemology, narrative literature reviews are often used as this approach is broader and better enables researchers to understand the topic they intend to investigate (Bryman & Bell, 2011). A narrative literature review allows for more flexibility concerning the boundaries of the review and alterations of the same as data is collected and insights are gained (Bryman & Bell, 2011). For these reasons, a narrative approach to the literature review was chosen for this study.

The process of identifying relevant literature was based on the suggested general process presented by Bryman and Bell (2011). However, it was adapted to make up a more iterative process in accordance with the narrative approach.

The identified literature was, as mentioned, used as a framework for the collection and analysis of empirical data from the case study. The process outlined was iterated through multiple times. Both literature and empirical findings guided the researchers towards new topics relevant to include in the literature review.

The initial step of the process was based on two sources of input – the supervisors from both Volvo Cars and the supervisor appointed by Chalmers. Here the researchers took advantage of both of the combined academic experience. The Volvo Cars appointed supervisor had academic experience ranging up to a PhD from Chalmers, and the Chalmers appointed supervisor over a decade of academic experience including a PhD from Chalmers also. These sources provided both direct material for review and names of potentially relevant authors within the field of study. This led to several articles and a few dissertations being identified as potentially relevant through a review of abstracts. This literature allowed for both direct snowballing of new articles from their respective list of references and development of keywords used for further searching using google scholar as the primary source with material deemed relevant subsequently downloaded using Chalmers Library services.

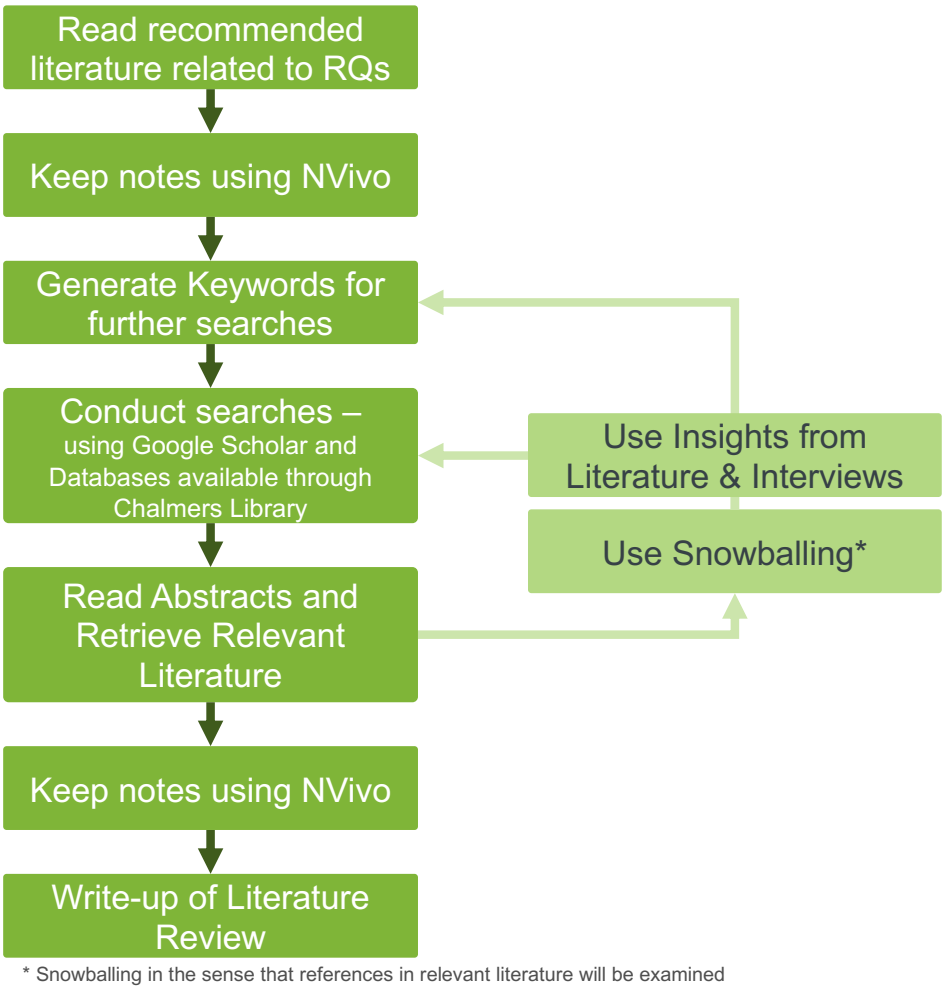

Figure 3.3: Illustration of the literature review process for this study based on the general process by Bryman and Bell (2011, p. 110).

3.3.2 Interviews

In qualitative research, the most common empirical data collection methods are interviews and observations (Bryman & Bell, 2011; Lüders, 2001). There are multiple advantages and disadvantages to either compared to the other (Bryman & Bell, 2011). Most relevant of these for the choice of interviews as the primary data collection method in this study is the ability to be more focused in interviews (Bryman & Bell, 2011). This property aligned well with the constraints of this study as a Master's thesis project in terms of time and resources. Additionally, the choice of method was similar to research design choice influenced by practical implications (Bryman & Bell, 2011). Given the global and local circumstances surrounding the COVID-19 pandemic, observations could early on be deferred on the basis of practicality.

In qualitative research, interviews are typically unstructured or semi-structured to allow for flexibility, enabling the exploratory nature of such research (Bryman & Bell, 2011). In order to enable some form of comparability in the analysis between

interview data (Schmidts, 2001), the semi-structured interview method was chosen for this study. Furthermore, Bryman and Bell (2011) argue that semi-structured interviews are preferable when more than one person will be conducting the interviews, which has been the case in this study with interview responsibility shared between the researchers – i.e. one was the primary interview leader while the other took notes and vice versa in some interviews. When conducting semi-structured interviews, it is useful to have an interview guide prepared (Bryman & Bell, 2011). The development of such a guide for this study followed the basic elements for interview guide preparations suggested by Bryman and Bell (2011) – see Figure 3.4. The interview guide was revised following the conclusion of the first three interviews based on the interview experience. Furthermore, a separate and slightly different interview guide was developed to better suit the P&Q interviews conducted. The resulting guides used for the vast majority of the interviews are attached to the thesis paper – see Appendices 6.2 & 6.2.

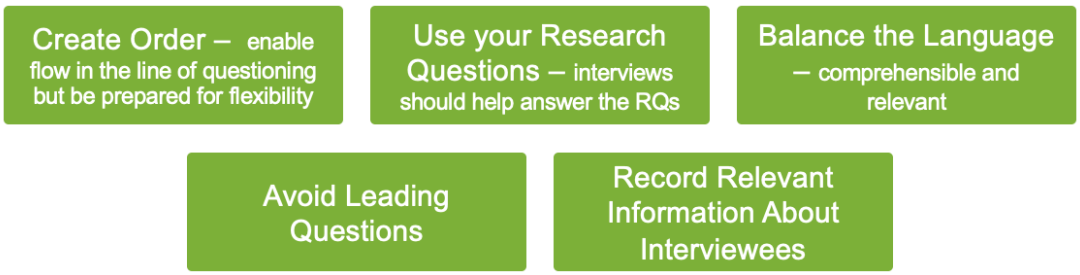

Figure 3.4: Illustration of the common elements for developing an interview guide for semi-structured interviews Bryman and Bell (2011, p. 475).

Another critical aspect to consider besides the choice of data collection method(s) was sampling technique (Merkens, 2001). Typically, qualitative research often benefits from extending samples and sample frames as knowledge is gathered during the study (Merkens, 2001). This type of sampling – often labelled as theoretical sampling – is common practice in qualitative research (Bryman & Bell, 2011; Merkens, 2001). Theoretical sampling was chosen for this study on the merit of its iterative nature, which aligned well with the planned process of the investigation – see Figure 3.2. Furthermore, this sampling method's foremost value is that it allows for the researchers to evaluate along the way and determine when further data is no longer needed (Bryman & Bell, 2011). This practice was applied in this study, and the interview process was concluded when the researchers agreed that data deduced from interviews were mainly repetitive.
However, for practical reasons related to the dependencies of this study to Volvo Cars, the starting point of interview sampling was influenced by elements of both convenience sampling and thereafter also took on a snowball sampling nature. Convenience sampling is a non-probability sampling technique based on the availability of interview subjects (Bryman & Bell, 2011). Snowball sampling is a subset of convenience sampling where the choice of interviewees adheres to the identification of potential candidates during interviews conducted (Bryman & Bell, 2011).

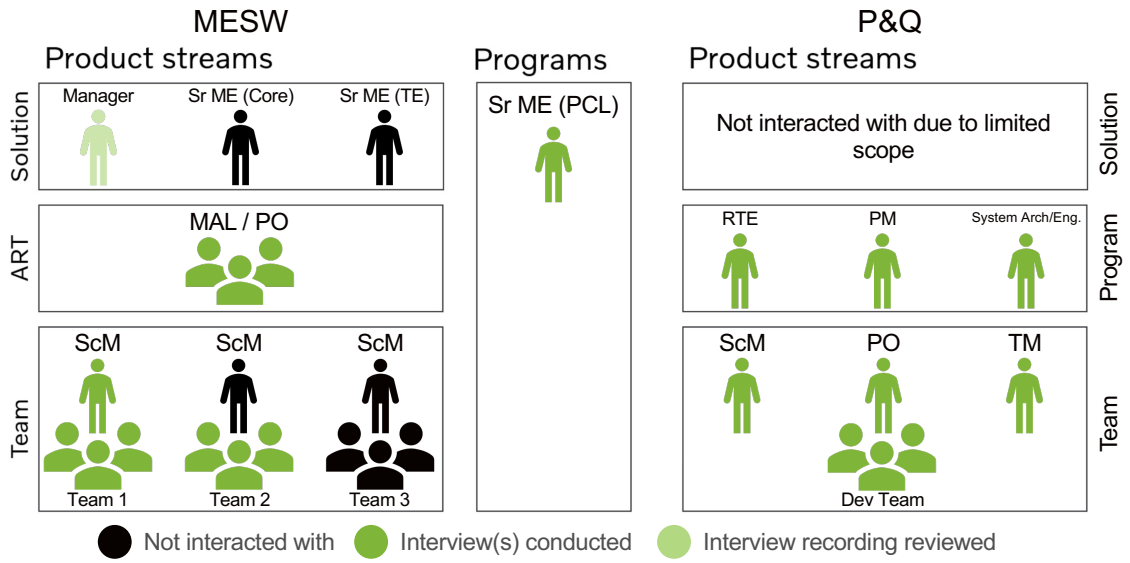

Figure 3.5: Illustration of the roles covered in MESW and the P&Q ARTs included in the study.

For the same reason, two interviews conducted included more than one interviewee to accommodate Volvo Cars' employees' limited availability and the interviewees' preference. Finally, one interviewee represented two roles' perspective during the interview as this person had experience both as PO and ScM. These practicalities have been listed in Table 3.1 below as separate interviews to clarify the number of roles interviewed rather than emphasising the number of interviews scheduled.

For an overview of the roles covered during the interviews at both MESW and P&Q, see Figure 3.5. This study emphasised inter-organisational coordination on the team level, as the coordination on the levels above can be seen as facilitators of coordination further down. As agile principles also emphasise coordination directly between the team members, their perspective and the layer above formed the basis for the interviews. As no suggestions from interviewees included roles on the solution level, and data collected suggested that coordination was emphasised on the team level and the program level within Volvo Cars, no interviews were conducted on the solution level. However, one interview recording was reviewed on the solution level for MESW – for more details on this data source, see Section 3.3.3. The range of roles interviewed combined with the number of ARTs and teams represented – see Figure 3.5 and Table 3.1 – provided a solid foundation of the analysis. Through this, the empirical data was able to cover the perspective of all roles involved in the collaboration on the team and program level. Furthermore, the interviewees were affiliated with multiple of the different P&Q ARTs that MESW most commonly interact and collaborate with. Because of this, the empirical data was able to cover a wide range of findings relevant to the research questions of the study.

Table 3.1: Table of interviews conducted during the study.

Title	Affiliation*	Date
Program Commodity Leader	MESW	2021-01-20
Scrum Master	MESW Team 1	2021-02-04
Manufacturing ART Leader	MESW	2021-02-08
Manufacturing ART Leader	MESW	2021-02-09
Development Engineer	MESW Team 1	2021-02-16
Development Engineer	MESW Team 2	2021-02-18
Product Owner	P&Q ART 1	2021-02-19
Scrum Master	P&Q ART 1	2021-02-19
Team Manager	P&Q ART 2	2021-02-19
Development Engineer	P&Q ART 3	2021-02-22
Release Train Engineer	P&Q ART 4	2021-02-22
Scrum Master	P&Q ART 5	2021-02-23
Development Engineer	MESW Team 1	2021-02-23
Product Manager	P&Q ART 6	2021-02-24
Product Owner	P&Q ART 7	2021-02-25
Product Owner	P&Q ART 6	2021-02-26
Scrum Master	P&Q ART 6	2021-02-26
Release Train Engineer	P&Q ART 3	2021-02-26
Release Train Engineer	P&Q ART 3	2021-02-26
Product Owner	P&Q ART 8	2021-02-26
System Architect	P&Q ART 9	2021-03-12

* The P&Q ARTs and the MESW teams were anonymised for confidentiality reasons.

3.3.3 Other Empirical Data

Volvo made available a range of resources to assist the investigation and help the researchers establish understanding and contexts to findings. These resources included illustrations and documentation of the VCAF, MESW team structures, and agile role descriptions. These documents were used in a preemptive investigation to provide a more solid knowledge of the case – in terms of contextual and linguistic understanding – as a basis for the research going into the interview phase. Furthermore, these resources provided a search and identification-ground for potential interview subjects based on available role and contact descriptions.

Additionally, the study made use of ethnographic observations in the effort to triangulate and further strengthen findings from the primary data sources. These observations emerged as an opportunity during the research as Volvo Cars had their

PI-planning for all ARTs and agile teams during week ten of 2021, which conveniently aligned with the conclusion of the interview phase of the data collection. This opportunity was used as a means of triangulating data revolving around the first research question – see Research Question 1 – related to the agile ways of working in MESW and P&Q, respectively. Due to the limitation of time and the fact that the researchers could not be in more than one meeting each at a time, observations were limited to MESW and ART nine. To cover more meetings, the researcher decided to divide their focus by each attending different meetings. The meetings collectively covered were PI-session 1 with MESW and ART nine, the Scrum of Scrums with MESW and two Scrum of Scrum meetings with the P&Q side, and the same number of PO-sync meetings.

Finally, interview recordings were reviewed from interviews conducted by another master's thesis group conducting a study on agile maturity within the same context as this case study. The respective studies had questions that overlapped to some extent in the respective interview guides pertaining to the ways of working at Volvo Cars. For this reason, Volvo Cars suggested that interview recordings be shared between the groups to share insights and avoid unnecessarily asking the same questions to the same people and thereby risk wasting precious employee time. These interview recordings were reviewed but were concluded to be of limited use to this study given the predominantly differing purpose of the data collection. Furthermore, the risk of overlapping interviews being conducted was mitigated by communication across the groups, and ultimately only one interviewee appeared in both studies, and this person did not appear to have any issues related to questions that overlapped.

3.4 Data Analysis

Qualitative data analysis concerns identifying categories and themes in data and the relationship between them to better understand the phenomenon studied (Hilal & Alabri, 2013). There is an inherent difficulty with data analysis in qualitative research due to the often cumbersome nature of the data created (Bryman & Bell, 2011; Hilal & Alabri, 2013). However, there are strategies and techniques to deploy in the execution of these strategies that help qualitative researcher conduct thorough analysis (Bryman & Bell, 2011). In this study Grounded Theory, using coding of data was chosen for the analysis.

Coding is the cornerstone of data analysis in qualitative research (Hilal & Alabri, 2013) and entails flexibility as coding schemes are iteratively developed as data is collected (Bryman & Bell, 2011). In this manner, the literature review helped form the first basis of the coding schemas, and all methods of data collection subsequently contributed to the development of these schemas as the study progressed. This less rigorous way of conducting the analysis is defensible given that the nature of qualitative data and the fact that findings from qualitative research only contribute with significance to academia when interpretation by the researchers is incorporated according to Bryman and Bell (2011).

To facilitate the coding process, the choice was made to use the Qualitative Data Analysis Software, NVivo. The software is a popular analysis tool in qualitative research and facilitates an easier coding process while simultaneously improving the quality of research (Hilal & Alabri, 2013; Siccama & Penna, 2008).

Tying back to the research questions, the literature mainly supported the development of coding schema for the empirical data to answer the first questions as this specifically ties to Volvo Cars – i.e. the literature helped create categories for defining differences, such as agile ceremonies and roles adopted. In contrast, the second research question was intentionally framed to be more generally applicable, and the analysis conducted to answer this question drew upon data from both the interviews and literature. The analysis of data from these resources drew upon the established applicability of findings from the software domain – see Section 2.2 – and used earlier research to frame empirical findings related to challenges. Similarly, concerning research question three, previous findings related to solutions in academia were used as a basis for the analysis together with ideas from the researchers.

