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**Process Definition for EDI Onboarding of Suppliers Within the
Automotive Industry**

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Master Thesis

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Abstract

In today's fast-paced business environment, buyers and suppliers need to create and implement a communication flow that makes it possible to exchange business information in a complete and fast way. Electronic Data Interchange has been a standard in business communication for many years, especially in the automotive industry. Due to the short call-off times and just-in-time production, EDI is a must for any automotive OEM. This project seeks to study the current testing flow on onboarding suppliers in the EDI scope, focusing on identifying the existing bottlenecks and how to improve them.

This study was carried out using a Design Science Research methodology with a qualitative research component. First, a deep analysis of the AS-IS situation, mapping the current flow and identifying potential problems. Workshops were conducted to collect diverse and detailed insights into stakeholders' perceptions. The collected data gave a clear perspective of the pain points in the testing experience. Next, and with the aim of improving the testing flow, a redesign of the testing process was conducted and detailed, followed by a comparison between the AS-IS and TO BE and an evaluation of the new redesign testing flow.

The study provided a clear understanding of the current scope of the case study; a redesign was conducted closely following the DSR methodology, which provided clear learning, development, and evaluation steps. It also made it possible to understand how important it is to act on existing problems and pain points and how correcting those can improve efficiency and the quality of the processes used.

Resumo

No atual ambiente empresarial de ritmo acelerado, comprador e fornecedor precisam de criar e implementar um fluxo de comunicação que torne possível a troca de informações comerciais de forma completa e rápida. *Electronic Data Interchange* tem sido, durante muitos anos, um padrão na comunicação empresarial, especialmente na indústria automóvel. Devido aos curtos tempos de pedido e entrega e à produção *just-in-time*, o EDI é uma obrigação para qualquer automóvel *OEM*. Este projeto procura estudar o atual fluxo sobre a integração de fornecedores no âmbito da EDI, concentrando-se na identificação dos *bottlenecks* existentes e na forma de os melhorar.

Este estudo foi realizado utilizando uma metodologia de *Design Science Research* com uma componente de investigação qualitativa. Em primeiro lugar, uma análise profunda da situação *AS-IS*, mapeando o fluxo atual e identificando potenciais problemas. Foram realizados *workshops* para recolher perceções diversas e detalhadas sobre a experiência das partes interessadas. Os dados recolhidos permitiram uma perspetiva clara do que eram os pontos de dor na experiência de teste. Em seguida, e com o objetivo de melhorar o fluxo de testes, foi conduzido e detalhado um redesenho do processo de testes, seguido de uma comparação entre o *AS-IS* e *TO-BE* e avaliação do novo fluxo redesenhado.

O estudo forneceu uma compreensão clara do âmbito atual do *case study*, foi realizada uma reformulação seguindo de perto a metodologia da DSR, que forneceu passos claros de compreensão, desenvolvimento e avaliação. Permitiu também compreender a importância de agir sobre problemas e pontos de dor existentes, e como a correção dos mesmos pode melhorar a eficiência e qualidade dos processos utilizados.

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List of Abbreviations

ASN - Advanced shipment notice

DESADV – Despatch Advice

DSR – Design Science Research

EDI – Electronic Data Interchange

EDI OT - Electronic Data Interchange Onboarding Team

EDI PL - Electronic Data Interchange Project lead

1. Introduction

This dissertation is part of the final semester of the Masters in Service Engineering and Management. The goal was to be part of an institution and produce meaningful and new work related to the area and theme described in the first proposal.

A company's processes are one of its most valuable assets; it is one of the main reasons two competitors can differ so much working in the same market. Therefore, this project takes a deep dive into INEOS Automotive EDI Onboarding processes, exploring the flaws, bottlenecks, constraints, and solutions and a new way to pursue the company's objective to be more efficient every day. The Automotive industry is a high pace market with a great level of complexity; therefore, a well-developed process can make a difference in every other aspect of the company.

The landscape described below, and the work created was developed during a curricular internship at INEOS Automotive, an OEM (Original equipment manufacturer). The company provided a welcoming and supportive environment throughout the internship, allowing a complete e detailed view of such a complex and interesting business.

The project intends to explore and define methodologies for developing a new artefact, putting it to the test and detailed comparison between the old and newly developed processes.

1.1. Project Background

To secure logistics activities, authors have observed how Electronic Data Interchange can play a vital role in securing automated, secure, and frequent communication among manufacturers' and suppliers' networks (Sumah et al., 2020).

Due to the use of this technology in a variety of business areas, the case to be analysed is the Automotive industry; it is important to understand how its implementation can improve the communication between buyers and suppliers daily. Therefore, EDI systems have a keyhole in companies' desired competitive role (Yunitarini & Santoso, 2018).

Adopting such technology can deliver a series of benefits - eliminating paperwork, speeding up communications, and reducing costs while increasing productivity (Tuunainen, 1998). To manage the implementation and integration of over 150 suppliers in the EDI environment, a strategic plan is required to support the complex task that an automotive OEM face in building a new vehicle, involving multiple stakeholders and a team working from multiple zones.

In a broader perspective, this work intends to identify and characterise adequate business processes for the EDI integration of suppliers. A comparison between the processes required for the different stages of vehicle production, aiming to achieve vast comprehension of how the work must be structured to respond to the different requirements of each production phase.

1.2. Problem Description

In today's crowded marketplace, companies made major modifications in how they cooperate. Such modifications are associated with the use of unified logistics management methods. In order to gain a competitive space over competitors, companies have to plan their supply network operations, adopting information technologies to support this shift (Sumah et al., 2020).

The use of information technology offers a diverse set of possibilities for the successful coordination of business processes. These possibilities can assume multiple forms, Just-in-time management, corporate alliances, and many others. On the other hand, technical structures use markets and electronic constraints, using distinct responses like Electronic Data Interchange and networks (Tuunainen, 1998).

The benefits of EDI are directly related to the number of businesses using it, “suppliers claimed to have realized operational or first order benefits from the use of EDI, in addition to the major benefit of staying in business with the car manufacturers” (Reekers & Smithson, 1996). Organizations placed in high uncertainty markets can become vulnerable to other organizations that cope with the rising challenges. Thus, EDI systems can transform the power balance of these business relationships (Reekers & Smithson, 1996).

Therefore, optimizing the onboarding process of suppliers became a priority and a necessity if the company wanted to take advantage of the set of benefits that EDI brings.

In this way, after the problem description, it is possible to summarize it in the following points

- The role of EDI in the Automotive industry.
- How the company can benefit from a standard working method for the series production phase.

1.3. Research Questions

After a better understanding of the research project, as well as its main problems and objectives, it was possible to define some research questions. These questions will be a pillar for this project and will steer the way to a conclusion and development of a better solution on the subject.

- How can EDI implementation help optimize the processes related to the buyer-supplier relationship in the Automotive industry context?
- How can the creation or selection of a structured and standard way of working can benefit the management of the EDI onboarding process?

1.4. Report Outline

This report is divided into seven major phases: introduction, literature review, methodology, Case study (AS IS), Project model (TO BE), Results and Conclusion.

In the first phase, it is possible to find a brief introduction about the context of the project, the main problems and objectives that will be addressed throughout the report, as well as the research questions that serve as a guide to solving the issues of the entire project to be developed.

Following this, a literature review is presented with the key concepts for understanding the theme and its context, focusing on concepts such as Electronic Data Interchange, Buyer-supplier relationship, and Business processes.

This research methodology used to obtain the necessary information for the development of the whole project is explained. In this section, the methods and techniques to be used are presented to better understand the problem described and gather information for developing a new service solution.

The case study chapter presents a detailed description of the AS-IS landscape, starting with a brief description of the company and the product. After that, the major bottlenecks in the day-to-day steps are explained in a problem identification section.

The Project model, or TO BE, is where the methodology is explored to provide a framework for developing the solution presented. In this section, the remaining parts of the Design Science Research for Information Systems are applied, creating links and relations between each phase of the methodology and of the project itself, and displaying the solution created, a new process description for the onboarding of suppliers through EDI messages.

In the results chapter, official data are shown to prove, once more, the efficiency of the new process developed and to compare the changes done and how much effect they have on the corrections of the bottlenecks.

In conclusion, a summary of the project and a reflection of what can be done next to continue the work.

2. Literature Review

2.1. Electronic Data Interchange

Electronic Data Interchange (EDI) is an application of information technology that allows business partners to send and receive commercial documents (e.g., invoices, bills) electronically from computer to computer instead of writing and mailing them (Hansen & Hill, 1989). EDI was invented in the 1960s as a way of communication between the United States army. However, it was only in the early 1990s that the technology began to be used for supply chain integration.

The Onboarding of a supplier consists of integrating and connecting the supplier's system with our own; we do so by translating information from both sides into a common language, EDIFACT, that is then transmitted and interpreted by the supplier's system. Once there is a channel for the message, tests with the supplier begin.

The implementation and use of EDI on business transactions have had an influential role in companies' practices, particularly in the vital and required relationship between buyer and supplier. EDI has radically changed the way information is circulated between inter-organizational partners, bringing a set of benefits for the organizations that opt to embrace it (Premkumar et al., 1994).



Figure 1- EDI process — no paper, no people involved

With the continuous evolution of manufacturing techniques, other business sectors also had to change and follow up on the improvements and new manufacturing methods. One of those areas was the dependency on computers and information technology to control assembly productions. As a direct measure, links between suppliers and manufacturers become even more necessary due to the ability and capacity of EDI to transmit an error-free and fast message. In the automotive business, with its short call-off notices and urgency on the assembly, EDI was a necessary and useful system to keep up purchasing lead times (Reekers & Smithson, 1996).

