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Analysis of Software Ecosystems in Freight transport

An investigation of the concept of eCall as a technological platform

Master's thesis in the Master Degree Program Software Engineering

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Abstract

The industry of road freight transport has a tradition of little or no information sharing, both between the transport actors and the customers of transport, and an overall scepticism towards implementation of new technologies, which historically has resulted in the business having a high level of information asymmetry for the end-users of transport. As the area of freight transport is a growing sector where goods sent by road is becoming more and more frequent, more information is documented and the supply chains become increasingly complicated in their structure. In combination, the road accidents are no longer decreasing, as more transport is done by road. If more information is shared, the road efficiency will increase, and if the goods carried by trucks was known and digitally documented, it is possible that the emergency services would have the possibility to minimize the effects of an accident. The purpose of the study is to seek an understanding if it is possible to increase the information shared between the parties of road transport by using the concept of software ecosystems, where the concept of eCall would be the platform around which a software ecosystem will evolve.

The technology of eCall is a concept where a car sends information to emergency services in Europe in case of an accident about location, direction on the road and other data. The project of I_HeERO are investigating the possibility of implementing eCall in heavy goods vehicles, buses, taxis and two wheeled vehicles in Europe. With the industry of freight transport being late adapters of new technology, the sharing of data about a vehicles load and location is something the actors are sceptical towards, and it is needed to investigate the possibilities with eCall, and not solely the imagined drawbacks of sharing information.

Based on the the Ecosystemability Assessment Method by Knauss and Hammouda (2014) the possibility of a software ecosystem evolving around a platform of eCall is investigated and analysed, and based on this information a general assessment of software ecosystems in road freight transport is concluded, stating that the possibility of a software ecosystem requires obvious individual benefits for the freight transport actors, as these need a push in order to adapt new information technologies. It is as well found that there are many barriers towards the implementation of software ecosystems, but these are considered social rather than technical. Moreover, it is possible that legislating the information shared by the haulage contractors and other transporters is the only way to enforce the information being shared, as many actors only advantage is the information they possess and therefor are unwilling of sharing, even though it would benefit the sector as a whole. If using a governmentally initiated software as eCall as the platform in the software ecosystem, it can be a benefit as this kind of software often have a clear roadmap and clear legislations, but a possible disadvantage can be the possibility of the fundamental functionality being decided upon too early, resulting in a limited and sluggish solution.

In order to use the concept of software ecosystems, the stakeholders of freight transport are recommended to take action. The transport organisations are advised to increase their interaction with software companies, enabling the possibility of shared and better software. The actors in freight transport are advised to investigate the possibilities of information sharing and cooperation in software ecosystems. The customers of freight transport are recommended to ask question about the transport purchased and demand information. Finally, the academia are advised to further investigate projects of information sharing in freight transport, with a close cooperation with the industry and a clear connection to practice.

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Andrea Dahlgren

Glossary

Actor	A company, organisation or entity that is a part of the software ecosystem
eCall	Initiative with the purpose to bring rapid assistance to motorists involved in incidents on European roads. It involves Technology in the car as well as at Public-safety Answering Points (PSAP)
eCMR	Electronic consignment note
E-documents	Also called digital documents, electronic documents and eCMR and stands for electronic documentation
I_HeERO	A project partially funded by the European Union with the goal to facilitate the deployment of eCall
IRU	International Road transport Union, an organisation which upholds the interests of bus, coach, taxi and truck operators
Platform	The central company, product or family of products that a software ecosystem evolves around
PSAP	Public Safety Answering Point, an emergency service call centre
Software ecosystem	A technological platform, a set of actors and the relations between the actors that together create an ecosystem

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1 Introduction

In the following chapter the background to the project is presented, as well as the purpose of the study and in relation the research questions to be answered. Finally, the delimitations and the outline of the project are presented.

1.1 Background

Road transport is a central part of the European economy and single market. It delivers goods across Europe every single minute. About 44% of goods transported in the European Union go by road. Road transport is a vital economic sector in its own right, employing about five million people across the European Union and generating close to 2% of its gross domestic product (European Commission, 2012). The international road freight transport has increased significantly over the last seven years, resulting in higher loading on the European roads (European Commission, 2016).

In freight transport, one of the biggest challenges faced by companies today is to rapidly respond to volatility in demand (Lou et al., 2011). It is stated that the emerge of Internet has made a significant impact on the rapid growth of information sharing over Internet between companies, their suppliers and their customers in logistics and supply chain management. Data are essential in freight transport, and obtaining good data can be hard since it is difficult to observe freight processes directly, and there is a poor data acquisition infrastructure (Tavasszy and de Jong, 2014). According to the European Commission (2016), digitalisation of the transport sector can significantly improve transport management through more accurate information on the conditions of traffic and infrastructure conditions as well as the locations of vehicles and goods. The European Commission state that a better access and sharing of digital transport data for as well private as public stakeholders can create seamless information flows, as well as open up a wide range of new business opportunities (European Commission I, 2016). Some of the benefits according to the European Commission would be shippers benefiting from better information on available transport services, factories would have information on arrival times of goods, being able to optimise the inventory management and production. Logistic service providers would be able to optimise transport operations in real-time and quickly react to unexpected events, and public authorities could benefit from more accurate and reliable information on the use of infrastructure and cargo, giving that they can contribute to a better efficiency and operational safety of networks.

With transportation on road, both freight and personal, related accidents follow. In 2014, almost 25 700 accidents were reported in the European Union. Although the overall long-term trend is decreasing numbers of accidents, the decrease rate slowed down in 2014 (European Commission, 2015). It is possible that the current situation, with a heavy usage of the road infrastructure in Europe might require an innovative way of handling the accidents that occur.

The European Commission has since 2013 been discussing the possibility to implement electronic emergency calls in vehicles in the European Union; eCall. The eCall system communicates the exact location of the vehicle involved in an accident and the time of the incident to the emergency services. The call can be generated either manually by vehicle occupants or automatically via activation of in-vehicle sensors, following a collision. When activated, the in-vehicle eCall system will establish a voice connection directly with the relevant Public Safety Answering Points (PSAP). Simultaneously, a minimum set of data is sent to the PSAP operator receiving the voice call, providing the location and other relevant

vehicle data (International Road transport Union, 2014). eCall can use digital transport documents, or e-transport documents, as a mode of communication between the system and the emergency services.

On 28 April 2015 the European Parliament voted in favour of eCall regulation which requires all new personal cars be equipped with eCall technology from April 2018. The mandate currently does not cover other types of vehicles than personal cars, such as buses, coaches, motorcycles or trucks. Therefore, a new European project, Infrastructure Harmonised eCall European Pilot (I_HeERO), has been launched to support PSAP mandatory implementations, and to look into eCall for other types of vehicles. This report aspires to further investigate the introduction of eCall in other vehicles in order to further increase road safety.

The combination of increased transport on road and related increased number of accidents with the need in the industry for more data from the freight transport sector indicates a need for a shared information system that all actors can benefit from. As the eCall technology will be shared between many actors, such as governments, freight companies and rescue services, the software of eCall will function as a common platform that creates relations between the actors. The possibility of a software ecosystem would presumably benefit many of the actors (Knauss et al., 2014).

The topic of software ecosystems has exploded during the years from 2009 and forward, according to a systematic literature review by Manikas and Hansen (2013). The increase shows the rising interest of the concept and its benefits. The definition of a software ecosystem is, according to Jansen Finkelstein and Brinkkemper (2009, p. 18), “A software ecosystem is a set of actors functioning as a unit and interacting with a shared market for software and services, together with the relationships among them. These relationships are frequently underpinned by a common technological platform or market and operate through the exchange of information, resources and artefacts.” A real world example is the Apple App store, where Apple owns the company and many actors can build, use and buy applications from it, creating their own relations based on the platform of Apple. According to Vilijanen and Kauppinen (2011) there are obvious benefits of a software ecosystem, such as network effects for the actors, positive feedback loops as well as decreased costs for all actors (Bosch, 2009).

The aim of the report is to find an understanding if it is possible to implement the concept of software ecosystems in the area of freight transport. A software ecosystem would presumably benefit the actors, but could as well increase the risk for the actors. It is possible that there are barriers towards a more shared view of the eCall software as a software ecosystem, and the report intends to explore the possible resistance of a software ecosystem, as well as possible benefits and barriers.

1.2 Purpose

The purpose is to investigate the possibility of applying the concept of software ecosystems in the freight transport domain in order to facilitate service related communication.

1.2.1 Research questions

It is of importance to understand the current situation and map the possible stakeholders of a possible software ecosystem in the area of freight transport. This will be done by investigating the concept eCall for trucks and buses as the technological platform for a software ecosystem. As of today, the impact of the digital sharing of information with digital transport documents

or the possibility of a software ecosystem is not investigated or documented. In order to fulfil the purpose of the thesis the following research questions need answer:

RQ1. How would a software ecosystem in the freight transport domain benefit its actors?
RQ2. What are the barriers against a software ecosystem in the freight transport domain?
RQ3. How can the eCall technology serve as a technological platform in a software ecosystem in the freight transport domain?

1.3 Delimitations

Freight transport domain
In order to ensure the depth of the project the report only investigates the transport of heavy goods, dangerous goods and buses and excluding coaches, taxis and two wheeled vehicles, even though these are investigated in I_HeERO project. This since this category of vehicles require other types of investigations than the chosen type. As well, the focus lies on the digital transformation of data with eCall and not the voice channel with the same concept.

Geography
A limitation of the project is that of geography. Since the project is carried out in Göteborg, Sweden for the first half of the project, the contact with as well interviewees as supervisor at IRU in Brussels, Belgium is sometimes limited to emails and phone calls. This can possibly cause information loss, both because of language barriers and the way of communication. This risk is in large extent reduced by the researcher travelling to the locations during the project.

Sampling
The interviewees are chosen based on their skill set in different areas, with the intent of creating a complete picture of the current situation in road freight transport, road safety and possible implementation of information technologies and software ecosystems. There is a possibility that the interviewees had barriers of sharing information about the different areas as well as a possibility of areas of interest not covered in the interviews. These risks are minimised by triangulation of information from many sources as well as an ensured saturation in the data from interviewees. As well, some times the interviewees have written some of the literature included in the theoretical framework. When these situations occur, the information from interviews and literature is compared and if the sources are too equal, the literature is discarded. As well, many times the literature have more than one author, which increases the diversification of the literature.

Descriptive report
Finally, the report is describing a possible application of software ecosystems onto freight transport, but will not go further into the process of practically applying the concept onto the industry. Recommendations are given on how to proceed further.

1.4 Outline

Initially, the Method chapter is explaining the choice of research strategy as well as the research process. The literature study, data collection methods and the data analysis is described. The trustworthiness of the study as well as ethical consideration will also be discussed and justified.

Following a chapter presenting the Theoretical framework summarizing the relevant theory already existing within the field of freight transport and its relation to information technology, introduction to eCall and the project I_HeERO. Moreover, an introduction to software ecosystems and its characteristics is presented.

Thereafter the Empirical results are introduced, where information gathered from interviews is presented. Following the Analysis chapter will present and discuss the possibility of software ecosystems for freight transport as well as possible barriers towards the implementation.

The following chapter consists of a Conclusion of the thesis, where the research questions are answered individually. Lastly in the chapter Recommendations for the different stakeholders of a software ecosystem in freight transport are presented.

The last chapter consists of a Discussion where the report is discussed and possible aspects affecting the analysis and results of the project. Here is as well Further research presented with possible future work in the area of information sharing in road freight transport industry.

2 Method

In the following chapter the research strategy and approach and the research process of the report are presented. Following, the outline of the literature study as well as the qualitative data collection methods are discussed, followed by an introduction of the data analysis. This is followed by a discussion of the trustworthiness and ethical considerations of the study. Finally, a methodical discussion is presented.

2.1 Research strategy and approach

A research strategy concerns the general orientation of research and the way it is to be conducted (Bryman and Bell, 2011) and in the following study the orientation is to gather information from two separated areas, road freight transport and software ecosystems and analyse them together in order to see if it is possible to apply the concept of software ecosystems onto freight transport. The aim of the study is to contribute to already existing research, rather than confirming it. In order to clarify the current state of software ecosystems in the area of road freight transport, a qualitative research is conducted in form of interviews with different interviewees with complementing skill sets. The concept of eCall is investigated as the possible technical platform for a software ecosystem, the chosen research design is a case study, which according to Bryman and Bell (2011) is suitable for this kind of research.

The abductive research approach of systematic combining is applied in the report, where empirical studies of interviews are conducted in parallel with theoretical studies of as well software ecosystems, eCall and freight transport domain. Dubois and Gadde (2002) describe systematic combining as a process where the framework for theory and empirical framework and case analysis evolve simultaneously. By continuously alter between different types of research activities as well as between theory and empirical investigations a deeper understanding is obtained, Dubois and Gadde (2002) propose and the aim of the process is to reach as high understanding of the area as possible.

2.2 Research process

The research process of the study is visualised in Figure 1.

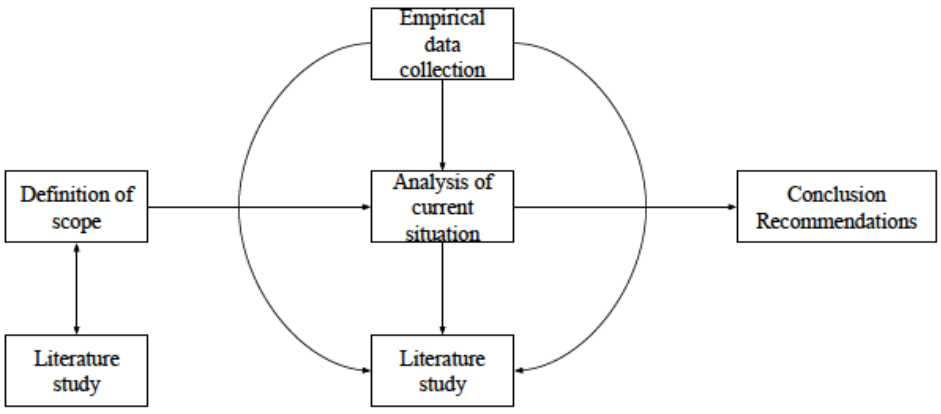

Figure 1 The research process of the study.

The first description of the study was vague in its description, and therefor the first step of the project is to define the scope in relation to all areas of interest, such as software engineering and freight transport. In parallel with defining the scope, and understanding of the concept of software ecosystems by a broad literature review is gained, which is considered necessary for the study to be initiated and conducted.

Following the initial phase, the research process consists of one main phase, see Figure 1, including literature study, data collection, analysis and verification of data. As these activities often occur in parallel the main phase is circular with several loops within the main loop in order to reach an understanding and conclusion of the scope of the study. The first step of the study is to gain an understanding of the area of interest for the technological platform, namely the eCall concept, and focuses on the research questions in the relation to eCall, se chapter 1.2.1 Research questions. The following phase concerns the current situation in freight transport in relation to information sharing and information technologies and the implementation and usage of these, in order to understand the area of where eCall presumably will be an active part. In parallel, information about software ecosystem is obtained and documented in order to understand the concept, its parts and requirements in order to be active and well-functioning.

The literature study is conducted as an iterative process in parallel with the empirical study, all throughout the project. The literature study is partly based on issues arising during the collection of empirical data, following that the literature study focuses more on these issues, such as information sharing in road freight transport industry. Though, since the lion's share of the theory is related to software ecosystems and modern technical solutions in freight transport, these contributions mostly deepen the understanding of the situation rather than changing the game plan. It must although be stated that all of the literature of software ecosystems are concerning pure software companies and originate from that area of science, and it is important to clarify the difference of this and of an analysis of software ecosystems in the environment of freight transport.

In order to conduct quantitative analysis of the subject of eCall in trucks and buses, quantitative data was requested. The aim is to conduct data from emergency services regarding the implementation of eCall in trucks and buses, and what barriers this can imply. However, due to long lead times to receive the data from stakeholders, as well as deficiencies in the raw data, it is considered appropriate for the researcher to focus mainly on the qualitative analysis. Therefore, the study solely analyses qualitative data in relation to the literature study.

The main phase of literature study, data collection and analysis of the current situation is followed by a conclusion of the possibility of software ecosystems within freight transport, as well as recommendations to relevant actors, see Figure 1. Since the study investigates eCall, it cannot be stated for certain that the result is accurate for another concept in freight transport as a technological platform, although it can be argued that the concept of software ecosystems for the industry freight transport can be generalised as the idea is representative for the whole business.

2.3 Literature study

The literature study is conducted through the main part of the project in order to enable a thorough analysis. The theory studied is mainly on the subject of modern technical

communication solutions within freight transport, and the adaptation to these solutions, the concept of eCall and theory of software ecosystems The first step of the literature study is to conduct a rigorous literature review within these areas of interest. As well older literature as more recent is covered. Databases of transport and software engineering and IT are used, as a main share of articles and literature about the subjects can be found. A systematic search including keywords such as *software ecosystems*, *e-documents for freight transport* and *freight transport barriers information technology* are applied. Since the study is in the borderland of software and freight transport, parts of the literature is considered too technical in the software field, as well as investigations of freight transport not related to new technology are discarded. In combination, a snowball sampling technique is used to find further relevant literature. The snowball sampling technique means that the reference list in found papers will be studied and guide the literature research forward (Bryman and Bell, 2011)

2.4 Data collection

To answer the research questions in chapter 1.2.1 Research questions, different methods is applied, resulting in the empirical study consisting of qualitative data. The qualitative data was collected from as well primary as secondary sources. The difference between primary and secondary data is that primary data is created for the purpose of the study while secondary data is created regardless of the study (Bryman and Bell, 2011). The qualitative and data collections are conducted in parallel with other activities in the study in order to aim for a higher understanding of the problem area.

2.4.1 Qualitative data collection

The method for data collection used regarding qualitative data is semi-structured interviews where different interviewees with different areas of knowledge are interviewed about the concept of freight transport today as well as digital solutions for the industry in general and about eCall and software ecosystem more specifically. The interviews aim to cover the main aspect of the stakeholders in freight transport concerned by a possible software ecosystem, as well as software ecosystem in general. Some of the information overlap and confirms the theories of the project whereas in other areas the information from the interview completes the picture. The aim is to create an understanding of the studied area with information form the interviews.

2.4.2 Interviews

Semi-structured interviews are held and used as the main data collection method throughout the study. The interview template is found in Appendix I. Interviewing is, according to Bryman and Bell (2011) probably the most widely applied research method within qualitative research. The method is chosen as the most appropriate due to the design of the research, as well as the complexity of the area in terms of stakeholders and possible sources of information. With this background, the interviewees are encouraged to speak freely as well as giving the opportunity to ask follow-up questions in order to gain a more extensive understanding of the research area. Semi-structured interviews are held with several stakeholders of the eCall concept as well as persons with an extensive knowledge of the area of software ecosystems as well as digitalisation of freight transport. The interviewees are selected based on their background, expertise and experience in the areas studied in the report.