3.5 Research Quality

Quantitative and qualitative research inherently differs in their nature in terms of the purpose of investigations conducted and their goals (Merkens, 2001). Therefore, it is appropriate to use different evaluation criteria when evaluating the quality of the different research domains (Bryman & Bell, 2011; Steinke, 2001). In this study, the commonly used approach of evaluating the research based on its trustworthiness was chosen. According to (Bryman & Bell, 2011), trustworthiness can be evaluated based on the four criteria:

- *Credibility* – how believable the findings are
- *Transferability* – applicability of findings in other contexts
- *Dependability* – how time persistent the findings are within their context
- *Confirmability* – The degree to which the researchers have allowed their values to influence the study

The credibility of the study was reinforced through several measures. First, informed consent was obtained to record all interviews to ensure all details were captured in their entirety and with the correct formulation. Furthermore, credibility was strengthened by using the concept of respondent validation – i.e. confirmation of correct interpretation by the interviewers was obtain by repeating back to the respondent what had been perceived as said and confirmation/clarification received (Bryman & Bell, 2011). Finally, as others have before this study made use of the tool NVivo as a means of strengthening credibility as this enhances validity (Siccama & Penna, 2008), which parallels credibility (Bryman & Bell, 2011).

Transferability is always a concern in qualitative case studies as the characteristics of the case studied are likely to be unique (Bell et al., 2019). By providing a

detailed description of the case and including a general literature review, it is believed that some transferability both within and without Volvo Cars will be possible.

Dependability refers to the potential for other researchers to replicate the study and arrive at the same results (Bryman & Bell, 2011). This criterion can be achieved through thorough documentation of procedures to make it easier to replicate the study by following the same approach and process. Bryman and Bell (2011) argue that dependability is strengthened by making interview guides used available. This measure was used in this study to increase its quality – see Appendices 6.2 and 6.2.

Confirmability can arguably never be fully achieved in qualitative research as it depends on the researchers' interpretation (Bryman & Bell, 2011). However, measures can be taken to strengthen it, and so this has been done. As a first measure, the analysis and conclusions drawn were always shared between the two authors to provide a first layer of protection against the intrusion of personal values. Furthermore, collaboration with supervisors at both Volvo Cars and from Chalmers provided an additional layer of protection. However, it is important to note that these layers do not constitute perfect protection. Particularly the perspective of the supervisor from the case company had to be carefully considered as such, and measures were taken to make sure that the internal perspective did not overrule interpretation of the data collected during the study.

3.6 Ethical Considerations

Ethical considerations and the adoption of good research ethics can make research more difficult – e.g. more time or resource consuming – or even constitute a barrier to creating new knowledge entirely (Hermerén, 2017). However, the evaluation of research quality needs to incorporate ethical considerations (Hermerén, 2017).

Research ethics can be divided into four main principles as listed according to Bryman and Bell (2011):

- *Harm to participants* – both physical and psychological harm to participants as a result of the study
- *Informed consent* – concerns informing prospective participants in the study significantly enough for them to make an informed decision regarding their willingness to participate
- *Invasion of privacy* – concerns transgressions into the subjective nature of what can be considered private for a participant
- *Deception* – concerns misrepresentation of the research

During this study, there have been no indications of physical harm to participants. As this was predicted, the focus for this principle lay on mitigating the risk of psychological infringements. Particularly the researchers took great care with anonymity and ensured that informed consent was obtained from all participants about the collection of data. As complete anonymity may not always be possible due to the risk of deductive disclosure (Tsai et al., 2016), information about this was shared

with prospective participants. Paradoxically, the study results were assumed to have greater credibility with more transparency regarding who participated in the study. Therefore, roles covered in interviews – see Figure 3.5 – was included despite the evident risk of deductive disclosure, given that some roles covered are only held by a single individual. However, to protect participants' integrity, all ARTs covered in the study were anonymised and quotes included were limited in the description of its origin. It protected against deductive disclosure in terms of what was said by each participant but did not eliminate the risk of participation being deduced, particularly by employees of Volvo Cars. Numbering the ARTs provided a means of strengthening credibility while ensuring strong protection of anonymity.

Informed consent and invasion of privacy are linked (Bryman & Bell, 2011), but more decisive action can be taken to ensure informed consent. In all interviews, information about the research, its purpose and aim, and how it would be conducted was disclosed to allow participants to ask questions, object to participation, and the option to back out after interviews had started was provided. It was more difficult to ensure no invasion of privacy occurred as this is highly subjective, but the researchers treated participants as unique individuals and with respect. On one single occasion brought up an invasion issue but not of privacy to the individual, but rather to Volvo Cars as a company. This was discussed after the recording of the interview had been terminated and revolved around issues of confidentiality. This was discussed after the recording of the interview had been terminated and revolved around issues of confidentiality. Extra care was taken to ensure this participant felt comfortable with the information shared. Follow-up emails with direct documentation from this paper were provided, allowing the participant to provide feedback on content disclosed and consent to the documentation of his/her statements. Furthermore, information about the screening process of the thesis through Volvo Cars appointed supervisors was provided to the participant to further ensure that the interviewee felt comfortable with the publishing of the content in this thesis.

Being truthful in the disclosure of information will also make sure deception is avoided. As deception revolves around misrepresentation of the study (Bryman & Bell, 2011), misinforming participants or neglecting to inform altogether can constitute transgressions of this principle. Therefore, information about the study was provided beforehand to all prospective interviewees and reviewed with the participants before interviews commenced. Furthermore, during the ethnographic observations, the researchers introduced themselves when they entered the meetings observed. This felt particularly important given the remote setting for the observations – they were conducted during meetings over Microsoft Teams – since presence in a non-physical meeting is more easily unnoticed by others than it would be in physical meetings.

In addition to these general principles, there are other ethical considerations as well. Data protection, for instance, is both a legal and ethical concern when conducting research (Bryman & Bell, 2011). In this study, three perspectives were considered in terms of data protection. First, the legal aspect of compliance with the GDPR.

Second, data protection in accordance with Volvo Cars' policies for protecting sensitive information – e.g. the sole use of Volvo Cars internal platforms for handling any sensitive company data. Finally, the personal perspective of research participants in the way data collected is managed – e.g. through deletion of recordings following the conclusion of the study. Furthermore, ethical considerations arise in the use of copyright material for the study and have been handled in accordance with Chalmers policies.

3.7 Discussion of Methods Chosen

The methods chosen were apt to perform the study and conduct the analysis that led to the conclusions drawn. However, the chosen methods could have been adjusted had there been more time available for the project. For instance, interviews could have been conducted with all ARTs at P&Q to provide a more comprehensive perspective. Additionally, had more time been available for the interviews conducted, a more detailed deep-dive could have been conducted during each interview. In this study, most interviewees had limited time and scheduling a full hour was difficult enough. This made it impossible for the researchers to pursue every lead in all interviews, impacting the potential to gain more comprehensive empirical support for coordination challenges identified in the case studied. This results in perhaps fewer interviewees providing documented support for specific issues – see Table 4.1 – than would otherwise have been found. This could potentially have carried impact on the analysis of the different problems in terms of importance.

Furthermore, observations could have, given more time and resources, been used as a primary data source to answer the first research question – see Research Question 1 – revolving around differences between MESW's and P&Q's agile adoption. This is because observations provide a more objective perspective as it is a direct source of data without the subjectivity of an interviewee to be considered. Instead, triangulation using observations was used on a limited scale, providing some of the advantages that this would have had as a primary data source.

Finally, the literature review provided a basis for analysis and some guidance for solutions to the challenges identified. However, given the relative infancy of the body of knowledge related to inter-team coordination in scaled agile contexts the intent in the onset was to identify a specific conceptual framework that could be used to conduct the analysis and simplify the identification of case-relevant solutions. This intent could not be fulfilled as no comprehensive framework was identified regarding the classification of coordination challenges, which subsequently led to the researchers having to use the raw data and find patterns themselves to conceptualise both challenges and solutions.

4
Findings

This chapter presents the relevant empirical data necessary for the reader to understand the context of this report. Furthermore, the chapter presents answers to all of the research questions based on an analysis of the empirical data and relevant literature.

The first section describes Volvo Cars as a company on a high level and explains why it is relevant as the target for this case study. Furthermore, the first section provides the reader with the necessary context to understand the upcoming analysis. The second section describes how agile is implemented at MESW and P&Q, ultimately answering research question one. The third section includes a description of the key problem areas identified through the empirical research and draws upon the literature to suggest potential solutions. Additionally, this section relates the problems at Volvo Cars with problems identified in the literature and attempts to cluster the problems based on this. The third section aims to provide answers to research question two and three.

4.1 Case description

Volvo Cars is a global automotive OEM developing and producing cars targeted at the premium segments. While founded and based mainly in Sweden, Volvo Cars is owned by the Chinese automotive manufacturer Geely. The company has more than 40000 employees globally and sold more than 700 000 cars in 2019 (Volvo Car Group, 2020).

The development processes at Volvo Cars are characterised by advanced and high-level engineering, including both hardware and software development. Tasks are performed concurrently to achieve a short time-to-market, and follows a traditional stage-gate model that drives the overall development of the vehicles. The development cadence of all ARTs and teams is set to match Volvo Cars overall product development pace. Base Product Development – the product development process at Volvo Cars – drives the cadence of new complete vehicle development and coordinated the build-up of product through product stream solutions. These solutions are contributed to in set intervals of six months with the Product Increments scheduled to fit into these iterations.

The combined focus on hardware and software requires a wide range of engineering

competence and cross-functional teams. There are several engineering disciplines involved, ranging from mechanical engineering to software engineering and manufacturing engineering. On a high level, Volvo Cars is divided into three key organisations: Manufacturing – i.e. production in the plants – Manufacturing Engineering and Product Development – referred to as P&Q in this report. These organisations are structured differently, for example, Manufacturing Engineering is divided into departments – e.g. MESW – while P&Q divides its' organisation into Agile Release Trains (ARTs). Subsequently, a department or ART is typically divided into multiple teams.

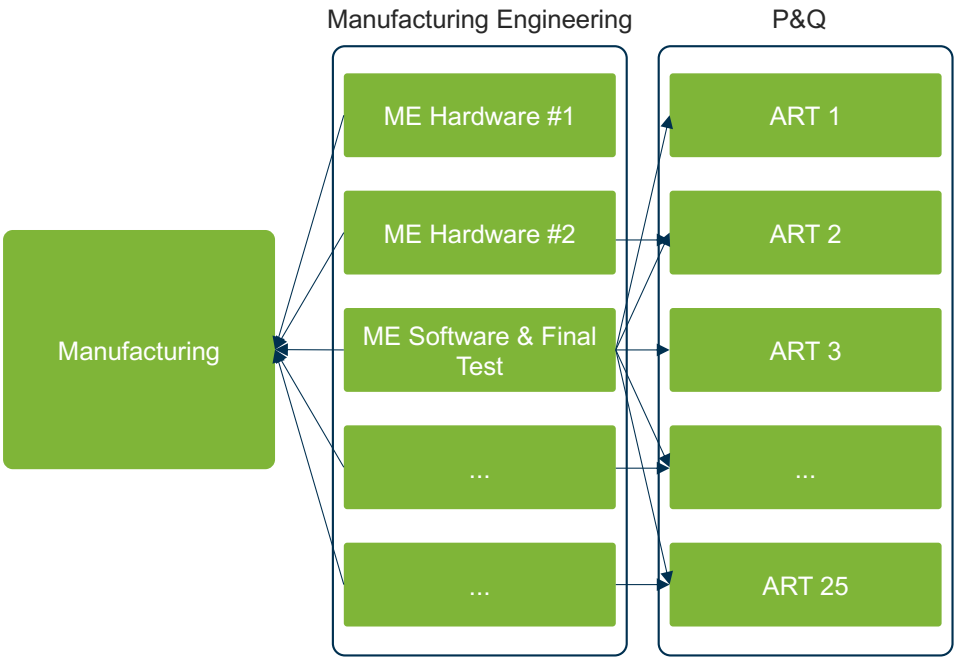

Figure 4.1: Illustrative and simplified figure showing the main organisations at Volvo Cars and how they are interlinked on a high level.

P&Q is responsible for driving the development of new components and vehicle programs. Currently, P&Q and other organisations at Volvo Cars are going through an organisational transformation and are implementing agile principles and ways of working. The agile implementation is based on the Volvo Cars Agile Framework – a customised adaption of SAFe (see the Subsection about SAFe under 2.1.1) – which is described in the following sections. Following this, P&Q is divided into multiple ARTs and teams based on which part of the vehicle they are responsible for.

Manufacturing Engineering (ME) acts as an interface between P&Q and Manufacturing – i.e. the production plants. The overall responsibility of ME is to ensure manufacturability of newly developed systems and components. Furthermore, ME helps develop smart and efficient manufacturing solutions and ensure new vehicle launches are successful. As described above, ME is divided into multiple departments, each typically responsible for coordinating with one or two P&Q ARTs and Manufacturing. Each department is also responsible for developing manufacturing solutions for specific stations in the manufacturing plants. This thesis focused on

one department within ME called Manufacturing Engineering Software Download & Final Test (MESW).

Unlike ME Hardware departments, MESW coordinates with more than 25 ARTs at P&Q and are responsible for multiple stations related to components & systems across the entire car. In addition to ensuring correct software is downloaded to the different ECUs, MESW is responsible for different calibration processes, filling up brake fluid, and multiple checks & tests (i.e. roller bench tests, chassis setting, wheel and light adjustments, Short Track Test, and Final Health Checks). MESW's stations are located at the end of the production line. After the car successfully passes through all of MESW's stations, it is ready for delivery to the end customer.

4.2 How Agile is Implemented at P&Q and MESW

This section presents how agile is implemented at some P&Q ARTs and MESW. Implementing agile is in this report considered from two perspectives: 1) based on the agile roles implemented and the responsibilities that come with these roles, and 2) based on how agile impacts general ways of working – e.g. through the implementation of agile ceremonies and principles.

First, this section presents the framework used to guide the different organisations in their agile implementation journey at Volvo Cars. This framework is called the Volvo Cars Agile Framework and is referred to as the VCAF. Following this, the agile implementation at MESW and P&Q is presented. Finally, the section concludes with a synthesis aiming to answer the first research question – see Research Question 1 – relating to how agile adoption differs across organisations.

4.2.1 Volvo Cars Agile Framework

Volvo Cars are currently undergoing their company-wide agile transformation through implementing an adaption of the SAFe framework called the VCAF. VCAF builds on the foundation of SAFe, incorporating some of the key roles, processes and artefacts, but adds additional layers of complexity.

Similar to SAFe, VCAF is divided into organisational layers – see Figure 4.2 – including agile **development teams** utilising Kanban and Scrum ways of working, a **Program level** responsible for coordinating multiple development teams in an ART and the **Portfolio level**, which sets the overall business vision and strategy. In addition, VCAF adds another layer called the **Solutions Layer**, which is responsible for product streams that aim to "provide a continuous flow of products with the highest customer value in the shortest sustainable lead-time" – essentially corresponding to the value streams in SAFe.

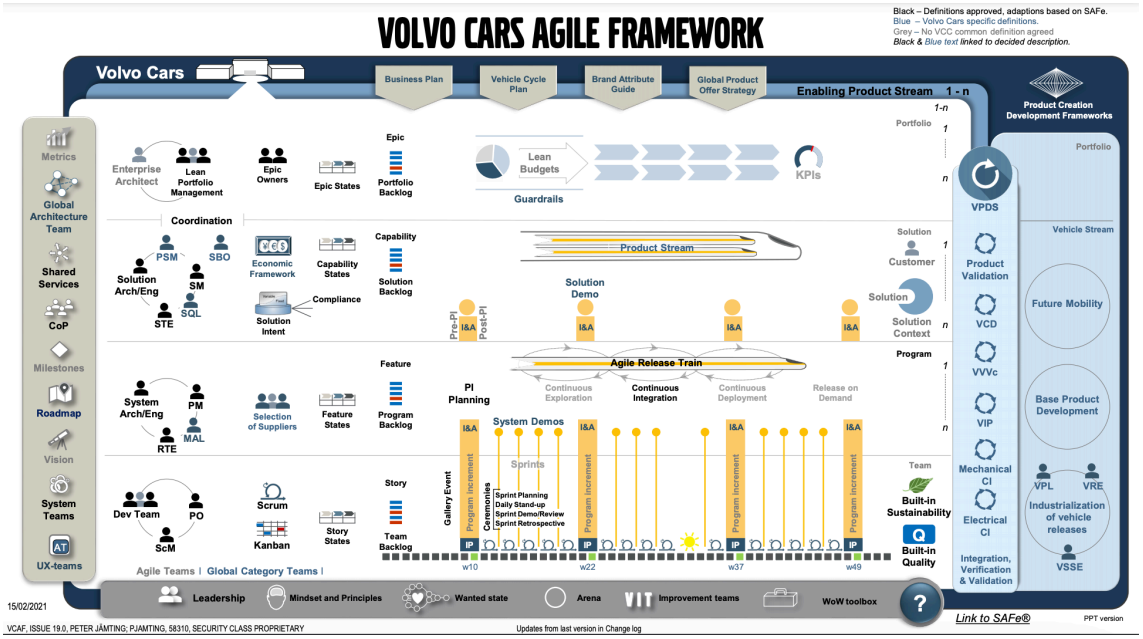

Figure 4.2: Volvo Cars Agile Framework as of 2021-02-15

On the Team level, VCAF mimics the SAFe structure. The team consists of a Product Owner, a development team and a Scrum Master. The team works in two-week Sprints to deliver program increments – PI. The PIs are 12-week periods and control the pace of the product development process in the entire company. The content planned in PIs dictate the work that is subsequently broken down by teams into two-week Sprints of work. The team works using either Kanban or Scrum methodology. The team Backlog is managed by the Product Owner, who is communicating and coordinating with the Product Manager at the Program level.