Firms integrated EDI aiming to strengthen their logistics processes and capabilities, such as order fulfilment, stock and inventory control, increased order accuracy and shorter lead times (Sumah et al., 2020). Among logistics advantages, EDI also provides many other important advantages for companies, such as reduced costs, faster turnaround, and better customer relations (Premkumar et al., 1994).

EDI's time to transact business information is relatively low compared to normal methods. That characteristic gives EDI the ability to increase trading efficiency, enabling a faster output of goods, and making it easier to meet the customer's expectations (Sumah et al., 2020). According

to Bergeron and Raymond (1992), "EDI allows the organizations to improve the quality of service to its customers. It decreases the transmission time of transactions and the number of errors" this is not only a competitive advantage among rivals but also a sign of professionalism for suppliers and customers. Creating this link among the supply chain represents a strong barrier to new entrants and creates new difficulty levels for rivals to offer the same service level (Bergeron & Raymond, 1992).

EDI potentially facilitates profound changes in organizational behavior, use of technology and inter-organizational relationships. It allows partners to create a new way of communicating and integrating between companies. Such integration makes it possible to change their processes when procuring suppliers, logistic procedures, and financial transactions (Webster, 1995). The impact created by EDI implementation can be found at multiple levels of a business. However, some of them may be more difficult to be seen as those benefits were not clearly anticipated as the known ones brought by EDI (Narayanan et al., 2009).

2.2. Buyer-Supplier Relationship

Interorganizational relationship has been a research theme for a long time for a different number of business segments. In many of these studies, a great number of conclusions say that, in a buyer-supplier relationship, if a strong connection is established between them, it should lead to better performance for both organizations involved (Autry & Golicic, 2010).

Companies tend to create such relationships with the assumption or the hope that this link will create some competitive advantage and improve operational performance and the outcomes for all parties involved (Day, 2000).

The way in which supply chains are built requires an effort to optimize every part of it instead of focusing on one or other aspects. Therefore, an ecosystem is created between the multiple firms and relationships existing in a value chain. This set of connections plays an important role in the ability and capability to manage such business relationships, which is a critical success factor of supply chain management. A strong relationship is a valuable asset in any industry. The possession of this asset can lead to higher performance, and as a way of comparison, it is not easily replicated by competitors. A solid relationship should exist with the combination of both economic value and social value; the social value acts like a "glue" to maintain the relationship; a company wants to keep this relationship because it believes that it will be reciprocated favourably in the same way in the future (Autry & Golicic, 2010).

Coordinating the multiple tasks on logistics and production between the members of the supply chain can be a difficult assignment. Fortunately, this coordination can be facilitated by using information technologies and their tools, especially when these technologies are used to increase the normal boundaries of the supply chain. The relationship between buyer and supplier can be well developed when combined with the supply chain management context, which emphasizes the flow of information and material, creating a certain synergy between the customer's requirements, from raw material to the end consumer. In fact, information sharing between buyer and supplier is a major indicator of the beneficial use of supply chain management. When information flows seamlessly between both ends, it becomes a powerful tool for increasing performance as you unite the different small supply chains into one long chain (Yunitarini & Santoso, 2018).

Supply chain management is known to integrate crucial business processes from the customer through the original suppliers to deliver goods, services, and information that add value for

clients and other stakeholders. The essential supply chain business operations penetrate functional silos within the organization, and the numerous corporate silos throughout the supply chain, as well as the information and product, flows. As a result, corporate operations are integrated into supply chains that span intra- and intercompany boundaries. A shift from managing various functions to integrating activities into crucial supply chain processes is necessary for successful SCM. Historically, the supply chain's upstream and downstream segments have interacted as disjointed entities, exchanging occasional flows of information across time (Lambert & Cooper, 2000).

In today's competitive environment, businesses must expand their integrated behaviour, incorporating clients and suppliers to be almost a part of their own business. Implementing Supply Chain Management, in this case, is like living by a philosophy, following the activities, and coordinating efforts. For such structure work, mutual information shared commitment is required, especially for planning and looking over processes; for example, a buyer can even share information like inventory level, forecasts, sales strategies and marketing to their suppliers; this attitude can result in a great performance increase. With cooperation and information, sharing also comes the mutually risks and rewards; enduring the risks is necessary for the long duration of such partnerships, as the rewards will also be for both sides (Mentzer et al., 2001).

2.3. Business Processes Modelling

Andersen (2007) says that process modelling is a graphic representation of business processes or workflow. He adds that it is also useful to translate what all interested stakeholders comprehended from the system and is also a tool to clarify certain assumptions and scenarios and define system objectives.

BPM is a priority in today's companies, understanding and perceiving a company's process is a powerful way to explore the strengths and weaknesses that are present in multiple areas and is also a way to document the processes of the organization. The high interest in modelling for business processes has started a "movement" of creating a different range of modelling techniques. Consequently, the more competitive the market, the higher the effort and attention companies will give to this subject, every time looking for that small but important advantage over competitors. Process modelling is used in organizations to increase awareness and knowledge of the processes happening daily, reducing organizational complexity (Recker et al., 2009).

Doing such modelling on a large, company-wide scale can bring a whole new set of challenges and efforts. First, it will require an investment in tools, methodologies, and personnel training so the benefits can appear over time. Without it, you may end up frustrated as the people involved in the modelling process will not be able to perceive the real reasons and utility for the modelling (Indulska et al., 2009)

There are two main categories related to process modelling techniques. The first one is Intuitive graphic modelling; this category is directed to capture and perceive the process for project definition and for developing business requirements and process improvements when discussing with key stakeholders. The other category, based on mathematical and rigorous paradigms, intends to support the process analysis or execution, making it easier to simulate or experiment with the multiple process scenarios developed. Selecting which technique or notation is an important task in the modelling development process. Different techniques have different characteristics and capabilities to handle real-world problems. Each technique will do

a better job if used in the right domain, emphasizing the aspects of each process (Recker et al., 2009).

Without further examination and analysis of the business process model, business process modelling does not significantly increase value. Similarly, process analysis is ineffective unless it contributes to the optimization or improvement of a business process. Process improvement can be achieved through related formal methodologies that assist both the modelling and analysis of business processes (Vergidis et al., 2008).

There are several techniques for business process modelling. The first one was plain graphical representations (e.g., flowcharts) used to develop software specifications. They were simple and used to depict a business process, but most of the time did not use a standard notation. Through related formal methodologies that assist both the modelling and analysis of business processes, process improvement can be achieved and therefore lead to the development of standard methodologies such as Unified Modelling Language (UML) for process modelling and/or software development (Vergidis et al., 2008)

The most common language today is BPMN, also used in this work. Business analysts and developers can create business process diagrams using BPMN, a graphical flowchart-like language. On BPMN, events, gateways, atomic activities (or tasks), compound activities (or subprocesses), sequence flow, and text annotations are just a few of the symbols that are employed in this design. The beginning and end of the process, as well as the intermediate timeout state (Stuck), are marked by events, which are represented by little circles. The procedure is conditional split and joins phase is shown by gateways (diamonds). Actual work is represented by activities (boxes). Tasks are discrete operations, whereas subprocesses carry out the logic that can be arbitrarily complicated (Havey, 2005).

3. Methodology

The methodology to be used in the development of this project will be the *Design Science Research*, more specifically the framework developed by Peffers et al. (2006), which follows the *Design Science* paradigm. The author designed and demonstrated a process to follow the Design Science research applied in information systems.

At first, it will be detailed the conceptual grounds of DSR, followed by a clear explanation of every phase regarding the method proposed by (Peffers et al.). Towards the end, it will be provided with the connection between the method itself and the research to be developed.

This research used DSR to create a new instantiation of a process description since there is the need to develop a new sequence and apply it in the real world, creating an effective artefactual solution, following the stages of DSR applied in information systems Peffers et al. (2006):

- 1) Problem identification and motivation.
- 2) Objectives of a solution.
- 3) Design and development.
- 4) Demonstration.
- 5) Evaluation.
- 6) Communication.

3.1. Qualitative x Quantitative

It is also important to enhance that there are two approaches typically used as a research strategy: quantitative research and qualitative research. However, many authors consider it relevant to distinguish between these two approaches. Thus, the quantitative approach can be defined as a research strategy that relies on quantification in data collection and analysis, implies a deductive approach to the relationship between theory and research, and embodies a perspective of social reality as an emerging property in constant change (Bryman, 2016).

A qualitative approach follows a different set of steps than those used in qualitative studies, and these steps vary according to the qualitative research methods used (Bernard & Bernard, 2013). Thus, qualitative research involves an interpretive, naturalistic approach to the environment, allowing for interpret the meaning that individuals attach to a social or human problem (Denzin & Lincoln, 2011).

Therefore, it is necessary to collect data in a natural environment and be sensitive to the people involved in the study. Qualitative methods make it easier to study issues in greater detail and depth by talking to participants about their experiences and perceptions (Patton, 2002). In analysing quantitative and qualitative data, it is possible to use multiple research techniques, such as surveys, interviews, and ethnography, to collect and analyse empirical data (Lawrence Neuman, 2014). We conduct qualitative research when we want to empower individuals to share their stories, hear their voices, and minimise the power relationships that often exist between a researcher and the participants in a study (Creswell & Poth, 2016). In this sense, the qualitative approach was more appropriate in the project context.

3.2. Design Science Research

This chapter describes the methodology followed in the project, which involved a Design Science Research (DSR) approach incorporating a qualitative study. DSR is a methodological approach focused on designing artefacts that serve human purposes (Dresch et al., 2014). It is a form of scientific knowledge production that entails developing innovative constructs aimed at solving problems faced in the real world. For that reason, DSR has been pointed out as a suitable research approach when researchers need to work closely with organisations to test new ideas in a real-world context (Dresch et al., 2014).