Altogether, six semi-structured interviews with eight interviewees is performed in order to cover the possible aspects of stakeholders within a supply chain as well as within a freight transport software ecosystem. As the concept of eCall still is in the bud, it is possible that

possible future stakeholders of a software ecosystem have been overseen. The interviews are held in person if possible, and otherwise via telephone. The interviews focus on the possibilities of eCall as a platform and software ecosystems, as well as possible barriers with the concepts. All interviews are focused on that specific stakeholder and its situation, for example Volvo Group Trucks Technologies as a vehicle delivery stakeholder and emergency services as users of the eCall concept in PSAP.

2.5 Data analysis

The data obtained during the project is analysed with the technique of triangulation. Triangulation entails data sources and theoretical perspectives using different research methods (Curry and Nunez-Smith, 2015). The technique is combining qualitative research methods with theory in order to see if the data results in the same answer. Miller (2008) suggests that triangulation is a good basis of knowledge discovery in software engineering. The analysis of qualitative data is conducted in an iterative process where the collection of the data and the analysis is conducted simultaneously, which, according to Bryman and Bell (2011) is common when analysis qualitative data. In order to evaluate the possibility of a software ecosystem with eCall as the technology platform, as well as how well such an ecosystem would function, the Ecosystemability Assessment Method (EAM) is used. The method is presented further in chapter 3.7 Ecosystemability Assessment Method.

It is suggested by Miles and Huberman (1994) that an analysis of qualitative data should include three procedures; data reduction, data display and conclusion drawing. During the interviews of the project, the information is documented first during the interview, but also afterwards. Since only information considered relevant for the study is documented, this action can be considered a first reduction of the data. To gain a comprehensive understanding of the current situation, the empirical data is displayed visually in order to map the current state in the EAM, presented in Table 3 in chapter 4.7 Illustration of empirical data in the EAM method. The analysis of the data that results in the conclusion drawing is made by analysing the current situation and collected data with the EAM presented by Knauss and Hammounda (2014). The method aims to assess to what extent a software system represented by its architecture as well as its development environment supports the vision of an ecosystem (Knauss and Hammounda, 2014). The EAM method is quality-centric, focusing on the nature of ecosystem, governance and the software platform. Together, these three themes form an elicitation and analysis guide that allows characterisation of a software ecosystem as well as capturing business requirements and conceptual properties that impact decisions about the evolution of the technological platform (Knauss and Hammouda, 2014). As the software ecosystem of eCall yet is in the bud and a theoretical software ecosystem, the aspect of *Deployment activities* discussed by Knauss and Hammouda is disregarded, as this aspect of a software ecosystem is regarding the platforms ability to deploy activities of extensions. This aspect becomes too theoretical, since as well the platform actions and the extensions are to be imagined, and because of the multiple error factors of the aspect, it was discarded.

The model by Knauss and Hammouda (2014) is an extension of other assessment methods of software ecosystems which are mainly architecture-centric and focusing on analysing specific software artefacts. In the EAM, Knauss and Hammouda (2014) aims to address various dimensions and needs of software ecosystems, and analyses beyond the model of ATOM by Kazman, Klein and Clements (2000) which is a method for architecture evaluation. It is as well quality-centric, like EAM, but with the main focus of architecture. As the software ecosystem of the eCall concept is a theoretical ecosystem, it is considered important to weigh in more themes than the architectural team, whereas this assessment method is chosen.

2.6 Trustworthiness

To increase the trustworthiness of the study, the credibility, transferability, dependability and confirmability must be considered, according to Bryman and Bell (2011). Credibility means the believability of the study and was increased with triangulation, mentioned in the chapter 2.5 Data analysis. To increase the transferability, a thick description of the situations during the data collection as well as a thorough description of the research methods applied is used. Thirdly, the dependability is, according to Bryman and Bell (2011), the ability to replicate the findings in other contexts, an aspect than can be more difficult than the earlier two. By supporting the empirical findings with literature, the research is presumably generalizable in other situations. The conformability of the study means the objectivity of the researcher (Bryman and Bell, 2011). No researcher is ever completely objective, but the intention of this study is to strive towards being as objective as ever possible.

To avoid misunderstandings and misconceptions during the qualitative data collection it is of importance to use a language understandable for the interviewees and not use a terminology foreign to them. As well, there can be situations when the interviewees aim to please the interviewer and therefor modifies its answers in a way she believes pleases the interviewer. In order to reduce the risk of these issues, each interview contains a thorough introduction including the aim of the project and the focus on the importance of every interviewees input was emphasised.

2.7 Ethical considerations

During the study ethical considerations are an important factor to have in mind. Bryman and Bell (2011) emphasise four main areas of ethical principles in research; harm to participants, lack of informed consent, invasion of privacy and deception. These ethical aspects are central during the project. Although not asking interviewees on a personal level how they work and what issues they work with, they can still feel criticised during an interview. This can have negative consequences in case there will arise sensitive information during the data collection (Bryman and Bell 2011). In order to reduce the impact of these issues, the interviewees are constantly reinsured that the interviews are to build a picture of the current state, and no answers are wrong in any way. It is as well emphasised that the participation is voluntary, and it is of importance to inform participants about the study in order for them to make a decision to participate or not. The information to the participants is therefore clearly stated the purpose and aim of the project to avoid lack of informed consent and deception.

2.8 Methodology discussion

The study is mainly consisting of semi-structured interviews, some face-to-face and some via telephone conference. Some of the interviews are conducted with solely one interviewee, and some were conducted with several interviewees simultaneously. This method is considered the most appropriate method to understand the process as well as the most feasible, but it is important to mention how this method can affect the outcome of the study. First, when interviewing people within an organisation, only their personal view can be collected and it is difficult to to draw any conclusions if that view is consistent with the view of the rest of the organisation or division. Secondly, there is a risk that the answers reflect how the work is supposed to be, rather than how it really is. Finally, there is a risk that the interviewees do not want to talk about problems or barriers since they feel they blame someone else or put themselves in poor light. With this in mind, observations of meetings and actual work would have been an appropriate method, but since the concepts of eCall, as well general as a technological platform, and software ecosystems are yet in the bud, this was not possible.

The study does not include any detailed plan or comprehensive solution regarding how a software ecosystem within freight transport should be initiated. This since it is not considered as appropriate or possible to include such details in this type of study. The aim of the study is to contribute with knowledge regarding if the concept of software ecosystems is feasible in the area of freight transport. In order to create conditions for a software ecosystem for freight transport in a long term perspective, it is considered as important to focus on the knowledge and principles of software ecosystems. This since organisational and technical knowledge regarding change management and initiation of a new technical platform is required in order for the concept to function in a long term perspective.

3 Theoretical framework

In the following chapter the theoretical framework used in the report is presented. First of all, the theory of freight transport and the attitude towards information technology within the business is presented, followed by a presentation of the concept of eCall and the project I_HeERO. Thereafter, the concept of software ecosystems is presented with its characteristics and possibilities.

3.1 Logistics and freight transport

The term logistics is a widely used term considering many aspects of the society today. The term originates from military and the aspect of military operations considering the procurement, distribution, maintenance and replacement of materiel and personnel (The American Heritage dictionary of the English language, 2011). A broader term is logistics to be the planning and coordination of details of any operation (Random House Kernerman Webster's College Dictionary, 2010). In the report the area of interest is the logistics of road freight transport. Freight transport is the physical process of transporting commodities and merchandise goods and cargo.

3.1.1 Current situation of freight transport

The whole transport industry is today facing increasing demands on reducing as well the environmental impact as the cost of freight transport (Sternberg et al., 2010). Research has shown that transport planning, system integration and control are some of the factors to achieve these goals and reach more sustainable transport set-ups. One of the main barriers to a more sustainable transport future is, according to Sternberg et al. (2010) the complexity of the supply chains of transport today. The supply chains often act on an international market with several involved actors. According to Andersson and Sternberg (2016) the transport industry is characterised by high information barriers, and the lack of transparency in the business is linked to a growth of unsustainable business practices.

Traditionally, research in logistics and supply chain management suggests that transport activities typically take place within relatively simple constellations with relationships of dyadic or triadic relations between shippers, transport operators and customers (Bask, 2001). There has as well been literature discussing collaboration between shippers and transport operators, among other by (Esper and Williams 2003) as well as collaboration between transport operators themselves (Schmoltzi and Wallenburg, 2011). The results are according to Sternberg (2013) generally described as positive and the collaboration gives high effect in relatively simple organisational structures. Sternberg, Germann and Klaas-Wissing (2013) on the other hand describes a situation that is more complex, with more actors and more relationships among them. Sternberg, Germann and Klaas-Wissing (2013) explains that the supply chains today have inter-organisational constellations of multiple actors with different functions, and actors can have different functions in different constellations. It is suggested that the structures of contemporary road freight transport markets have a majority of transport operators operating very small fleets. There is as well a high level of outsourcing in freight transport (Deepen et al., 2008).

The case study of Sternberg et al. (2010) show the big complexity of supply chains today. The transport market is highly fragmented, making planning and control of the supply chain very complex. The transport market has intermediaries which add to the complexity. Since the business is dependent on human and truck resources, which results in a need for planning coordination and control spanning over the company borders (Sternberg et al., 2010). The

different actors and their relationships result in several nested levels of planning, control and outsourcing (Sternberg et al., 2010) To gain an understanding of a possible situation, a presentation of a framework for transport planning is presented in Figure 2 presenting the complexity of freight supply chains (Sternberg et al., 2010).

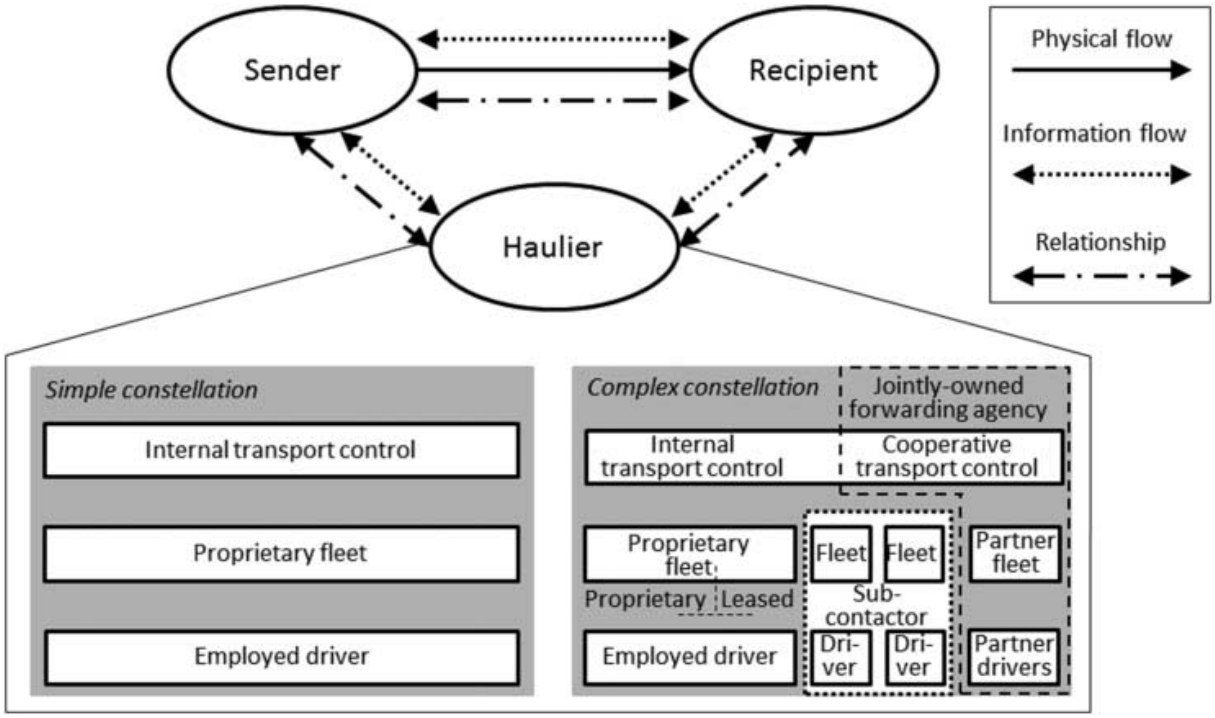

Figure 2 Expanded framework for transport planning and control (Sternberg et al., 2010).

3.1.2 Communication in freight transport

Introducing the complexity of freight transport in the section above, there is an increasing need for integrated planning and control and information sharing, possibly via information and communications technology between the actors involved in order to increase the transport efficiency in the supply chain. Sternberg et al. (2010) present a barrier in the fragmented market structure, where there are many small- and medium-sized market players, which impede such integrated approaches.

Today the transport business is affected by information asymmetry. Information asymmetry is essentially a substantial information advantage on behalf of the seller (Andersson and Sternberg, 2016). Information asymmetry causes a general decline in price as well as quality to the detriment of the buyer of products or services. It can also force companies selling high quality services and products to either sell lower quality goods or eventually close the shop (Andersson and Sternberg, 2016). When the average market price declines too low, it generates pressure on behalf of the sellers of services or products to transform internal cost to negative externalities. This has direct negative impact on all three aspects of sustainability; social, economic and environmental (Brundtland, 1987).

In order to impede such kind of development, increased regulation and increased information transparency is recommended (Andersson and Sternberg, 2016). In an era of digitalisation and big data it seems reasonable that the big amount of information available, predominantly through the Internet, would have a direct effect on the transparency.

3.1.3 Transparency in road freight transport

There has been a considerable amount of research project in information technologies in the freight transport industry. One issue regarding the reviews of European research projects where that the main effort has been to research technology oriented solutions rather than adoption studies (Sternberg, Prockl and Holmström, 2014). Andersson and Sternberg (2016) explain that the transport market is under transformation, since digital solutions reduces the need for transport in general, for example removing the need for physical documents to be transported, however the increase of e-commerce drive the growths of transport and offsets the possible decline in interest in transport.

There are numerous information system innovations that have improved the transport operations efficiency. However, recent initiatives, such as electronic freight documents have not been widely adopted, in spite of attracting significant research funding during many years (Andersson and Sternberg, 2016). These initiatives have failed to have any large impact due to the opaque and fragmented characteristics of the transport industry (Sternberg and Andersson, 2014). There have been examples of some successful sustainability innovation recently, concerning *informating*, where on an individual level embedded vehicle systems used for example routing and guidance have become widely spread. These solutions reduce fuel-consumptions. The difference between the examples is that the latter about *informating* is active on an individual level, rather than on a supply chain level (Andersson and Sternberg, 2016).

According to Andersson and Sternberg (2016) the lack of success when adopting information systems can be explained by the industry logic that is characterised by severe fragmentation resulting in a lack of transparency. The catch 22 is that this very lack of transparency can successfully be addressed by information system measured designed to *informate.* A successful digital strategy has to include information transparency in the stakeholder web. They explain that in a firm level, passive reporting of number is not enough in order to reach a higher level of transparency. On a governmental level, legislating and enforcement is inefficient and some times even impossible. Successful digital strategy promoting sustainability through transparency requires the active participation of multiple parties. Andersson and Sternberg (2016) suggest regarding action design to increase transparency through *informating*, and information systems have to operate on multiple levels, top down and bottom up simultaneously. Transparency is a phenomenon on many levels, encompassing the individual, the group and the organisation levels as well as the entire supply chain and the surrounding society. Creating sustainable transparency using information systems should combine initiatives on all levels mentioned.

3.1.4 Decentralised ICT for freight transport

Many authorities and organisations have applied Information Communication Technology (ICT) in the quest for higher efficiency in freight transport. Sternberg and Andersson (2012) present the concept of decentralised intelligence in freight transport, where ICT is implemented with a higher degree of sohistication than the current standard, which is assumed to have a large effect on the efficiency of the freight transport. Decentralised information communication pushes the control form a top-down control to a bottom-up control, with the intelligent units

contacting a higher level when necessary (Sternberg and Andersson, 2012). For more than a decade, it has been concluded that freight transport is becoming more and more complicated, centralised planning becomes unefficient and difficult. Thus, decentralised and autonomous control of the logistics processes is required (Scholz-Reiter et al., 2004). In combination with an intelligent logistic system, there are as well ideas of the freight transportd being intelligent. According to European Commission (2008) most of the goods transported within European borders will be intelligent in the sense of self-awareness, context-awareness, and connected through a global telecommunication network, which will support a wide range of information services for logistic operators, public authorities as well as users from the industry.

Stefansson and Lumsden (2009) are applying a freight centric perception on logistics, and propose decentralised feight intelligence to improve the efficiency of transport of freight, but acknowlage that the transport compaines interviewed were sceptical to having parameters controlling the freight of the truck.

There are, according to Sternberg and Andersson (2012) some crucial challenges when implementing a decentralised freight intelligence system. The network concept of freight transport in supply chains today demand a critical mass must be achieved in order to be profitable. For people and organisations to implement and adapt new technology, the investment in the technology depend on a chritical mass, and often as well needs some perceived usefulness on the individual level. It is recommended companies implementing ICT to focus on innovations that displays usefulness for the inividual companies and persions first. IT innovation in freight industry and transport is characterised by very complex arrangements of multiple heterogeneous organisations, where incentive is not conductive to the collaborative strategies that decentralised freight dictates (Andersson et al., 2008).

3.1.5 Introduction Barriers to information technologies

The reaction to innovative technologies vary for all actors. According to Siddiki et al. (2015) the respond depend on how motivated the actors is by a range of internal and external factors and the informational and cost barriers they face. Governments often employ various strategies to reduce cost barriers for technologies where a broad adaptation of the technology would benefit the governments broader policy goals. The government can for example make policy-directed investments that subsidize the cost of research and development (Siddiki et al., 2015). According to Damodaran and Olphert (2000) has the rapid technological process during the years from the 1990s made knowledge-based systems, such as information systems and other advanced information technology solutions an integral part of every organisations effort to manage its knowledge assets effectively. Though, it is suggested that it is not the availability of more and more sophisticated technology that is unavailable, instead it is the companies that rely on a *technology push*. Dorethy and King (1998) state that one of the important factors of an information system being used effective in the organisation is the structure and culture of the company. According to Damodaran and Olphert (2000) this is worrying since it has been suggested that a culture of knowledge-sharing is the most important organisational condition for the knowledge management and exploitation to be successful. The article by Iljana et al. (2011) investigate the implementation of an information system. The result show that the uptake of the system was slow, in spite of a committed management and belief in the systems' importance. The major finding was the shortfall between the promise of the system and the actual delivery. According to Damodaran and Olphert (2000) the main barriers towards the utilization of the technology was inadequacies of the technology, lack of user-friendliness of the system, the fact that the current workload was high and there was no spare capacity for new tasks and failure to *institutionalise*, to create a

best-practice around the system and an appropriate culture. Iljana et al. (2011) in some way overlap and extend those barriers in their study of technology adaptation of information and communication technology. Primarily external barriers have been investigated, and suggest that the perceived external barriers were among other factors high cost, security concerns and an unfavourable economic environment. When looking at the internal barriers towards an uptake of an information system, those included poor internal communications infrastructure, a lack of awareness and knowledge of the system, as well as too few managers and workers who were capable of working with the system. Other factors were insufficient financial resources and the perceived lack of relevance or value added by the system (Damodaran and Olphert, 2000).