On the Program level, VCAF adds some additional roles and processes compared to SAFe. Similar to SAFe, the Program level has a Product Manager (essentially a product owner across multiple teams), a Release Train Engineer (essentially a Scrum master across teams) and a team of system architects and system engineers. In addition to this, VCAF adds a role called Manufacturing Art Lead – henceforth referred to as MAL. The MAL represents Manufacturing & Logistics in the ART management team and is responsible for setting requirement specifications regarding manufacturability, standards and guidelines of new product solutions. Ultimately, the MAL is the one who gives the manufacturing approval of a product solution. MAL is also responsible for the manufacturing-related Stories in the ART Backlog. In addition to the MAL, VCAF adds processes for the selection of suppliers and compliance at the Program level.

The Portfolio level in SAFe is divided into two levels in VCAF: The Solutions layer and the Portfolio layer. The Solutions layer is responsible for driving the product streams, which corresponds to the architectural and business value streams in SAFe. On the Solution layer, the roles are similar to the Program level but with a broader scope – consolidating deliverables from multiple ARTs to drive value to the

end customer. Mimicking the SAFe role of Solution Architect/Engineer, Solution Manager – SM –, and Solution Train Engineer – STE – are included in the VCAF. In addition, a few additional roles are added to the solutions layer. Procurement Solution Manager – PSM – is a VCAF specific role charged with product stream procurement responsibility – ensuring quality, cost and capacity for the supply chain of the Solution level. Solution Business Owner – SBO – is a role assigned with ensuring the business perspective and best interest are captured in the epics. Solution Quality Leader – SQL – is a servant leader role focused specifically on integration and release work from the ARTs, and the encouragement of built-in quality mindsets.

On the Portfolio level, lean budgets are set, and KPIs are investigated by a Lean Portfolio Managers and Enterprise Architects team. On this level, epic owners are responsible for determining the Portfolio Backlog of epics. Epics are long-term, large bodies of work that can span across projects and often stretch across multiple organisations, departments, ARTs and teams. Epics are broken down into smaller Features, which are subsequently broken down into even smaller Stories that are being worked on by the development team.

4.2.2 Agile Ways of Working

The agile work at Volvo Cars is carried out following classical agile processes and practices called agile ceremonies, albeit tweaked to fit the unique context of Volvo Cars and specific needs of teams and departments/ARTs.

Agile Adoption at MESW

MESW adapts the VCAF to suit their specific context and needs, including slight changes to the PI structure and the agile ceremonies. On a high-level, however, MESW follows the overall agile structure prescribed by the VCAF. This section describes how work is organised in MESW and how coordination with P&Q is managed.

The basis for all work conducted by MESW is the *Product Backlog*. The *Product Backlog* for a Sprint contains Stories of varying clarity that are refined and subsequently pulled from the Backlog for execution by the teams. These executions are divided into Program Increments – PIs – stretching over 12 weeks aligned with P&Q's PI cadence. Subsequently, PIs are broken down into Sprints of two weeks, during which a predetermined subset of the Backlog items are pulled from the *Product Backlog* to the Sprint Backlog and processed during the upcoming Sprint. The Backlog for a PI contains items called Features, which can be seen as Stories spanning across the entire PI.

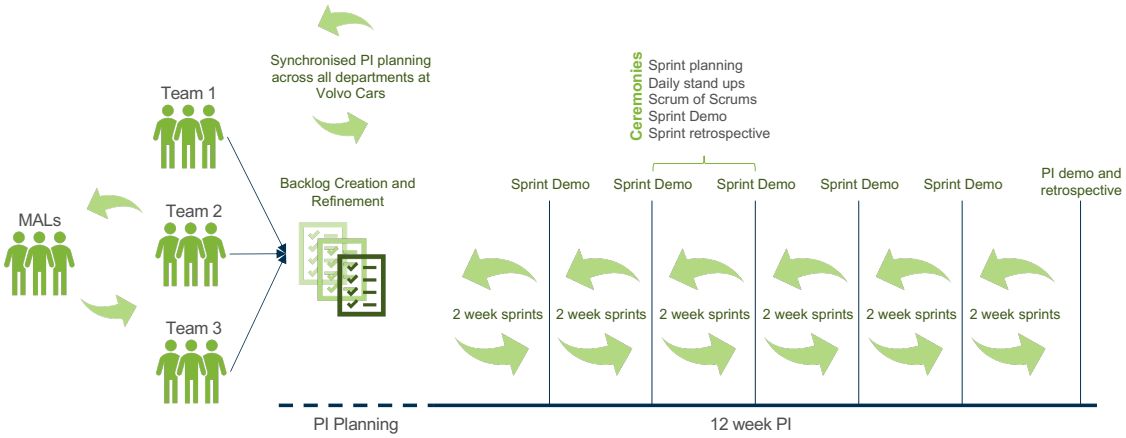

Figure 4.3: Illustrative and simplified figure showing how MESW utilises agile ways of working

The planning and execution of work can be described in phases starting with the Pre-PI planning. During the Pre-PI planning phase, the MALs are responsible for coordinating and collecting high-level information from the P&Q ARTs with whom MESW is currently collaborating. This high-level information is refined – i.e. defined with more specificity – by the MALs and ScM jointly to Features, also known as Backlog items. The Backlog typically contains a substantial number of Features prioritised from low to high, where refinement is the key driver for prioritisation. As items become more and more prioritised, more details are added until eventually they meet the Definition of Ready criteria and can be drawn from the Backlog into Sprint Backlogs.

The second phase is the PI planning, which is a week-long occurrence every 12 weeks. During PI session one, the MALs are focused on retrieving information to help them better understand what needs to be done during the PI and how to prioritise. At the end of the week, during PI session two, MALs present their final PI plan to the teams. This involves details on the load and capacity of each team during the Sprints in the upcoming PI and includes a risk assessment element where the team provide feedback and highlight difficulties they foresee. This final presentation is based on the information obtained in session one and ongoing collaborative sessions between MESW and P&Q during the week. During the PI planning week, the team will mainly work on breaking down the Features, compiled by the MALs during the Pre-PI phase, to concrete and actionable Stories that should be worked on during the upcoming PI. Some interviewees describe that the team will also determine what detailed information they need to collect from P&Q and subsequently pursue this information by manually reaching out to P&Q team members.

The PI plan outlines the intended Backlog items to include in each Sprint for the teams. However, the final content of the Sprint Backlog is decided during the first Monday of every Sprint. The Stories are based on the PI plan, but potential clarifications and changes can be made in consultation with the MAL. During this Sprint Planning meeting, a Sprint Goal is defined by the team, and two major questions

are to be answered:

- What can be delivered to the increment resulting from the upcoming Sprint?
- How will the work needed to deliver the increment be achieved?

The Sprints first week – on the Thursday – also includes a Backlog refinement session to incorporate the latest findings and knowledge gains into the Backlog items. The following Thursday of the Sprint, the Sprint Demo occurs. The team reviews what Stories have been completed during the Sprint by reviewing work done against the story's acceptance criteria. The demo is conducted jointly with all teams to ensure transparency and shared learning. Finally, Sprints are concluded by the Sprint Retrospective on the final Friday. The retrospective entails examining how the Sprint went from a people, relationship, process, and tools perspective. It emphasises a review of how things have been done and involves the creation of a process improvement plan for the team.

Throughout the entire Sprint, the team holds Daily Stand-Ups of approximately 15 minutes where each team member answers three questions:

- What did you do yesterday?
- What are you doing today?
- Do you need support/have any issues today?

In addition to this, MESW participates in organisational wide agile ceremonies such as *Scrum of Scrums* for the ScMs. These meetings are intended to facilitate escalation of issues the development teams experience and learning from others to help improve the agile way of working in one's own team. Finally, the PIs include demos and retrospectives just as the Sprints do and have the same purpose but on the Program level.

P&Q Implementation

P&Q consists of more than 25 different ARTs belonging to seven product streams, with which MESW has dependencies. Both the agile implementation and the dependencies with MESW vary between the different ARTs. In the following section, the ways of working in the ARTs – with whom interviews have been conducted during this study – is described. The emphasis is on the differences in the agile way of working compared to MESW as described in the previous section.

The ways of working in different ARTs is influenced by the time they have had to adjust to the agile transformation. All ARTs interviewed in this study have transitioned to agile. However, some other ARTs still cling to the old project-based structure, according to interviewees from several ARTs. Furthermore, one interviewee from ART 1 stated that they maintain some waterfall practices from the earlier structure in order to accommodate for other, non-agile parts of the company. Furthermore, there are ongoing projects which were started before those entities

changed to agile, and as these projects have a long duration, there is a need to maintain some structures for completion of these.

When it comes to the agile practices and ceremonies outlining the way of working for P&Q, most ARTs adhere to the same structure as MESW, with the PI as the overarching drumbeat executed through the Pre-PI phase, PI planning, the increment itself broken down to two-week Sprints and concluding with the PI demo and retrospective. P&Q's Pre-PI phase is similar to that of MESW. The main difference is the absence of the MAL role and inclusion of the POs for all teams in the ARTs. The Feature development and subsequent information distribution down to the team is a PO responsibility for the ARTs.

The PI planning follows the same procedures MESW's, again with the MAL's responsibility being absorbed by the PO in P&Q ARTs. As is the case with MESW, a focus of the PI planning is to ensure good collaboration, and several interviews emphasise the importance of identifying and planning for dependencies management during the upcoming PI. However, in contrast to MESW, the ARTs at P&Q focus their attention on other teams within their ART primarily and other ARTs within P&Q secondarily. Coordination and dependencies management with MESW is not viewed as a necessity during the PI planning. One interviewee stated that there are dependencies with MESW but that these are not something that should be managed as other dependencies during the PI planning. Several interviewees adhere to this perspective on dependencies with MESW, and one interviewee even stated that there is a role assigned with managing dependencies between P&Q and ME – the Launch Leader – and therefore, it is not something that the team work with during PI planning. This was also observed during the PI-week *Scrum of Scrums* attended at both MESW and P&Q. The *Scrum of Scrums* are used by both sides, but MESW uses this forum to focus heavily on dependencies they perceive are essential in the upcoming PI. For one P&Q ART, limited attention was given to dependencies with MESW in the Scrum of Scrum meetings observed. This ART included a status check for each team on dependencies, but the discussion was limited, and when dependencies were brought up, they referred to P&Q internal ones.

During the rest of the PI iteration, the ARTs' way of working follows closely to that described for MESW in most cases. However, ART 3 has recently implemented three-week Sprints working with Scrum, and before this, they used Kanban on the Team level as their way of working. An interviewee from ART 3 described the change as sudden and something that has not had time to set with the teams.

Thus, apart from a few distinctive differences, the overall way of working is similar between MESW and the ARTs at P&Q. However, several interviewees mentioned the necessity of adaption of agile to one's specific context, and the reality of this gives rise to subtle differences between and within the two organisational entities. These nuances in the agile adoption were found in the description and enactment of different roles and their responsibilities and will be described in the upcoming Section 4.2.3.

The Collaboration Process Between P&Q and MESW

The collaboration between MESW and P&Q will either be initiated because MESW is experiencing issues with newly developed components, or if new components are being developed by P&Q that requires changes in the way MESW operates their processes in the plant. Changes could, for instance, include new software that has to be downloaded or new calibration processes. A majority of interviewees from both P&Q and MESW agree that MESW members are typically the ones to initiate the collaboration in both scenarios. Sometimes, albeit seldom, P&Q will proactively provide information to MESW. One interviewee at MESW mentions that this is mainly done in scenarios where the P&Q ART and MESW has a history of working together, and the responsibilities of MESW is well known to the specific ART.

Coordination that is *not* on a Team level is mainly handled by the MALs, according to interviews with MALs at MESW. They proactively attend multiple meetings – e.g. architect meetings, PI planning events – and reach out to representatives at P&Q to identify changes that could potentially affect the manufacturing process and MESW's work in the future. Additionally, some interviewees mention that since the MALs cannot cover all P&Q ARTs, they use MALs in ME Hardware as sources of information. The ME Hardware MALs will actively listen for information that might affect MESW during P&Q meetings that they attend. One interviewee mentioned that the aim is to have efficient coordination with the ARTs during the PI planning, but due to the high volume of ARTs that MESW has to coordinate with, this is typically difficult to achieve. Once a development project that will affect MESW is identified, the MALs will work with the ScM to determine what Features need to be developed by the team at MESW in response to the development at P&Q. The MALs will provide Features to the team during the PI planning phase, which the team breaks down into Stories.

During the process of breaking down Features to Stories, the team at MESW will identify dependencies at P&Q. The team will initiate the process by identifying the most relevant P&Q team members to collect information from and subsequently reach out to them with the aim of securing crucial information for their work, which needs to be included in the team's Stories. Depending on the team at MESW, the process for contacting P&Q representatives seem to differ. Some interviewees from the MESW Team 1 mention that it is always the MAL who will *direct* the team to coordinate with P&Q, but it is up to the team members to reach out to the correct person. One MAL mentioned that they are always involved in coordination meetings between MESW and P&Q but that this should ideally be handled independently by the teams themselves. Team members from different teams at MESW instead describe a process where they independently reach out to P&Q without involving the MALs.

Team members at MESW describe that in situations where an issue occurs with a newly developed component or ECU at one of MESW's station, they will follow a similar process to contact the relevant P&Q representatives and try to initiate a collaboration. Depending on the issue, MESW and P&Q will discuss which party

should be responsible for creating a solution.

MESW currently interacts and coordinates most frequently with a few P&Q ARTs, where most of their current dependencies and development projects are conducted. Prioritisation is continuously evaluated by the MALs and guided by which ECUs and systems/functional changes in the car are undergoing the most significant product development and change.

Once an initial point of contact has been identified and collaboration initiated, the MESW team will often send over a document called the Technical Regulation (TR) for the P&Q representative to fill out. The TR should always be used if P&Q has requirements on a specific process and is not required for other product changes – e.g. developing new systems. However, many interviewees from MESW mention that it is often beneficial to use a TR and generally want to see a TR being correctly used in most collaboration instances between MESW and P&Q.

The TR will contain all the information necessary for MESW by outlining what changes are needed in their processes. A TR that is correctly filled out significantly improves MESW's workflow as it provides them with all the information they need. Furthermore, some interviewees mention that the TR makes it easier to distinguish areas of responsibility – if MESW does everything outlined in the TR correctly, they can "wash their hands" as interviewees expressed it, and are not responsible if this does not solve the issue. Once the TR has been filled out and collaboration formally initiated, many interviewees from both P&Q and MESW describe the collaboration as working well. Both parties describe each other as very knowledgeable and willing to help out.

4.2.3 Roles and Responsibilities

While the VCAF outlines roles and responsibilities that each layer of the organisation should include, these roles are highly customised depending on which context the team, ART or department. This section outlines the roles found in MESW and describes examples of role adaptions in some of the ARTs at P&Q.

Roles and Responsibilities at MESW

MESW's area of responsibility is vast and spans across multiple areas of the cars developed as described in Section 4.1. Due to this broad area of responsibility, the MESW teams work in a unique context compared to other teams within Manufacturing Engineering (ME) at Volvo Cars. A typical team at ME will cooperate with one or two ARTs within P&Q, which often results in a strong relationship with close cooperation and communication. MESW cooperates with more than 25 ARTs at P&Q due to the specific context in which the team operates. Therefore, roles and responsibilities in MESW has been adapted to fit their context resulting in deviations from the VCAF. This includes changes to both Team and Solution level – the Solution level introduces a role that has the responsibility of both a MAL, as indicated in the VCAF, and a Product Owner. At the same time, the role of a

Product Owner on the Team level is removed. Additionally, MESW is not an ART but a support team.

MESW is organised on three levels: the Solution level, the ART level – corresponding to the Program level in VCAF – and the Team level. Overarching the three-level structure is the final layer of the MESW structure with the Program Commodity Leader, bridging the three levels.

On the Solution level, there are three roles:

- **Manager** – Engages in resource planning and management and prioritisation of *what* the teams are to be doing. The Manager does not direct *how* work is conducted but instead supports and facilitates the team members' development.
- **Sr Engineer *Core*** – develops and governs the manufacturing prerequisites, strategies and product stream/ART specific manufacturing requirements on the product solutions. Ensures fulfilment of manufacturing prerequisites on the product on the Solution level.
- **Sr Engineer *Technical Expert* (TE)** – operates on the Solution level and is responsible for developing the architectural runway on which the development teams subsequently progress with development to accommodate new Features and Capabilities. The TE supports the teams in their development by participating in planning and decision-making on the Program level and helps the team explore alternatives and determine non-functional requirements on the Program level.

The Program level of MESW contains the **Manufacturing Art Leaders (MALs)**, which also incorporates the PO role of teams within MESW. The MAL is the primary coordinator on a program level between MESW and the P&Q ARTs with whom they are coordinating. Currently, there are three MALs at MESW, and together they are responsible for coordinating with more than 25 ARTs at P&Q. The responsibility of the ARTs is shared across all MALs, meaning everyone is equally responsible for all the ARTs with whom they coordinate. Coordination between MALs is handled through Daily Stand-ups, where prioritisation and planning occur. The MALs are responsible for collecting high-level information about new development projects in the different P&Q ARTs and delivering this information to the team, who breaks it down into Stories. The MALs will tell the team *what* to do but not *how* to do it. This was observed during the PI planning when the MALs delegated the responsibility of a program to a local team in MESW.