The artefacts are constructs, models, methods, and instantiations (i.e., applications of artefacts) that are innovative and valuable in such a way that they offer a research contribution (Teixeira et al., 2019). Purposeful artefacts are built to address previously unsolved problems and evaluated concerning the utility provided in solving those problems. Models use constructs to represent a real-world situation, the design problem, and solution space (Simon, 1996). Models aid problem and solution understanding and frequently represent the link between problem and solution components, making the exploration of the effects of design decisions and changes in the real world. Methods define processes and guide how to solve problems, that is, how to search the solution space. Instantiations show that constructs, models, or methods can be implemented in a working system (Hevner et al., 2004). They demonstrate feasibility, enabling concrete assessment of an artefact's suitability to its intended purpose. Also, it gives out researchers the possibility to learn about the real world, how the artefact affects it, and how users appropriate it (Hevner et al., 2004).

Adding to that, it is necessary to highlight the importance of co-creation and co-design in qualitative approaches, as it reinforces domains of collective creativity, which in this project was fundamental to obtain relevant results. Thus, it is possible to distinguish two approaches for interacting with users and customers during the co-creation process. In interviews, people talk, and the researcher interprets what they express. In creative workshops, people can jointly explore and articulate their latent needs and explore and "make" solutions. The main benefit of such "making" or co-designing approaches is that they help organise joint creativity (Sanders, 2002); this is highly relevant for this specific study since a workshop was conducted to interact with users and the team behind the project.

3.3. Application of the DSR

The method proposed by Peffers et al. was developed through a scientific revision of authors that had also prescribed solutions and developed artefacts for an existing problem.

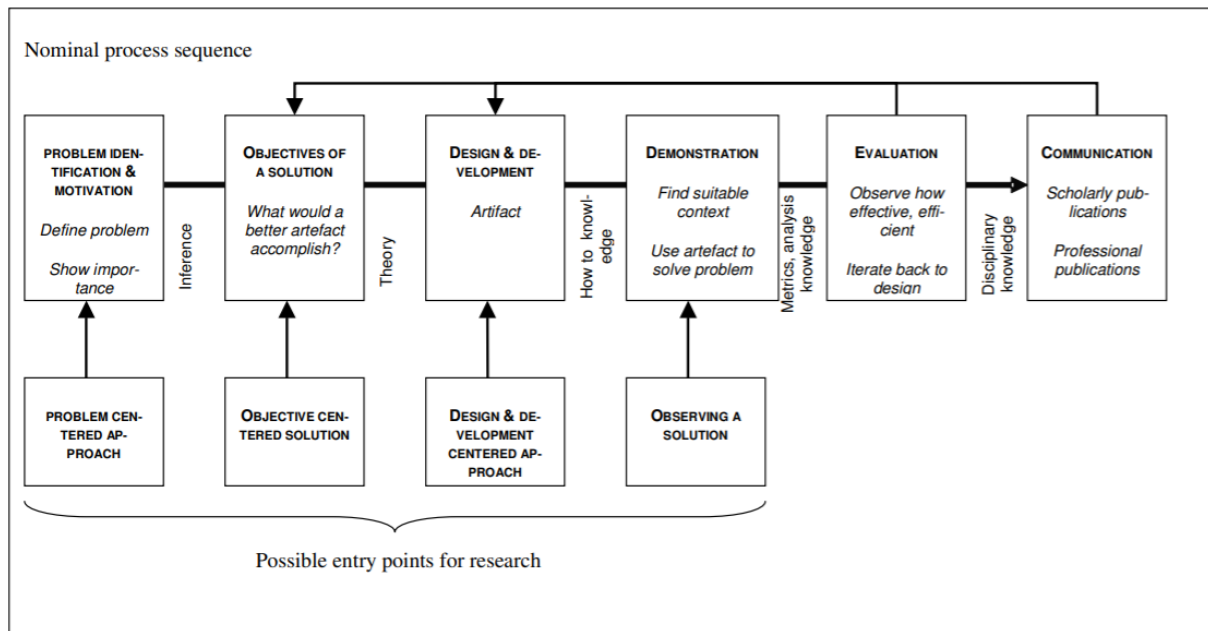


Figure 2- Design science research process (DSRP) model proposed by Peffers et al.

At first sight, the first activity regarding this method is **Problem Identification and motivation**. In this phase, the researcher must justify the importance of the research itself, considering its relevance to the field of study, the seriousness of the problem and the applicability of the proposed solution.

The second level is related to the **Objectives of a solution** for the problem, and the authors suggest that the established objectives can be as qualitative as quantitative. The third stage, the **Design and development**, refers to the moment where the artefact that is being developed to solve the problem is created. The artefact's functionalities, architecture and development should be defined in this phase. Besides, the authors Peffers et al. (2006) say that the researcher must use theoretical knowledge to propose artefacts that will support the resolution of the problem.

The fourth step is related to the **Demonstration**, which is when the artefact is used in a simulation or experiment directly intended to solve an issue. The Fifth Stage is the **Evaluation** of the artefact, and the researcher must compare the performance results with the requirements for the problem to be solved (second step of the DSR process); in this stage, you observe how efficient the artefact is. If the results are not satisfying, the researcher can go back to the Design and Development phase and build a new artefact.

Lastly, we have the **Communication** phase, which is related to the moment the researcher presents the problem and its relevance. In this phase, the rigour followed in the research must be presented as well as the efficiency of the solution. Although this method has a sequential structure, there is no obligation to start at the beginning or the end of the last phase. The authors also add that the presented method can be adjusted consonant to the type of problem and research objective.

3.4. Methodology used in the project

This investigation will use a qualitative approach, so all the procedures and techniques used in each step of the method followed will be described in this section.

To decision to follow a qualitative approach was due to this work being based on a case study logic; therefore, the methods of research, data collection and analyses are better suited. The qualitative approach allows a deeper understanding of the problem, as it better supports communicating with stakeholders and understanding their perceptions and thoughts on the subject.

A case study is a research methodology that produces a thorough, multifaceted understanding of a complex problem in its actual setting. The case study method is particularly helpful when trying to understand a topic, event, or phenomena in-depth and in the context of real-world experience; it can also provide more information about any delivery gaps or the rationale behind the selection of one implementation strategy over another (Crowe et al., 2011).

In the Problem Identification phase, a literature review will be carried out to understand how different authors approach the subject and how they solve problems in the context of this research project. In addition, all the information collected and knowledge acquired will serve as a basis for creating important structural limits to start the next step.

The initially established objectives respond to the Definition of Expected Results once they are good goals to be achieved through the application of this methodology. Considering the Design and Development stage, several data collection techniques will be applied, namely, an ethnographic study through observation whose main purpose will be to analyze the structuring of activities. In addition, informal conversations will be held with key players in these activities because they have a deeper knowledge of the organizational processes under study. The sample will be part of the INEOS EDI team. They are key stakeholders in the processes regarding EDI. The objective is to improve the definition of activities, routines, procedures, and tools. Finally, the processes will be mapped following a business process modelling approach based on BPMN that allows a complex system to be depicted and displayed; it also allows the collection of all relevant information, maintaining a simple model that can be easily perceived.

Given the development of artefacts, the advancement to the Demonstration phase in the simulation mode of how activities take place following the suggested models. Later, an evaluation will be carried out to ascertain the results.

4. Case study – INEOS Automotive

INEOS Automotive was founded in 2018 with the goal of developing and manufacturing a utilitarian 4x4 vehicle, the INEOS Grenadier. The Grenadier is, so far, the only model being produced by the company, with plans to develop new models in the near future. The Grenadier 4x4 was launched in mid-2021 and is now reaching its final testing phase to start production in the coming months after several rounds of development and thorough testing. To build such a vehicle, INEOS has over 200 hundred different suppliers, 1500 employees and seven different offices spread across the globe.

4.1. Current project model – AS IS

To connect with its 180 plus suppliers, INEOS uses Electronic Data Interchange, one of the world's standards for the automotive industry and many business segments. EDI consists of interchanging messages between businesses (buyer and supplier). Such messages are generated automatically through a system and contain almost every information needed to complete a business transaction.

The EDI project at INEOS started in 2019, while the car was also being developed and maturing within the company. Currently, the project is reaching a critical phase, as there are still suppliers to be onboarded, and the company is close to the start of production (SOP). Although the EDI integration is a key achievement for the company's workflow, the business areas that benefit from it are finding ways to get the job done efficiently.

In the INEOS case, suppliers can be divided into two categories: companies that invest in an EDI provider and an intermediate company that can receive and process these messages into the customer's system. These suppliers are called "classic EDI suppliers". As not all suppliers are big companies, sometimes, it does not justify a small/medium company making such investments as the return may not be worth it. INEOS provides a webpage capable of simulating a systemized EDI work frame for these cases. Those are "web EDI suppliers". Classic EDI provides a huge advantage in automation and efficiency, while the web EDI works as a solution for companies that do not judge necessary upgrades to their systems.

The table below describes the number of suppliers by type of EDI connection, with classic EDI being the majority:

EDI Type	N° of suppliers	%
Classic EDI	118	65,2
Web EDI	63	34,8

Table 1 - Distribution of suppliers by EDI type

So far, INEOS is working with two different message types, DELFOR and DESADV. INEOS sends the DELFOR message to the suppliers. This message is similar to an "order", where information like quantity, delivery dates, product information and more are transmitted. Then, this message is integrated at the supplier side, and the order is fulfilled in time for the parts to reach the Grenadier factory site.