3.2 eCall

The main idea with the concept of eCall is to facilitate the contact with emergency services for passengers involved in traffic incidents in the European Union through an automated method to alert about incidents in road traffic. According to the European emergency number association (EENA, 2014) there are many situations where occupants of a vehicle involved in an accident might not be able to make a call to the emergency services using a mobile phone, either because of injuries or because the person is trapped. There might as well be situations when the person does not know the telephone number to the local emergency services. Furthermore, there might be situations when the passenger is unable to provide the exact location of the car or accident to the emergency services, not only because they have suffered an incident but as well because they might only have a very approximate knowledge of the location, especially if traveling in unknown areas or abroad. In addition, travellers driving abroad may encounter language barriers when communicating with emergency services. EENA (2014) mentions that there are studies that shows that having a person speaking to a person involved in an accident and caring about what happened have a positive impact on the stress levels of the injured.

According to EENA (2014) the reasons for the need of an automated alarming method for road traffic is that the method automates the notification of certain traffic incidents. eCall transits data from the vehicle and establishes a voice channel between the vehicle passengers and the emergency services. eCall furthermore allows vehicle occupants to manually, possible through a button in the car, alert emergency services of other emergencies in or around the vehicles, such as traffic incidents that do not need the threshold of the automated notification, for example a vehicle passenger with a medical emergency or reporting the need for help on behalf of another person (EENA, 2014). eCall also sends a set of data to the PSAP, with information about the location of the vehicle and its direction on the road to complete the information.

In a non legislative resolution report on *eCall – a new 112 service for citizens* adopted July 3rd 2012, the European Parliament stated that eCall should be a public European Union wide emergency call system, embedded in the vehicle and based on 112 telephone number and on common Pan-European standards (European Parliament, 2007). In April 2015 the European Parliament voted in favour of eCall regulation which require all new cars will be equipped with eCall technology from April 2018 (European Commission, 2015).

In order for the eCall concept to work, there is need for two requirements, technology for the PSAP as well as in-vehicle equipment.

3.2.1 Public-safety answering points

A public safety answering point (PSAP) is a call-centre responsible for answering calls to an emergency telephone number for police, firefighting and ambulance services. A PSAP facility is running 24 hours a day, dispatching emergency services or passing calls to 112 on to public or private safety agencies (Techopedia.com, 2016).

Most PSAPs can now identify caller locations for landline calls as well as determine the location of mobile phone callers. Each PSAP has between two and 12 answering point units. These receive land-line and wireless enhanced emergency calls. For a land-line caller, the answering point units shows the name, address and number. For a wireless caller, the system displays the address of the wireless tower that delivers the call, the mobile number and the estimated location of the caller (Techopedia.com, 2016).

There has to be new procedures developed for the PSAPs in order to handle eCall. eCall have to receive the same treatments as traditional calls to the emergency services in regards of priority, privacy, language and other factors. Although, there are special situations that the PSAPs have to take into account regarding eCall. As both data is sent and voice connection is established, there might be situations that the persons working at the PSAPs are not used to, for example silent calls but MSD is available, or that the voice connection is established but nobody speaks (EENA, 2014).

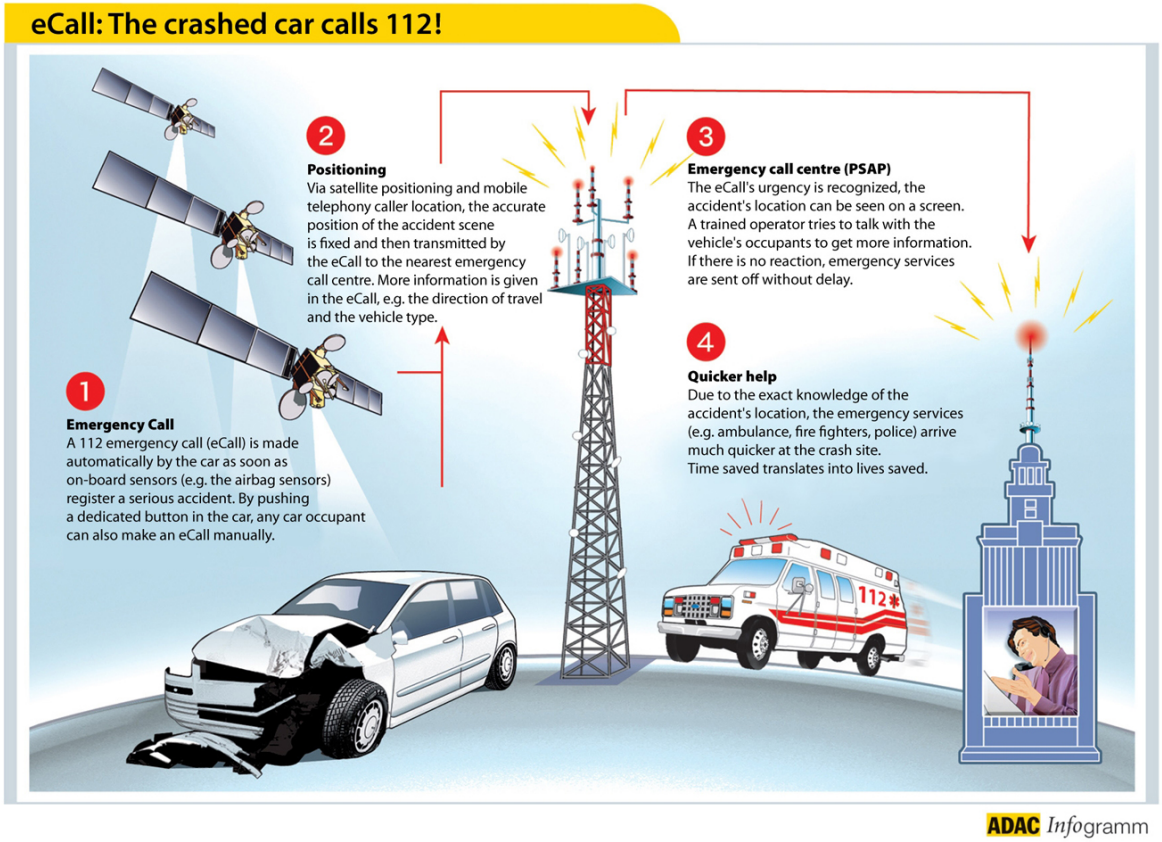

Figure 3 Introduction to the functionality of eCall (E2e.ti.com, 2016).

3.2.2 In-vehicle equipment

In case of a vehicle accident, an eCall-equipped car automatically calls the nearest PSAP (European Commission II, 2016). The eCall system in the car sends details of the accident to the rescue services, including the exact position of the vehicle, the direction of the travel and the time of the accident (EENA, 2014). The Pan-European eCall uses the 112 telephone number to send data and to establish the voice channel between the occupants of the vehicle and the emergency services (EENA, 2014).

EENA (2014) explains that the legislation from the European Commission for the in-vehicle equipment will be dealt with by an amendment to the Type Approval Regulations. This means that if a vehicle manufacturer wishes to sell a vehicle in Europe the vehicle must comply with Type Approval from March 31st 2018. eCall will form part of the type approval regulations for all new types of passenger cars and light duty vehicles, as well as the right of the vehicle owner to use a third party service eCall in-vehicle system providing a similar service, in

addition to the 112-based eCall in-vehicle system (European Parliament, 2015). Pan-European eCall and third party service eCall will potentially co-exist (EENA, 2014). In Figure 3 the functionality of eCall is explained by E2e.ti.com (2016) with the different technologies and actors involved when eCall is activated.

3.2.3 Means to initiate eCall

eCall can be initiated either manually or automatically from the personal car. If manually initiated, the passengers of the vehicle will trigger the call to emergency services (EENA, 2014). The design and implementation of the mechanism has yet to be decided upon by the vehicle manufacturers. An automated call will deploy in case of an accident if one or more sensors generates an automatic eCall with immediate transfer of the accident data (EENA, 2014). EENA states that the generation of this type of eCall is dependent on the sensor system of the car.

3.2.4 eCall stakeholders

Since the triggering of eCall involves different technologies, standards and concepts, there are as well multiple stakeholders involved when deploying the concept of eCall. The stakeholders all have separate interests and responsibilities. According to EENA (2014) the main actors in eCall are:

In-vehicle equipment provider(s)
Mobile network operators
Telecommunication National Regulators
Authorities, can be European, national or regional
Public safety answering points (PSAP)
Emergency response organisations
Third party service providers, in case of third party service eCall
Citizens
Road operators

3.2.5 eCall minimum set of data

When eCall is triggered information is sent to the emergency services. In order for the PSAP to receive as complete information as possible to decide the format of the rescue, a minimum set of data (MSD) has been standardised by the European Committee for Standardisation. Below follows a non-exhaustive list of the standardised data presented by EENA (2014):

- Message identifier: MSD format version, where later versions is to be backwards compatible with existing versions
- Activation: whether the eCall has been manually or automatically generated
- Call type: whether the eCall is real emergency or test call
- Vehicle type: passenger Vehicle, buses and coaches, light commercial vehicles, heavy duty vehicles, motorcycles
- Vehicle identification number
- Vehicle propulsion storage type: Of importance particularly relating to fire risk and electrical power source issues
- Time stamp: Timestamp of incident event
- Vehicle location: determined by the on-board system at the time of message generation. It is the last known vehicle's position, latitude and longitude)

- Confidence in position: this bit is to be set to “Low confidence in position” if the position is not within the limits of +/-150m with 95% confidence
- Direction: helpful to determine the carriageway vehicle was using at the moment of the incident
- Recent vehicle location n (Optional): vehicle’s position in (n-1) and (n-2)
- Number of passengers (Optional): number of fastened seatbelts
- Optional additional data (Optional): in some cases, optional data may be available in the MSD (at the vehicle manufacturer discretion). This data incorporates a tag for the identification in the beginning of the optional data (type and structure identification). This data will be registered and maintained. PSAP will have free access such data registry data.

3.2.6 eCall data registry

In addition to the minimum set of data discussed above, there can be some optional additional data that is not mandatory but still adds valuable information to eCall, such as information about the load a truck is carrying. This information is named eCall HGV, which provides two options. First, a link to an IP address where detail of the content on the HGV can be found, and secondly detail about the cargo on board (eSafetyData, 2016). This data is provided by actors in the eCall concepts, such as PSAPs, insurance companies or automotive companies to the eCall data registry service, and shared between the members (eSafetyData, 2014)

3.2.7 Electronic documents

In 1956 the United Nations Economic Commission for Europe (UNECE) founded the legal instrument convention on the contract for the international carriage of goods by road which is an international convention that regulates international transport of goods on road. The convention forces the transporters to have a responsibility for the goods transported carried, as well as the owner of the goods (UNECE, 2011). In order for governments to manage the growing trade volumes and increasingly complex supply chains, they are adopting new technologies by implementing electronic governance solutions. UNECE explains that electronic documents are a possibility to use electronic consignment notes in international road transport. These documents can be a possible source of information for the concept of eCall.

The information for eCall will be shared through electronic documents. Electronic documents, or digital documents e-documents or eCMR, are secure documents driven by national and international policy and legislation (Trojani, 2009). The European Commission consider an e-document any document in electronic format containing structured data and unstructured data used in the context of an administrative process (Karaklajić et al., 2015). The e-documents are exchanged between organisations, governments and citizens, and different rules apply for different situations. With the usage of e-documents it is possible to obtain more functionality than with the usage of traditional documents. One main aspect is the possibility to search the document, and it would be possible to extract metadata form the documents which could be used for classification and policy access control. Another aspect according to Karaklajić et al. (2015) is the possibility of code recognition, the ability to read a descriptive code in order to identify the electronic document, a service that would possibly decrease the time spent. Another aspect is secure logging. Many organisations maintain very strict policies for security. With secure logging an audit trail can be possible, which can contain information such as who interacted with the e-document, at what time, what kind of interaction and from which device (Karaklajić et al., 2015.

The e-documents needs to be preserved properly as a part of the lifecycle of the digital documents. All documents have a specific retention period, and are stored in a document management system. The e-documents can be stored locally, and government e-documents shall as well be stored nationally if its content possesses national archival value (Karaklajić et al., 2015). After the retention period, the process of deleting e-documents requires authorisation from authorities, when the e-documents are government documents (Karaklajić et al., 2015).

3.2.8 I_HeERO

Infrastructure Harmonised eCall European Pilot (I_HeERO) is a pilot project, supported and partially funded by the European Union, with the objective of preparing and expanding the deployment of public-safety answering points (PSAP) in European countries. The I_HeERO project is developing an implementation plan for its twelve member states, which will allow an upgrade of their infrastructure to support eCall as a true Pan-European concept. The main goal is to support implementation of eCall PSAP infrastructure in Bulgaria, Cyprus, Czech Republic, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Portugal, Romania and Slovenia. The second goal of the I_HeERO project is to support a study into how eCall could be adapted to the needs of vehicle types other than cars such as buses, coaches, motorcycles, trucks, and to look into new technologies and standards (I_HeERO, 2016).

The project proceeds from January 1st 2015 to December 31st 2017. I_HeERO builds further on earlier projects where pre-deployment of eCall started with the European Union co-funded projects HeERO and HeERO 2. In these earlier projects, 14 European Union participating member states and one associated country analysed the feasibility and robustness of the eCall service with pilot installations on both the PSAP and the vehicle side of technology. The I_HeERO project draws directly from the results of the earlier projects and aims to add real world value to the work already done, and aims to achieve mandatory deployment of eCall based on the 112 telephone number for member state PSAP by October 1st 2017 (I_HeERO, 2016).

I_HeERO is taking into account both heavy goods vehicles and buses and coaches, and will prepare for deployment of eCall for heavy goods vehicles, dangerous goods and long distance coaches, as well as two wheeled vehicles. A central aspect of the project is to look into advancements in the management of data for emergency calls via eCall. If a truck is involved in an accident, emergency services could benefit from knowing what goods are carried by that truck before they reach the scene of the accident, especially if the truck is carrying dangerous goods. Even information on other types of goods being transported could be of benefit to the emergency services. Many paths are tackled, from how to get real time information on the cargo during the whole trip, through potential use of e-documents as source of data for the eCall; to the definition of reliable source on dynamic passenger data, and the creation of dependable connections between data sources on passengers and PSAPs. While digital transport documents, such as e-documents, hold promise of improving efficiency of logistics chains they are also becoming a key element in improving road safety. Therefore, the I_HeERO project intends to create a bridge between these two often disconneted fields, logistics efficiency and road safety (I_HeERO, 2016).

3.3 Software Ecosystems

The term software ecosystem has been around for more than ten years. The oldest definition found was stated in 2005 by Messerzmitt and Szyperski, who defines it as "Traditionally, a software ecosystem refers to a collection of software products that have some given degree of symbiotic relationships." Further on, more definitions have been found as the term evolved and became more mature. In a systematic literature review of software ecosystems research by Manikas and Hansen (2013) it is found that the papers in the review refer to five different definitions of software ecosystems. The most frequently used definition, by Jansen et al. (2009), is as well the definition mainly used in this report. Jansen et al. (2009) refer to the following definition of software ecosystems:

"We define a software ecosystem as a set of business functioning as a unit and interacting with a shared market for software and services, together with the relationships among them. These relationships are frequently underpinned by a common technological platform or market and operate through the exchange of information, resources and artefacts".

What connects the definitions according to Manikas and Hansen (2013) is that they all have three main elements; common software, business and connecting relationships. This lays the base for the term software ecosystem, and the result is a platform where a set of actors interact, resulting in a number of software solution and services. An example of a software ecosystem is the Apple App store. The Apple device is considered a platform, and in the App store multiple actors can create and sell their applications. There are a set of rules provided by Apple that the actors operating on the platform have to follow. The created applications can be bought by end-users, creating relations between the application creators and the end-user without any interaction with Apple.

3.3.1 The software ecosystem platform

Many times, a software ecosystem is a development from a company with one or multiple products, where the company is redefining its product as a platform. The reason the term software ecosystems is becoming more common is because organisations are facing the difficulty when the amount of functionality required to satisfy customer needs is more than what represents a reasonable investment (Bosch, 2009) (Viljainen and Kauppinen, 2011). By opening up their product into a platform in an ecosystem, the companies also give up part of their control and design capabilities (Ghazawneh and Henfridsson, 2012) to attract open innovation (Yoo, Henfridsson and Lyytinen, 2010). The platform should support the operations of its extensions and the applications build on the platform. As well, the platform should support the deployment activities when new or updated application and extensions are developed. However, there is no guarantee that take on the strategy of software ecosystems will lead to a great success (Ghazawneh and Henfridsson, 2012). Within a software ecosystem, third-party applications are typically end-user applications that are built on top of platform architecture by third-party developers. The third-party developers and applications utilize the assets of the ecosystem that are referred to as platform boundary resources (Ghazawneh and Henfridsson, 2010). Platform boundary resources are the key means for exposing and extending the platform architecture in order to facilitate third-party application development (Ghazawneh and Henfridsson, 2010), and an important factor for successful ecosystems. In order for a software platform to function for a long period of time, through developments and changes, there should be a clear extension model for the platform, facilitating development for as well the applications built on it as for the platform itself.

3.3.2 Trade-offs in software ecosystems

According to Knauss et al. (2014) a growing number of software systems are characterized by interdependence with other software systems. Such software system constellations often promise increased innovation power and support for customer oriented software services of scale. These kind of software systems are characterised by a certain openness of their flows of information. While such an openness supports project and reputation management, it also brings some challenges to the requirements engineering within the ecosystem (Knauss et al., 2014).

By opening up and attracting third party actors into joining an ecosystem, an organisation increases its innovation power and market reach (Knauss et al., 2014). There are different strategies regarding openness for a software ecosystem when initiating and maintaining the ecosystem, and the openness varies in a range from closed information flows around a defined set of actors to a more open information flow, such as in open source ecosystems, as can be viewed in Figure 4 (Knauss et al., 2014).