One interviewee suggested that the purpose of the MALs is to support the team to take ownership over their work. Furthermore, the same interviewee proposed that MALs should ideally take a step back and allow the team to independently coordinate with the correct ARTs on detailed questions without involving of the MALs. As outlined in the internal documentation, the MALs are the owners of the MESW deliveries needed towards their respective ARTs at P&Q – e.g. delivery of

System Manufacturing Approval, ME budget for the ART, and communicates and handshakes manufacturing requirements on the product solutions. The role entails coordination with relevant POs in the corresponding ARTs.

On the Team level, MESW consist of three development teams, each in turn consisting of manufacturing engineers and a Scrum Master (ScM):

- **Scrum Master** – are servant leaders focused on enabling their teams to develop their agile practices and performance continuously. Internal documentation suggests that the ScM should coordinate and facilitate agile ceremonies for the team, such as Daily Stand-ups, Sprint Demos and Plannings. One interviewee mentioned that ScMs work towards removing obstacles and ensure the team is moving forward but notes that this is only a part of the responsibility since the role of ScM is not an official title, and there is an understanding that 50% of the ScMs' time is dedicated to the official Manufacturing Engineer role. The same interviewee suggested that the ScM should act as an interface between Solution level engineers and the team and also play a part in coordinating with P&Q ARTs – specifically during the planning phase. During the PI planning, and the weeks leading up to it, the ScM receives high-level information about new Features that need to be developed from the MALs and is responsible for working with the team to concretise this into Stories that the team can work with during the PI. Based on the documentation, the ScM should also assist the MALs in Backlog management and prioritisation.
- **Manufacturing Engineers** – are responsible for incrementally providing value to manufacturing and products. This is done by drawing Stories from the Backlog with prioritisation support from the MAL and completing work during Sprints in a teamwork focused manner. The objective is to ensure manufacturability of products according to interviewees. While the ScM will support the team, it is up to the team to break down Features to detailed Stories. The team members decide *how* to execute and are accountable for meeting the Definition of Done (DoD) criteria. The team members are responsible for communicating and collaborating with relevant stakeholders, both at MESW and with team members from P&Q ARTs, to get their Stories both ready and done. However, if more significant issues occur or other teams are unresponsive, the team can escalate questions to the MAL, which will help facilitate further coordination. According to some MALs interviewed, all *detailed* communication should ideally be handled by the team members independently – without involving anyone on the Solution level. According to several interviewees, the engineers often have a specific area of expertise with which they predominantly work. One interviewee stated that the bulk of work as an engineer is reactively following up on issues that emerge but that coordination with P&Q occurs when there is a proactive attempt from MESW to reach out on something they anticipate.

Stretching across the three levels of MESW is the Program Commodity Leader (PCL). The PCL supports and leads the MALs and the Senior Engineers by driving

and organising ME deliveries to complete vehicle Programs following the Base Product Development milestones. The PCL manages the connection between teams and the program by escalating team issues, aggregate team PI objectives to the Program objectives, help teams fully understand the Program perspective and the Pre- and Post-PI meetings.

Roles and Responsibilities at P&Q

The roles adopted in P&Q differ to a varying degree from those of MESW depending on the level of abstraction. In this section, the roles adopted in P&Q is described starting with the Team level and moving up to the ART-lead and Solution level roles. As roles are described, instances of both inter- and intra-organisational differences are highlighted. As one interviewee put it:

> "The role descriptions are the same across the ARTs and teams, but the actual responsibilities of roles differ in practice." – P&Q representative

On the Team level, P&Q has the same basis as MESW, with development team members often with a specific expertise area. However, interviewees noted that there is an aim for development team members to have what is referred to as a T-profile, one area of expertise but with the skills to handle other team members jobs on a sufficient level if needed. In reality, these T-shapes are not always attainable in the context of the complex products being developed at Volvo Cars since there is a diverse range of skills required in the team, according to interviewees. Some interviewees described the development team member role to include ongoing management of coordination as needed to complete the Stories on which they work. One interview describes the coordination involvement – as a development team member – to depend on experience and knowledge and stresses that it is easy to get pulled into coordination management if you have a lot of experience.

> "In reality, the T-shape we have is more like if the team's members face each other in a big circle, we are supposed to be able to handle our own area plus those of the people on our closest right and left." – P&Q representative

Together with the development team members, the ScM role definition is similar between MESW and P&Q at the Team level. The roles have similar responsibilities in both organisations. ScMs in P&Q facilitate agile ceremonies like the daily stand-up, calculate velocity, and support the team with the breakdown of Features to Stories ready to be picked up from the Backlog. Furthermore, the ScM focuses on predicting and managing dependencies for the P&Q teams, just as in MESW. However, the dependencies managed and focused on by the P&Q ScMs interviewed in this study are predominantly within their own ART. One ScM from P&Q explicitly stated that ME dependencies are managed by the Launch Leader – a role affiliated with manufacturing in the plants – reactively rather than by the ScM in PI planning. Only one ScM interviewed from P&Q's side expressed emphasis on dependencies with ME. For this ScM, these dependencies were a top priority since

previous experience had made it clear that the development of products is innately dependent on manufacturability for its success. Another noteworthy difference is that ScMs in P&Q is full-time dedicated to the role, in contrast to the unofficial designation and part-time assignment of ScM in MESW. Finally, one of the ScMs interviewed mentioned that facilitation of PI-events – e.g. collecting items demo in the PI-demo – is a role responsibility.

> "The Scrum Master needs to be a good communicator, motivate other people, establish connections, keep the agenda and try to get the deliveries out." – Scrum Master in P&Q

For MESW, the Team level roles conclude with these two as previously described. In P&Q, however, the same is not true. P&Q teams also have additional roles affiliated with them that sometimes transgress team boundaries as part of more than one single team. The first of these is the PO, responsible for the Backlog and described as a team representative of the customer by some interviewees. According to Volvo Cars' internal documentation, the POs also coach the teams with backlog refinement and prioritisation of backlog items – both Features and Stories. One interview added system design as a responsibility in addition to Backlog refinement and prioritisation. According to the documentation, POs are also responsible for coordinating content dependencies. This was only mentioned by one of the POs interviewed, and others stated that the ScM manages dependencies.

The other team affiliated role in P&Q that does not exist with MESW is the Team Manager – TM – which like POs, are associated with more than one team in some cases. The TM role is not predefined in the VCAF, and thus no documentation on the role exists. Findings on this role are therefore based on interviews. One TM was interviewed and described the TM role as an HR manager for the teams with which it was associated, including the PO. This entails coaching and career development of the team's members, resource planning for the team, and salary responsibilities. According to the TM interviewee, the role's practical reality depends to a great extent on the individual embodying the role since it is about leadership and leadership styles differ between people. The interviewee's interpretation of the TM role was to facilitate and push the team members to do their work to the best of their abilities by taking a background role and supporting them from behind rather than taking the lead and pulling the team members forward by active participation. Some other interviewees shared their perspective on the TM role as the resource responsible and supporting role teams can turn to for assistance with issues. In the hierarchical sense, the TM is the superior of the POs and the other team members.

On the Program level, interviews were conducted with one PM and three RTEs. These are both roles prescribed in the VCAF and implemented in the ARTs included in the scope of this study. The PMs own and manage the program Backlog from which the POs subsequently pull and break down items to the *Product Backlog*. The interviewed PM stated that involvement with other ARTs and stakeholders revolve around the development and the level of abstraction applicable to

the program Backlog. This aligns with findings from documentation stating that involvement with the Solution Train and ARTs is part of the job in order to enable the breakdown of Epics and Capabilities – the Portfolio and Solution level Backlog items – into manageable Features for the teams. However, one interviewee stated that the PMs also facilitate dependencies management by organising meetings with the POs within the ART. Furthermore, the interviewee stated that the PM works mainly with upcoming PIs rather than focusing on ongoing increments. Planning for future work in the ART is the primary concern, but in practice, assistance to the teams is something PMs engage in as well. The role of PM is absent in MESW as an individual role and has rather been incorporated in the MAL role utilised.

The RTE role revolves around organising and facilitating the agile ceremonies of the PI, such as the Pre-PI, PI planning and Program Demo. This focus is found in the role documentation and supported by all RTEs interviewed. In addition, the RTEs have a bridging function as two RTEs express that they have recently started working closer to the ARTs teams in a project management type of capacity and simultaneously all RTEs interviewed stated that the line between RTE and PM is somewhat fuzzy. Some of the RTEs interviewed mention that coordination is not something they are directly involved with, but they can help the engineers find the right people if needed.

In contrast to the setup in MESW, one RTE stated that organising the *Scrum of Scrums* was assigned to the role. This responsibility was specifically mentioned only by one RTE and is not included in the documented role description. Furthermore, the same interviewee stated that it is the RTEs responsibility to own the *"problem Backlog"* and distribute these on a Feature level to appropriate teams in the ART.

In addition to the P&Q roles interviewed, another two roles are prescribed in the VCAF on the Program level. The first being the MAL, a role described in the previous section for MESW. On a generic level, the MAL represents the manufacturing perspective (ME) in P&Q ARTs. ME Hardware usually has one MAL assigned to one ART, and in some cases, the MAL is engaged with two ARTs, according to interviewees. Some ARTs have the MALs described as a part of their ART in the documentation of the composition of their ART, but no MESW MAL is included in this way in the ARTs studied.

The second role is that of the System Architect. This role is described in the VCAF as operating mainly within the ART domain, assisting the teams with trade-offs – e.g. between systems, components, functions. The System Architect is also described as working closely with the Solution level and the Solution Architect in particular.

Finally, several ARTs studied have been found to adopt additional roles outside the boundaries of the VCAF. These roles were not mentioned in the context of the interviews conducted, and documentation of what these roles entail is sparse. Examples of roles adopted but not described are Dep Manager, GCM, ADM, and

Concept Owner.

4.2.4 RQ1: How the Adoption of Agile Differs Between MESW and P&Q

The foundation of the agile adoption on both sides is the same – following the guidelines outlined in the VCAF – both in terms of ways of working and roles implemented.

The differences identified are subtler and can be traced back to the constitutional difference between the two sides. P&Q is structured and divided into ARTs based on which systems/components the teams are responsible for developing. MESW is not considered an ART but rather a collection of support teams. This provides for several differences in the agile adoption between the two sides to emerge.

First, MESW is small compared to the ARTs studied and was one of the first entities to go agile. This means that they had more time to adjust and get comfortable with the new structures and processes. This results in the first difference between MESW and P&Q, which manifests itself in the way parts of the P&Q organisation – teams and even ARTs – have yet to shed themselves of traditional development methods completely. Furthermore, the relatively small size of MESW makes their agile adoption more uniform compared to P&Q's. MESW and P&Q follow the same development cadence – 12-week PIs – divided into Sprints. On the Sprint level, however, a difference emerges. MESW has uniformly adopted 2-week Sprints, and so has most of the teams within P&Q, but not all. Some P&Q ARTs have teams utilising 3-week Sprints, and until recently, Scrum was not the only Team level way of working. The maturity with which MESW and P&Q work agile and the uniformity of the adoption is a crucial difference.

Second, the purpose of MESW to act as support for P&Q in their development efforts drives another subtle difference. Both sides make use of Backlogs – both for Features and the subsequent breakdown into Stories – and manage these through a coherent company-wide software application called VIRA, which allows for easier integration across teams and organisations. What sets the Backlogs apart, however, is their content. For MESW, the Backlog content is mainly reactive and depends on the content of P&Q's Backlogs, which in turn are more proactive and independent.

The third difference identified connects to the second. Given MESW's purpose to support P&Q, they depend upon them, which leads to subtle differences in PI planning and the agile ceremonies used there. The events held are quite similar between the two sides – e.g. Pre-PI planning weeks and *Scrum of Scrums* – but their focus is slightly but significantly different. Both sides aim to identify, plan, and handshake their respective dependencies during PI planning. The focus of these dependencies is the differing element. MESW needs to manage the dependencies of their Backlog, which is dependent on P&Q, and thus focus heavily on coordination with P&Q. P&Q, on the other hand, is much more focused on internal issues revolving around

securing and managing dependencies primarily within their own ART and secondarily with other P&Q ARTs.

Fourth, the constitution of MESW as a department consisting of support teams rather than an ART affects the roles implemented. Both sides base their roles on the VCAF's prescription. On the Team level, they both have development engineers and a Scrum Master for each team. However, that concludes the similarities of roles on the Team level. P&Q additionally have the prescribed PO role – with a technical responsible and ownership over the *Product Backlog*. This role is absent in MESW as an individual role. Instead, the responsibility is absorbed by the MAL on the Program level. The size of ARTs within P&Q has also lead to the adoption of Team Managers for some teams, which most closely correspond to the Manager role of the entire MESW – found on the Solution level. The differences in terms of roles continue further up the hierarchy. On the Program level, MESW has MALs supported by the PCL – which is a role that operates across the levels – whereas P&Q has a PM, a System Architect, and one or more RTEs. Again, the closest corresponding roles are on different levels – e.g. PCL and RTEs, or TE/Core Engineer and System Architect.

Finally, perhaps due to the different roles adopted, the responsibilities of the roles differ. For instance, the Scrum Master at MESW has a broader responsibility for breaking down Features into Stories and managing dependencies compared to the typical Scrum Master role at P&Q. Additionally, just as the uniformity of ways of working constitutes a difference, the differing size of P&Q ARTs has also lead to different ARTs dividing responsibilities differently. For instance, some ARTs have more than one RTE, some ARTs have adopted customised roles, and some teams within P&Q ARTs share a common TM and or PO while others have one specifically dedicated to their team.

To summarise, agile is implemented quite similarly in MESW and P&Q on a high level – but differs significantly under closer scrutiny. This is true for both the agile ways of working utilised – i.e. the agile ceremonies and principles used – and in the agile roles and responsibilities implemented. Differences exist both widely across the interface and, in some cases, adhere to internal differences within P&Q.

As described in the literature review, scaling agile is all about adapting and tweaking the agile frameworks to the specific needs and context of different teams, departments and organisations – see for example (Ebert & Paasivaara, 2017). This is evident at Volvo Cars, where the agile implementation differs across organisational boundaries and between individual ARTs. Some P&Q ARTs might implement agile in a very similar fashion to MESW, and some will implement it in a completely different way. Kasauli et al. (2020) described this form of customised agile implementation as natural when scaling agile but warns that it might result in methodological islands where methods, practices, culture and mindset are significantly different between different ARTs and teams. These methodological islands can create a foundation on top of which coordination challenges arise. Therefore, the

differences between MESW and P&Q is not to be viewed as anomalies but rather as inherent customisation to fit differing contexts, which needs to be considered as it affects coordination conditions between the two.

4.3 RQ2 & RQ3: Challenges Identified in the Interface Between MESW and P&Q and Potential Solutions

Several areas of improvement at Volvo Cars were identified during interviews and meeting observations – henceforth referred to as issues. This section is divided into subsections, starting with an analysis of the coordination challenges from the literature review followed by a detailed description of issues identified in the case study, including examples of how the data sources presented the issues. Furthermore, these subsections include an analysis of how the issues relate to challenges found in the literature – see Table 2.1.

In total, **seven** issues were deemed relevant for this study and are presented in this section. Each issue was given a title and an ID and is presented in Table 4.1 below. The table presents the titles of all issues selected and which data sources support the issue.

Table 4.1: Table of relevant issues identified during interviews and meeting observations.

		Interviewees		Meeting
Issue Title	**Issue ID**	**MESW**	**P&Q**	**Observation**
Lack of Awareness and Understanding of MESW	ID1	4	7	No
Sub-optimal Involvement of MESW in Development	ID2	6	10	Yes, multiple
Different Targets and Prioritisation	ID3	2	4	Yes, multiple
Relationship Dependent Collaboration	ID4	3	9	Yes, one
Unclear Collaboration Process	ID5	4	5	Yes, multiple
Unclear Distribution of Accountability	ID6	4	7	Yes, one
Ununiform Agile Implementations and Reorganisation Complications	ID7	3	5	No

Each subsection also presents an overview of potential solutions to the corresponding issue. The solutions are based on the analysis of the issue and the mechanisms identified in the literature – see Table 2.3 – focusing on how these mechanisms can be used to mitigate the issues. As there are no concrete and detailed solutions or frameworks prescribed in the literature for these types of issues, the solutions and mechanisms outlined here are not exhaustive. The solutions are intended to provide an overview of what alternatives *might* be applicable when facing the issues outlined in this section and do not intend to describe detailed plans for solving these issues.

4.3.1 ID1: Lack of Awareness and Understanding of MESW

A lack of awareness and understanding of how MESW is structured, operates, and their responsibilities is considered an issue by representatives from P&Q and MESW.

One interviewee from MESW described a lack of awareness as a critical issue and that a greater understanding of MESW, on P&Q's part, would enable MESW to work more effectively. This refers to MESW's purpose, their areas of responsibility, and what information they require from P&Q to be able to fulfil their purpose. Some interviewees also mentioned that P&Q sometimes are unaware of what changes to existing systems/ECUs will affect MESW. This was also supported by P&Q interviewees, with one interviewee, responsible for coordinating with MESW, mentioning that he lacks knowledge about when to involve MESW, whom to contact and what in detail they do. Another P&Q interviewee mentioned that his team has never interacted with MESW, despite them being one of the 'end customers' of the component they are currently developing. Two interviewees mentioned that this extends beyond MESW and is relevant for the entire ME organisation and that most P&Q developers have never been to the factory and do not fully understand the value of ME.

> "I would have no idea about who to talk to about what we need to do, what kind of information they need and so on..." – P&Q representative

Some MESW interviewees also mentioned that P&Q often do not understand that MESW is a support team to P&Q in their development efforts. One interviewee mentioned that while the purpose of MESW is to support and help P&Q, they sometimes do not realise this and might even perceive MESW as annoying.