When it is time to ship the goods, INEOS asks the supplier to send the DESADV message, also known as ASN (advanced shipment notice). In this message, the supplier sends information

regarding the delivery of the goods detailed in the DELFOR message, such as shipped quantity, date of production, expiration date, estimated delivery time, type of packaging and bar code to be scanned when the goods are entering the warehouse.

Both messages require detailed testing; a minor mistake can impact the line of production, causing delays and monetary losses to the company. Therefore, each supplier must go through a defined and rigorous set of processes to complete both message testing phases and be ready to receive and send EDI messages.

Before the beginning of the message tests, the EDI project leader at INEOS receives the information regarding the supplier, for example, supplier ID, company name, plant location, part numbers to be tested and more. This information is used to register the supplier into INEOS systems and organise which tests will be carried out during the scheduled time. After the information is stored, the responsibility to carry out the tests is passed to an EDI onboarder.

EDI onboarders are in charge of starting, managing and finishing the whole EDI test with a supplier. Currently, the EDI onboarding team is composed of eight employees, and the team is based in 3 different countries, France, Portugal and Romania. The EDI project leader is responsible for distributing suppliers among onboarders and setting the deadline for the completion of each phase of the tests. At this moment, each EDI onboarder carries out 8 to 15 supplier testing simultaneously. At the beginning of the project, this number could get up to 20 to 30 suppliers.

Such a team structure has advantages and disadvantages. On the upside, it creates a diverse team capable of speaking five languages, which can help ease the discussion and integration of over 180 suppliers from the most varied countries. Another positive aspect is the different time zones, giving the team greater flexibility when dealing with urgent problems. On the negative side, it creates an extra difficulty in the information flow between the team. Therefore, the team has always relied on e-mails or calls to share information, which always takes more time and increases the chance of miscommunications.

After all information about the supplier has been registered and has already been assigned an EDI onboarder, tests are ready to begin. The EDI onboarder then creates the scheduling agreement, like a contract with the supplier to supply the determining part for a determined time. After creating this agreement, the onboarder creates dummy dates and quantities and sends the first DELFOR message to the supplier. To complete the DELFOR test, the supplier has to integrate the DELFOR message into their system and send a series of screenshots where the onboarder will match the information on the message and how it was integrated into the supplier's system. If all items in the test checklist are complete, the supplier receives the confirmation of completion for this phase. With this validation, INEOS can send DELFOR messages via EDI in the production environment while the DESADV tests begin.

The process described below is a simplified representation of the AS-IS on the delfor test phase. The full process has sixty unique steps. To provide a simpler demonstration, the complete process was reduced to its most crucial parts, being the red arrows the bottlenecks identified and detailed further in the text.

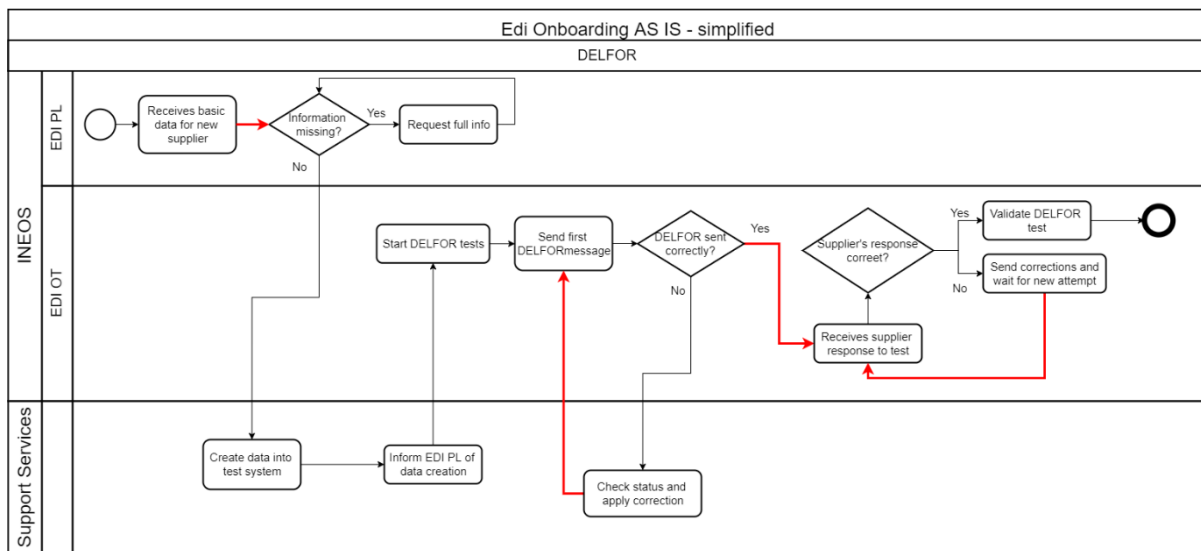


Figure 3- DELFOR AS IS (simplified flow chart of the testing phase process)

DESADV messages are a way more complicated and expensive test. As it involves actual (not in the test phase) parts and deliveries, it deeply impacts the company's production. Parts can be delivered in many containers, each with a different characteristic, width and height, capacity and ownership. In the first part of this test, the supplier sends a DESADV message as a "reply" to the last DELFOR sent by the onboarder. When the message is received, the onboarder must check for any errors or missing fields and then provide feedback to the supplier. This step will go back and forth until the supplier's system has the perfect template for the message, this happens because suppliers can have business with multiple customers, and each one of them can have their list of mandatory fields or data to be passed on; this is called the *mapping* of the message.

When the mapping for the message is correct, the EDI onboarder integrates it into the INEOS system and checks if the system reads it correctly, creates the receipt for the delivery and if the stock for that part has been updated correctly. If the integration is correct, the first part of the DESADV tests are complete, and we move on to test the same thing but with multiple materials to be delivered and other possible scenarios.

The process map displayed below is regarding the AS IS for the DESADV message test. As done for the DELFOR, this is also a very simplified version of the complex process that the whole DESADV test represents. The complete process has ninety-three unique steps, as it covers both phases of the DESADV test, where one and multiple materials are tested to ensure the supplier's and INEOS systems can integrate it correctly.

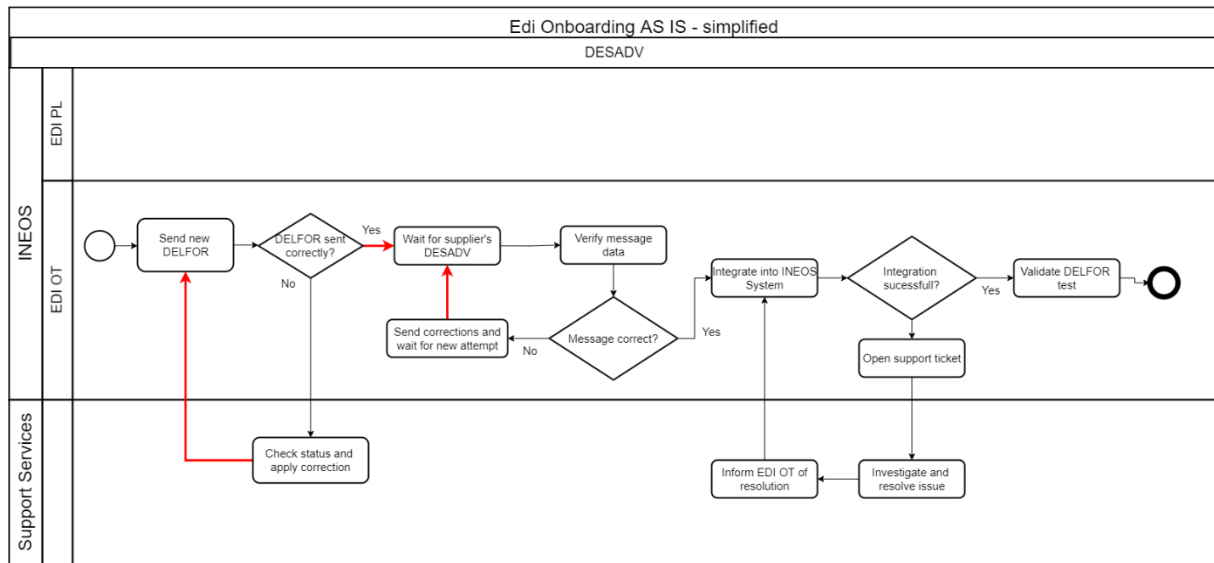


Figure 4- DESADV AS IS (simplified flow chart of the testing process)

On the second and last part of DESADV tests, the EDI onboarder sends a new DELFOR containing two different parts. This creates extra complexity for the system and the necessity of an updated version of the mapping done for the first part.

To make sure everything will work as it should on a productive system, the EDI onboarders test five different scenarios: Multiple parts (Non Hierarchical): One shipment containing more than one part in different containers that are not pallets.

- Multiple parts (Hierarchical): One shipment containing more than one part in different containers (pallets).
- Mixed pallets: Consists of shipping pallets or a single pallet with more than one different part inside it.
- Partial quantity: Shipping of a container that is not full.
- Excess quantity: Shipping more parts than asked for.

These tests ensure that the supplier will be ready for the most common situations when sending real parts to INEOS.

The AS-IS scenario at INEOS regarding the onboarding of suppliers, until recently, was a very obstructed process flow due to frequent and common transfer of responsibility. The subcontracted IT companies were playing a bigger role than it was supposed to, dragging deadlines and increasing the number of people involved in each step. Onboarders were having difficulty in the decision-making process, waiting for confirmation up the chain of command. All these problems confirmed that the mapped processes were not clear and precise, creating an extra difficulty for the EDI team and the whole company that relies on this technology.

4.2. Current bottlenecks

The constant change, the singularity of each supplier and the complexity of the processes implemented at the onboarding can create bottlenecks and difficulty in completing the whole process. Such bottlenecks will lead to failed deadlines, miscommunication, and potential negative impacts on the vehicle's production.