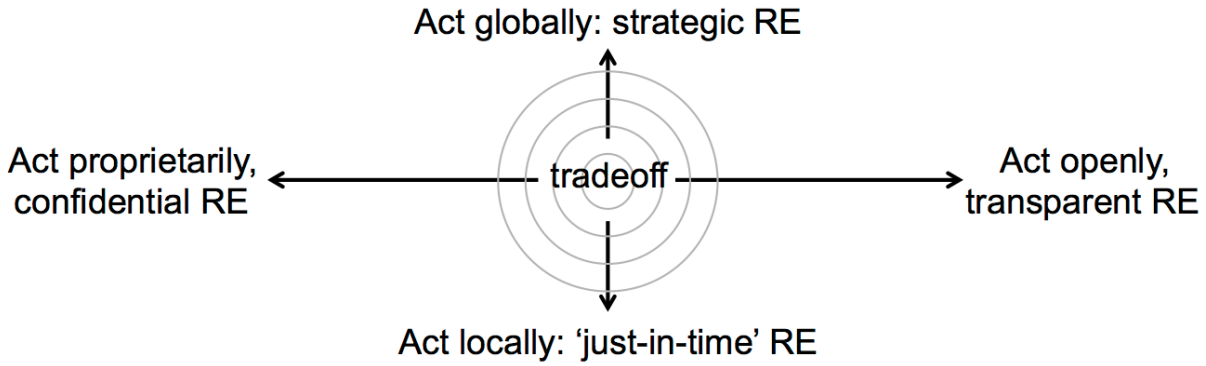

Figure 4 Trade-offs in software ecosystems (Knauss et al., 2014).

According to Knauss et al. (2014) there are underlying trade-offs that openness and transparency brings to how requirements are managed within the ecosystem, as well as the factor of acting locally or globally, as can be seen in Figure 3. Knauss et al. (2014) present an open-commercial approach to an ecosystem, where every actor in the ecosystem has access to an issue tracker where the current progress of the project can be viewed. Such an approach facilitates the communication and information flow between actors in the ecosystem, from end-user to software managers. This level of transparency in the information flow can be an opportunity in how software project are engineered. On the other hand, there can be cases where customers of the software system are reluctant to sharing information needed in projects, for example old reports or information that would facilitate the work on the current project, since the customer considers this information immediately relevant for their central business processes. Knauss et al. (2014) suggest that at solution to the openness trade-off is to introduce layers between customers and developers, where sensitive information is shared from the customers to the developer in charge. This strategy hinders the information flow, significantly adds to the management effort and increases the effort to create a holistic product strategy that is in line with context specific requirements of specific customers.

Knauss et al. (2014) introduce the trade-off of acting globally versus acting locally, as can be seen in Figure 4. In order to define a global strategy in a software ecosystem that often is complex, a strict top down approach is suitable. It is acknowledged the other side of the spectrum, where there are very local decisions, that is needed in order to adjust services to meet the ever changing consumer needs. In constantly evolving software ecosystems, these fast and agile decisions ask for local empowered development teams.

3.3.3 Benefits of a software ecosystem

A software ecosystem involves many different actors and companies, all with different goals. According to Bosch (2009) there are at least two reasons why a company would be interested in moving towards a software ecosystem. In main, the organisation may realise that the amount of functionality that is needed in order to satisfy the needs of their customers is far greater that what can be built in a reasonable amount of time and with a reasonable investment. Secondly Bosch (2009) adds that the trend of mass customization drives the need for a significant investment in research and development in order for a software application to be successful. The two reasons mentioned above are driving forces behind the emerge of a software ecosystem, for instance for companies that have reached success with its earlier software product may now be compelled to open up the product and develop it into a platform where other actors can contribute as third party providers.

There can be many appeling reasons for a company to move towards a software ecosystem structure. Bosch (2009) lists multiple arguments for a software ecosystem approach:

- Increase value of the core offering to existing users
- Increase attractiveness for new users
- Increase stickiness of the application platform, meaning it is harder to change the application platform
- Accelerate innovation through open innovation in the ecosystem
- Collaborate with partners in the ecosystems to share cost of innovation
- Platformize functionality developed by partners in the ecosystem (once success has been proven)
- Decrease total cost of ownership for commoditizing functionality by sharing the maintenance with ecosystem partners (Bosch, 2009)

3.3.4 The nature of software ecosystems

Software ecosystems consist of different aspects, both technical and social. Below, the architecture, software engineering and the business and management aspects of a software ecosystem are introduced, as well as the roles and relationships.

3.3.5 Software ecosystem architecture

Software ecosystems, as mentioned before, consists in large of a platform and several actors and their relations. In order for a software ecosystem to function properly, other aspects of the ecosystem have to be taken into consideration in order for it to function and develop.

3.3.6 Software ecosystem software engineering

The technical aspect of software ecosystems is central in order for everything to function and for the continuous use of a platform and its extensions. According to Manikas and Hansen (2013) the software architecture of a software ecosystem should support the nature of the ecosystem, meaning that it should be adapted to the needs of one specific software ecosystem. The architecture should as well follow the software ecosystem management, restriction and business rules and allow the integration and existence of multiple functionality in a secure and

reliable manner (Manikas and Hansen, 2013). Viljainen and Kauppinen (2011) suggests a modular and flexible architecture, which would result in easier integration and interoperability of the already developed software. As the software constantly evolves the process requires adaptation of the software development processes. The continuous development of the software should, according to Bosch and Bosch-Sijtsema (2010) be integration-centric, the deployment should be independent and releasing of updates and new software should be organized in groups.

3.3.7 Software ecosystem business and management

For all software ecosystems there is an organisational and management entity responsible decision making, monitoring and operation of the software ecosystem. In order to ensure that the software ecosystem is functioning well, specific measurements should be introduced in order to provide an overview of the state of the software ecosystem, as well as the possibility to compare software ecosystems (Manikas and Hansen, 2013). This concept is referred to as the health of the software ecosystem (Iantisi et al., 2004).

After monitoring the software ecosystem and concluding decisions, next step is to execute the decisions. According to Viljainen and Kauppinen (2001) one way of execution is communication within the organisation. A clear view of the direction that the ecosystem would move towards and communication of this view to the actors in the ecosystem and involved parties is emphasised as a necessity. Long-term strategic planning of the ecosystem allows each actors to plan their actions and activities in the ecosystem and align their business models with the roadmap of the software ecosystem (Kakola, 2010).

Business is one of the main elements in the definition of a software ecosystem. Manikas and Hansen (2013) explains in their literature review that the term *business* implies a wider sense of the word, rather than solely profit or revenue models. The terms as well includes possible benefits outside the financial revenues, for example the benefit an actor would obtain by the involvement in a project. Without a solid business and business model serving the software ecosystem and the actors within it, the ecosystem is threatened to loose its actors to competitive business ecosystem and by extension risk extinction. Worth noting is that the value for the actors not have to be financial., a software ecosystem might include other benefits than benefits in its business model. A good example is the possible advantage over competitors or visibility in the market (van Angeren et al., 2011). According to Manikas and Hansen (2013) this implies that the traditional software company business models where the revenues are a result of the selling of software licences can not be fully applied in the concept of a software ecosystem.

3.3.8 Roles in software ecosystems

Manikas and Hansen (2013) state that an open technological platform with a set of management processes and business models cannot create a software ecosystem without the social aspect, and continues that a community or a social network communicating and interacting, both with the platform and among themselves, is essential. Because of this interaction, the platform has to be designed with this in mind (Manikas and Hansen, 2013). The management process and business models become more complicated while at the same time the evolution of the system is faster and towards several directions while the software ecosystem gains privileged position in the market (Manikas and Hansen, 2013). There are multiple actors who can be a part of the software ecosystem. In the literature review, the following were encountered in the literature and will be referenced in the report.

Platform owner is, according to Manikas and Hansen (2013) a company, department of a company, a set of actors, community or independent entity that is responsible for the function and well-being of the software ecosystem. This entity is traditionally managing the ecosystem by running the platform, creating and applying rules, processed, business procedures, setting and monitoring quality standards and/or orchestrating the software ecosystem actor relationships (Manikas and Hansen, 2013).

Niche player is the actor in a software ecosystem who contributes to it by typically developing or adding components to the platform and producing required functionality from customers. This actor is a part of the software ecosystem and complements the work of the platform owner by providing value to the ecosystem (Manikas and Hansen, 2013). The niche players might influence the decision making in the software ecosystem management, depending on the management model.

External actor is an entity who make us of the possibilities the ecosystem provides and because of this provides indirect value to the software ecosystem ecosystem. This actor is external to the ecosystem management and usually has an activity limited to the actors' interest. (Manikas and Hansen, 2013). Dependent on the software ecosystem management the external actor might develop on top or parallel to the software ecosystem platform, promote the ecosystem or its products and purpose improvements.

Vendor is defined by Manikas and Hansen (2013) as an entity that is is mainly a company or that makes profit from selling the products of a software ecosystems to customers, end-users or other vendors. The products sold might be complete integrations, components or selling or leasing licenses or support agreements. A vendor that is modifying the software ecosystem product by combining components or adding functionality for example, VAR.

Customer or End user is the person, company or entity that either purchases or obtains a complete or partial product of the software ecosystem or a niche player either directly from the software ecosystem/niche player or trough a vendor (Manikas and Hansen, 2013).

3.3.9 Relationships in software ecosystems

Different software ecosystems apply different models for allowing actors to contribute to the ecosystem. According to Manikas and Hansen (2013) these models are many times related to the nature of the platform, and to what extent it allows or supports different kinds of collaboration, but the main factor is the business model behind the software ecosystem. The openness and closeness of a software ecosystem describes how easy it is for an actor to access and participate in an ecosystem. The level of openness depends on parameters outside of the ecosystem social network perspective, according to Manikas and Hansen (2013) but is analysed as a part of it since it is of such weight for the social network. te Molder et al. (2011) claim that the openness and closeness of a platform not is binary, but there are many different levels. Jansen et al. (2012) make a separation between the supply and demand of a software ecosystem and say that a software ecosystem can choose to open either or both supply and demand.

Riis and Schubert (2012) analyse in their article how relationships evolve when a software ecosystem vendor is pushing an upgrade to a newer version. Here, the relationships are push-oriented, where the vendor pushes the updates to the vendors and eventually to the customers. The relationships can as well be pull-oriented, where the customer might request an older version from the vendors and eventually from the platform owner. Popp (2010) numbers three

distribution channels, the first direct through vendors, secondly indirect through service organisation and third and last direct to customer.

There are many ways of describing relationships in general and as well in software ecosystems more specifically. Yu et al. (2008) use the natural symbiotic relationships in the software symbiosis, mutualism, where both systems benefit from their relations with each other, commensalism, where one system benefits form the relations and the other is unaffected, parasitism, where one system benefits while the other system is harmed by the relationships, amensalism, where both systems are harmed and finally neutralism where none of the systems are affected by the relationships. A study by Kabbedijk and Jansen (2011) investigates at the interaction of developers within a software ecosystem and noted three different roles. The Lone wolf, who operates mainly alone and produces a big part of the system used by others, the Networker who is connected to many of the other developers and finally the One-day fly that have created only one popular component without significant work afterwards.

3.3.10 Level of ecosystem stack

A software stack is a group of programs that work in tandem to produce a result or achieve a common goal (Techopedia.com, 2016). The term can as well refer to a set of applications that works in a specific and defined order toward a common goal, or any group of utilities that work as a set. There are three levels of a stack, top, middle and bottom level, which refers to the various architectural layers that provide the delivery. There are more providers on the top level than on the middle and bottom level, as shown in Figure 5.

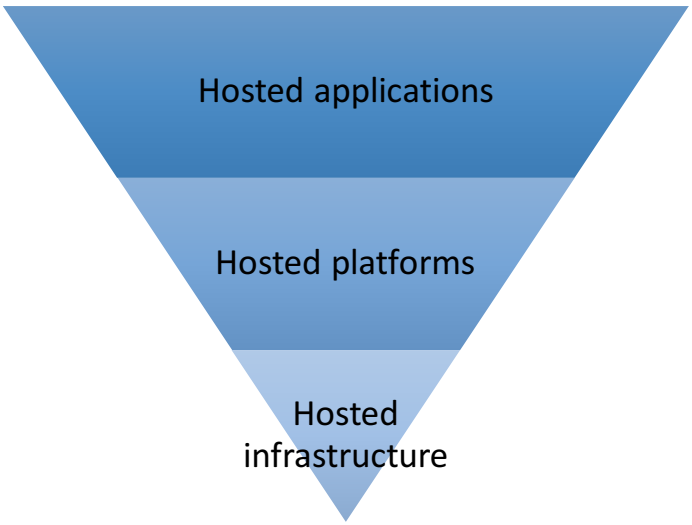

Figure 5 The three levels of ecosystem stack.

The bottom level, the *hosted infrastructure,* forms the foundations that is needed for services to function, and includes physical infrastructure and computing resources such as servers and storage capacity, to name two. This level is the basic functionality needed in a software ecosystem. The middle level, the *hosted platforms,* provides an operational environment for the management, development and deployment of solutions. There are more actors in the level of hosted platforms, as the model in Figure 5 illustrates. The top level, *hosted applications,* provides software applications to its end-users and customers (Apprenda, 2016). The third level has more actors than the other two, as these software requires less effort and are not as crucial to the software ecosystem as the two lower levels.

3.3.11 Extension market

According to Jansen, Brinkkemper and Cusumano (2013), many software are ecosystems centralised around a market of extensions, sometimes known as app stores or app markets. An ecosystem can have no extension market, a simple list of extensions, an actual extension market, a commercial extension market and multiple extension markets. If there is no extension market, components may be available through known third party providers. A list of extensions is a more mature way, where for example the developer contributions can be listed on a webpage. The next level enable parties to distribute and level sell their extension on the market. A commercial extension market is used by the owner to make money. The final example of multiple extension markets, when for example the platform owner is not interested in creating its own add-on store and left it to the market to create the solutions (Jansen, Brinkkemper and Cusumano, 2013).

3.3.12 Governance of software ecosystems

The governance of ecosystems includes strategic decisions of what to offer to the actors as well as how to design the platform in order to have the best actors.

Roadmapping

A roadmap is a plan that matches short-term and long-term goals with specific technology solutions that help meet the goal. Historically, software development has been characterized by disconnects between, planning development and implementation (Fitzgerald and Stol, 2015). It is argued for a continuity in the activities of software development and presents a roadmap for continuous software engineering. According to Bosch (2009) the best long term approach for a software ecosystem is to publically release a long term platform roadmap that indicates the intentions of the platform company. This would allow external developers to move towards more differentiating functionality, at the same time as abandoning the area where the software company intends to move into (Bosch, 2009).

Niche creation

Niche Creation is the ability of the software ecosystem to increase meaningful actor diversity over time (Manikas and Kontogiorgos, 2015). Niche creation is measured in two terms, first the growth in company variety and secondly growth in product and technical variety, also called value creation that measures the increase in value the growth brings (Manikas and Kontogiorgos, 2015).

Entry barriers

The entry barriers of a software ecosystem are there to ensure that only the right companies can join the ecosystem (van den Berk, Jansen and Luinenburg, 2010). If the entry barriers are too low it can risk a decreased stability of the software ecosystem because of uncontrolled growth and loss of quality, both in developers as well as the components they develop. This increases a risk of an unhealthy ecosystem (van den Berk, Jansen and Luinenburg, 2010). On the other hand, if the entry barriers are too high then innovation is at risk. Too many companies can be scared away by high entry barriers and instead move to other, competing software ecosystems, which can have a negative effect on the niche creation (van den Berk, Jansen and Luinenburg, 2010). An example of an entry barrier in the application approval policy of Apple for the iPhone OS. The rationale behind this is that applications cannot contain inappropriate content or degrade the core experience of the iPhone, in turn assuring quality, but it also leads to lower niche creation as developers are scared away by these

imposed entry barriers. Choosing the right balance quality and innovation is central for the health of a software ecosystem.

3.4 Ecosystemability Assessment Method

The Ecosystemability Assessment Method (EAM) presented by Knauss and Hammouda (2014) is a method intending to assess the extent to which a software system, represented by its architecture and its development environment, supports the vision of ecosystem. the model is used to evaluate software ecosystems in order to understand in that area, here called themes, an ecosystem should be improved in order to increase the benefits of an ecosystem. As described earlier in the report, a software ecosystem has been defined as a set of businesses functioning as a unit and interacting with a shared market for software and services, together with the relationships among them (Jansen and Capelleveen, 2013). Jansen and Capelleveen (2013) explains that the relationships often are underpinned by a common technological platform and operate through the exchange of information, resources and artefacts. The technological platform in a software ecosystem is often represented by a software system, enjoying various levels of openness. There are multiple aspects to a software ecosystem, considering as well the technical aspect of a functioning platform, as well as business incentives for external actors to interact in the ecosystem as well as future possibilities if an actor decides to involve the company in the ecosystem. Knauss and Hammouda (2014, p.1) define the *Ecosystemability* as "… To which extent a software system, represented by its architecture and its development environment, supports the vision of ecosystem". Since the trend of software ecosystems is relatively recent there are, according to Knauss and Hammouda (2014), little technical guidelines on how to grow and maintain a sustainable ecosystem.

The EAM seeks to extend previous work on evaluating software ecosystem architecture and aim to include other aspects, such as stakeholders, both internal and external, quality attributes and output of the software ecosystem. earlier work has not been focusing on all aspects of a software ecosystem, but rather on separate parts, such as the architecture. EAM is quality-centric, focusing on three EAM assessment themes, *Nature of ecosystem, Governance* and *Software platform.* In the *Nature of ecosystem* theme, the degree of openness, the level of ecosystem stack and extension market is viewed and analysed. In *Governance,* roadmapping, niche creation and entry barriers of the possible ecosystem is presented and analysed and finally in the *Software platform* theme, the extension model, deployment activities supported and operation supported by extensions are documented. With these three themes and eight sub-categories the ecosystem is evaluated, and together they build a complete picture of the current ecosystem as well point out in what areas an ecosystem should improve. The themes are presented in Table 1 (Knauss and Hammouda, 2014) below.

Table 1 The Ecosystemability Assessment Method, based on Knauss and Hammouda, 2014

Theme	Item	Significance
Nature of ecosystem	• Degree of openness • Level of ecosystem stack • Extension market	There is a tradeoff between the need to protect intellectual property and the need to be open with partners in the software ecosystem.
Governance	• Roadmapping • Niche creation • Entry barriers	A software ecosystem with high entry barriers can afford lower understandability than a software ecosystem with lower entry barriers, aiming for not discouraging a continious stream of new actors.
Software platform	• Extension model • Operations supported by extensions	Reasons to limit the freedom and power of extensions include the ability for non-functional testing of the whole system or to protect the business model of the software ecosystem market place. The architecture of the technological platform should be designed to enforce such decisions.

4 Empirical results

In the following chapter, the empirical data from interviews are presented. The interviews were held with eight parties in six interviews from which information is presented. The information is presented in the interviews respectively, and an overview of the interviewees can be found in Table 2 below.