> "I think it is really important that these people [MESW] are part of the regular development... P&Q need to understand what MESW is doing" – P&Q representative

Both P&Q and MESW representatives agreed that ideally, P&Q would be fully aware of what MESW does, what information they need and what changes will affect them. This would help MESW work more effectively and improve collaboration between the two sides. One P&Q interviewee – who described the current collaboration with MESW as great – exhibited a good understanding of MESW and

described their work as crucial to the creation of functioning products.

> "If every P&Q ART knew what MESW do and how they operate, it would allow MESW to work more efficiently" – MESW representative

These issues identified in the interface between MESW and P&Q parallels the *Lack of Awareness* challenge deduced from the literature – see Table 2.1. There is clear evidence of knowledge dependencies between the two, particularly relating to who knows what and what requirements there are from MESW on current development efforts. Additionally, the evidence suggests that some people within P&Q misconceive MESW as something other than the support team they are intended to be. This aligns with Berntzen et al. (2019)'s finding that suggests that separated groups often have different perspectives on reality – i.e. thought worlds – and thus further reinforces the notion of methodological islands and issues stemming from their existence.

ID1: An Overview of Mechanisms and Solutions That Can Have a Mitigating Effect

Awareness requires increased interaction and exchanges between MESW and P&Q, something suggested by participants as a means of creating an understanding of what MESW is doing. To establish and continuously improve awareness, efforts could be made on both sides to improve coordination. This subsection aims to provide an overview of potential solutions and mechanisms for mitigating the underlying causes of the issue described in Section 4.3.1.

MESW need to take responsibility for creating means for P&Q to start building an awareness of their existence as a start, according to interviewees. Subsequently, a common understanding can be built on the capabilities, purpose, and requirements across the interface. In order to do so, MESW can utilise coordination mechanisms prescribed in the literature and outlined in Table 2.3.

Wikis can be utilised to facilitate the search and identification of information on P&Q's part – at Volvo Cars, 'Confluence' can be used as a platform for this mechanism. However, for this to work, there needs to be basic knowledge of MESW with P&Q. Otherwise, they will not be able to make use of the knowledge contained in the *Wiki*. MESW can take measures to establish this basic knowledge and create awareness of themselves as a department by participating in Communities of Practice, as prescribed by the VCAF, and utilise other interactive mechanisms – for instance, engaging in *Lunch Seminars*, *Experience Forums* and other interactive knowledge-building sessions such as *Workshops*).

To mitigate the lack of awareness of whom to talk to and what information is needed from P&Q, MESW could build a high-level decision-gate that P&Q can use to help them answer the yes/no question: does this development require any coordination with MESW? If the resulting output is *yes*, then a point of contact can be automatically provided. This could potentially be facilitated by a brief form yielding a

contact form – e.g. the TR and contact info for MESW if the answer is yes.

MESW could also use vertical information channels and use the interaction on the Solution level to make P&Q Solution level roles more aware of this issue and put pressure on their teams to increase their focus on dependencies with MESW in the development work. If deemed necessary, *Contracts* – as described in 2.3 – could be used to ensure this increased consideration to MESW on P&Q's part.

With these efforts, MESW can be considered to do what they can on their own. For effective coordination through increased awareness, P&Q would need to make changes and efforts on their end to mitigate the issue. For instance, P&Q could actively invite MESW representatives to participate in *Demos* and *Testing* of components/systems developed. This would enable feedback on development from the manufacturing perspective in a more frequent and timely manner – see Table 2.3 for further explanation of the mechanism *Testing*.

Since P&Q is significantly larger, they are better positioned to take active measures to participate and engage with MESW for awareness-building purposes. P&Q can take action and actively engage with MESW teams through appointing representatives to participate in MESW meetings or utilise the prescribed mechanism of *Team Member Rotation* – see Table 2.3 – across the organisational interface. For instance, team members from different ARTs could take turns and rotate as representatives participating in Sprints with MESW as observers and contributing resources. This would help build understanding among individuals within P&Q ARTs and help build a collective awareness across the interface. Apart from rotations, the appointment of a responsible role – see Table 2.3 – within P&Q for coordination purposes with MESW could help establish an improved awareness. Another effort that P&Q can make is to engage in visits to the factories and pilot plants to start building an understanding of the environment in which their developments are eventually produced.

Measures that can only be achieved through mutual effort – that can supplement each side's aforementioned mechanisms and efforts – also exist. Increased interaction and dedicated coordination efforts between the teams to help build awareness could be implemented. Scheduled joint meetings could be used on different levels. Some mechanisms from Table 2.3 would be highly relevant here – e.g. *Scrum of Scrums*, *Metascrums*, or *Team Leader Meetings* that are held with participants from both sides. However, these meetings need to consider the relative size of the departments or risk becoming too large and therefore inefficient. One solution could be to have ScMs from MESW together with the PCL engage in *Metascrums* with either RTEs or PMs from the different P&Q ARTs. On a Solution and Feature level *Project Meetings*, *Team Leader Meetings* – i.e. with managers – could help facilitate an improved awareness within their teams.

Furthermore, *Reference Architectures* and *Resource Budgets* – see Table 2.3 – can be incorporated into *Wikis* on both sides to facilitate identification by active search by members of the opposite side of the interface. Both sides could also implement

Dependency Maps as part of their *Product Backlogs*. By doing so, they could ensure increased attention to dependencies across this interface. All of these measures taken should be conducted with a commitment to a *Universal Language Use* to make sure that the globally distributed resources of Volvo Cars can engage with information and people on the same premises.

4.3.2 ID2: Sub-Optimal involvement of MESW in development

Multiple interviewees from both MESW and P&Q stated that MESW's involvement in the development process at P&Q is sometimes problematic. Issues raised by interviewees include the timing with which MESW is involved, the initiation of said involvement and the nature of the information exchange between the two sides – i.e. its direction.

Regarding timing of involvement, multiple interviewees agreed that MESW is involved *too late* in the development projects. This often results in issues with the manufacturability of components and their compatibility at different stations in the production plants. Some interviewees from MESW mention that when they are involved too late in the development, overly complex solutions have to be made to accommodate for issues that occur in the plants. In addition, MESW's ability to have a positive impact on the design of the component is negatively correlated to the timing of their involvement in the development phase. Furthermore, if MESW is provided with detailed information about development projects sooner, they can better plan ahead and avoid delays in their stations. One interviewee mentioned that this is true for all of the projects concerning MESW. Another interviewee at MESW described the nature of collaboration as reactive instead of proactive and that coordination is mainly initiated when issues occur in the plant, instead of proactively trying to prevent the issues from occurring in the first place.

> "... for all current projects, we would have wanted the information at least two months earlier" – MESW representative

One interviewee from MESW also mentioned that there are issues with MESW being involved too *early* in development projects. The interviewee argued that if MESW is involved too early, there is a risk that their time is 'wasted' as they are unable to provide any valuable input at that stage.

Some interviewees, both from P&Q and MESW, mentioned that all involvement should ideally be handled during PI planning. By sorting out the dependencies before the PI Sprints are initiated, it is easier to plan ahead. One interviewee from P&Q described this as 'critical' for a successful collaboration. The importance of sorting out dependencies during PI planning was also mentioned during PI planning meetings observed. However, a discussion ensued where some team members felt as if dependency discussions with P&Q during PI planning could lead to time wasted due to P&Q not being able to provide MESW with the necessary information.

> "Right now, P&Q develops for a long time. In the end, they involve MESW. MESW would want to be part of this development earlier." – MESW representative

Concerning initiation of coordination and the nature of information exchange, interviewees from both sides agree that P&Q typically neglects actively involving MESW in their development discussions. Several interviewees describe that MESW, in almost all cases, has to reach out to P&Q ARTs to investigate whether any of the current development efforts will affect them and subsequently collect the necessary information. Interviewees describe how MESW team members and MALs need to "hunt down" P&Q representatives and extract information to determine whether changes to systems and components (e.g. ECUs) or new systems/components developments will affect them. This is discussed further under Section 4.3.5. One P&Q interviewee describes an example where a new concept is being developed that he knows will significantly impact MESW's work, yet, no one involves MESW in the discussions and development of this concept.

> "My dream is that P&Q has a tendency to contact ME actively - not for information but rather that they pull MESW **people** into the P&Q process when P&Q need it. I would ideally want MESW to **work together** with P&Q - being actively involved. That would be the best scenario." – MESW representative

Two interviewees also suggested that MESW team members should be pulled in to be a part of the development team instead of just used as an information source. One interviewee stated that the best coordination between teams across the organisational interface was experienced when cross-functional teams were utilised before agile was implemented:

> "Historically, we [P&Q] had ME members in our teams. We had cross-functional teams, which was common in the industry. [...] and that was very powerful teams. Everyone that worked in this time always says that it was the best cooperation that they have had." – P&Q representative

While most interviewees are aware of how this information exchange process is handled, they often agree that this is not how it should be done. One P&Q interviewee even stated that the **only** feasible way for MESW to do their job effectively is if P&Q members actively involve MESW in discussions and 'push' relevant information out to them. However, the same interviewee emphasised that MESW needs to inform P&Q so that they know what information is relevant for ME. Many interviewees from both P&Q and MESW agreed with this and described an ideal world where MESW can efficiently support P&Q by being involved in development projects that affect them. Some interviewees also shared such instances and described cases where P&Q had proactively 'pulled in' MESW into the development process, and all such cases were described as successful collaborations.

> "Probably the only manageable way for MESW is that P&Q team members proactively reach out and informs ME of changes that would affect them." – P&Q representative

The timing with which MESW is involved seems to connect to several of the categories of challenges described in the literature – see Table 2.1 – but perhaps not completely fit within either. The first related category is *Misalignment*, where the suggestion of joint collaboration and involvement in the PI planning provides a more or less self-evident connection. This connection is further supported by the fact that most mentions of timing pertained to late involvement. This can arguably be connected to a tendency to focus on one's own Backlog and neglect dependencies with others. However, this could also be argued to adhere to an inward focus. Regardless, this reinforces the connection to the misalignment challenge found in the literature and described in Table 2.1. Finally, communication challenges have been found to stem from a lack of high-quality communication across interfaces, of which one determining factor is timeliness. This leads to a potential parallel of this issue to the challenges reviewed, namely *Communication Issues*. The direction of information exchange described reinforces the relation to the communication challenges. Furthermore, one side – in this case MESW – having to pursue the other for information does not constitute problem-solving communication. The absence of problem-solving communication also constitutes grounds for *Communication Issues* as this leads to lower communication quality, according to Berntzen et al. (2019).

ID2: An Overview of Mechanisms and Solutions That Can Have a Mitigating Effect

In order to improve the involvement of MESW in the development process, awareness constitutes a prerequisite – since it is difficult to involve with something of which one is unaware. Therefore, the first step to mitigate this issue is to build awareness through the means discussed in Section 4.3.1. Apart from increasing awareness, there are multiple other mechanisms – see Table 2.3 – and solutions available. This subsection aims to provide an overview of some of these additional mechanisms and solutions that can be used to further mitigate the involvement issue described in Section 4.3.2.

Some mechanisms can be implemented to address the timing with which MESW is involved. *Roadmaps* and *Contracts* – see Table 2.3 – can be used to identify and understand the appropriate timing of involvement of MESW and subsequently enforce this in practice. As several interviewees suggested, joint PI planning events – e.g. *Workshops* and *Scrum of Scrums* – could benefit coordination and ensure planned and enacted involvement. Furthermore, these joint planning sessions could facilitate the implementation of tasks in the respective Backlogs, specifically concerning dependencies across the interface – i.e. tasks of the likes 'involve/inform MESW'. The PI planning could also be an opportunity to implement *Open Space Technology* – see Table 2.3 – which would allow MESW to have their voices heard and help spread knowledge about themselves within P&Q. This could lead to P&Q finding it easier

to be more proactive towards MESW.

Identifying dependencies is essential to appropriate involvement since it involves determining if and when MESW need to be involved. A critical mechanism to implement could therefore be *Dependency Maps* – see Table 2.3. These can be drafted during PI planning and continuously refined in conjuncture with *Backlog Refinement*, thereby maintaining the highest possible level of static dependencies in relation to emergent. This would mean that dependencies can more easily be planned for and coordination included in both PI-plans and Sprint planning meetings. If coordination is planned more accurately, then the timing and nature of involvement can be assumed to improve. For this process to continuously improve over time, the *Retrospectives* can be used as a mechanism to facilitate joint contemplation, and improvement efforts focused on the coordination between MESW and P&Q – see Table 2.3. To further improve the evolution of coordination, through improved involvement of MESW in the development process, the mechanism called *Trace Links* can be used – see Table 2.3 for details. *Trace Links* can be helpful when implementing additional mechanisms – by ensuring that the purpose of new and existing mechanisms are understood and can be tracked easily, the risk of redundancies can be reduced.

Overall, a critical changes that would help overcome the issue described in this section is a mindset shift within some of the P&Q ARTs. As many interviewees have suggested, in an ideal world, P&Q would act proactively regarding their dependencies towards MESW. This in terms of both *pushing* out information that MESW needs and actively *pulling* MESW into development and utilising them as a support team. This would further require clear definitions of accountability in the interface between the two organisations – further discussed in Section 4.3.6.

4.3.3 ID3: Different Targets and Prioritisation

Interviewees from P&Q and MESW mentioned misalignment, in the form of different targets, between P&Q and MESW. Furthermore, there is evidence of a siloed focus that inhibits coordination between MESW and P&Q. This sometimes results in misaligned prioritisation, resulting in delays and other issues.

One interviewee from MESW described issues with getting P&Q to prioritise correctly filling out the TR. The interviewee mentioned that P&Q will, in some cases, delay filling out the TR, forcing the team at MESW to pause their work. In some cases, they do not fill out the TR at all. Discussions surrounding this lack of TR-prioritisation from P&Q was also observed during PI-event meetings at MESW, where multiple examples were mentioned. Another interviewee concurred, stating that P&Q and MESW often have different goals and targets. Items that are on the top of MESW's priority list can be at the bottom for P&Q's.

Some interviewees indicated that P&Q members, in some cases, have a 'siloed mentality' during their development process – meaning they are focusing their efforts on

creating a well-functioning component without considering the impact this might have on other systems/components or the manufacturing processes. In many cases, this siloed mentality impacts MESW as they are not considered until the end of the development cycle. This relates to the involvement issues previously discussed – see Section 4.3.2. Some MESW representatives perceive the collaboration as one-sided, where MESW tries to collaborate with P&Q but not the other way around.

> "We work with P&Q, but they don't work with us." – MESW representative

One P&Q interviewee mentioned that P&Q does not prioritise dependencies with MESW and instead focus their efforts on securing dependencies with other P&Q development teams. Another interviewee from P&Q stated that some ARTs do not put on the 'manufacturing goggles' during the development phase. Other P&Q interviewees concurred, explaining that P&Q rarely considers manufacturing's point of view. This issue was also reinforced during observations of P&Q dependency discussions during the PI planning events, where dependencies with other P&Q ARTs were discussed but not with MESW – not even during dependency discussions that revolved around development requiring in-plant calibrations. At the same time, the dependency MESW has with P&Q is considered very important and is discussed at great lengths during the MESW PI-events.

> "We could be better at considering the impact to manufacturing processes when developing something." – P&Q representative

> "Sometimes P&Q forget that they work in a car company. They focus on making their component work and forget that is it part of a whole that needs to work, and that this is the true objective." – MESW representative

These underlying issues have corresponding items within the *Misalignment* challenges category deduced from the literature – see Table 2.1. The evidence of a lack of prioritisation of the TR – a prerequisite for continued work within MESW in some cases – parallels the neglect of dependencies underpinning Misalignment – see Table 2.1. Further support for the fit of this issue with the literature-based category was found in the description of goals and prioritisation diversity between MESW and P&Q, which parallels the inward focus rather than joint goal achievement of Misalignment. Furthermore, the siloed focused described supplements the link to Misalignment through the connection to losing sight of the bigger picture. The perception of this underlying problem is evident from the quote above about P&Q forgetting the end product on which they work. The lack of manufacturing perspective perceived and the negligence of dependencies to MESW on P&Q's part shows that Misalignment is clearly evident in the interface between the two organisations.

ID3: An Overview of Mechanisms and Solutions That Can Have a Mitigating Effect

To achieve proper alignment of targets and prioritisation, both P&Q and MESW need to know whom they are coordinating with and how the other side operates. Because of this, an increased awareness between the two sides can be considered necessary. Therefore, some of the mechanisms and solutions discussed under Section 4.3.1 could apply to the issues discussed under this section as well. In addition to increasing awareness, there are multiple mechanisms – see Table 2.3 – and solutions applicable to achieving alignment. This subsection aims to provide an overview of some of these potential solution ideas and mechanisms that can help mitigate these issues.

It can be assumed that accountability of dependencies with MESW would make P&Q more likely to prioritise coordination. Such prioritisation would increase alignment between the two sides towards common objectives. Therefore, issues surrounding who is responsible for what needs to be sorted out if proper alignment is to be achieved. This would create an incentive for P&Q to have a broader perspective and avoid a siloed focus. Overcoming issues with the distribution of accountability is discussed further under Section 4.3.6.