After the definition of the AS-IS flow chart for the test process, the main bottlenecks of the process were identified. The bottlenecks discovered were the following:

- Supplier Data not ready
- Unresponsive supplier
- EDI Onboarder overload
- Supplier not fully dedicated to onboarding process
- Ticket (helpdesk) resolution time (internally and externally)

4.2.1. Supplier data not ready

To create a network of integrated systems, INEOS works closely with other service providers to ensure the information flow works correctly. Intermediate service providers support the sending and receiving of EDI messages; the EDI project lead and onboarders work close to those providers almost daily.

One of the first responsibilities of the EDI project lead, when he receives the supplier data from other sectors inside INEOS, is to pass that data to one of the providers so they can integrate it into our systems. In that step, two problems may occur: missing information from the supplier or delayed data integration for various reasons.

The delays caused by that can interfere with the start of the tests and consequently with the testing deadline fulfilment.

4.2.2. Unresponsive supplier

Nowadays, with the internet era, our communication goes mainly by email, and this is even more intense in the business world.

Suppliers can be unresponsive for multiple reasons. The most common ones are priority management, the wrong contact being addressed, and vacations. When a supplier is unresponsive for multiple days, management escalation begins to get a response from the supplier and to get the tests back on track and into an ongoing status.

As important milestones for the company are coming, every day is valuable in attempting to onboard a new supplier and to have one more on the “live” list.

4.2.3. EDI onboarder overload

EDI onboarders can deal with multiple suppliers simultaneously. Carrying over a full onboarding process takes a minimum of one month and can go up to three-plus months, depending on the supplier's responsiveness.

The team is composed of eight employees, but at the start, when there were fewer, each onboarder was onboarding more than 20 suppliers, which led to bigger response times from the INEOS side and increased pressure for test completion.

4.2.4. Supplier not fully dedicated to onboarding process

In the same sense that INEOS has hundreds of suppliers, those suppliers also have dozens or more customers, and each of those customers can have its own demands and workload to those same suppliers. Therefore, sometimes suppliers are not fully dedicated to the testing phase, which means they are not replying as required or are not fully invested in the testing process, leading up to higher onboarding times.

This issue will improve the chance of the other ones also happening, namely the EDI onboarding overload, as new suppliers keep rising and the team cannot finish old ones in time.

5. Design – TO BE

Applying the DSR methodology to the project's scope, the first step was to define the **Objective of the solution** to be developed. The main Objective was to improve the productivity of the EDI onboarding team, which in practical terms means to conclude more tests in less time, as pressure was always increasing due to the proximity of the product launch.

Peffer et al. (2006) stated, "The objectives can be quantitative, e.g., terms in which a desirable solution would be better than current ones, or qualitative, e.g., where a new artefact is expected to support solutions to problems not hitherto addressed."

The defined Objective was to increase efficiency regarding the EDI onboarding tests. Usually, the full test process can take at least one month. The desired goal was to reduce this time and the bottleneck's effects on the test process. To reach that goal, the whole test process was revised with valuable inputs from the onboarding team. That new process would support the company to give a better response and gain better control of supplier's responsiveness, acting directly on the problem and avoiding hiccups on the full process landscape.

5.1. Workshop

Besides several processes revisions sessions, a workshop was held following the study about the current state of the onboarding process, obtained from the existing documentation and the team's experience. The participants were composed of five internal collaborators, divided between people who already had previous knowledge about the whole process and people who were new to the context, aiming to have two different perspectives for the generation of the new process. The major goal of the workshop was to brainstorm solutions, comments, and suggestions about the bottlenecks and their impact on the current scope.

In the first moment, all the participants were brought together in order to explain the context of the project, as well as to provide a background of AS IS. Firstly, was carried out a brainstorming session, and then discussed the ideas among the group. Finally, the participants voted on what bottleneck they thought was the most relevant to work with. To vote, each participant had ten "balls" (same color) to distribute the way they find fair, the possibility to have ten votes creates a weighted opinion, which makes more sense on this scenario. This workshop allowed for the alignment of ideas, the pooling of thoughts, and the results to work on improvement for the new

design. The brainstorming session made clear that the bottlenecks were deeply affecting the onboarders ability to conclude the tests with their suppliers.

On your opinion, what could be done to reduce these bottlenecks?

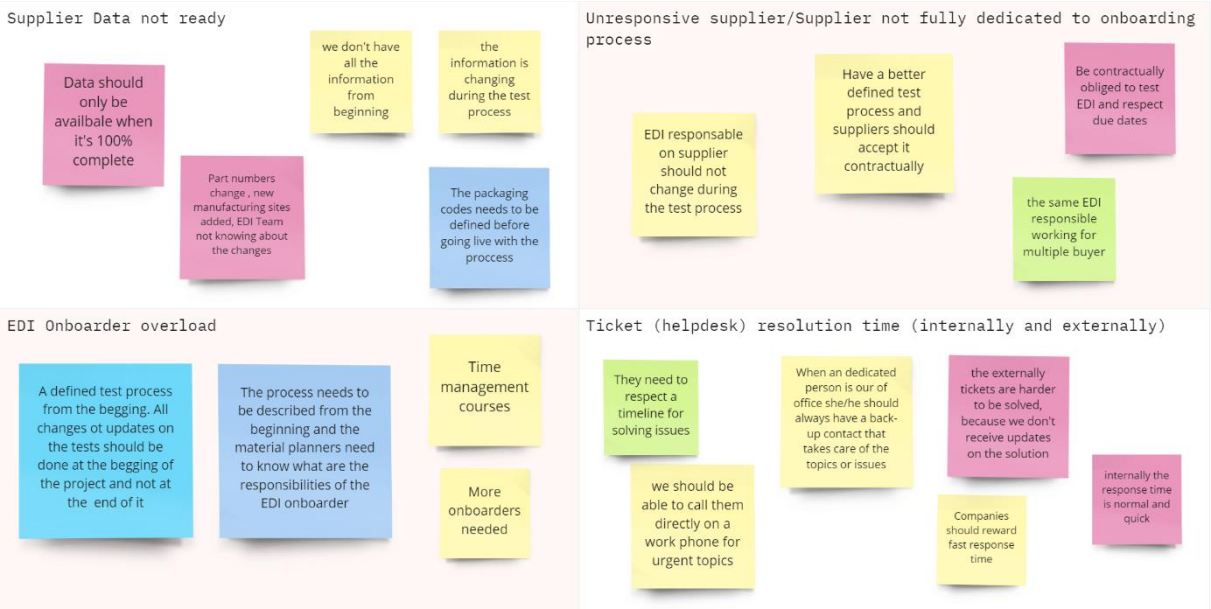


Figure 6- Workshop insight (1)

Which of those bottlenecks have more impact on the Onboarding or supplier?

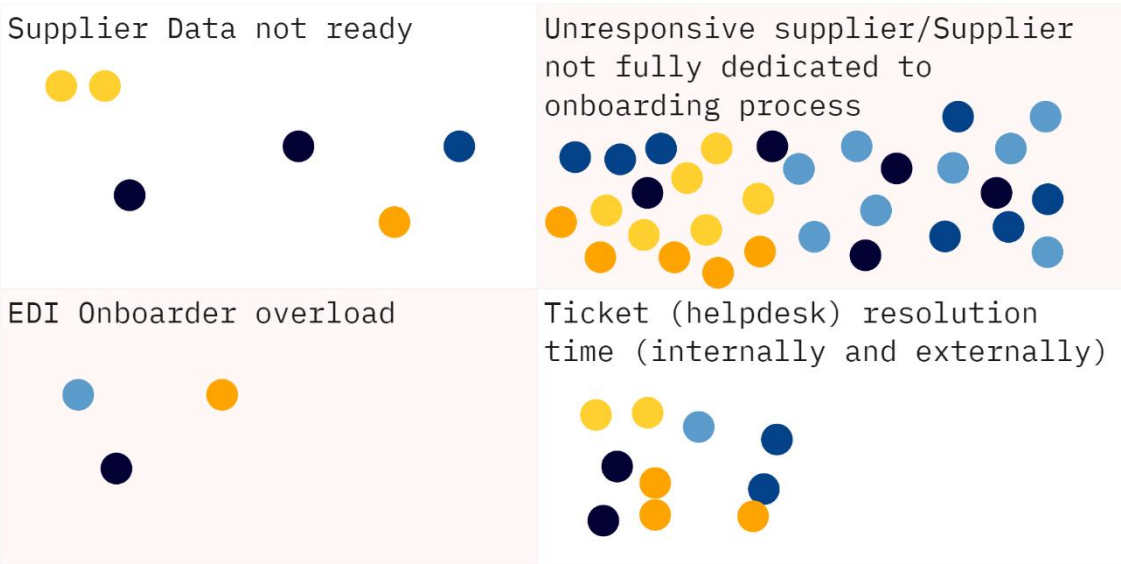


Figure 5- Workshop insight (2)

The first topic discussed was the “Supplier not ready” bottleneck. Between the four bottlenecks discussed, this one took third on the list. This means that it is not the most critical but can still be a blocking point now and then. Many opinions and suggestions were made to counter this issue; the two most relevant were:

“Change of part numbers, new manufacturing sites added, this makes EDI Team not knowing about the most recent updated, leaving us dependant and on hold for an information that should already be defined and available”

“Onboarding (material onboarders) team should only send the data when it's 100% complete and start EDI only after”

The second bottleneck, “Unresponsive supplier/Supplier not fully dedicated to onboarding process”, was identified as the one with the highest impact on the test process. Not surprisingly, on the voting part, this issue received the most votes with a big difference from the next. This problem is the worst that the onboarder can have due to a lack of control over the direction of the testing. Suppliers can simply not reply, leave e-mails without replies or do not pick up any calls. When such a problem occurs, that is not much the onboarder can do other than keep trying for a couple of days, try to set up meetings, and if none of this works, it will be needed to escalate to issue to other areas at the company. The team brainstormed on this bottleneck, and the following insights were taken out of it:

“EDI onboarding person on supplier side should be assigned and known from the begging and not changed until tests are finished.”