Table 2 The interviewees of the study

Interviewee	Title	Company	Knowledge
Lennart Liljeroth	Responsible operative IT support, future IT solutions	Emergency services, Göteborg municipal	• eCall possibilities and barriers • IT communications solutions effects on emergency services • Dangerous goods
Anders Berger	Transport solution specialist	Volvo Technology	• ICT solutions for truck manufacturers • ICT effects on halauge contractors • ICT in road transport
Magnus Andersson	Research manager	Viktoria ICT Sweden	• Digitalisation of freight transport • eCall • Digital documentation
Mikael Johansson	Law, safety and regulations	Volvo Trucks Technology	• Safety and security regulations in truck industry • eCall for trucks • Barriers to eCall implementation
Claes Avedal	Safety manager	Volvo Trucks Technology	• Safety and security regulations in truck industry • eCall for trucks • Extension market
Patrizio Pelliccione	Associate professor	Chalmers Univerity of Technology	• Software ecosystems
Eric Knauss	Associate professor	Chalmers Univerity of Technology	• Software ecosystems
Jørn-Henrik Carstens	Senior advisor	ITD	• Freight transport industry • ICT barriers in freight industry

The interviews are structured individually and every interview stands for itself. The interviews are structured after the EAM model, presenting each interviewees interests and opinions divided into the themes and sub-categories of the EAM model, presented in chapter 3.7 Ecosystemability Assessment Method in order for the information to be accessible. In the final sub-chapter of chapter 4.7 Illustration of empirical data in the EAM method an overview of the empirical findings is presented, stating some of the main points from each interview in relation to the analysis model of EAM.

4.1 Lennart Liljeroth, Greater Göteborg Fire and Rescue services

Lennart Liljeroth is working as a responsible for the operative IT support in the emergency services in the greater Göteborg, Sweden. He has a history of working with different projects related to future IT-solutions that could possible benefit the emergency services. Examples of this are digital maps and other technological solutions. The interview was held April 26th, 2015 over the telephone from Brussels, Belgium to Göteborg, Sweden.

Governance – Entry barriers

Liljeroth[1] says he believes that there are more advantages than disadvantages with an implementation of eCall in trucks and buses for the emergency services. He believes that the security aspect is of importance for many companies as well as the society in general, meaning that any action towards a safer road infrastructure is beneficial. Liljeroth believes that serious actors within the freight transport would want to take actions towards decreasing the effects of accidents. When asked about possible drawbacks, Liljeroth states that a possible drawback for the emergency services would be if the information sent with eCall about dangerous goods is faulty, if the substance given turns out to be another substance, the emergency service personnel would prepare for the information given to them. When arriving to the scene they would find out the dangerous substance carried by a truck is not what they believed, the personnel would have to rearrange and possibly travel and retrieve other equipment brought to the scene. Liljeroth states that this could be counterproductive and a risk for as well the personnel as the surroundings. Liljeroth states that the person denouncing the information about the dangerous goods sent to eCall have to be trustworthy and credible.

Liljeroth believes that the information about what kind of goods a truck is carrying already is known and in many cases digital in some form, although not in a standardised manner. The issue is to collect the information effective and in a feasible manner make it accessible for the emergency services if an accident occurs. This is, according to Liljeroth, a possible barrier when implementing eCall in trucks and busses. He as well believes that another possible barrier would be the interpretation coming from the eCall concept to emergency services in Sweden. Some of the PSAPs in Sweden are privately operated and some collectively, and the personnel at the different offices need to interpret the information from eCall. There is according to Liljeroth a risk that the personnel are trained differently to handle the information coming in, resulting in a difference of the emergency actions taking place.

When asked about information from eCall from buses, primarily stating the number of passengers of the bus, Liljeroth claims that this is not of great importance. Liljeroth explains that it is not the number of passengers on the bus that is the critical information when a bus is involved in a road accident, but rather the damage on the bus and surroundings. He believes that the emergency services usually receive multiple calls when a bus is involved in an accident, all calls completing each other to create a clearer view of the range of the accident. Liljeroth explains that accidents involving buses always are considered important and receives great attention and big amount of action from emergency service personnel. When an accident involving a bus occurs, often passengers call emergency services, people around the scene and the chauffeur calls to describe the accident. Usually chauffeurs have communications with its company, and the company also contacts the emergency services.

Software platform - Operations supported by extensions

[1] Lennart Liljeroth, responsible operational IT support, Göteborg municipal, interview 26th of April 2016.

Liljeroth explains that he believes that more information in general about an accident where trucks are involved would truly benefit the emergency services. Liljeroth says that dangerous goods are an area where the emergency services could benefit from more information earlier. Usually during an action, the emergency services arrive to the accident not knowing anything about the goods the truck is carrying. When they arrive, they can collect the information about the goods from the driver or form documentation in the cabin. The personnel have to rely on the information they can gather when they arrive. Concerning dangerous goods, there can be multiple types which each require different actions. Liljeroth gives the example that flammable load requires the personnel from the emergency services to wear fireproof suits. If the goods instead are of corrosive kind, the personnel have other suits that they need to wear in order to handle the accident. If the emergency services would receive the information about the accident earlier, such as if a truck is involved in an accident, if it is carrying dangerous goods as well as what kind of dangerous goods it is carrying, the activity could be enrolled more effectively, since the personnel would know more about the accident and prepare beforehand, rather than arriving and then be able to prepare. This would save time for the emergency services by the action being more effective form the beginning, as well as being able to start the activity immediately the arriving to the scene of the accident. This could possibly save lives of people involved in the accident, either in the trucks or in its surroundings, according to Liljeroth. He adds that it as well could be a possible benefit for the environment. If the goods carried by the truck an environmental hazard, a faster action to prevent the spreading of the goods could decrease the effects on the local environment, and in some cases the regional environment. He states that the personnel as well is a concern for him, and more information about an accident would as well protect them in their work.

Liljeroth says that for him, the obvious help from eCall would be the information about dangerous goods. When asked about if he believes that it would be good for the emergency services to have information about any kind of goods that is involved when a truck is in an accident, he believes that information to not be of big importance for the personnel at the emergency services. He says that the information part is to make the information about the dangerous goods accessible for the emergency services when an accident occurs. Other valuable information for the emergency services is according to Liljeroth information about sender and recipient of the dangerous goods involved. Sometimes an accident involves substances that are not known to the personnel from the emergency services arriving at the site of the accident. If so, the personnel are delayed in its work since they have to ascertain what kind of substances is involved and how to handle it. Thereafter, they can act out the appropriate actions. This line of actions is time consuming. If information about sender and receiver was known, the emergency services could contact the parties to investigate what kind of substance it is and how to handle it in the right manner.

4.2 Anders Berger, Volvo Technology

Anders Berger is a transport solution specialist at Volvo Technology. Berger works in projects regarding solution services, and is overlooking a development portfolio together with for Volvo Technology external research funding. Berger is mainly investigating development of services for the end customer, meaning the company or person buying a truck from Volvo Technology. Berger sees an increased interest of services from Volvo Technology customers, and the needs of the customers are usually to increase the productivity. The main work for Berger is to add service content for the customers, and find new ways to find advantages in a business of freight transport, where the competition is hard and ubiquitous. The interview was held April 27th, 2015 over the telephone from Brussels, Belgium to Göteborg, Sweden

Nature of ecosystem – Degree of openness

Berger[2] means that the product Volvo Technology will deliver in the future is service to the customer. Volvo Technology is not there today, but is moving there. The company is moving towards a digitalisation, according to Berger, and attracts the customer with services rather than the material functionality of a truck. Berger means that it is increasingly more difficult to differentiate a truck solely based on the truck functionality and states that the trucks available for the customer today are increasingly looking more alike, delivering the same advantages. What Berger and his colleagues work on is to increase resource utilization of the truck by the customer by offering different services from a central level within Volvo Technology.

Berger believes that for the business of freight transport to change and have more transparency in information sharing, new institutions in the society is needed, as well as new forms for the appearance of the involved organisations. He means that the way it is formed today will not be enough for a new type of system to work. A suggestion from Berger is that this change and new institution would be partially founded by the society. The reason he believes it should partially be founded by the society is because many of the advantages a more transparent network are advantages for the society, such as a decrease of emissions and increased safety. The companies involved in the network do not share their information freely without seeing big benefits, and every actor needs to see an individual benefit. In order for the customers to participate, Berger believes following a shared standard and form of information sharing, which is a commercial risk, and the benefits at a high level is usually for the society.

Governance – Entry barriers

With an increased focus on services delivered digitally, this brings as well advantages as disadvantages, according to Berger. He points at the control of the information from the companies that is possible to share, and that every company involved has information that they can choose to share or not. Digitally connected vehicles can share information with others, according to Berger, but only if this actually favour the company. Berger points out that this is not an altruistic system. The companies are afraid of someone hacking the information, retrieving the information valuable for the company, which would be a big disadvantage for the company.

Berger believes in the value of standardisation of sharing of information. Many Volvo Technology customers have a fleet of vehicles of different brands, and they want the possibility to use them seamlessly together, not having different systems using and sharing information. But, as Berger views it as of today, there is a need for even more sharing of

[2] Anders Berger, transport solutions specialist, Volvo Technology, interview 27th of April 2016.

information in order for a shared information network within freight transport to work. He specifies that a forwarding agent has the information about the customers buying the transport service, the haulage contractor, who is the customer of Volvo Technology, want to make as efficient transports as possible in order to save time, money and distance travelled. The haulage contractor does not want to share the information with other haulage contractors, but would benefit from more information from the different forwarding agents. A solution for this is according to Berger the possibility of more transparency in the business by a cooperation of the different companies, sending their information to an independent trustee. The goal is to use the utilities as effective as possible in order to increase the profits.

Berger believes that when the business model is not working properly, as the current situation of information asymmetry in freight transport today, the solution is legislation. Cooperation within freight transport stills mainly brings benefits for the society.

According to Berger, the incentives for haulage contractor to implement eCall are small. It is hard to calculate the benefits of eCall, as accidents happens rarely, but when they do, the service of eCall is of big value. Berger means that eCall is a kind of insurance for the haulage contractors, something much more difficult to calculate profit from than for example a more effective combustion engine. He also says that the eCall concept does not decrease the damage for the haulage contractor when an accident has happened. Instead, the real improvement eCall adds is community benefit. By adding more service to the eCall platform, the haulage contractors would se more benefits that in a broader sense would be possible to calculate. Then, the cost of eCall would appear less and the incentives appear bigger.

Software platform – Extension model
Regarding standardisation of the communication of trucks, Berger means that the standardisation only goes to a certain level, so that there is still room for competition for Volvo Technology. The companies have to find a level of standardisation so that it is still possible for the competitors to offer additional services.

4.3 Magnus Andersson, Viktoria Swedish ICT

Magnus Andersson is research manager in digitalisation strategy at Viktoria Swedish ICT in Göteborg, Sweden. Andersson is interested in IT innovation. He has published multiple articles in the area of IT within freight transport and is renowned in the area. The interview was conducted in Göteborg, Sweden on 21st of April, 2016.

Nature of ecosystem – Degree of openness

When discussing software ecosystems, the common example of the domain of Apple App store is according to Andersson[3] totally different from a European Union technology platform. Apple is a company that always have been selling technological platforms in different forms. Within freight transport, it would in theory be good if all actors shared the information, but there is a reason to why no actor is currently doing so. The whole business is, according to Andersson, characterised by being closed. As the businesses within freight transport are built today is to not be transparent with information regarding business, and there are no indications that this fact is about to change. Andersson states that this is one of the big mechanisms of how the business of freight transport work today. He gives the example of third part logistics who do not have any physical resources, like trucks, themselves, but have an information network. Because of this information network they are able to find solutions to freight transport, creating value solely out of the information they have. For Andersson it is clear that these actors have no reason to open up this source of leverage for other actors in a network. In order for actors in freight transport to open up and share more information they ned to see enormous winnings and benefits, Andersson believes, and states this to be one of the basic problematic in the industry today. Many actors are there today, which is a problem today when information is shared. This complexity is central when trying to create a network where information is shared. Andersson explains that this complexity gives that a network would be much more complex than the comparison of Apple App store. The work with information transparency n the transport sector is a big project, according to Andersson, and in order to succeed the central issues of the industry have to be addressed.

Andersson believes that there is an overconfidence today in the idea of open platforms within freight transport and their ability to attract new services. He says the the possible implementation and adaptation is more complicated that people in general want to believe. He says that there are certain buzz words one should be critical towards, such as open systems and ecosystems. Andersson says that one has to be careful when starting that something is open. He continues that the term needs to be defined and actually discuss how open things are. He gives the example of the rules and legislations very seldom being open and that this aspect is something that the platform owner in general is in charge of. There are according to him few exampled where all actors have access to something that is called open, and that it is impossible for every actor to make decisions and organize the Apple App store. There is one actor controlling the platform with a firm hand, which is the usual way according to Andersson. Ecosystems where all actors are equal with equal power of the platform a considerably rarer.

Andersson is in general sceptical towards an implementation of eCall for different reasons. He states that eCall is the safety solution for road transport developed furthest by the different solutions available on the market today. Andersson is sceptical towards governments deciding upon overall solutions like eCall, but he states that there is an obvious benefit of working the

[3] Magnus Andersson, research manager, Viktoria ICT Sweden, interview 21st of April 2016.

way authorities have worked with eCall, since it took a long time for connectivity to be spread within the car industry on its own. He says that that it is not in any way certain that a model where each car manufacturer creating its own safety solutions equal to eCall would have been better, but one would have avoided the situation of conflict there is today between authorities and other actors involved. Andersson as well discuss the equality aspect of eCall, which is an obvious benefit when government deciding upon solutions. If each car manufacturer would have implemented their safety solution in their cars, only premium cars would have had that functionality, meaning that people with one pays for a better security. eCall, implemented in all cars, is in some way a more equal solution regarding road safety.

Nature of ecosystem – Extension market
Andersson gives examples of other software platforms initiated by authorities, as there have been multiple initiatives in the past regarding software for the society. Historically when a software system is implemented and up and running, the authorities realize that some added functionality would be beneficial, whereupon the authorities adds this functionality and thereafter calls the system *open*, according to Andersson. The reason the authorities calls the system open is because they believe this would attract new actors. Though, after additional functionality is added and the software opened towards new actors, there are not any incentives for the actors to interact with the system or to share information. Just because a system technically is build with functionality for sharing information, does not mean that actors actually are willing share information in the system or use the system at all. If no business models or incentives are connected to the system, Andersson means that there are no incentives for external actor to interact, and in the end that the solution in a way is not worth anything at all. There are according to Andersson many examples where solutions are built but not used, because the organisational and business reasons are simply not there.

Governance - Roadmapping
The European Union work regarding software systems today is very rigid, according to Andersson. This affects every projects where the European Union is involved, he says. This is how the institution works and would as well affect the eCall concept as a software platform in an ecosystem, he believes, making the solution rigid and hard to operate and interact with for the external actors. This fact needs to be taken into consideration is planning a software ecosystem project where the European Union is involved. In relation to creating a software ecosystem where governance is involved is the issue of creating an attractive ecosystem, according to Andersson. He believes that it is of importance for the software platform to be able to offer the sight kind of services for the involved actors and incentives for the actors to have an urge to cooperate and interact in the ecosystem.

The implementation of e-documents is slowly starting to show in the industry, according to Andersson. Although, he states, that this is rather a solution of digitalising documents, for documents in pdf-form instead of a physical document. The solutions are not yet showing the functionality of e-documents, where it is possible to search the documents or create statistics from them. The current implementation does not, according to him, suggest a seamless system where every actor related to one specific electronic document can take part of the information it carries. Andersson believes that the e-documents not have implicated any change in the work of the actors in freight transport, and the handling of information, no matter what type of documentation, is unchanged.

The idea of documenting the goods carried in freight transport today not only concerns the type of goods carried, by the specific article, like a specific tube of toothpaste. The beliefs of

this kind of documentation are strong, Andersson says, but the industry of freight transport is not close to implementing any solutions for this kind of documentation today. There are fundamental barriers that need to be removed before there can be discussions of solutions for this kind of ubiquitous documentation. Andersson says that he has not seen anyone presenting anything near implementation of a solution like this today. There are according to him many pilots in the area, but none of the solutions have been implemented in a big sector. Andersson believes this is because the actors in freight transport do not understand the complexity of the business nor the complexity this implementation implies.

Governance – Niche creation

Andersson means that as long as the information shared with eCall is information regarding the vehicle, eCall is a good system of sharing that information. Although, as soon as there are interests in sharing other types of data and to document other information, such as driver information or data about the goods carried, eCall is not the right software system. He means that these sources of data are other interactions not in relation with the truck in general. Information about goods or the truck driver, loosely coupled to the vehicle that can be substituted frequently, not is a good thing to document in the eCall system. Andersson thinks it will be hard to legislate this type of information being shared with eCall, as there today are other rules and legislations in the intending to keep this type of information hidden, protecting the inner market in Europe. Andersson also believes that the administrative burden of documenting the goods carried by a truck today is insurmountable today. The way goods are divided into categories to day is very cumbersome today, and he says that this have been discusses for more than ten years, not yet bringing a solution.

Governance – Entry barriers

There are both technical and social barriers towards an open platform, according to Andersson. He says that if generalising, the technical aspect is not the big concern, rather peoples' attitude. There is no need for technical innovations today, but rather a change of how business of freight transport is functioning and its structures. Andersson states that he believes this to be the major challenge. One main structure according to Andersson is the ubiquitous scepticism of sharing data and information within freight transport. There is a complexity of actors wanting to use shared systems and open platforms, but are not willing to share the information needed for the system to work. Andersson states that this is a part of the culture within freight transport and it is not something that the implementation of one system can change. According to him, the culture needs to be changed from the ground up, eliminating the information asymmetry where the transport deliverer has access to the main part of the information about a transport and the transport buyer has little or no access to the same information.

According to Andersson, the technical aspect of eCall is possibly shattering the stakeholders. The current solution of eCall is a closed solution, solely including critical information for the exact functionality of eCall. The idea is according to Andersson not at all to apply new functionality in the future. Instead, there is a big need for implementation for as well software and hardware to handle a limited task. In relation, Andersson describes many projects he has studied where the innovative technical solutions were good but that these initiatives many times were missing a link back to the practice in the freight transport industry when implementing a solution. The technical solutions then did not receive the attention they needed in order to be broadly implemented and used in the industry. In order for eCall to function as a bigger software solution in freight industry, Andersson states that the connection to industry practice is important, and the platform needs continuous improvement Although

the technical aspect of a shared platform is that the platform has to be built strong in order to handle new functionality being added a bit into the future, regarding speed, space and other aspects. This is a very costly continuous process where the platform owner has to see the incentives of keeping the platform alive, according to Andersson.

Andersson explains that one main issue with the documentation of goods in general is the lack of structure on how this information should be documented. Today, there is no requirements of documentations of the type of goods transported, indicating that it first of all is a need for a standardisation of information of goods, before actually sharing it with eCMR, according to Andersson.