Additionally, many mechanisms from the literature – see Table 2.3 – could have an aligning effect if used appropriately. Scheduled meeting mechanisms – e.g. joint *Scrum of Scrums* and project meetings – could support alignment since these can be used as forums for dependencies and trade-off discussions. *Workshops*, specifically with this purpose, can help the two organisations to agree on common goals and prioritisation. *Wikis* containing a description of capabilities, processes and requirements can help build a shared mental model, leading to a common perception of goals and thus could help align MESW and P&Q. *Retrospectives* can facilitate continuous improvement of inter-organisational alignment by highlighting improvement areas and facilitate the development of plans for their mitigation.

Furthermore, common goals exist inherently in the VCAF structure given that Product Streams, broken down to Solutions, Programs, and finally to *Product Backlog* items, provide a connection of the individual tasks to the bigger picture. However, what may be missing is a dedication to this connection and a way to visualise and understand it. *Features* are brought up as a coordination mechanism – see Table 2.3 – and they are part of the breakdown and used by both MESW and P&Q. *Technical Corners*, and *Reference Architecture* – see Table 2.3 – could be used to improve the Team level understanding of the connection of their work to the higher level, common, objective. This could, for instance, be in the form of meetings between Team level representatives, e.g. the ScM, and Solution level architects, or clear descriptions that explain how *Features* fit in the whole. The utilisation of joint *Priority Lists* – see Table 2.3 – could further help teams create individual and intra-team prioritisation guidelines aligned with inter-organisational objectives.

Development of *Dependency Maps* – see Table 2.3 – and inclusion of these in *Project*

Management Tools – e.g. VIRA used at Volvo Cars – could significantly help visualise dependencies. This would help people on both sides understand the connections of their Stories and, as a result, also understand the potential effects of sub-optimisation and misalignment. This would further reduce the gap between targets and hopefully the issues that come with it.

4.3.4 ID4: Relationship Dependent Collaboration

Interviewees from both P&Q and MESW mentioned that in most cases, coordination is initiated through previously established relationships between individual team members from both sides. In situations where pre-established relationships exist and where the teams from both P&Q and MESW has experience working together, the collaboration often works well.

One interviewee from MESW mentioned that successful coordination with P&Q is almost always correlated with experience from previous engagements. Multiple interviewees from P&Q mentioned that these close, personal relationships are needed because it is otherwise difficult knowing whom to contact. One P&Q interviewee stated that they currently have a very well functioning collaboration with MESW, which is attributed to establishing a personal relationship with MESW representatives early on. The literature supports this, describing that relationships often are enablers for effective communication – see, for example, Berntzen et al. (2019) and Evbota et al. (2016).

One MESW interviewee mentioned that the general ME structure, which the MESW department is based on, was designed to coordinate with one or two ARTs. MESW is, however, currently coordinating with more than 25 ARTs. This results in MESW having to form working relationships with many representatives from different teams in different ARTs. Additionally, some MESW interviewees mentioned that they have difficulties determining with which P&Q ARTs to prioritise forming relationships. P&Q interviewees supported the existence of these issues, describing that while MEHW has MALs dedicated to working with their specific ART, MESW has no one specifically dedicated to them – making it difficult to form relationships. This is a typical challenge of agile scaling, where some agile designs and organisational structures were originally originally intended for small teams but are now being applied to a larger setting (Bjørnson et al., 2018; Evbota et al., 2016; Theobald & Diebold, 2018; Uludag et al., 2018).

> "It is hard to pick a few ARTs to prioritise" – MESW representative

> "We [P&Q] are a rather large organisation, and I don't think that the number of people in Manufacturing Engineering is balanced really." – P&Q representative

Some interviewees from P&Q mentioned that there are risks associated with this form of relationship-based collaboration due to employee turnover – when experi-

enced people leave, relationships might be lost and collaboration hampered. Another P&Q interviewee added to the risks, mentioning that due to the high workload and pressure P&Q team members are under, there is no dedicated time to proactively building relationships with ME departments – relationships are typically formed when issues occur, which is arguably not the preferable way of starting a collaborative relationship. Some P&Q interviewees also stated that they have never interacted with MESW and presently lack relationships with them. This contradicts some agile principles, promoting direct interaction and face-to-face communication, and can result in further communication-related issues.

During MESW's PI planning meetings, discussions arose about the difficulties of finding who to reach out to at P&Q regarding dependencies. During these discussions, it was observed that in situations where the MESW team had less experience working with the P&Q team members and had 'weaker' relationships, they found it more difficult to obtain the necessary information about development projects.

> "We would benefit from having a better relationship with MESW... Forming relationships is key when handling dependencies" – P&Q representative

A dependency on relationships between individuals for efficient coordination implies overlaps with the *Dependency on Individuals* challenge deduced from the literature – see Table 2.1 – as commonly present in scaled agile contexts. The evidence of experience working together being positively correlated to well-functioning coordination between MESW and P&Q parallels the described dependence on individuals' knowledge. Furthermore, the difficulty of finding the right point of contact and challenge from employee turnover suggests a connection to relationships for communication and a dependency on individuals' networks. Finally, one could also argue for a connection to *Communication Issues* – see Table 2.1 – via both the described issue of MESW having to coordinate with a vast number of ARTs and difficulty finding the necessary information. These underlying issues parallel the communication challenge's time-in-meetings paradox and lack of appropriate channels for communication.

ID4: An Overview of Mechanisms and Solutions That Can Have a Mitigating Effect

As many interviewees have described, a success factor for effective coordination between the ME and P&Q organisations are strong relationships between individuals. This notion is also supported in the literature, where large scale agile often rely on individual relationships and networks for coordination across interfaces – see, for example, Berntzen et al. (2019) and Evbota et al. (2016). Furthermore, some sources – e.g. Stray and Moe (2020) – explicitly describes relationships as an enabler for effective communication. This subsection provides solution ideas and describes mechanisms from the literature on how to potentially overcome issues stemming from a lack of relationships between MESW and P&Q – see Table 2.3. Some solutions and mechanisms focus on maintaining and building new relationships, while

some focus on identifying potential substitutes to relationships and is viewed as short-term fixes to this type of issue.

One change that can strengthen the relationships between P&Q ARTs and MESW is if P&Q becomes more proactive – i.e. actively and timely involving MESW when needed. This would allow MESW to form stronger relationships with the most critical P&Q ARTs and effectively overcome some of the perceived prioritisation issues that they face today. Solutions to involvement issues are discussed further under Section 4.3.2.

The literature outlines concrete mechanisms that could be applicable when searching for solutions to issues with relationship dependence – see Table 2.3. Standardised and regular interactions would strengthen relationships – e.g. *Scrum of Scrums*, *Team Leader Meetings*, *Workshops*, and *Demos* – see Table 2.3.

Furthermore, utilising *Metascrums* – see Table 2.3 – to create more standardised meetings and check-ins between the MALs and RTEs/PMs could lead to additional opportunities for building relationships between senior representatives from both organisations. Building and maintaining relationships on this level can arguably be considered easier given the relatively limited number of people involved. Such relationships could potentially also facilitate stronger relationships on a Team level.

In addition to formal meeting mechanisms, *Team Member Rotation*, *Physical Informal Meetings* and *Experience Forums* – e.g. Community of Practice – could also bolster the creation and continued development of relationships between MESW and P&Q.

Unfortunately, due to MESW's unique position and dependencies with such a large number of ARTs, it is difficult to establish working relationships with representatives from all relevant teams – presently or in the future – from P&Q. As seen in Pernstål et al. (2012), this type of coordination issue can stem from an imbalance between the manufacturing engineering organisation and the development organisation, and is not a new phenomenon. Due to this, *finding potential substitutes for relationships* could provide a mitigating effect and constitute a short-term solution to this issue. While this may contradict some agile principles, some compromises have to be made when scaling agile, as previous research has shown. Examples of substituting mechanisms for relationships outlined in the literature – see Table 2.3 – could be extensive documentation in the form of *Wikis*, using collaboration *Contracts* – e.g. the TR, which could be used to a greater extent – and more concrete product development *Roadmaps*. Additionally, more robust and structured processes for coordination could also be considered a substitute for relationships – such processes are further discussed under Section 4.3.5.

However, given the persistence of this issue, combined with the increasing software complexity and importance of said software to car companies, a more *radical solution* might be warranted. Thus, *reorganising* the MESW department to shift the balance

towards P&Q, potentially overcoming the balance issues outlined in Pernstål et al. (2012), could be a warranted solution.

4.3.5 ID5: Unclear Collaboration Process

Interviewees from both P&Q and MESW agreed that the processes for collaboration between the two sides are currently not implemented in an ideal way, hampering the collaboration.

Multiple interviewees at P&Q described the collaboration process between MESW and P&Q as informal. They mentioned that there is currently no structured process for how the two parties should coordinate and that there is no proactive work being done to facilitate or improve coordination.

One interviewee at P&Q described a lack of frequently established interactions with MESW and mentioned that this would be highly beneficial for coordination purposes, especially as development approaches the pilot-plant prototype phase. In the literature, the frequency of interactions is described as paradoxical – see, for example, Gustavsson (2020) and Evbota et al. (2016). Frequent and direct interaction is prescribed with benefits, but with the drawback of the time required for such interactions (Stray & Moe, 2020; Wohlrab et al., 2019). To balance this, more indirect forms of communication – e.g. emails – are often used to supplement direct communication. However, these asynchronous communication methods are often described as inefficient and undesirable (Evbota et al., 2016).

MESW representatives described the process as them having to pursue P&Q team members for information that *might* affect MESW and that this process is highly unstructured and cumbersome. A discussion regarding this issue was observed during a MESW PI planning event, where some MESW team members were unable to coordinate with P&Q despite actively seeking them out and that they were unsure how to proceed. The solution that came out of the discussion was to escalate this issue to the MALs, who would continue to seek out P&Q representatives that might have the necessary information. Additionally, some MESW interviewees stated that P&Q perceive request from MESW for information as annoying, further reinforcing the issue, which is similar to those described in Sections 4.3.3 and 4.3.2.

Additionally, some of the detailed information exchange between teams at MESW and P&Q is currently facilitated through the MALs, which adds to the issue. One interviewee suggested that this is unnecessary and inefficient. Instead, the detailed information exchange should ideally be handled by the teams independently. This goes in line with agile literature prescribing more coordination responsibility to the team members – see, for example, Evbota et al. (2016) and Gustavsson (2020). However, doing so has also proven to create coordination challenges due to confusion of responsibilities. From P&Q, one interviewee personally had an informal coordination responsibility with MESW, despite perceiving oneself as ill-equipped for this responsibility. This further points towards a lack of structure and unclear

delegation of responsibility regarding coordination across interfaces. This parallels the challenges of *Unclear Roles and Responsibilities* deduced from the literature, with delegation resulting in confusion – see Table 2.1.

Furthermore, interviewees at both P&Q and MESW expressed a lack of an established process for finding the correct point of contact when trying to coordinate across the interface. Some MESW interviewees described the process of finding the correct point of contact as cumbersome. Both P&Q and MESW representatives described scenarios where MESW team members get "passed around" within an ART during this process and that they often have to contact multiple P&Q representatives before finding the correct point of contact. Discussions around this issue were observed during PI planning events at MESW.

> "When someone tries to get in touch with the correct person, they sometimes end up being passed around in the system" – P&Q representative

Some MESW interviewees brought up the vast number of ARTs they have to work with as a root cause behind the issue with finding the right point of contact when coordinating with P&Q. One P&Q interviewee further mentioned that ideally, they [MESW] should have a single point of contact for P&Q to reach out to in MESW. This shows an increased need for solid processes and routines for how to manage coordination. However, assigning responsibility for coordination can also be problematic and can result in challenges – see Table 2.1. Simply adding new resources for coordination purposes can help but can also create a paradoxical need to coordinate the coordinators.

The elements constituting this issue can be linked to various challenges deduced from the literature, as described in Table 2.1. First, there is evidence suggesting a connection to *Communication Issues*. The vast number of ARTs can create a paradoxical need for too many meetings, and the described lack thereof can be a reason for ineffective coordination. Second, both the creation of the MAL role and the proposed coordination delegation to the team members from the MALs parallel examples one and two of *Unclear Roles and Responsibilities* – see Table 2.1). Furthermore, the third example of the same challenge – ambiguity of dependency ownership – can arguably be linked to people attempting to coordinate ending up being passed around. Finally, being passed around could be a factor contributing further to MESW having to actively seek out P&Q people and information, which in turn relates to inward focus and lack of proactive communication on P&Q's part and could therefore be perceived as a form of *Misalignment*, as described in the literature – see Table 2.1. The issue is also described in non-agile literature by Pernstål et al. (2012) and thus seems to be persistent, indicating that the structure of how to coordinate has not improved due to the agile transformation. At least not yet, as some interviewees described. The agile ways of working have not yet set, and giving the transformation more time is believed by some to help mitigate coordination issues – see Section 4.3.7.

ID5: An Overview of Mechanisms and Solutions That Can Have a Mitigating Effect

In order to overcome some of the issues described in this section, interviewees suggest that the overall process for collaboration should be more structured and adequately defined. This subsection aims to provide an overview of different solution ideas and mechanisms (as outlined in Table 2.3) to formalise the collaboration process and potentially overcome issues described in Section 4.3.5.

One of the issues identified is that coordination responsibility sometimes ends up being informally delegated to a person that is not comfortable with this responsibility. Thus, one of the proposed solutions is to establish accountability, specifically in terms of who is responsible for initiating coordination across organisational interfaces. As discussed in Section 4.3.4, the person responsible for coordination should preferably be someone with a good relationship network across interfaces. This should also be done on an ART/Program level for the P&Q side – e.g. giving RTEs/PMs of P&Q a gatekeeper role. This would mitigate the issue of finding the correct point of contact for MESW. This is already implemented on the MESW side, where the MALs are responsible for coordinating on a higher organisational level. By implementing this gatekeeper role on the P&Q side, the time MESW representatives are being "passed around" when trying to initiate contact with a P&Q ART could be reduced.

The mechanisms outlined in the literature – see Table 2.3 – prescribe different ways to formalise the collaboration process. This could, for instance, be in the form of having more recurring and set meetings – e.g. joint *Scrum of Scrums*, *Team Leader Meetings* and *Project Meetings* – where guidelines for how the coordination process should be structured are determined. Furthermore, joint *Testing* and *Demo* sessions where P&Q demos ongoing development projects relevant for MESW could also provide opportunities for formalised interactions. Section 4.3.4 describes more examples of mechanisms that could create opportunities for interactions where the process could be formalised. A more formalised collaboration process could potentially reduce the amount of time MESW representatives are passed around within the P&Q ART when looking for information.

During the interviews, it also became clear that representatives from both sides want a collaboration process where P&Q is more proactive in their work with ME, actively providing information when needed. This could further help avoid situations where MESW has to seek out P&Q representatives for information. How to achieve this is elaborated further under Section 4.3.2.

While these formalised suggestions can be perceived as counter-intuitive when it comes to implementing agile as it brings the form of coordination further away from mutual adjustment, it is described as a balance in the literature – where the trade-off between detailed and lightweight documentation need to be considered (Kasauli et al., 2020). In fact, the literature further describes that agile planning methods and processes in a scaled agile context can sometimes be ineffective when working

with multiple teams (Badampudi et al., 2013; Evbota et al., 2016), again indicating that a balance between formal and informal needs to be achieved. As discussed in Section 4.3.4, this balance becomes increasingly important given MESW's context and need to coordinate with such a large number of different ARTs.

4.3.6 ID6: Unclear Distribution of Accountability

Determining who is accountable for when an issue occurs and who takes ownership of ensuring a solution is found is not always clear, according to multiple interviewees at both P&Q and MESW. This issue of accountability sometimes contributes to sub-optimal problem solving and coordination between the two parties.

In general, multiple interviewees from both MESW and P&Q agreed that P&Q should, in theory, always be the one with ownership over issues. One interviewee mentioned that P&Q should be responsible for ensuring successful coordination between the two sides and that ME should act as support. However, in reality, this is not always the case. One interviewee from MESW mentioned a collective mentality on both sides of wanting to "wash their hands" of accountability when an issue occurs. The issue of accountability was also observed during a PI planning event for P&Q when a discussion surrounding who was accountable for a particular issue unfolded. During the discussion, it became apparent that the aspect of accountability for this specific issue was highly ambiguous. Contrary to most participants, two P&Q interviewees stated that it is up to MESW to own the responsibility of coordinating and solving the issue, involving P&Q when needed. This further reinforces the notion that accountability is not clear.

> "P&Q argues they can't change the software because it is too late in development, and MESW argues they can't simply change their processes."
> – P&Q representative

Some interviewees mentioned that this discussion of accountability can lead to conflict between the two parties and that ideally, it should be clear from the beginning who is accountable. One interviewee from MESW mentioned that while P&Q should be held accountable, the responsibility for coordinating and pursuing the correct information needed to find a solution ends up with MESW – previously discussed in Section 4.3.5.

This issue of unclear accountability for solving issues when they occur parallels the ambiguity of dependency ownership underpinning the *Unclear Roles and Responsibilities* challenge deduced from the literature – see Table 2.1. Furthermore, the mentality of wanting to 'wash one's hands' in favour of actively engaging in problem-solving could arguably be linked to the inward focus constituting a part of the *Misalignment* challenge – see Table 2.1.

The issue of accountability contributes significantly to other issues identified and is, therefore, imperative to solve. If P&Q does not feel accountable for issues that

might occur from coordinating with MESW, they will not work towards fixing it, and vice versa.