“Define the EDI process from the start of procurement onboarding. In the contract there should be a defined process for EDI and supplier needs to sign and agree to the process and time.”

“Suppliers should be contractually obliged to test EDI and respect due dates”

The third point was the “EDI onboarder overload”. This bottleneck can appear for multiple reasons: not enough onboarders allocated to the EDI testing process; lack of personal time management; and requests that are not properly a responsibility of the onboarder. This ends up creating a higher response time to the testing-related tasks. Besides that, what makes this bottleneck a special case is that it can appear as a result of another bottleneck when the supplier is unresponsive or not fully dedicated to the tasks. Tests get stuck, and it is easy to have an overload if multiple suppliers go back on track at once. This issue was less voted than the others, and one of the proposed solutions for this issue is exactly the artefact that was developed. The following insights were taken out:

“Have a better process description from the begging. All the big developments and EDI guidelines should be done at the begging of the project and not at the end of it.”

“The process needs to be described from the beginning and the other areas need to know what are the responsibilities of the EDI onboarder.”

The last topic discussed was the “Ticket (helpdesk) resolution time (internally and externally)”. This bottleneck was one of the most important to be addressed. The reason is that sometimes the resolution for a fix can take weeks, and often those fixes can easily overload the support team. Often the easier or smaller problems are left off the priority list, causing the more onboard

to be stuck on one supplier due to a fix that could take one hour or less to solve. This problem was the second most voted by the onboarding team; some of the suggestions were the following:

“External tickets should be linked with the solution behind. In that way we could fix it ourselves or even discover what leads to the issue to avoid it happening on the first place.”

“A deadline should be defined related to the difficulty level of the issue, this way it would make easier to track each topic by categories”

5.2. Design and development

EDI onboarding of suppliers at INEOS is constantly being developed and updated to fulfil the business necessities. Such evolution brings changes and new challenges to the team and puts our processes to the test. Although the processes and test steps are changing, a major and definitive change was needed due to the critical timing for the production ramp-up in the company. That was the starting point for the new process design described in the following paragraphs.

The design and development phase of the methodological approach is about creating the actual solution based on the determined objectives, defining the artefact's functions and how it will be built (Peppers et al., 2006). The artefact that was developed was a new process description for the onboarding of suppliers for the EDI technology. Such artefact was created to provide a better vision and clear set of steps for the ongoing tests and to guarantee a better and tested process for any new suppliers that may come when the vehicle is already in full production. As defined by Hevner et al. (2004), "IT artefacts intended to solve identified organizational problems. Such artefacts are represented in a structured form that may vary from software, formal logic, and rigorous mathematics to informal natural language descriptions." therefore, the artefact created is a formal logic of conducting certain tests in a defined and controlled set of steps.

The starting point for the design of the new process description was to use the current process knowledge and the everyday experience on the onboarding function to have a deep and complete understanding of the challenges and difficulties that existed and needed to be overcome.

After laying down and describing the objectives to be achieved, it was necessary to define how would be approached the development of the new testing process. The selected way was multiple sessions, where each process was revised and discussed. These sessions were held remotely with one team member from each location, ensuring different points of view regarding the same step. Those inputs helped evaluate how needed each of them was to successfully complete an onboarding from start to end and how INEOS could take back some of the control on every step of the full test process.

The redesigned process of the DELFOR and DESADV testing phase is represented in Figures 7 and 8.

Process Definition for EDI Onboarding of Suppliers Within the Automotive Industry

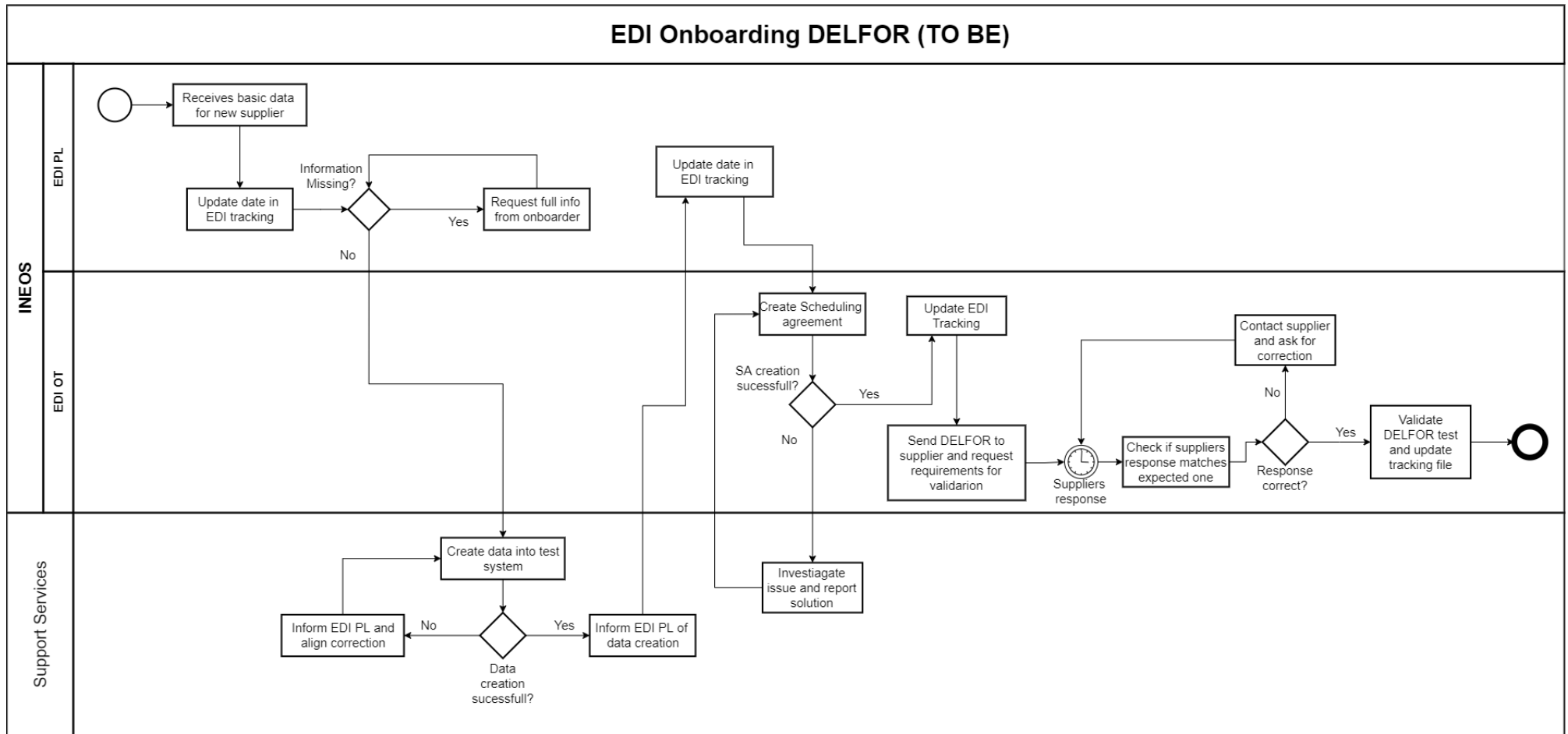


Figure 7- EDI Onboarding DELFOR (TO BE)

Process Definition for EDI Onboarding of Suppliers Within the Automotive Industry

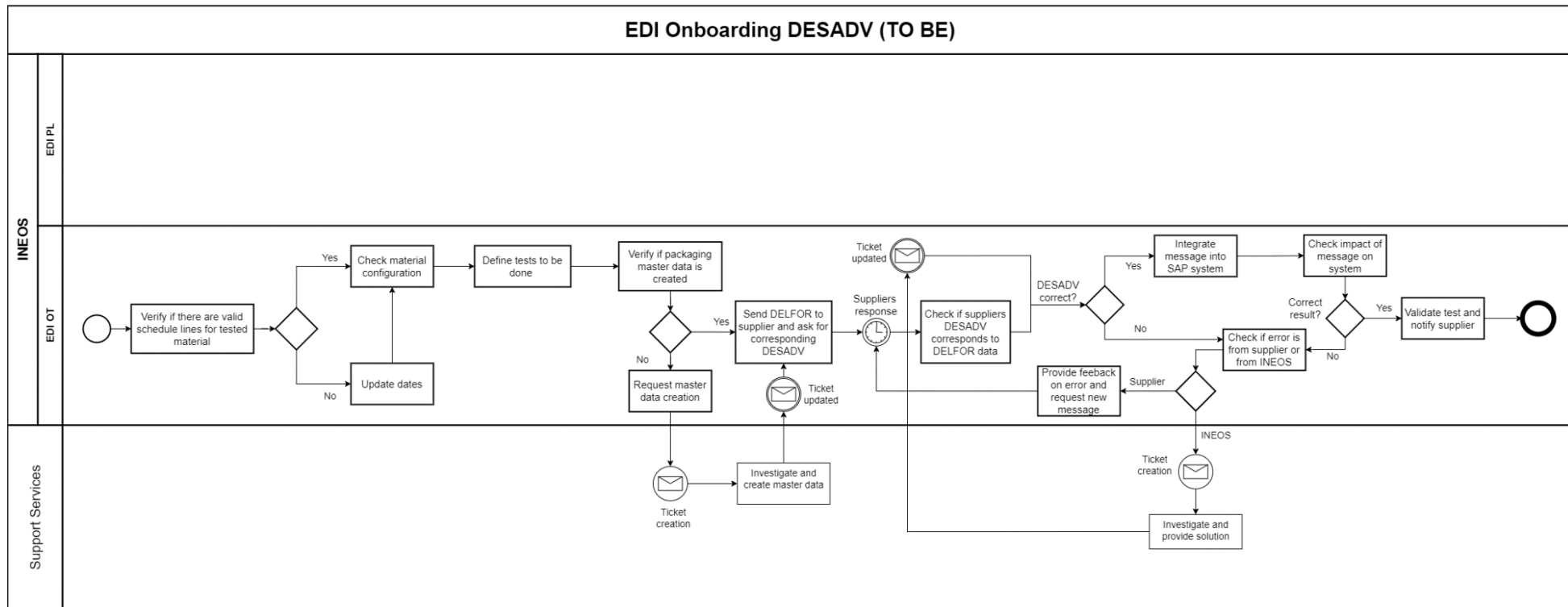


Figure 8 - EDI Onboarding DESADV (TO BE)