Software platform – Extension model

Andersson interprets the basic functionality in eCall, is the eCall technology sending a message if a car stops in a way that is not the usual way, which can imply that there has been an accident. This message then goes to the affected authorities or other responsible organisations. According to Andersson have many car manufacturers been critical towards the implementation of eCall. One reason is that many premium car brands already had started to develop similar techniques, giving basically the same kind of service as eCall, as a service for its customers. With different cars brand having their own safety solutions, this could have been a possible competitive factor for the manufacturers. There are different models when creating and spreading innovation, Andersson says. Andersson gives the example of seat belts, which was not a decree from authorities or the European Union, but a service to increase the security from different car manufacturers, and for the companies to make business form. He asks which model is best to create and spread this kind of innovation, free competition or directives from authorities. He says that it was a big divergence how the companies and European Union viewed this, and is still obvious according to Andersson.
It was a long journey for European Union to come as far as they are today, where they have not gone hand in hand with the vehicle industry. This of course brings disruption to the actors involved in the development and implementation of eCall, he states.

Andersson describes that he has participated in many project with authorities on a strategically level. There are a lot of initiative equal to eCall in the sense of only looking at the small, defined services with no interaction with other solutions. The only focus of eCall is emergencies, for example. Andersson says that he notices that a lot of these projects are authority oriented, meaning that they all work in the same manner, only looking at their single project with no intention of trying to work together. This would in the long run mean many different kinds of hardware and software implemented in cars, not effectively using the resources implemented. The authorities as well often seek for a function that can be statutory, and Andersson claims that these solutions then become cumbersome. Almost all other digitalisation in the society have been developed on other principles than this, says Andersson, and he believes that there becomes a collision there, meaning that the effect of the digitalisation not is the highest possible. He says that the solution becomes sluggish, with the standards set early, maybe too early at times, giving a limited solution. The advantage, Andersson says, is that if the solution is implemented it is a broad solution, similar in all of Europe.

4.4 Mikael Johansson and Claes Avedal, Volvo Group Trucks Technology

Wednesday the 20th of April 2016 an interview was held with Claes Avedal and Mikael Johansson at Volvo Group Trucks Technology (Volvo Trucks. Avedal works as a safety manager, focusing of traffic safety and is included in the discussions about eCall. Johansson works with the aspects of laws and regulations, which includes safety, at the same company. The discussions concerned eCall and the possible implementation of it in trucks, and the effects this could have as Volvo Trucks and its customers.

Nature of ecosystem – Degree of openness

The customers of Volvo Trucks prioritise safety, and this is one of the reasons safety is central for Volvo Trucks when developing new technology, and it is a reason customers stay with Volvo Trucks. A driving force for implementing eCall is the will of the society to become more safe, Avedal[4] believes, but it would as well benefits customers of Volvo Trucks. Avedal and Johansson[5] emphasises that it is important that the PSAPs can handle the calls and information from eCall and sufficient distribute the emergency services. They are both concerned that the services of eCall might be misused, and not solely use the technology if an actual accident occurs. Volvo supports the idea of implementing measures in order to reduce consequences and number of road accidents in Europe, and if there are data and information confirming eCall is improving rescue during a road accident, they both state that eCall could be a good solution. Their point of view is to implement the most effective road safety solutions in terms of benefits of saved lives and costs.

Nature of ecosystem – Extension market

One of the main driving forces for development and implementation of eCall in trucks is the society and the public opinion regarding road safety, The customers of Volvo Trucks as well has a big demand of safety, As the truck driver often is alone for a long period of time in combination with being in unknown surroundings away form their home country, the driver requires a sense of security, Today, Volvo Trucks offers Volvo Action Service, which is a system where the driver can push a button inside the truck to connect to a service team. According to Avedal this improve security for the driver and reduces standstill, since they get support if there are problems, such as tires or truck technology. The service does not include road safety services such as calling the emergency services or reporting an accident, but is more oriented towards the individual truck. The demand for safety services is high for the customers of Volvo Trucks. Today there are already arrangements with security companies involved if a truck is transporting valuable goods, where the security company can follow the geographical location of the truck and discharge if needed.

Governance - Roadmapping

Volvo Trucks investigates eCall as one of many possible safety measurements possible to implement and develop. As safety is one of the core values for the company, it is an area that is thoroughly investigated and as well something that is central for the customers. For Volvo Trucks safety, including both truck drivers and other road users, is a competitive factor. As eCall for trucks is discussed as a potential legally requirement in Europe in the future, as eCall for personal cars will be in 2018, Volvo Trucks is interested in the technology. Though, according to Johansson, there are multiple safety measurements that are interesting for Volvo

[4] Claes Avedal, safety manager, Volvo Trucks Technology, interview 20th of April 2016
[5] Mikael Johansson, law and regulations, Volvo Trucks Technology, interview 20th of April 2016

Trucks to implement, and that the company primarily will implement the ideas with the best effect on traffic safety and for their customers.

Governance – Niche creation
The main goal with the investigation of new and innovative safety technologies is to gain as much safety benefits as possible for the time and money invested, according to Avedal. The ambition of Volvo Trucks is to provide the safest solutions for trucks with the best damage reducing solution. Volvo Trucks wants to extend their offering of safety services.
As Volvo Trucks is moving towards becoming a company offering services rather than the physical truck, it is of interest form the company to offer a new niche of services such as safety for its customers, according to Johansson.

Governance – Entry barriers
According to Avedal and Johansson, there are multiple challenges towards the usage of eCall. The first disadvantage, they state, is the increase of administrative work it would imply for the transportation companies. Documenting the goods carried by different trucks every day would imply a massive work load where information possible needs to be updated multiple times a day for different trucks and truck drivers. For the eCall concept to work for goods, the goods need to be documented and administrated in many steps of the transported way. This would take a considerable amount of time, which the transportation companies do not benefit from since increased time for administrative aspects will decrease the revenues. As the industry of freight transport looks today this would be a major change in they way of work, Avedal believes.

Another challenge is of the sharing of the information. If the truck is carrying valuable goods, the risk of leaking of information can lead to an increased risk for robbery and following accidents increase. This is a big risk for the driver as well as the transportation company. If the transportation company not is convinced of the security of the data for the goods being transported, there is a considerable risk of the company stating that the goods is something else when declaring the information to the eCall, in order to reduce the risk of incidents.

In general, Avedal and Johansson believe that their customers, meaning forwarding agent and transport companies, might be sceptical towards sharing data to the eCall system. Avedal believes that the geographical location of the truck and other information that is suggested being sent with eCall is not of any concern for the truck diver, since the driver is working and the information already is official to the company and to its customers. The factor is rather to share the information of the goods and its customers, which information would be unfortunate in the wrong hands. eCall is a European Union centralised database, so the data is already exposed there, according to Avedal. IT security has a short life span, according to Johansson, and therefore insecure. It is possible, according to them, that there are other solutions that might be better.

A technical barrier and challenge for trucks is that they do not have the same sensor systems as private cars and accidents are not detected as easy as in a passenger car. eCall in private cars is activated if the car is in a road accident, and the sensor system of the car is activated and sends automatic information to the PSAP. If a truck is in an accident, it rarely experiences as severe effects, for example retardations, on the cabin or the truck if involved in an accident with personal cars. According to Avedal and Johansson, the driver is often uninjured and conscious after a collision. Johansson stated that eCall only would benefit the individual truck when not involved in an accident with personal cars. If involved with personal cars, the eCall

of that car would action and send data to PSAP. Avedal suggested that eCall could be used in roll-over accidents for trucks.

Software platform – Extension model
If eCall is to be implemented in heavy goods vehicles, Volvo Trucks will provide the technical solution for the implementation of the technology and the practical installation in the trucks. As Volvo Trucks already today work with services similar to eCall in the sense of bringing security to the truck driver and the goods carried by the truck, the company already have a growing group for an extension of this functionality. Johansson added that the company in complement to already existing Volvo Action Service might add additional security services.

4.5 Patrizio Pelliccione and Eric Knauss, Chalmers University of Technology

May 2nd, 2016 a meeting was held at Chalmers University of Technology premises at Lindholmen, Göteborg with Patrizio Pelliccione, associate professor, Software Engineering and Eric Knauss, associate professor and docent, software engineering, both at Chalmers University of Technology. Both Pelliccione and Knauss are knowledgeable in the area of software ecosystems. Present as well at the meeting was a master thesis student, Rob van der Valk, exploring software ecosystems at Volvo Trucks Technology software department.

Nature of ecosystem – Degree of openness

One main aspect is for the company with the platform to decide is how open the platform should be, according to Knauss[6]. This is an important aspect that deserves attention since this would affect every actor interacting on the platform, as well as the platform owner, resulting in how many services that can be offered as well as what kind of services. Regarding the rules and legislations of the platform, it has to be decided if all actors should be allowed to decide on the openness and legislations, or if this is something that the platform owner solely is responsible for, Knauss says. According to him, it is not very common that all actors have the possibility to decide on rules and legislations, but rather the platform owner and some of the major actors involved.

Nature of ecosystem – Extension market

According to Knauss, software ecosystems are often complex and usually it is not easy to interpret if there are one or many ecosystems present when investigating a company's software department. Software ecosystems often overlap, with actors acting in multiple ecosystems at the same time, possible with different roles in different ecosystems, or offering different services. Many software ecosystems are initially a software product line, according to Pelliccione, meaning that they grow out of a product family that has many similar attributes within the family. A software product line is an effective way to use resources and create synergy effects within a company, as well a good possibility to create a product line with similar products, offering the customers something they recognize and know how to use. Companies with software product lines or a single software system often decide to open up their product family into a platform for other actors to act on when the company realise that the waiting time for new features in the software becomes increasingly longer if the company it self is going to develop the feature, Knauss explains. A software ecosystem is a good way to develop for a company in order to mitigate the waiting time for its customers, according to Knauss. A software ecosystem is a way to keep the customers coming back and using the company services, knowing that the functionality they require will be developed in a foreseeable time.

Governance - Roadmapping

According to as well Knauss as Pelliccione[7], the concept of software ecosystems is something that is growing and becomes increasingly popular within the software development area. The reason, they believe, is the increased demand for more functionality faster and the urge for mass customisation that can be seen in the business today. Knauss explains that it is of great importance that the platform owner has a strategy of the usage of a software ecosystem and the platform. The platform owner has to be sure of what kind of software ecosystem is to be

[6] Eric Knauss, associate professor, Chalmers Univerity of Technology, interview 2nd of May 2016

[7] Patrizio Pelliccione, associate professor, Chalmers Univerity of Technology, interview 2nd of May 2016

offered from a strategic point of view, possible for many years ahead. By opening up products to a platform for others to interact on, it is of importance that the platform owner has an intended strategy to follow, as well regarding the development of the platform from a technical point of view as the services offered on the platform.

Software platform – Extension model

A software ecosystem often has a very strong core, a platform surrounded by very strong rules and legislations, according to Pelliccione. He states that a main aspect for the platform owner is to have continuous improvements of the platform so that it can perform well over time and constantly be a sufficient platform for other actors to act on. It is of importance to create an attractive platform that actors want to stay on. There is always a risk that actors change and become more active on other platforms if they do not see the benefits of the current platform, according to Pelliccione.

4.6 Jørn-Henrik Carstens, ITD

Jørn-Henrik Carstens is senior advisor in politics and technical affairs at ITD, the Danish industry organisation for road transport of goods. Carstens has a long history within the transport industry, and has worked as a technician of trucks as well as in advisory positions during his career. Today he is as well invested in IRU as a part of the Danish Member Association in questions regarding technical aspects of road transport development. This results in Carstens being involved in the development of eCall for trucks. The meeting was held the 11th of May 2016 in Prague, Czech Republic.

Nature of ecosystem – Degree of openness

eCall is according to Carstens[8] a system that is closed for unauthorised, but it is needed that all actors are aware of this, and knows that the information is only shared to emergency services and not is accessible by outsiders or competitors. It will only share information about the truck and cargo when there is an actual accident. He states that he believes in the system, but that many of the members of ITD are sceptical towards sharing data in general, since it is a competing factor for many of them, regardless of size of the companies. He states that it is important that the storage and transition of data is safe and not possible to access unless you are a verified actor in the system. Carstens believe that the members of his organisations are suspicions of sharing information in digital form, afraid that competitors will access the information, or be hacked. Although Carstens says that many of the actors know that having information in physical form on paper is very insecure, more insecure than in digital form, does not prevent them from being hesitant of a transfer to digital documents.

Nature of ecosystem – Extension market

When discussing the possibility of a software ecosystem evolving around eCall, Carstens states that additional services building on the technology of eCall would be of interest for the members of the organisation ITD. He says that the ground functionality of eCall is in majority only beneficial for the society as a whole, and not for individual freight transport operators. He welcomes initiatives increasing the benefits for haulage contractors, as long as the information stored is safe. He states that there is a wide range of actors considering size and activities, but believes that many of them would be interested in additional services, such as increased security.

Governance – Roadmapping

According to Carstens, he believes that the most important issue is to clearly decide the central parts of eCall for trucks and buses. He states that first of all, the absolute minimum set of data shared in eCMR needs to be decided, following the secure communication of data. Only when this is concluded it would be possible to look at following solutions and other possible sources of data for the eCall concept. He states that he believes that for actors within freight transport to share information with eCall, he believes legislations is the only possible way to handle the issue. He says that the members within his organisation are serious in their business, all willing to adapt to new strategies, but he believes that in order to have a thorough system where all information is in place and correct, there is need for legislation. Otherwise, some actors will avoid sharing data, both because of respect for the possible competitions and possibly as well because of time consumption or pure laziness.

Governance – Entry barriers

[8] Jørn-Henrik Carstens, senior advisor, ITD, interview 11th of May 2016

The companies and organisations Carstens meets and represent are in general hesitant towards documenting in a digital format. The reason, he believes, is the false security a physical paper brings. He states that although many of the organisations knows that is it easy to counterfeit documents today, the physical form is still considered safer than digital. Carstens says he think there is a need for a big change within the freight transport industry in general in order for the digital documents to be the norm, and states that this is such a big action that simply the project of eCall and I_HeERO is not enough. What is needed is a change of standards in documentations, for all kinds of actors.

Software platform – Operation supported by extensions
Carstens believe in the possibility of expanding the system of eCall, making it involve other services for actors in eCall, in general freight transport operators, since this is the actors he represents. The concept of eCall for trucks is yet to be constructed in many aspects, but Carstens says he believes in more information sharing and the possibilities this would bring. Carstens believe that it is possible that security companies could be interested in getting information about a trucks whereabouts, as well as insurance companies. He states that this concept is something that needs to evolve from a platform of eCall, already functioning for its core functionality.

4.7 Illustration of empirical data in the EAM method
Below, the empirical information collected is presented in Table 3, illustrated with regards of the Ecosystemability Assessment Method and its themes.

Table 3 Description of the empirical results presented in the EAM model

	Nature of ecosystem			Governance			Extension model	
Interviewee	Degree of openness	Level of ecosystem stack	Extension market	Roadmapping	Niche creation	Entry barriers	Extension model	Operation supported by extensions
Lennart Liljeroth, Emergency services Gothenburg municipal						Dis-information to emergency services Misreading of eCMR		
Anders Berger, Volvo Trucks Technology	Service delivering company Needs equal openness					Only sharing information of there is obvious benefits Lack of standardised communications for different truck brands Information assymetry	Room for truck manufacturer competition	
Magnus Andersson, Viktoris ICT Sweden	Ecall closed, small system with only one task Authority platform results in closed system		Hard to add functionality on already set platform of eCall Little or no incentives for other actors	Begin looking at structuring data of goods Analyse the situation of e-documents Analyse EU platform	eCall not a good system to share anything other than minimal data	Social aspect the biggest concern eCall a far too closed system Scepticism from actors of sharing data	eCall a small share of what could be needed	
Mikale Johansson and Claes Avedal, Volvo Trucks Technology	Customers afraid of what an open platform would mean PSAP should be sufficiently safe		Safety issues central for the customers of Volvo Trucks	Volvo Trucks only interested in implementing the best safety solution	Volvo Trucks wants to provide safety solutions to the customers	Big administrative work for Volvo customers Reluctant of sharing information	Volvo Trucks believes in service add-ons such as Volvo Action Service	
Patrizio Pelliccione and Eric Knauss, Software Engineering, Chalmers University of Technology	Decide on rules and legislations for openness		Software ecosystems open up in order to offer more features for customers	Intended strategy for the platform of importance			Continious improvements of platform needed Attractive platform important	
Jørn-Henrik Carstens ITD and IRU	eCall should be a closed system with stated informaiton chanels		Additional services of interest for truck operators	Clearly decide rules and legislation for the eCall platform the central question		Hesitation of information being digitalised		More information sharing would bring a possibility of a new market

5 Analysis

In the following chapter the analysis of the empirical and theoretical studies is presented. The analysis follows the framework of Ecosystemability Assessment Method (EAM) presented by Knauss and Hammouda (2014), which is divided into three categories with sub-categories respectively.

Table 4 The Ecosystemability Assessment Method, based on Knauss and Hammouda, 2014

Theme	Item	Significance
Nature of ecosystem	• Degree of openness • Level of ecosystem stack • Extension market	There is a tradeoff between the need to protect intellectual property and the need to be open with partners in the software ecosystem.
Governance	• Roadmapping • Niche creation • Entry barriers	A software ecosystem with high entry barriers can afford lower understandability than a software ecosystem with lower entry barriers, aiming for not discouraging a continious stream of new actors.
Software platform	• Extension model • Operations supported by extensions	Reasons to limit the freedom and power of extensions include the ability for non-functional testing of the whole system or to protect the business model of the software ecosystem market place. The architecture of the technological platform should be designed to enforce such decisions.

The analysis of the empirical data and the theoretical framework is by the Ecosystemability Assessment Method by Knauss and Hammouda (2014), presented above. The information is analysed in each sub-category individually with information from interviews and theory.

5.1 Nature of ecosystem

The category of the nature of the ecosystem discusses how a software ecosystem is concerning its openness, its level of stack and its extension market.