ID6: An Overview of Mechanisms and Solutions That Can Have a Mitigating Effect

As many interviewees from both sides have suggested, the most logical division of accountability is that P&Q is accountable for coordinating and ensuring collaboration is established. Since P&Q is driving the development projects forward and have significantly more resources compared to MESW, making them accountable makes sense in theory. However, this is not how it works in practice – the division of accountability is currently not clear. This subsection aims to provide an overview of different solution ideas and mechanisms – see Table 2.3 – that could potentially be used to overcome the issues stemming from this unclear division of accountability.

For P&Q to effectively increase their sense of accountability over the coordination between the two parties, it is vital that P&Q increases their awareness of MESW and works towards becoming more proactive in terms of communicating to and involving MESW. This could be done through means discussed under Sections 4.3.1 and 4.3.2. By clearly defining and communicating this distinction of ownership of *establishing* collaboration, there will be less confusion and more effective coordination between the two interfaces.

Once collaboration is established, the mechanism described as *Contracts* – see Table 2.3 – can be used to define areas of accountability for the particular engagement clearly by correctly filling out a contract, stating the exhaustive information needed and areas of accountability by both parties, issues regarding who is accountable for what can be mitigated. The TR is an example of this – when properly filled out, MESW should know exactly what to do and have all the information they need. If they encounter issues within the boundaries of the TR, it would be MESW's responsibility to fix these.

More formal and structured interactions between MESW and P&Q ARTs could also reduce confusion regarding accountability. Ways to achieve more formalised collaboration processes are discussed under Section 4.3.5. Additionally, organising a retrospective after each Sprint and or PI, including collaborative work between the two sides, could yield improvements.

Finally, the issue of accountability might be paradoxically related to the issue of *Lack of Awareness*. As discussed under Section 4.3.1, many P&Q ARTs lacks awareness of what MESW do, how they operate, and their areas of responsibility. It is thus difficult to define their accountability boundaries when it comes to collaborative engagements. Because of this, increasing awareness of MESW seems critical to overcoming issues related to accountability. On the other hand, however, increasing awareness on P&Q's part would arguably require a sense of accountability within P&Q for coordination issues across this interface. Without a sense of accountability, there might not be enough incentive for P&Q representatives to gain knowledge and

increase their awareness of MESW. This is what was identified during the interviews – most P&Q representatives are aware that they *should* be responsible for coordination, but since they are unaware of how important their collaboration with MESW is in order to avoid issues, they are not feeling incentivised to improve collaboration. Overcoming this paradox and solving both of these issues will be critical for Volvo Cars to improve coordination between MESW and P&Q.

4.3.7 ID7: Ununiform Agile Implementations and Reorganisation Complications

The implementation of agile and the ongoing organisational transformation at Volvo Cars brings changes described as problematic by interviewees from both MESW and P&Q.

Some P&Q interviewees argue that due to the different context and circumstances of the different teams, ARTs, departments and organisations at Volvo Cars, the agile implementation is happening at different paces and forms. Interviewees from both sides mentioned that this could result in coordination issues since it is difficult to know how different teams operate. This type of issue could be considered a methodological island issue related to the *Lack of Awareness* challenge described in the literature – see Table 2.1. However, interviewees from both P&Q and MESW argue that these issues *might* diminish over time as the agile implementation matures and ways of working set.

> "The agile ways of working are still very new to us, and we are trying to adapt every PI" – MESW representative

Three MESW interviewees mentioned that the agile transformation results in frequent restructuring of the organisation. This makes it hard to understand how the different teams at P&Q is working and who is accountable for what. Some interviewees described that each team and ART implement agile in their own way. This relates to challenges with *Unclear Roles and Responsibilities* identified in the literature – see Table 2.1 – and issues with methodological islands described by Kasauli et al. (2020). Additionally, this might be considered a contributing factor behind the issue of *Unclear Distribution of Accountability* as described in Section 4.3.6.

> "Every team and ART at P&Q has their own flavour of working agile... some are agile on paper but are not even working agile in reality" – MESW representative

Some interviewees mentioned that the agile transformation shifts responsibilities for dependency management to the individual engineers. This puts increased pressure on efficient coordination from everyone at the Team level. This type of issue can be considered related to the coordination challenge *Unclear Roles and Responsibilities* in the literature, where agile is described as prescribing more coordination responsibility to team members, resulting in local adaptions and inter-team confusion – see

Table 2.1. Additionally, the issue can also be related to the coordination challenge *Dependency on Individuals* in Table 2.1.

ID7: An Overview of Mechanisms and Solutions That Can Have a Mitigating Effect

This subsection aims to provide solution ideas from interviews and mechanisms from the literature – see Table 2.3 – that could potentially be used to mitigate issues outlined in Section 4.3.7.

As described by some interviewees from both P&Q and MESW, one potential solution related to issues with the reorganisation happening at Volvo Cars is to let the current agile implementation mature and avoid too frequent changes – once the new ways of working are set, some issues might be solved. According to some interviewees, by trusting the new organisation structure and letting the teams become accustomed to the new roles, responsibilities and ways of working, issues described in Sections 4.3.6 and 4.3.1 could potentially be mitigated. This does not mean that Volvo Cars should stop trying to find ways to improve their organisational structure – as outlined in the literature, a key to scaling agile is to take a dynamic approach to agile ways of working and always search for continuous improvement (Berntzen et al., 2019; Wohlrab et al., 2019).

A mechanism identified in the literature that could help with managing continuous change during an organisational transformation is the usage of *Trace Links* and proper documentation of the organisational changes the company is going through – see Table 2.3. *Trace Links* can help Volvo Cars document why specific organisational changes were made, the intention, and the result. This can help Volvo Cars avoid making sub-optimal organisation changes in the future and provide an opportunity for continuous improvement.

In order to overcome issues with localised adaptions of the agile implementation, there are multiple mechanisms suggested in the literature that could be helpful – see Table 2.3. One of these mechanisms is to utilise proper documentation, e.g. in the form of *Wikis*. For Volvo Cars, this could, for instance, mean utilising wiki pages to standardise a format that clearly and concisely describes how they are implementing agile. Some ARTs / departments are already doing this well, but it could be utilised throughout the entire company. Furthermore, mechanisms that promote frequent communication and interactions between organisations, e.g. *Scrum of Scrums* or *Team Leader meetings*, could reduce these issues. Finally, properly utilising retrospectives to continuously and regularly re-evaluate the effectiveness of the organisational structure can create a means of continuously improving collective performance through collaboration.

4.4 Classification of Issues Identified and Relations Between Them

The issues identified at Volvo Cars are all interconnected, and aiming to resolve one issue in isolation will most likely not be feasible. Instead, one could view these issues as a collective coordination challenge that can be overcome through a combined effort by both P&Q ARTs / Teams and MESW. This section aims to clarify and synthesise how the issues are related to one another, analyse which issues are general and which are unique to the coordination between MESW and P&Q, and finally analyse how/if the issues are related to agile.

4.4.1 Relationship between coordination issues at Volvo Cars

The Issues of *Lack of Awareness and Understanding of MESW* was perceived by several interviewees as critical and was found to contribute to most other issues identified in one way or another – as discussed under Section 4.3. For instance, if P&Q were fully aware of MESW in terms of how they operate and what information they need, issues related to sub-optimal involvement, different targets & prioritisation, and unclear distribution of accountability could be alleviated.

Another issue that has been found crucial is that of *Unclear Distribution of Accountability*. As discussed under 4.3.6, the solutions behind this issue category are intertwined with achievement of awareness across the interface, and solving one of the two issues is dependent on mitigation of the other. By defining clear boundaries of accountability and ownership, the two organisations would have more concrete incentives to improve the coordination and work towards finding solutions to other issues. For instance, if P&Q felt accountable for ensuring coordination with MESW worked well, intuition leads one to conclude that they would strive to increase their awareness of the department, thus mitigating *Lack of Awareness and Understanding of MESW*.

Other issues outlined under Section 4.3 are also related to one another as previously described but cannot be considered root causes in the same way as issues related to *Lack of Awareness and Understanding of MESW* and *Unclear Distribution of Accountability*.

4.4.2 Classification and Generalisability of Coordination Issues

Most of the issues identified at Volvo Cars are related in one way or another to the coordination challenges outlined in Table 2.1. Some of the issues at Volvo Cars could thus be considered general and applicable to most large organisations. Others are seen as specific to Volvo Cars, and some only related to the specific interface between MESW and P&Q. Furthermore, some of these issues seem heavily connected to agility, while other issues could be a result of other factors.

Some issues described are more easily classifiable through their connection to the challenges deduced from the literature. Foremost of these, is perhaps *Lack of Awareness and Understanding of MESW*, which by its name indicates its fit with the *Lack of Awareness* challenge in Table 2.1. This issue can therefore be determined to constitute a non-Volvo Cars specific coordination challenge. Additionally, since *Lack of Awareness* was found to be evident outside of the agile context – see Section 2.3.3 – it could be argued to constitute a prominent issue regardless of organisational structure and processes. However, the evidence for issues outside of the agile context was limited to a study conducted with the same case company and one more within the automotive industry. This could mean that the issue is, in fact, an inherent element of environments with high uncertainty since this is a characteristic of the automotive industry and a contributing factor for the emergence of agile methodologies. For a more deterministic answer to this question, however, further research would have to be conducted. *Different Targets and Prioritisation* can, similarly to the issue of awareness, be directly connected to one literature challenge, namely *Misalignment* – see Table 2.1. Based on the same logic, this issue can be considered transferable outside the Volvo Cars context, but the question remains how far outside the case boundaries such generalisations can be made.

Furthermore, it can be argued that two other issues can be considered generalisable and not necessarily agile specific. First, *Unclear Distribution of Accountability* connects to two of the challenges deduced from the literature review and can therefore be argued as generalisable within a scaled agile context. In addition to this, the issue can be related to challenges described with the same case company prior to the agile transformation. Pernstål et al. (2012) described an issue with a tendency of reluctance of actively taking ownership in favour of waiting for implementation ready solutions in the two automotive companies studied. This can be perceived as similar to the willingness to wash one's hands of accountability discovered in this study.

The second, *Ununiform Agile Implementation and Reorganisation Complications*, relates to several of the categories of challenges deduced from the literature – e.g. *Unclear Roles and Responsibilities* and *Dependency on Individuals* as described in Table 2.1. The multitude of the connections to categories could result from this issues clear connection to the concept of methodological islands, which can be seen as an umbrella concept for all categories. Reorganisation inherently means change, and changing at different paces means discrepancies between how parts of the company operate, which is the essence of methodological islands and the reason it leads to coordination issues. However, one could also turn the gaze to change management and inherent challenges experienced during a transformation. The nature of such challenges transcend this study's scope, and, once again, the extent of the generalisability of some issues requires further study.

Some issues found in this case study can be characterised as generalisable but argued to be so mainly within the scaled agile domain. First, issues with *Relationship Dependent Collaboration* connects strongly to the common agile coordination issues

segmented under the *Dependency on Individuals* challenges. The issue can arguably be determined an inherent agile challenge based on the outspoken favour of mutual adjustment mechanisms to manage coordination rather than standardising and utilising rules. This also leads to the second issue identified in this study which can arguably be determined agile-specific, *Unclear Collaboration Process*. Similarly to relationship dependence, this issue connects to multiple challenges from the literature and the fact that processes are perceived as unclear supports a connection to methodological islands here as well. If people do not feel they know how to operate, it seems inevitable that they should not all act identically. Therefore, the issue can be seen as generalisable within the agile context. The notion that these challenges both adhere to agile explicitly is supported by the constitution of agile itself, with its manifesto explicitly stating that one should favour people over processes.

One of the contributing factors to both these issues – *Relationship Dependent Collaboration* and *Unclear Collaboration Process* – adheres to the number of people with whom coordination is needed and issues stemming from an inability to find effective means of managing this issue. This could mean that the applicability of these issues extends only to the scaled agile context and that there could potentially exist a size-wise boundary for the generalisability of these issues within that context. On the other hand, evidence suggests that the coordination between both MEHW and P&Q, and between ARTs at P&Q works well. From this, one could argue – given the significant size of MEHW and the limited relative contribution of MESW on the collective size of P&Q and MESW – that these issues are context-specific and adhere to the few-to-many characteristic of the interface studied.

Finally, one issue constituted a classification difficulty with its partial and multiple relations to literature challenges – *Sub-optimal Involvement of MESW in development*. This could be a result of an imperfect segmentation of the diverse – and previously non-conceptualised – literature data on coordination challenges across agile team interfaces. However, the answer could also lie outside of the scope of this study. Perhaps the issue of involvement is not necessarily classifiable as a coordination challenge in the scaled agile context. The agile transformation is yet young in its tracks at Volvo Cars, and some ARTs represented in the study are evidence of this. The product development literature outside the agile realm could perhaps provide an answer for this – for instance, Wheelwright and Clark (1992)'s discussion on how late involvement often is a significant cause of development delays. The appropriate classification of this issue could therefore be argued to be a non-agile specific one.

It thus appears that all issues could be potential problems for companies going through agile transformations but not necessarily limited to such companies. However, it is important to note once again that the transferability of findings from case studies is limited. The same caution should be used regarding whether the issues identified exist specifically in the inter-organisational context or between teams on the intra-organisational level. However, the evidence suggests a stronger likelihood of the emergence of several issues across interfaces, particularly between departments within different organisations – such as ME departments and P&Q ARTs.

For instance, awareness of dependencies was actively discussed and managed on the intra-organisational level, but issues described revolved mainly around dependencies between departments across organisational interfaces – i.e. MESW and P&Q ARTs. Similarly, accountability was emphasised as an inter-organisational issue. Division of accountability between ARTs within P&Q and between MESW and MEHW was never mentioned as an issue. The reason for this could be an increased likelihood of methodological islands between inter-organisational entities, given the contribution of methodological islands to the emergence of coordination issues.

5
Conclusion

This thesis primarily identifies key coordination challenges between teams across organisational interfaces in scaled agile companies and analyses how these challenges can be mitigated. The thesis utilised the literature and a case study of teams across different organisations at Volvo Cars to answer the research questions and fulfil the defined purpose. Specifically, the entities constituting the boundaries of the case study at Volvo Cars was the MESW department in the Manufacturing Engineering organisation and multiple ARTs from the P&Q organisation. First, the present situation in terms of the agile adoption in the different organisations was mapped. This was followed by a deep-dive into coordination issues and potential solutions to these between the two organisations.

It could be concluded that MESW and the P&Q ARTs investigated in this study had many similarities in how they adopted agile and some distinct differences. The similarities reside on a high abstraction level, with both sides utilising the Volvo Cars Agile Framework as a basis for the implementation of agile roles and ceremonies. Additionally, both sides follow the same overall development cadence coordinated through company-wide product streams. Specific agile ways of working, such as scrum, are also utilised on both sides. There is one key difference between the two sides on the high level of abstraction, residing in their respective organisational structure and characterisation. P&Q distribute their teams in ARTs, while ME teams are considered *support teams* to P&Q distributed in departments – e.g. MESW. However, most differences adhered to more specific details and were evident both between the two sides and within P&Q – both on an ART-to-ART level and between specific teams. Teams in both organisations adopt and adjust the VCAF to fit their unique context – both in terms of ways of working and roles implemented and their respective responsibilities. These differences constitute grounds for coordination challenges to occur due to methodological islands created as a result.

Seven categories of coordination issues were identified in the interface between MESW and P&Q ARTs at Volvo Cars. The issues are briefly presented in Table 5.1 below. All issues were identified in a scaled agile context and can, to some extent, be related to coordination challenges outlined in the literature on agile coordination – see Table 2.1. However, some issues were found to correspond to coordination issues described *outside* of the agile domain, some were found to be *remnants of organisational heritage*, and some issues were found to be the *result of the organisational transformation* process happening at Volvo rather than being strictly related to the nature of agile. Because of this, it can be concluded that most issues are not

necessarily unique to the scaled agile ways of working, nor unique to Volvo Cars' specific context, and some have existed since before the agile transformation.