5.2.1. DELFOR Processes

Starting with the DELFOR message comparison, the first part related to the reception of the information regarding the supplier remained the same. This part is where the first bottleneck was discovered. Although in terms of the actual process, no change has been made, it was implemented internally with a higher sense of urgency and importance to this part, which led to a reduction in the overall time needed to unblock the suppliers stuck on this topic.

Following the data sharing process, the support service is responsible for creating the test data into the test system. Previously, that task was only from the support service responsibility. With the creation of new tracking files and an increased sense of responsibility from the EDI team, this task is now supervised to ensure that any errors are reported and documented, therefore reducing INEOS's lack of control of its own business.

When the actual tests begin, the EDI onboarder has almost the same step on the AS-IS as on the TO-BE processes, with an extra task on the TO BE that is to document the creation of the testing documents (Scheduling agreements). After that, the DELFOR message is supposed to be sent to the supplier. The major difference here is that in the AS-IS scenario, due to the lack of correct flow, errors would only be spotted when the DELFOR message is already supposed to be sent, which generated a higher volume of support tickets to find out where were the errors. Now, a check on the creation of such data allows problems to be spotted earlier and, therefore, easier to correct, as the onboarder has a better view of where is the problem.

Also, in this part of the process for the AS-IS, we have one of the identified bottlenecks. This one happens when for some reason, the DELFOR message is not sent. Most of the time, the EDI onboarder must open a support ticket to solve it. Those tickets can take a minimum of 2 to 3 days; on some periods of the year, they can go up to 8 to 10 days. As expected, this creates a major delay on the tests for a specific supplier, or if it is a system problem, it can affect all of them at once. To improve this bottleneck, the onboarders took on a more active role in the problem resolution, performing minor corrections when possible and avoiding the creation of tickets.

After the sending of the DELFOR, another major bottleneck was identified. After receiving the message, the suppliers are expected to send proof that the data regarding dates for delivery and quantities were integrated correctly into their system. To validate this test, the EDI onboarder accepts a screenshot of the supplier's system, where the data can be seen and matched with the one sent on the DELFOR. The issue arises when suppliers take too much time to respond for numerous reasons: lack of time or commitment, not making EDI a priority, inability to understand the test, etc. This delay in the response creates a gap in the conclusion of the test, as every step that comes after will already be delayed. As every onboarder has no less than ten suppliers simultaneously, tests end up piling up, creating more difficult to manage. One countermeasure implemented to reduce such bottlenecks was giving suppliers a deadline day to complete each phase of the tests. In case of failure, a meeting with managers on higher hierarchical levels is scheduled to align priorities and commitment levels.

Following the reception of the message by the supplier, it must send a screenshot of the integrated data on its system. Then, the EDI onboarder will check to verify if every information matches what is expected. If the supplier correctly integrates the information, the onboarder can move forward and validate this supplier to start receiving productive DELFOR data. If the proof

sent by the supplier is not valid, the onboarder will then proceed to give the supplier feedback on what was wrong and ask for new and correct proof. In this flow, another bottleneck has been identified sometimes; suppliers are not fully dedicated to the testing process, either due to other tasks on their side or because they do not give enough importance to it, which often leads to responses that do not match the "expected" criteria.

After the testing process is complete, it is up to other business areas to change part of the supplier's configuration of this supplier so the new orders can start to be sent by EDI (via DELFOR messages) and no longer through email communications.

5.2.2. DESADV processes

As detailed before, DESADV messages are way more complex and important for the success of the business and the product being developed. This message can be described as a response to the DELFORs. In other words, it works similar to a receipt in the common world. The complexity lies in the fact that when INEOS sends out a DELFOR message, it sends the same version for every supplier, and that supplier needs to integrate the best way their system can. On the DESADV message, INEOS have to convince the over 190 suppliers to send back a message with the exact rules that INEOS systems require to integrate it correctly and for the information available to be as precise and as correct on the screen as on the plant and warehouses.

Comparing the processes for the DESADV message, the first process on the AS-IS was to make an attempt to send a test DELFOR to the supplier so he could one more time integrate it into their system. The onboarder has to check if the message got sent correctly. It is now up to the supplier to send a test DESADV message; if any errors occur on the sending of the message, the onboarder will open a support ticket so the reason can be identified and the correction to be applied. A lot has changed in the newly designed process; before sending the DELFOR to the supplier, the onboarder must verify several prior details, like material configuration, if there are any valid delivery schedules and define which scenarios will be tested. Only then the DELFOR message will be sent. The scenarios to be tested are defined consonant the number of different materials supplied by that supplier and packaging types, as there are shipping containers that cannot be stacked or mixed. The addition of these steps prior to sending the message translated into a significant reduction in the time spent to complete the tests, the change addressed one of the DESADV bottlenecks, the time needed to resolve the supporting tickets when the sending of the DELFOR failed.

Continue the process after the sending of the DELFOR, it is up to the supplier to send a DESADV message corresponding to the sent DELFOR. This process can vary from supplier to supplier as each one of them can have a different ERP system. However, generally, the supplier's system generates a message automatically, but someone must adjust how this message will be structured to follow INEOS guidelines.

When the onboarder receives the message, it is necessary to check the structure and data inside it. This task can become complicated depending on the complexity of the message. For it to be accepted and integrated correctly into INEOS systems, the structure needs to be perfect and in accordance with the guidelines. A DESADV message is composed of lines of segments, each segment regarding certain information, and for different types of demand and packaging, the message can have different segments. To check the message, the onboarder must ensure that every mandatory segment is present. If the information in it is correct and is what is expected,

two results are possible after the check, but a correct message is not guaranteed it will integrate correctly.

If the message has structural data problems, it will always be an issue on the supplier side. Therefore, if the onboarder identifies such issues, the supplier will provide feedback, and a new test file will be asked. This sequence usually creates a bottleneck as some suppliers can take long periods to check the corrections and to create a new test message. As described in the DELFOR process, if that period exceeds three or four days, the onboarder will proceed to escalate the issue to higher management. If the message has the correct structure and data, the onboarder will proceed to the integration of the system. On this part, again, there are two possibilities, either the system will integrate it correctly, which means the information on the DESADV will be displayed correctly on the system for the other business areas, or the integration may fail, and an error message will be displayed. There could be many possibilities for the reason why the message could not be integrated correctly; one of them could be simply human error; sometimes, the DESADV messages can be very extensive, and small detail, like a blank space or wrong digit, can pass the manual verification of the onboarder, for that case the supplier is again asked for a new test file. The remaining possibility is an error on the INEOS side, namely on the ERP system in which the message is being integrated. If the onboarder cannot fix it, a support ticket must be created, and the message reprocessed. The process ends with the validation of the message and the correct integration of the same.

Having the supplier fully tested and validated, the supplier is notified that he can start to send productive ASNs to INEOS.

6. Results

6.1. Demonstration

As a demonstration of the newly designed process, an under-development version has been applied to suppliers since February 2022. That version was constantly updated until the final version was reached.

As Peffers et al. (2006) stated, the demonstration phase goal is to “Demonstrate the efficacy of the artefact to solve the problem. This could involve its use in experimentation, simulation, a case study, proof, or other appropriate activity”. The application of the new artefact can be defined as a case study, as it was used practically with the intent to improve the problems previously stated. Also, as shown before, a workshop with the team provided great feedback and insights on where the new process could be better than the previous version.

The new processes were used with every supplier that was onboarded since February. It could be considered a risk to make such tests in a real environment. However, it also improved exponentially how we could exploit the problems and solve them, providing us with a better view of what could be expected at the start of production.

6.2. Evaluation

To evaluate how well the created artefact supported a solution for the defined problem, it was measured how long it took to complete certain parts of the test in 2021 and 2022 (after the new versions of the processes started to be developed), and it was clear that something changed in that period.

As stated by Peffers et al. (2006), “Depending on the nature of the problem venue and the artefact, evaluation could include such items as a comparison of the artefact’s functionality with the solution objectives, objective quantitative performance measures, such as budgets or items produced satisfaction surveys, client feedback, or simulations.”

Another important part of the Evaluation phase is to reflect on what has been done and decide whether to go back to step 3 (Design and development) in the attempt to increase the effectiveness of the designed solution or to continue to the next step and leave updated and improvements to future projects (Peffers et al., 2006). For the case study in evidence, the option to go back to the Design and Development step was frequently utilised. The process was constantly updated each week as new evidence would appear or any results on the tests that were not satisfactory enough. During the weeks that this cycle occurred, the processes and the team’s perspective on what was the best practice changed and made it possible for even more new information to be retrieved.