5.1.1 Degree of openness

The openness of any system is an issue for the concerned parties. The openness is defined by Manikas and Hansen (2013) as how easy it is for an actor to access and participate in an ecosystem. Knauss states that deciding on how open a platform should be is one of the main aspects of the platform owner, and it is important to look into the roles of the different stakeholders and their right to decide on legislation. Seven of the eight interviewees expressed a concern for the matter. The issue expressed regarding openness was for example the possibility of with an open platform share information with other actors in the ecosystem, but

who at the same time are competition, according to Carstens. There is an obvious worry about an open platform for the interviewees, and a small focus on the potential benefits it would mean to have more actors operate together. Knauss et al. (2014) describe that opening up a software ecosystem can increase its innovation power and market reach, as well as services that are more customer oriented. In general, the benefits of a software ecosystem depend on the technical platform being open, such as increased value of the core offering to already existing users, and the possibility of keeping users (Bosch, 2009). Johansson and Avedal indicate that it is possible that their customers would benefit from actors in a software ecosystem of eCall who offer other services than the ore service of eCall such as security. Berger as well believes, with the business of truck manufacturing moving towards becoming more an offering of service rather than a pure deliverer of vehicles, in the possibility of opening up a platform and offering services to customers. Both Avedal, Johansson and Berger obviously believe in delivering services form an open platform. Contradicting them, Andersson believes that using eCall as a software platform is not a functioning idea for a software ecosystem. He states that the term *software ecosystems* rather is a buzz word than a functioning concept within freight transport. Andersson as well points towards the importance of stating the preconditions of an open platform, and what an open platform actually is.

eCall is a Pan-European initiative intending to improve the emergency services in all of Europe, making the emergency call more equal and more effective. As the actors of freight transport today are working on an international market with several involved actors, according to Sternberg et al. (2010), this should be of importance for these actors as well, since they would know that they have a functioning emergency service network in every country they are active. As as well the actors of a possible software ecosystem with eCall as the platform are working internationally, and the technology of eCall is intended to connect several countries, internationality should be a factor to weigh in if pushing for a software ecosystem. In the trade-off between acting globally or locally by Knauss et al. (2014) it is pointed at the need for a strategy for the software ecosystem if working globally, using a top-down approach. The strategy should be long term, and the work should be considering actions in a big perspective, rather than working with a just-in-time model, making decisions on short terms.

The underlying trade-offs between acting confidential and acting openly presented by Knauss et al. (2014) shows that working openly with the requirements of a software can be an opportunity of how a software system is engineered. Andersson states that eCall is very closed with only one function and very firm legislations, meaning that no external parties have any possibility to affect the future and continuous development of eCall. The development of the hardware and software of PSAPs in Europe and the software in the vehicles is decided upon by the project group of the I_HeERO project. There are barriers between the stakeholders of eCall, and if the technology was to become a software ecosystem platform, this strategy would, according to Knauss et al. (2014) hinder the information flow and increase the effort of creating a holistic product strategy that can satisfy requirements of the customers and end users of the software ecosystem. The nature of ecosystems is many times related to the extent a platform supports collaboration, according to Manikas and Hansen (2013), and is as well affected by factors from outside the ecosystem social network. Since the business of freight transport, according to Andersson, is a closed business with little interest in sharing information, as well as information asymmetry (Andersson and Sternberg 2016). This could affect the platform of being a closed platform, not making it possible for actors to enter the ecosystem nor collaborate on the platform. Carstens statement that eCall is a closed platform, and this is something desired of the actors of his network and even

something that needs to be marketed more in order to attract the users to eCall is an indication of possible actors of eCall nor being interested in extending the platform to being more open to new actors.

5.1.2 Level of ecosystem stack

The architecture of a software ecosystem should support the nature of the ecosystem, according to Manikas and Hansen (2013), this indicates that the architecture should be adapted to the needs of that specific software ecosystem. eCall is developed to only have one function, demanding hardware and software in both vehicles and PSAP, and the architecture in no way is developed to further support any other functionality. The concept has a minimum set of data required in order for the technology to function well and for the personnel of emergency service centres in Europe to be able to make a well-informed decision regarding the emergency activities. As Andersson states in the interview, the concept of eCall is very closed, with limited functionality with no intention of the development team of extending the functionality in the future. As the level of ecosystem stack is defined as a group of programs that work in tandem to produce a result, or in other cases applications that work in a specific and defined order toward a common goal, it is obvious that there is no such intention of the technology of eCall.

With the development of only one software, eCall, the management of the system lies solely with the involved partners of it, and has no intention of involving other actors. Viljainen and Kauppinen (2011) suggests a flexible architecture to ease the integration with other software. Andersson states in his interview that European Union software projects are known for being only focusing one one functionality, with no consideration for consolidating of different software in order to increase the benefits. There is continuous development of eCall, regarding the involvement of other vehicles than private cars, as well as the possibility of including more data than the standard minimum set, but eCall is still solely one technology, with one hosting infrastructure and solely hosted platforms and applications concerning the core functionality of eCall.

5.1.3 Extension market

As Jansen, Brinkkemper and Cusumano (2013) describes, there can be many different levels of extension markets. As for eCall not being implemented or yet used in heavy goods vehicles or buses, there is currently no extension market at all. The common example of Apple App store as a software ecosystem has a commercial extension market, where the platform owner benefits and creates own value from the market. As Andersson states in the interview is the comparison of the possible freight logistics software ecosystem and Apple ecosystem not a good comparison, since their services are very different, freight transport being much more complicated to structure than the usual example.

Many times, the reason software ecosystems arise is because a company has problems meeting the expectations of functionality from customers, and so the company decides to open up to other actors into an ecosystem, and at the same time giving up a part of their control and design capabilities (Ghazawneh and Henfridsson, 2012). eCall is a software with solely one purpose and one functionality, and the project team of I_HeERO has no intention of expanding this functionality. As Knauss says in his interview, having a software ecosystem is a way to keep customers coming back and using the company services since the waiting time for new functionality decreases with many actors creating functionality in an ecosystem. since the functionality of eCall is something that has been decided upon to be implemented in all personal cars by the European Commission, it is as well very likely that there would be the

same kind of regulations for trucks and buses. If so, there is no need for the platform owner of eCall to keep its users happy by extending the functionality, since the use of eCall would be regulated. Carstens, Berger and Avedal and Johansson all believe that the main benefits of eCall is for the society rather than for the companies and actors involved directly. Carstens and Avedal and Johansson all believe in adding some functionality to the core of eCall to increase the advantages for the freight hauliers implementing eCall in the trucks. Andersson, on the other hand, have the example of other platforms initiated by authorities, that are opened up for cooperation after the actual implementation. In those cases, there are the technical incentives for other actors to use the platform, but no business models or organisational reasons. If so, the platforms are not used at all, according to Andersson.

As eCall is a software system initiated by authorities, with no initiatives of opening up the system in the near future, eCall is very close to the examples given by Andersson in the interview. If eCall should open up to an extension market, it would be because there is an obvious need from the actors using eCall in their daily work, for example truck companies. Since the freight transport business is known for being a closed business with little or no information flow between the actors about their current business, the extension market actors would most likely be chosen carefully by the organisation behind eCall. It would most likely not be a commercial extension market as the market of Apple App store, but rather a simpler extension market, like a list of components that are offered as services for the eCall users, or a small market where the contributors can distribute and sell their services. One crucial aspect is how to make service providers use the platform. There have to be enough incentives for them to use the eCall platform to distribute their services rather than using another platform or a more traditional marketing and selling model. As this aspect is not something considered by I_HeERO today, this aspect needs to be developed after the actual implementation of eCall in trucks and buses. If so, there is a risk that the platform will only be open in the technical sense, and not in a business sense.

5.2 Governance

In the second category of EAM, Governance, the roadmapping of a software ecosystem is presented, as well as niche creation and entry barriers to an ecosystem.

5.2.1 Roadmapping

A roadmap is a plan that matches short-term and long-term goals with specific technology solutions that help meet the goal. According to Bosch (2009) the best long term approach for a software ecosystem is to publically release a long term platform roadmap that would allow external developers to move towards a more differentiated functionality, and at the same time abandon functionality the platform company intends to do. According to Andersson is the European Union's work regarding software systems very rigid, which affects every project they are involved in. this would as well affect the possible roadmapping of a technology project. For eCall, there is no roadmap released further than the actual projects regarding eCall, I_HeERO, that stretches from 1st of January 2015 to December 31st 2017, two years. There are projects before the current project of eCall, and there will most likely be projects following eCall, but this is nothing that is decided upon today. As the technology of eCall not yet is implemented, but the plans are to deploy the technology in the near future, there is a roadmap for the deployment but no official roadmap for the future work. As eCall is not a software ecosystem, there is no roadmap for how the platform possibly could benefit other actors than the actual drivers of vehicles with eCall installed.

According to Siddiki et al. (2015) governments can employ various strategies to decrease the cost barriers of a technology implementation if a broad use of it would benefit the governments broader policy goals. It is for example possible that the European Union would finance a project of documentation of goods of a truck with electronic documents. The problem would then possibly be that the freight industry has no incentives to change and start document the goods more intensively, since it is not the cost of the implementation of the technology that they fear, but their decrease of competition power. A roadmap of that change would possibly involve the actual implementation of a new technology, but would not for example handle the whole change it would mean for the freight transporters. The companies would have the possibility to make changes in the sense that Bosch (2009) suggests, but the changes would possibly not be enough for the actors to keep the upper hand in the competition with others.

As for Volvo Trucks, Avedal and Johansson explain that the company is very interested in implementing safety technologies, but only want to implement the best safety and security solution in order to keep their force of competition. The roadmap of implementation of eCall in trucks is not yet decided upon, possibly restraining the safety innovations at Volvo Trucks. Knauss states that it is very important for the platform owner to have a strategy for the software platform, which can be translated into the need of a roadmap. As of today, there is no roadmap for eCall for trucks and buses, and Carstens states that he believes that the most important issue is to clarify the central parts of the technology for trucks and buses. The minimum set of data of eCall would affect all involved parties, and first after that it would be possible to decide upon possible future moves for eCall and what actors would be interested to interacts on the software ecosystem.

5.2.2 Niche creation

The niche creation is the ability of the software ecosystem to increase meaningful actor diversity over time (Mankias and Kontogiorgos, 2015). As eCall today in theory only have actors using the eCall technology in their cars and personnel at PSAP receiving the eCall, there is no niche creation at the moment. The actors existing today are the platform owner of eCall and the end-user of eCall. If eCall was to open up to become a technical platform there would be more actors that were stakeholders in the development of eCall and the platform. Avedal claims as Volvo Technology are moving towards becoming a service delivering company, the company keeps the customers satisfied by offering the best services, of which road safety with help from companies specialised in the area is one. This is a possible growth in as well company variety and growth in product variety offered within the software ecosystem, but if the ecosystem intends to be strong and present, there should be more growth in both areas in order for the ecosystem to survive. As Andersson states in his interview, the terms and regulations of eCall for heavy goods vehicles is not yet decided, and he believes that the information shared in eCall not should handle the goods delivered in a truck. If this will be the case, the niche creation will be more limited than if more data was to be shared with service providers.

As explained by Sternberg, Germann and Klaas-Wissing (2013) the actors network of a logistics supply chain today is much more complicated than believed before. This indicates that the niche creation as well would be complicated for a software ecosystem within freight transport, and possibly hard to distinguish barriers between different ecosystems. As many actors in a supply chain often have different roles in different supply chains, this suggest that the same would be the case in a software ecosystem. in some software ecosystem, an actor

might possibly be a niche player, and in another a vendor. This would not grow the company variety of the niche, but possibly a growth in product variety offered.

5.2.3 Entry barriers

The entry barriers of software ecosystems, and the usage of information technologies in general was one of the main topics during the interviews. Entry barriers in software ecosystems are there in order to ensure that only the right companies can join (van den Berk, Jansen and Luinenburg, 2011). There is a risk of having too low entry barrier as well as too high. In a software ecosystem there are different actors, who would be the stakeholders if eCall become a technical platform of an ecosystem. the stakeholders of eCall today are ranging from citizens in society to road operators and mobile network providers. All of these would not be stakeholders in a software ecosystem directly, but indirectly by being dependent on the system and the services it offers. If the barriers are too low, there is a risk for all stakeholder that they would be in risk by actors not devoted enough to the ecosystem. On the other hand, is there a risk if the barrier to entering a software ecosystem are too high, not offering the stakeholders the whole range of services that possibly could benefits the stakeholders, creating a safer society and creating opportunities for organisations and companies when participating in a software ecosystem. In the report mainly active stakeholders have been discussed, such as PSAP and in-vehicle equipment as these would actively use the eCall software ecosystem, while road operators only would be effected in-directly.

There are multiple barriers towards digital communications in general and software ecosystems more specifically. Regarding the industry of freight transport, Sternberg et al. (2010) show that there is a big complexity in the market, it is fragmented which makes planning and control of the supply chains very difficult. In general, the business would benefit from sharing information in order to reduce the information asymmetry, which colours the current situation in the business. Andersson and Sternberg (2016) claim that information transparency could solve many of the issues that the freight transport industry suffers from today. The companies generally do not share information freely. Berger states that he believes that since freight transport is a business where every actor have to look to her own interest, he believes that no company is interested in sharing information with other actors, since they see no gain in their own part by sharing information with others. Carstens even claim in his interview that the companies are hesitant in sharing information in digital form, since they are afraid of sharing information with the wrong parties and believing they have less control over the information if it is in digital form. One reason for the hesitation could be the fear of sharing information about valuable goods transported in the truck on the roads of Europe, or too much information about the customers using the freight transport companies, according to Johansson and Avedal. Although eCall for personal cars today require a minimum set of data regarding the cars position and other information only activated and sent if involved in a crash, truck companies are still hesitant in the sharing, according to Avedal and Johansson. This is in line with the industry in general, being hesitant of using new technology as well as sharing information.

In line with the scepticism of sharing information with other actors, companies are as well afraid of being hacked and unwillingly and unknowingly share information with unauthorized actors. This is as well as sign of the small margins the freight transport industry suffers from, where information sometimes is their only leverage, but also a general fear of the use of digital documents being an unsafe method, although the fear is not relevant, as Carstens states in the interview. Liljeroth is concerned of the wrong information being shared about

dangerous goods or the information wrongly being shared. Although the projects team of I_HeERO and eCall are very clear on the fact that the minimum set of data of eCall only is shared if the occasion of an accident from the in-vehicle equipment to the PSAP, the freight transporters are still sceptical and afraid that this information would be shared to unauthorized actors. The dilemma of sharing information is a ubiquitous question in the society today, and the security of an important aspect of it, but it is still a factor that the business of freight transport is sceptical towards new technology. It is not the special case of the security of the data sharing via digital documents with eCall that is the main issue, but the beliefs about the system. As Andersson says, the big issue is peoples' attitude. On the other hand, is it important for the platform owner of eCall to take these concerns seriously. In the interview with Liljeroth when asked about information about buses, he believes that the information about number of passengers not is an important factor when a bus is involved in an accident. If this is true and the I_HeERO project group still want to have and document this information, the question arises why this data should be shared. The data shared with eCall should only be of crucial kind so that all involved parties feel safe, as well passengers of the bus as the companies sharing the data. If one type of data is not important, the actors should not be forced to share this piece of information. If they still are, this can possibly be a big barrier towards using eCall and the actors might feel forced, making the trust in the I_HeERO team decrease and causing frictions in the ecosystem. when deciding the minimum set of data for heavy goods vehicles, I_HeERO should make sure that this information actually is crucial before legislating on the documentation of it.

Liljeroth states in his interview that he believes that the information about the goods carried by the trucks today is already known and in many cases already in a digital form within the companies of freight industry. Andersson on the other hand believes that there is a lack of structure of the information about goods, and that this is a priority issue to handle, before documenting the goods carried in a truck in a system like eCall. Avedal as well believes in a standardisation of information from trucks, as this would make it feasible to share information between different brands of trucks, for example. Andersson says that there today is no standardisation of how to document the goods carried. Dangerous goods have to be documented, but traditional goods have no standardised documentation. He as well believes that a standardisation would be a massive administrative burden for the freight transport companies, and in a business where time is money this could possibly cause companies to have to close because they can not handle the administration a documentation of goods in eCall would require. Avedal and Johansson believes the same thing, and says that an increased time spent on administrative work would mean smaller revenues for many companies. Stefansson and Lumsden (2009) acknowledge that transport companies are sceptical to having parameters controlling the freight of the truck. There are with other words two issues with the documentation of goods; the actual structure of the information and the administrative load it would mean. If the users of eCall had a possibility of choosing if to participate in eCall or not, this is possibly a big factor for them when looking into the advantages and drawbacks of a software ecosystem. if the I_HeERO projects decides upon the need for documentation on all types of goods, it is possible that this would affect the whole business of freight transport.

Since transport include as well many different vehicles, different modes of transport and human capital, there is an increased need for integrated planning and control and information sharing. There are many solutions for sharing information in the age of Internet and big data, but the business as a whole depend on a *technology push*, according to Damodaran and Olphert (2000). Today, the business of freight transport suffers from information asymmetry,

where the sellers of transport gain the main share of the information while the buyer of transport has no access to it. This asymmetry is a barrier towards sharing more information via digital documents and possible participation in a software ecosystem. The issue with information asymmetry is that it would be cured with increased information transparency. There have been numerous projects proving the benefits of information systems increasing the information transparency which makes the operations in freight transport more efficient (Andersson and Sternberg, 2016). The lack is not within technology, but in the society surrounding the industry of freight transport, as Andersson states in his interview. Berger believes that with the current situation in freight transport industry with information asymmetry, resulting in business models not working properly, the only solution is legislation. He believes this to be the only way for companies to increase the information transparency. In the case of eCall, where the core functionality mainly is beneficial for the society rather than the individual companies, this especially is the case. Andersson and Sternberg (2016) believe in an increased regulation and information transparency to cure the state of information asymmetry state in the industry. Berger suggests a possibility to increase transparency in the business by a cooperation by the active companies, sending the information to an independent trustee. Transparency is as well an important factor in software ecosystems, and if the technology of eCall is to be opened up to an ecosystem platform, the requirements and strategy of the platform should be openly discussed, or there will be issues with the information flow, as Knauss et al. (2014) describe.

Even if individuals at companies believe in the benefits of eCall as a software ecosystem, it is possible that internal barriers would prevent implementation and usage. In the article by Iljana et al. (2011) they show that the uptake of an information system is slow, in spite of a committed management team and a belief in the benefits of the system. There are well internal as external barriers towards uptake, among other the fail of institutionalise the system in the company. As Andersson points out in his interview, a lot of the pilots tested for information systems in freight transport have forgotten to link back to the reality of the industry, making an uptake impossible in practice. If eCall is to be used as a software ecosystem, is has to be developed with the actual principles of freight transport in mind, and not a simplified version of supply chains. As Dorethy and King (1998) states in their article, one of the main factors if a software system is being used effectively in a company, is the structure and culture in a company. If this factor is ignored when developing a system or an ecosystem, there is an impending risk of the system not being adapted at all, as in the many pilots that have been run with information systems.

Today, eCall is a closed software system with one task, which requires an implementation of software and hardware in as well vehicles as in PSAP in all countries in the European Union. Andersson claim that small systems are very common in authority projects, and that they require much more hardware and software that they would if they could find a way to work together. If eCall is or will be a voluntary system for heavy goods vehicles and trucks, it is possible that the actors would question the limited service this system can offer. As eCall develops and possibly will be a part of the equipment in a heavy goods truck, the project as well have to investigate the technical difference between a personal car and a truck or a bus. If a truck is in a collision with a personal car, there will not be any sensor activity for the truck, as it would be for a personal car. As trucks are much heavier and higher, a sensor network would not work as a trigger for eCall in trucks. There have to be a technical development of the trigger of eCall in trucks and buses, and this solution have to be satisfactory for the truck companies in order for them to se the benefits of the system.