Table 5.1: A summary of coordination issues identified in the interface between MESW and P&Q ARTs at Volvo Cars

Issue	Description of the Issue	Connection*
ID1: Lack of Awareness and Understanding of MESW	There is a shared perception among P&Q and MESW of a lack of adequate understanding of MESW, what they do and how they operate. This leads to difficulties identifying contact points, prevents the flow of necessary information, and contributes significantly to other coordination issues.	*Lack of Awareness*
ID2: Sub-Optimal Involvement of MESW in Development	There is a lack of cross-functionality and involvement of the manufacturing perspective in the development of new products/systems/components. Furthermore, the direction of information exchange is presently ineffective, with the manufacturing side having to pursue information that both sides agree should be actively distributed from the development side.	Partially connected to *Misalignment* & *Communication Issues*
ID3: Different Targets and Prioritisation	Misalignment of targets and prioritisation between departments within the manufacturing engineering and P&Q organisations contribute to coordination issues and result in manufacturing problems.	*Misalignment*
ID4: Relationship Dependent Collaboration	Relationships across interfaces are critical to efficient collaboration. However, due to imbalances in size between departments, a lack of awareness, and an absence of means of establishing and building new relationships, there is currently a lack of existing relationships between MESW and some P&Q ARTs. This contributes to coordination issues. Furthermore, the loss of relationships – e.g. due to employee turnover – further contributes to these issues.	*Dependency on Individuals* & *Communication Issues*
ID5: Unclear Collaboration Process	Individuals experience a lack of direction and structure for how to coordinate across the interface. The result is a lack of understanding within the teams of how to act and solve coordination challenges, whom to contact and what role should be assigned with coordination responsibility.	*Communication Issues*, *Unclear Roles and Responsibilities* & *Misalignment*

Table Continues on Next Page

Continuation of Table 5.1

Issue	Description of the Issue	Connection*
ID6: Unclear Distribution of Accountability	There is consensus that accountability for manufacturability needs to be assigned and reinforced at P&Q. Currently, both sides perceive a lack of clarity regarding what side is accountable for solving issues that occur and that both sides, therefore, tend to shed accountability rather than actively taking ownership to solve problems.	*Unclear Roles and Responsibilities* & *Misalignment*
ID7: Ununiform Agile Implementations and Reorganisation Complications	Differences in agile maturity and experience working with agile processes lead to different ways of working, resulting in coordination barriers.	Indirectly and partially connected to *Lack of Awareness*, *Unclear Roles and Responsibilities* & *Dependency on Individuals*

* Refers to the deduced links to commonly described coordination challenges in the literature – see 2.3.1 and segmentation of challenges based on analysis conducted of these descriptions in Table 2.1

The issues outlined in Table 5.1 are not mutually exclusive but rather intertwined with one another. Some issues were deemed as more important than others by interviewees. The issue of *Sub-Optimal Involvement of MESW in Development* was emphasised by interviewees from both sides on all levels, from team members to PM's, as *necessary* to overcome in order for MESW to operate effectively. It can be concluded that it is not feasible for MESW to operate when P&Q does not proactively involve them. Additionally, two other issues were identified as key contributing factors to multiple of the other issues – i.e. *Lack of Awareness and Understanding of MESW* and *Unclear Distribution of Accountability* – and by finding solutions to these issues, other issues can be alleviated. To solve these two issues, one must consider their dependent relationship, which hinders mitigation of one of the two in isolation. Given the causality of the relationship these two issues have with other coordination issues, it can be concluded that Volvo Cars should prioritise solutions with mitigating effects on both these issues. Thereafter, identifying solutions related to *Sub-Optimal Involvement of MESW in Development* and other issues outlined in Table 5.1 will come more naturally.

A major challenge for practitioners attempting to utilise the perceived benefits of agile methods is to find the appropriate balance between pure agile coordination mechanisms – i.e. mutual adjustment related ones – and more formal and standardised ways of coordinating across interfaces. Companies need to find a unique balance tailored to their specific context when attempting to solve inherent coordination challenges. As Mintzberg (1989) indicated, the larger the organisation, the further towards the standardisation side of the spectrum companies need to go to find and adopt mechanisms that facilitate coordination across interfaces. This is evident in the interface between MESW and P&Q; given the organisational structure of MESW, where they have to coordinate with a vast amount of ARTs, coordination

purely through the form of mutual adjustment does not seem feasible. Instead, combining coordination through mutual adjustment with standardisation is needed. It can be concluded that finding this balance between traditional agile ways of working and formal and standardised coordination processes is a critical element for successfully navigating an agile transformation while maintaining successful coordination across organisational interfaces.

Finally, companies and organisations embarking upon agile transformations would do well to pay heed to existing coordination challenges and consider these as they progress in their efforts. Agile should not be expected to blissfully solve previously experienced coordination issues, nor should one expect it does not come with the risk for new challenges to emerge – e.g. finding the aforementioned balance. Agile ways of working on a wide scale can help mitigate some issues by providing new ways of managing dependencies. However, research in this area is still young, and specific solutions are scarce. The literature review in this study yielded a wide range of mechanisms for coordination in the agile context, which can potentially be used to help mitigate some of the coordination issues identified – see Table 2.3. These mechanisms should be considered part of a toolbox rather than a solution in itself. Adjusting, adapting and combining these tools to one's unique context and allowing the mechanisms to emerge and evolve over time is necessary to utilise their full potential. Thus, it can be concluded that simply going agile is not a solution in itself, but effectively utilising the tools that agile ways of working prescribe can help companies mitigate their coordination issues.

6
Discussion

This chapter contains a discussion revolving around implications for practitioners as well as academia. The intent is to provide a more granular guidance for practitioners when interpreting the results of this study to support improvement efforts, primarily within Volvo Cars. Furthermore, suggestions for future research are presented on what is believed to be the most pressing topics.

6.1 Practical Implications

This section aims to provide a more in-depth discussion of which of the issues outlined in Section 4.3 are considered the most important to solve first and the effects of solving these issues. Furthermore, a more concrete discussion regarding how to overcome these issues using the mechanisms and solutions outlined under each Subsection in Section 4.3 will be had. Finally, the discussion also focuses on how to adapt these mechanisms and solutions to Volvo Cars unique context.

As described in Section 4.4.1, the issues identified at Volvo Cars are all intertwined with one another, and the list is not mutually exclusive. This means that some issues can be seen as root causes to other issues, and one can thus consider certain issues to be more important than others. Two key examples of such issues are the issues related to *Lack of Awareness and Understanding of MESW* and *Unclear Distribution of Accountability*. As these issues significantly contribute to multiple other issues, solving them should be the top priority. However, it is important to note that neither issue can be solved in isolation, and the focus should therefore be directed to finding solutions that target both issues simultaneously and potentially also directly mitigate other issues.

By increasing the awareness of MESW at selected P&Q ARTs, issues regarding locating the correct point of contact, finding appropriate timing of involvement, ensuring timely information exchange, correctly filling out the TR, and much more could be significantly improved. The issue of *Lack of Awareness and Understanding of MESW* also has a causal relationship to *Relationship Dependent Collaboration*, as awareness is a prerequisite for establishing relationships.

Simultaneously, Volvo Cars should strive to clarify the distribution of accountability, which will incentivise both sides to work harder to improve coordination – potentially contributing positively to all other issues. Currently, it is perceived that there

are no clear boundaries of accountability and ownership in terms of the coordination between MESW and P&Q. While many agree that P&Q should, in theory, be accountable, it seems like it is often up to MESW to initiate and drive the coordination between the two parties. Due to the absence of accountability at P&Q, there is no incentive to find solutions to the coordination issues outlined here. This is strongly related to *Sub-optimal Involvement of MESW in Development* – where P&Q does not feel accountable for proactively involving MESW. Thus, one can conclude that resolving accountability issues could contribute significantly to resolving issues of sub-optimal involvement.

Issues with sub-optimal involvement were frequently mentioned among interviewees from both sides and are seen as another issue that should be afforded high priority. Given the current structure of MESW, where they have to coordinate with such a large amount of different ARTs, it is suggested that the **only** feasible way for them to operate effectively is if P&Q proactively involves them in a timely fashion. Increasing P&Q's awareness and making them accountable for coordination are two necessary first steps to achieving a more efficient collaboration. By utilising MESW more as a support team that is involved early in the development process, the relationship between MESW and P&Q would strengthen, and cross-functionality would be improved – this will, in turn, improve the development of manufacturable solutions.

For the implementation and utilisation of mechanisms to achieve improved coordination, the main focus has been on reviewing state-of-the-art research on the topic – see Table 2.3. However, while academia provided extensive lists of mechanisms utilised by other companies, little guidance for how to combine, tailor and implement these were provided. For those reasons, it is difficult to make explicit recommendations to practitioners on what mechanisms to use and how to implement and tailor their use.

Therefore, the recommendations provided here are more abstract than one would have wished at the onset of this study. However, the analysis conducted of mechanisms identified in the literature can provide some valuable insights – see Table 2.3. For instance, different forms of scheduled meetings – e.g. *Scrum of Scrums*, *Project Meetings*, and *Workshops* – provide a means of targeting several coordination issues with the same mechanism. At Volvo Cars, many such meetings are implemented and executed regularly, and yet the issues persist. This is due to the lack of inter-organisational focus and participation in these forms of meetings. For example, Scrum of Scrums are regularly conducted *within* P&Q ARTs and MESW, but never jointly between the two parties. These meetings only include participants from one side of the interface. Furthermore, observations from the P&Q side observations provided evidence that these meetings were not focused on solving dependencies across the interface studied here but instead on intra-organisational dependencies. Therefore, a recommendation is that Volvo Cars – throughout the company – review the use of meeting mechanisms utilised with the intent of strengthening interactions across interfaces. It is believed that such a review could lead to a conclusion of maintaining most current meeting mechanism and supplementing them with meet-

ings including participants from both sides of dependent interfaces – e.g. MESW and P&Q ARTs. The most prominent supplement is believed to be adding *Metascrums* – see Table 2.1 – with representatives from both MESW and P&Q and a joint retrospective in each PI.

Coordination within MESW, and even between ARTs in the P&Q organisation, seems to work better than between MESW and the ARTs in P&Q. Based on this, one could argue that coordination across interfaces becomes increasingly difficult as the level of abstraction on the interface increases – e.g. team level, department level, organisation level. Such levels of abstraction intuitively also correlate in some sense with increased size – i.e. more people involved. Increasing system size was the determinant for Mintzberg (1989)'s spectrum for how best to coordinate in organisations. This leads to MESW's particular situation needing careful consideration of the balance of informal versus formal coordination mechanisms. Therefore, recommendations for coordination across this particular interface is believed to benefit from more formal and standardised mechanisms. One such mechanism is already implemented and used to some extent at Volvo Cars, namely *Wikis* facilitated by the Confluence platform. However, the platform is perceived as somewhat challenging to navigate and contains significant discrepancies between teams and ARTs/departments in how their respective pages are structured and what information is available. Going forward, Volvo Cars is therefore recommended to outline basic requirements for what information should be available and provide templates from how to structure this information. One supplementing piece of critical information that should be included in these *Wikis* is *Dependency Maps* – see Table 2.3 – developed by each department/ART. Creating such maps and the availability of their content to others could help identify and subsequently include dependencies in PI plans and Backlog Items.

Furthermore, to establish clarity of accountability division, a recommendation is that *Contracts* be utilised between MESW and P&Q ARTs. These contracts could help reinforce prioritisation. An example of this is the TR, which is already being used to some extent. It is recommended that Volvo Cars continue utilising the TR and expand upon this form of contract – making it standard procedure in every collaboration engagement across the organisational interface. This will significantly impact the manufacturability of solutions developed by P&Q and the timing with which potential issues related to this is discovered in the development process. Currently, handshakes of manufacturing requirements between ME and P&Q sometimes occur. The issue is thought to adhere to the absence of handshakes in many cases, which could be alleviated by further standardising how the TR is used.

To reinforce a collaborative mentality, joint *Testing* – see Table 2.3 – should be conducted to a greater extent. If P&Q representatives attend testing further down the development pipeline, there will be an increased understanding of manufacturing requirements on the products and solutions developed from their ARTs. Joint testing will also provide an arena for discussing and agreeing upon the accountability of subsequent work. Through this, both key issues are mitigated, which can be

expected to have ripple effects carrying over to other issues experienced.

As a final remark, it seems appropriate for large organisations to incrementally adopt agile rather than attempting to change the entire company all at once. By doing so, more formal ways of coordinating can be adopted as more teams transform towards agile and the pressure on efficient coordination procedures increases. Through this, the appropriate balance between formal/informal coordination processes is iteratively reevaluated, and people within the company will more easily adjust to these small, iterative changes. Agile transformations are arguably never complete, given the inherent need to continuously manage the evolution of coordination. Taking this into consideration when transforming organisations towards agile is essential.

6.2 Implications for Research

Given the relative youth of the body of knowledge in this particular area of research, multiple interesting and relatively unexplored questions and topics have been identified. The following sections outline those perceived by the authors as most prominent.

Early on, the absence of a common taxonomy for coordination challenges in the scaled agile setting became evident. Most research hitherto draws upon taxonomies from older domains and apply these in the agile context, which creates a diverse set of taxonomies with significant overlaps. This is perhaps not surprising as it seems inherent with the development of new knowledge domains. However, given the status of current research, there is an opportunity to clarify and unite further research within the area by developing a taxonomy to classify coordination challenges in the scaled agile arena.

Furthermore, due to the lack of a challenge framework, coherent definitions of mechanisms as solutions is lacking, and the subsequent step should be to develop theory of how solutions can and should be used to mitigate coordination challenges. Here our research provides a small contribution in terms of mapping existing solutions. However, there is room for improvement, and a Structured Literature Review should be conducted to perhaps more exhaustively map existing prescribed solutions followed by studies revolving around their effectiveness in different settings. This will help practitioners understand what is out there and how mechanisms should/can be tailored to suit more specific needs.

In this study, *mechanisms* have been used as a collective term for solutions to coordination challenges. Perhaps there are reasons why one should divide different types of coordination mechanisms into categories depending on their characteristics. For instance, there may be reasons to separate forms of meetings from physical artefact such as whiteboards to better guide practitioners attempting to solve coordination challenges and future researchers when dealing with emerging mechanisms.

Finally, scaling agile requires compromise in the form of balancing standardisation

with pure agile means of coordinating through mutual adjustment. This implicitly leads to a step away from the pure agile way of working, built for the Team level. Some literature identified during this study referred to cases when agile methods were applied and mixed with more traditional processes as *hybrids* – e.g. Bick et al. (2017) and Thamhain (2014). Furthermore, studies have found evidence suggesting that there may be resistance and prejudice about agile ways of working (Dikert et al., 2016). This leads to questions of whether scaled agile is an appropriate terminology to use, given that it could potentially harm practitioners efforts to introduce changes and drive transformations. This provides a potential for research to be conducted to determine if an adjustment of the terminology used to label the scaled agile methodologies could impact the success of subsequent transformations.

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Appendices

Appendix A – Interview Guide First Version

This interview will be conducted for the purpose of collecting data for a master's thesis study at Chalmers in collaboration with Volvo Cars. The intent is to study issues that can arise concerning inter-departmental collaboration in the context of agile transformations such as the ongoing one at Volvo.

Participation in this interview is voluntary and all answers will be recorded anonymously.

> However, given the limited scope of the study we would like to inform you that complete anonymity can not be guaranteed as there are a limited number of people we will interview, particularly in the MESW team. We will make it a priority to ensure that anonymity is kept as high as possible to make sure that you as an interviewee feel comfortable sharing information with us. If you choose to participate and later feel that you would like to avoid answer any questions that arise, you are free to withhold any such information for whatever reason.

We would like to record this interview to ensure all details are captured and no misinterpretations are made by us while interviewing.

> Following the completion of this study all recordings will be deleted and during the course of the study we will store these recordings in accordance with regulations and Volvo policies.

Are you willing to participate in this interview and do we have your consent to record it?

If the respondent chooses to focus their accounts on issues and collaboration with other departments in an agile context allow for this but follow up with questions specifically directed at a broader context of collaboration. If the opposite occurs then direct follow-up questions towards the agile context specifically.

- What is your name and role within Volvo Cars?
  - How would you describe your role in more detail?
- Which teams or departments do you collaborate with in your work?

- Do you personally manage this collaboration?
  - **If yes,** how is the collaboration managed?
  - **If no,** who manages this collaboration?
- Which problems have you encountered in the collaboration with other teams/departments (P&Q)?
  - What do you feel that these issues are resulting in?
- Could you give a specific example of a situation where collaboration was not good?
- Do you have any ideas or thoughts on how to improve collaboration or mitigate specific problems?
- Who would you recommend that we talk to next?

Appendix B – Interview Guide Second Version

This interview will be conducted for the purpose of collecting data for a master's thesis study at Chalmers in collaboration with Volvo Cars. The intent is to study issues that can arise concerning inter-departmental collaboration in the context of agile transformations such as the ongoing one at Volvo.

Participation in this interview is voluntary and all answers will be recorded anonymously.

> However, given the limited scope of the study we would like to inform you that complete anonymity can not be guaranteed as there are a limited number of people we will interview, particularly in the MESW team. We will make it a priority to ensure that anonymity is kept as high as possible to make sure that you as an interviewee feel comfortable sharing information with us. If you choose to participate and later feel that you would like to avoid answer any questions that arise, you are free to withhold any such information for whatever reason.

We would like to record this interview to ensure all details are captured and no misinterpretations are made by us while interviewing.

> Following the completion of this study all recordings will be deleted and during the course of the study we will store these recordings in accordance with regulations and Volvo policies.

Are you willing to participate in this interview and do we have your consent to record it?

If the respondent chooses to focus their accounts on issues and collaboration with other departments in an agile context allow for this but follow up with questions specifically directed at a broader context of collaboration. If the opposite occurs then direct follow-up questions towards the agile context specifically.

Structure and Organisation

- What is your name and role within Volvo Cars?
  - How would you describe your role in more detail?
    - What are your areas of responsibility?
    - Time at current role and at the company?
    - Earlier roles?
- How is your ART/department organized?
  - How are you implementing agile?
  - What roles are there?
  - What does 'being agile' mean to you?
  - How does this organisation change make you more agile?
- How is your ART/department organised compared to other ARTs/departments?
  - Deviations from VCAF?
- Could you briefly go over a typical PI for us? Starting with pre-PI-planning → PI planning → Sprint work

Collaboration

- Which teams or ARTs/departments do you collaborate with in your work?
- Do you personally manage this collaboration?
- Specific to MESW; are you responsible for the collaboration with this department?
- Follow-up questions to the collaboration:
  - Initiating collaboration: Do you reach out to the opposite side and 'pull them in', or do they approach you when they think it is necessary?
  - How is the information exchange organised?
  - Agile vs non-agile: How has the collaboration been affected by the agile change? Better or worse now?
  - What problems have you encountered in the collaboration with MESW/P&Q?

Specific examples

- Could you give a specific example of a situation where collaboration with MESW/P&Q was not good?
- Do you have any ideas or thoughts on how to improve collaboration or mitigate specific problems with MESW/P&Q?
- In an ideal world; how would the collaboration between P&Q and MESW be handled?

Who to talk to next

- Who would you recommend we talk to next?

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