Comparing the new artefact’s functionality with our previously defined objectives, a better and improved version of the old processes were created. The target was to conclude more tests in less time without losing the quality and validity of the tests.

6.3. Communication

The Communication part is about spreading the solution presented in the artefact. Peffers et al. (2006) said that this part is about communicating the problem and its importance, the artefact itself, its utility, the rigour and design and how efficient it is to the relevant audience.

As this new process development is in a business environment in a private company, the relevant audience is all members or stakeholders related to the EDI project. Therefore, after the new artefact was concluded, it was shared with all relevant audiences to the EDI onboarding team for daily use and to higher management for approval.

6.4. Impact on the business

The graphics below represent the difference between each year of testing. The data was collected from INEOS’s internal tracking files, where every member of the EDI onboarding team and EDI project lead can keep track and consult data over each one of the suppliers, also insert data relative to the conclusion of each step of the tests.

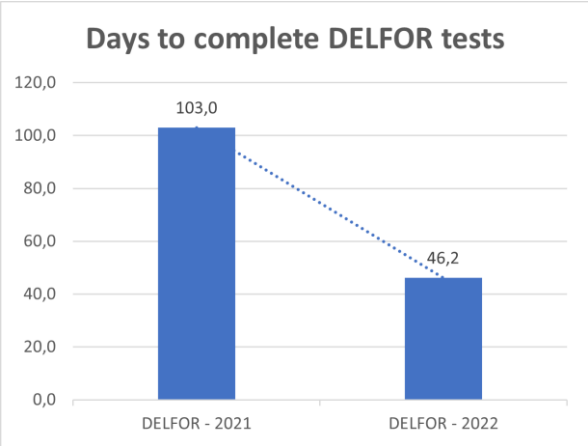


Figure 10- Days to complete DELFOR test (Average)

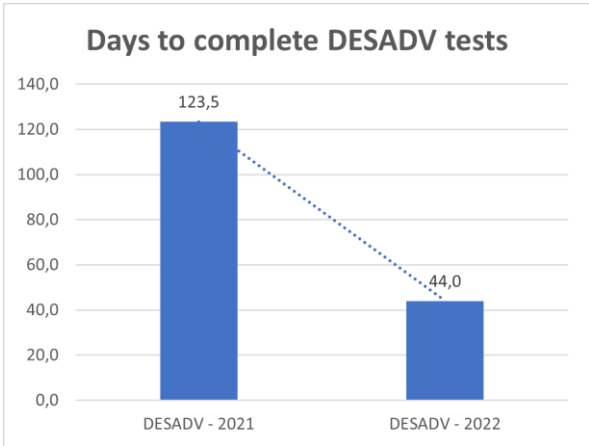


Figure 9- Days to complete DESADV test (Average)

From the DELFOR perspective, we had an average of 103 days from the start to the completion of a test for each supplier in 2021 while using a poorly defined and complete set of steps. In 2022, already using an early version of the new artefact, the average number of days to complete a test was 46,2 days, representing approximately a 55% decrease in time needed to have a supplier completely validated to start receiving productive DELFOR messages from INEOS.

From the DESADV perspective, the average number of days to complete the test was 123,5 in 2021. After using the new processes, in 2022, that number reduced by 64%, which led to 44 days on average to have a supplier DESADV validated, meaning that this supplier could also send messages to INEOS.

7. Conclusions and future research

The change to a new process was highly demanding for everyone involved in the supply chain area at INEOS. Without the EDI working correctly, everyone is responsible for extra work, and it gets way harder to keep up and track every shipment or demand needed for the vehicle's production. When a supplier does not have EDI validated, the whole communication goes through email and excel sheets, which is not the desired way of working on such a high-scale business. EDI integration makes storing and managing information about deliveries and demands easier.

Two researcher questions were defined to guide the project direction. The first one was "How can EDI implementation help optimize the processes related to the buyer-supplier relationship in the Automotive industry context?". This question is directly related to how the EDI implementation is successful. As stated previously, without the EDI messages, all communications between the company and its suppliers have to go through emails and other tools that are not as effective and efficient; EDI reduces the information gap between the two sides and increases the information flow exponentially.

The second question was, "How can the creation or selection of a structured and standard way of working can benefit the management of the EDI onboarding process?". These questions dictated the most relevant work done throughout this dissertation. The main point was to design "something" that could bring benefits to the method used before on the onboarding of suppliers.

It was established that a new process for the EDI onboarding suppliers for the automotive industry would be created. Many hours of observation, testing, and dedication were necessary to reach that objective. Looking at the results achieved, as shown before, the time needed to complete a testing phase from start to finish with a supplier was reduced by more than half the time for both messages. To reach that point, it was necessary to understand the process deeply and discuss with multiple stakeholders what were the points to be improved and what would be the best way to do it.

The selected methodology (Design Science Research) proved to be well suited for the case study approach. The clear steps defined by the authors provided clear guidance and a defined set of tasks. Starting with the problem definition, it was possible to understand the most critical pain points presented in the case study and gain a better understanding of the company's processes. The Objectives definition was also done if the experience and knowledge were gathered in the previous phase. After a clear understanding on what was the problem on what could be the possible solution, the design and development phase served as a workspace for the creation of the new artefact. The demonstration and evaluation phases closed out the application of the methodology by explaining how it was transmitted and the impacts of the newly developed process.

In personal terms, it was such a great experience to be part of the Grenadier project at INEOS Automotive and get to know how a vehicle is built from an idea on a piece of paper to the real product itself. As a master's student, it was very rewarding in multiple aspects. First, I could see many theoretical concepts learned in classes implemented in a business and corporate environment. Secondly, it allowed me to grow as a person and mostly the ability to talk and discuss topics with multiple levels inside a growing organization.

As further research goes, this project was based on a constantly changing environment. Therefore, these same designed processes could be revisited yearly or if the business goes through a big change. Also, as a growing business, new types of messages could be

implemented, and the processes could be updated to fit the new steps required to test and implement such messages.

Another area that could be studied is the best way to organize the Onboarding team in an organic sense and solutions on how to work with the issues that could exist once the vehicle is produced on a mass scale.

Finally, as this work was based on a focused case study, it is important to refer that the methods and research applied are better applied to the automotive industry. The same methodology for designing and evaluating may not work for different areas or businesses. Although EDI is not only utilized in the automotive business, in that area is almost a standard for the exchange of information. Therefore, a new study could be developed and explored in a different line of business.

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APPENDIX A: Example of a DELFOR file

Sensitive information has been left out.

UNH+ [REDACTED] +DELFOR:D:04A:UN:GAVB10'
BGM+241+8_TST+9'
DTM+137:20220623:102'
NAD+BY+[REDACTED]:92++ [REDACTED]: [REDACTED]+ [REDACTED]+
[REDACTED], [REDACTED]++ [REDACTED] [REDACTED]+ [REDACTED]'
NAD+SE+[REDACTED]:92++ [REDACTED]+ [REDACTED]++ [REDACTED]+'
NAD+SF+[REDACTED]:92++ [REDACTED]+ [REDACTED]++ [REDACTED]+'
GEI+3+37'
NAD+ST+[REDACTED]:92++ [REDACTED]+
[REDACTED]+ [REDACTED]++ [REDACTED]+'
LOC+11+[REDACTED]:92'
LIN+1++ [REDACTED]:IN'
PIA+1+[REDACTED]:SA'
IMD+F++11:: [REDACTED]
RFF+ON:[REDACTED]'
DTM+171:20220623:102'
RFF+AAN:8'
DTM+171:20220623:102'
QTY+83:318:KGM'
QTY+83:2247:KGM'
QTY+83:3675:KGM'
QTY+83:684:KGM'
QTY+70:5300:KGM'
DTM+51:20220623:102'
QTY+194:1060:KGM'
RFF+AAU:[REDACTED]'
DTM+171:20220421:102'
SCC+1'
QTY+113:1060:KGM'
DTM+63:20220628:102'
DTM+64:20220628:102'
UNT+30+[REDACTED]'

APPENDIX B: Example of a DESADV file

Sensitive information has been left out

```
UNH+1+DESADV:D:07A:UN:GAVF13'  
BGM+351+8391341585+9'  
DTM+137:20220531:102'  
DTM+17:202204062359:203'  
DTM+11:202205312359:203'  
MEA+AAX+AAD+KGM:1787'  
MEA+AAX+AAL+KGM:537'  
RFF+AAN:2'  
NAD+ST+ : :92++ +  
+ ++ +'  
LOC+11+ '  
NAD+BY+ : :92++ +  
+ ++ +'  
NAD+SE+ : :92++ + ++ +'  
NAD+SF+ : :92++ + ++ +'  
CPS+1++4'  
PAC+1+:35:AAC+ : :92'  
QTY+52:50:PCE'  
PCI+17+++S::5'  
GIN+ML+ 9061226:UN 9061226'  
LIN+1++ :IN'  
PIA+1+ :SA'  
IMD+++11::272: KURZ'  
QTY+12:90:PCE'  
QTY+11:50:PCE'  
ALI+DE'  
RFF+AAU: :1'  
DTM+171:20220531:102'  
RFF+ON: '  
CPS+2++4'  
PAC+1+:35:AAC+ : :92'  
QTY+52:40:PCE'  
PCI+17+++S::5'  
GIN+ML+ 9088449:UN 9088449'  
LIN+2++ :IN'  
PIA+1+ :'  
IMD+++11::272: '  
QTY+12:90:PCE'  
QTY+11:40:PCE'  
ALI+DE'  
RFF+AAU: :1'  
DTM+171:20220531:102'  
RFF+ON: '  
UNT+42+1'
```