For a software ecosystem to be used and continuously improved in its niches, the system has to be attractive to its stakeholders. For the actual direct users of eCall, the incentives are small. As Berger claims in his interview, the incentives for haulage contractor are small, and the benefits of the system is hard to calculate, compared to investments in more effective combustion engines, for example. As well, if a truck is involved in an accident, it usually is not the truck driver that is hurt nor the goods carried affected. There are fewer direct situations when eCall would help a truck than personal cars, as a personal car is more fragile. Instead, it is the society as a whole who benefits from implementing the eCall system. Liljeroth as well believe that the society would benefit from the information from eCall, as this would decrease the time for emergency activities. Siddiki et al. (2015) claim that the respond to innovative communication technologies depend on how motivated the actors are by a range of internal and external factors and cost barriers they face. eCall would imply a big investment cost and implementation cost in many different aspects, as well the cost of possibly investing in a less effective safety and security system than possible if the actors had the possibility to chose. It is possible that the actual development cost would be subsidized by the European Union since the project of eCall is governmental, but still other cost centres remain, affecting the actors. If implemented, it is of great importance that the system holds for what was promised to the different actors. Iljana et al. (2011) found that a main concern when piloting or implementing software communication technologies within freight transport industry is the shortfall between the promise of the system and the actual delivery. The system has to, according to Andersson, reflect the actual usage in freight transport in order to be accepted.

5.3 Software platform

In the third and final category of the EAM analyse model the extension model of a software ecosystem is presented, as well as the operations supported by the ecosystem extensions.

5.3.1 Extension model

The extension model is needed in order for a software platform to function for a long period of time, through developments and changes. The extension model should facilitate the development of the applications built on the platform as well as the platform itself. Berger means that the standardisation of communication between trucks and technology used in freight transport only should be developed to a certain level, so the room for competition is still there. When extending eCall this is important to keep in mind. As the relationships in a software ecosystem are push-oriented, according to Riis and Schubert (2012) as well as the business of freight transport are late adapters of information technology, it is important to understand that the new technology introduced might need to be pushed into adaptation of the end users. If so, the understanding the the nature of the actors and their relationships is important, or the extension of the technology might affect the end users badly as well, as in the example of Volvo Trucks above. Andersson gives his point of view where he questions the push-model from authorities, claiming that this might harm actors who already have developed something similar, but then find themselves with a good technology they have to abandon in order to implement the technology pushed by the authorities. Volvo Trucks are willing to change their technological platform in order to implement eCall in the best manner and offer more solutions, according to Johansson and Avedal. Indications like this should be seen and cared for from the side of eCall, as this would possibly simplify implementation of further functionality of eCall, and possibly inspire other actors to use and implement eCall as well. The extension model of eCall should take into consideration its actors markets and technical solutions in order for the platform to still attracts and keep its actors.

According to Pelliccione the continuous improvement of an ecosystem platform is important in order to work well over time as well as being an attractive platform to stay on for the actors. If not, there is a risk for parasitism, where eCall as a system would benefit from being used by many actors, while the actors would be harmed by using eCall. Since eCall is a governmental system decided upon by many parties, there is the difference that eCall does not need to develop the platform further in order to make the users stay on it, since they are already forced by non-legislative rules. According to Andersson there are issues with authorities developing software systems, since they usually only look to their own functionality and not to the possibilities of extending the functionality or work together with other software systems to create symbiosis. Andersson claims that authorities often seek for function that can be statutory and that these solutions often can become cumbersome. This most certainly can be the case for eCall, since it is an authorised software, only handling one very limited functionality. It is possible that because eCall is mandatory in personal cars, there is no incentives for the platform owner to further develop the platform or look into new possible applications of the system. There is a risk that this solution becomes sluggish, according to Andersson, since the standards of eCall are set early which results in a limited solution and limited extension possibilities. It is possible that another model, with free creativity and innovation would be a better model for distribution of safety regulations within the European Union, as Andersson mentions in his interview. On the other hand, he states that eCall is a broad solution involving all countries in the European union. The extension model will include all possible car brands and countries and since the business of freight transport is a cumbersome business with complicated relations, it is possible that a broad solution is better in order to get all actors on board.

5.3.2 Operation supported by extensions

The area of operations supported by extensions is defining what services are offered in the software ecosystem by the extensions rather than the platform itself. As of today, eCall is not used or in operation, and certainly not for trucks and buses, the discussion comes down to a theoretical discussion. As many of the interviewees have suggested, there is an interest for services regarding an extension of the security offered by eCall, for example a security company as well taking share of the information from eCall and then being able to secure the goods carried or the driver of a trucks if there is an incident. The information would be shared to the extensions in the software ecosystem by digital documents. Carstens believes as well security companies as insurance companies would be interested in being a part of a software ecosystem, extending the core functionality of eCall. Digital documents could extend the functionality of these companies today by being searchable documents which would give that information would be retrieved faster and easier, and possibly making an analysis of a situation more feasible. Liljeroth believes that more information shared with digital documents would benefit the emergency services and possibly other services as well.

It is possible that a software ecosystem with eCall as the platform would work well for extensions regarding security and insurance. The question is if these extensions are enough to satisfy the end users of the ecosystem, or if they in the future will require other functionality and an increasing growth of services available on the platform.

6 Conclusion

In this chapter the project is concluded by answering the main purpose of the report, which is to gain an understanding of if it is possible to use the concept of software ecosystems in the area of freight transport on road. In order to answer the purpose, three research questions were identified, which will be answered in the following chapter. The chapter is divided into three parts, each answering one of the research questions respectively.

The aim of the project is to evaluate the possibility of software ecosystems within the road freight transport industry, and if so, how well such software ecosystems will function with regard to the *Nature of the ecosystem, Governance* and *Software platform*, based on the Ecosystemability Assessment Method presented in chapter 3.7. as well as in Table 5 below. The empirical findings in interviews are analysed together with theory in order to find a conclusion of the possibility of software ecosystem is and their well-functioning. As a software ecosystem evolving around eCall today only is a theoretical idea, some of the aspects of Ecosystemability are of the nature where the qualification of the software ecosystem is only an estimation. The overall judgement of the industry where the investigation is conducted is that the business is very sceptical towards new information technologies in general, giving high barriers towards an implementation of eCall as a software ecosystem.

The analysis in eight sub-categories gives a picture of a complicated environment for software implementation in general, and software ecosystems more specifically. The openness of the eCall platform is considered very closed, and in order for it tom become a software ecosystem platform it is needed to investigate the possibilities to open up the software in order to ensure relations and activities on eCall. As the technology of eCall is yet in its early stages, the level of ecosystem stack is low, but with possibilities to develop more applications on top of the platform and infrastructures developed and used today. The infrastructure of eCall is well developed through projects with many involved parties, but since the aspect of an open software for as well external developers never where a part of the early stages of eCall, this aspect needs to be investigated more thoroughly in order to develop the levels of the software ecosystem. the extension market is considered a good possibility from the side of the customers and end-users of eCall. Many of them believe in extending the possibilities of eCall in order to further increase the benefits for the commercial actors. this, on the other hand, is not anything that has been regarded from the projects of I_HeERO to a large extent, and if eCall was to be further developed into a software ecosystem, the aspect of additional services upon eCall has to be a central question. The roadmapping of the project of a software ecosystem is not something developed today, but with the experience of the team behind I_HeERO and eCall and the experience from projects working with European Commission, a roadmap is an aspect where eCall as a platform would have a strong core. In relation to extension market, the niche creation of eCall is yet small, with the only suggestions being security and safety of the goods and drivers, which is close to the operations supported by eCall, but an area where further investigations are needed. The extension model has to be considered for this, especially since eCall is surrounded by many laws and legislations. There are many barriers towards an implementation of a software ecosystem in freight transport, barriers being partially technical but mostly social. These barriers need to be reduced in order to implement new information technologies, but as well in order to reduce the information asymmetry in the business.

Table 5 Ecosystemability Assessment Method adapted from Knauss and Hammouda (2014)

Theme	Item	Significance
Nature of ecosystem	• Degree of openness • Level of ecosystem stack • Extension market	There is a tradeoff between the need to protect intellectual property and the need to be open with partners in the software ecosystem.
Governance	• Roadmapping • Niche creation • Entry barriers	A software ecosystem with high entry barriers can afford lower understandability than a software ecosystem with lower entry barriers, aiming for not discouraging a continious stream of new actors.
Software platform	• Extension model • Operations supported by extensions	Reasons to limit the freedom and power of extensions include the ability for non-functional testing of the whole system or to protect the business model of the software ecosystem market place. The architecture of the technological platform should be designed to enforce such decisions.

RQ1. How would a software ecosystem in freight transport benefit its actors?
A software ecosystem would be a way for all the actors in freight transport today to more easily find and use information about services and possibilities available. In an era of Internet and big data, software ecosystems bring actors together, make the services available for more parties and decreasing the information asymmetry in freight transport industry. For the platform owner a software ecosystem might give an advantage compared to competitors by increasing the visibility in the market. A software ecosystem would as well benefit the end users by structuring the services available as well as possibly benefit the global ecological environment by more effectively use the resources available for road transport.

RQ2. What are the barriers to a software ecosystem in freight transport?
The business of freight transport is a complicated business, with many actors with different roles. What from a first glance looks like clear supply chains is in fact a complex network of actors in different levels, having different roles in different supply chains, offering different services to different actors. this complexity by itself results in a barrier towards a software ecosystem, since the roles are ever changing and the actors cannot be divided into different categories of stakeholders in an ecosystem. The complexity is the reality today, and it is as well resulting in information asymmetry, pushing the knowledge from the customers of freight transport towards the actors in the supply chain. The information asymmetry has many disadvantages, and regarding software ecosystem the information asymmetry results in actors not willing to share the basic information that a software ecosystem requires in order to function and offering services. Many times information is the only advantage an actor in freight transport has, which results in an unwillingness to share since it could result in extinction.

The business of road freight transport is characterised by a scepticism of sharing information with others, and a fear of other parties gaining the knowledge without permission. This affects every intention of implementing information systems; as multiple pilots have shown. There is a need of a common knowledge of the benefits of sharing information, and since there is no common movement of opening up to an increased information transparency, no one will take the first step. The business is as well late to adaptation of new technologies, and need a push in order to implement new technologies. This combination results in a strained situation of a catch 22 where, and it is possible that what is needed is legislations from a governmental level in order for the situation to change. As of today, there has not been enough benefits for the actors of freight transport to abandon their current positions and move towards a more transparent industry. As transparency as well is an important aspect of software ecosystem, this change is crucial in order for the concept to work within freight transport.

RQ3. How can the eCall technology serve as a technological platform in a software ecosystem?

The research question was answered by investigating the eCall technology as well as theory of software ecosystems. As can be read in the chapter Theoretical framework, eCall is a governmental project initiated by the European Commission, with only one purpose; to send information of possible accidents on road via digital documents to emergency services, and possible save lives. The eCall technology as a platform in a software ecosystem was evaluated by them Ecosystemability Assessment Method, which investigated different aspects of a software ecosystem, evaluating both external and internal factors.

The EAM concludes that there first of all is no intention of using eCall as a platform, which aggravates the possibility of a software ecosystem. The *degree of openness* of eCall is very low, and only accepted parties are invited to develop the system of eCall. As there currently is no ecosystem, no external actors can participate in eCall, using the data for other functions than the core function. The *level of ecosystem stack* is full in the sense that there are internal infrastructures, platforms and applications of eCall, and this functions potentially well for its task. But, if viewed from a software ecosystem point of view, there is no external platforms or applications. It is although possible that the ground infrastructure of eCall could be open, simplifying for other actors to interact on the platform. The *extension market* is somewhat limited. In interviews there was an obvious interest in extending the function of eCall but the suggestions were limited, and considering the closeness of eCall today, the extension market of an eCall ecosystem would probably be very regulated, resulting in a limited list of actors allowed to act in the ecosystem. regarding the *roadmapping* of eCall, there is a clear roadmap of the I_HeERO project, but no following roadmap and certainly no roadmap for eCall as a software ecosystem. as of today, opening up the system of eCall to an ecosystem is not possible, but since the I_HeERO project is a governmental project with many actors with experience within the field, it would definitely be possible from a strategic and planning point of view to open up eCall and create an ecosystem. The abilities are there; the only question is the incentives. *Niche creation* shows in relation to extension market that there is interest in using the ground technology of eCall for other services, such as security and safety related for the freight transport actors. Though this area of extension is limited, this can possibly be a case of the interviewees only discussing related areas of interest that are actual now. In the future, there might be other services that can use the data from eCall to create value for other actors. The *entry barriers* of a software ecosystem in general in freight transport was a big area of discussion during the project. The results are discussed in the next section of this chapter. The *extension model* of the eCall software ecosystem shows that the strict and closed

technology of eCall has no extension model today and that there is no interest in expanding the functionality or combine the functionality with other technologies from a governmental point of view. As eCall is not commercial there is no further benefits for the I_HeERO project team to implement a software ecosystem with commercial winnings. This affects a possible ecosystem, as this often is the incentives for actors to joint and contribute. The *operations supported by extensions* are today non-existent and cannot be documented. As with the case of niche creation, there is an interest in extending the functionality, but only to related areas such as security and safety issues for truck drivers.

eCall is built for one task, with focus on social benefits rather than opportunities and benefits for private actors or companies. The project's hard implementation of hardware and software in PSAPs and vehicles in Europe shows now intention of expanding its functionality, as there are no incentives from the eCall platform owners' point of view to extend the functionality in a commercial manner. As been shown in studies, older pilot projects of implementation of information technologies in freight transport has shown that an acceptation and adaptation is rare and calls for a broad acceptance. On the other hand, the legislative nature of eCall a possible positive aspect, as the report shows that this might be what is needed in order to change the view of information sharing in freight transport industry. As it is important to state the preconditions of a software platform, this is a possibility for eCall as a software platform since it has a clear functionality with clear stakeholders and their tasks.

A software ecosystem evolving around a technical platform of the eCall technology would most likely not be possible, as there are no incentives from the platform owners' point of view nor from other stakeholders or actors looking at the current situation of eCall.

6.1 Recommendations

In order for software ecosystems to prosper in the industry of freight transport different aspects needs to be considered and changes implemented. As the industry has different actors and stakeholder, not all recommendations are suited for all entities in the business. For transport organisations, like IRU and others, it is recommended to look into the possibilities to extend projects involving software to include external actors in order to increase the knowledge of software, but as well in order to increase the possibility to work with other systems, share software and hardware and possibly make the solutions less rigid. Many times the organisational actors possess the role of project leader in projects like I_HeERO, and having the possibility to develop the project and its roadmap, giving the possibility to decide what actors to take part of the project. Involving more software actors with technical as well as commercial knowledge could increase the quality of the software and ensure other actors about the safety and security of data sharing with software. As well, since the roadmaps of projects such as I_HeERO are quite long regarding time line, including software actors early can possibly increase the software quality and possible co-operation with other software, as well as possibly prevent software developing into a too rigid form.

The commercial actors in the industry of freight transport are many and of different kind. As concluded in the report different actors can serve different roles in several supply chains in freight transport, giving that recommendations are general and every actor possibly should act individually in order to increase the possibility of an implementation of software ecosystems. As an increased flow of information would decrease the presence of poor services and possibility of bankruptcy, a software ecosystem is one possible adaptation of increase information sharing in the business. The actors are advised to further investigate possible ways of sharing information with other actors and end-customers of transport services, as this

would decrease the number of trucks on road. As well, the actors can possibly investigate different digitalisation offers, as these solutions are safer than the traditional physical documentation of the business today. It is as well advised to further implement e-documentation of goods and other transport information, as this documentation possibly can increase the efficiency as well as bring the possibility to analyse the data documented, something that traditional documentation cannot offer. Further analysis could improve the business in general but as well for the individual company.

The end-users of transport are increasing in number, giving that this group receive more and more power of how a transport is executed, both regarding mode of transport and other aspects. The customers are advised to take on an increased role in the consummation of transport, demanding more information about how the transport is executed as well as factors such as environmental compensation as well as social security for drivers and other personnel involved in transport. As the information asymmetry of freight transport today is a factor affecting the end-users, an increased pressure about information can possible change the way information is shared, both to end-users and to other transport actors.

The academia is advised to further investigate the area of information sharing in the industry with a clear link to practice. As of today, many theoretical projects have been performed, but many of them have not been adapted by the industry as the idea have not functioned with the practice of the actors in freight transport. If performing projects in freight transport with information sharing via digital ways are performed, it is possible that a more practical view is better, involving the actors and not solely looking at the problem rom an academic point of view. In order to change the industry, sharing more information and making it more effective, it is clear that a consensus about the technology is needed. Therefore, showing the usage of a practical solution for the industry can possibly change the attitude of the business.

7 Discussion and further research

Qualitative data is collected through several interviews during the research process, and is combined with theory in order to build a picture of the current situation of software ecosystems in freight transport today. The interviews are held with people who are considered having extraordinary knowledge of the areas of interest, such as digitalisation of freight transport and software ecosystems. It is possible that the results would have been different if other people were interviewed, as the data is of qualitative kind and cannot be quantified. As the interviews many times overlap in their message, such as the characteristics of the business of freight transport and the attitude towards new technology, this area can in large extend be confirmed as true. In other areas only one or few of the interviewees contributing knowledge in an area, giving that this area in a smaller extent is verified. Many times interviews and literature are granting the same view of an area of interest, which further confirms the thesis of some questions. It is possible that other interviewees and other literature would have given another picture of software ecosystems in freight transport, although a thorough review of as well the people as the literature is done.

As eCall is the technology that has the main focus as a possible software ecosystem platform in the report, this of course influences the results and the analysis. It is possible that another software would have resulted in other answers towards software ecosystems in freight transport, as eCall is governmental software with a large extent of legislations and high introduction barriers in many aspects. Although it is more traditional in software to have a commercial product as the technical platform, to investigate a more closed product requires more investigations in the barriers and requesting a categorisation of the barriers. This aspect then becomes possibly more thoroughly investigated than if the platform was commercial, while other aspects, such as extension market or niche creation, are harder to investigate as they are very limited by the type of platform as eCall is today. If using a commercial platform in freight transport the possibilities might become more obvious, but so would the disadvantages for the commercial actors, as they are sceptical towards adapting new technology and communicating with other commercial actors. It is possible that a governmental platform with clear legislation and no commercial interest of its own is a good starting point for implementing software ecosystems in freight transport.

As the theory of software ecosystems is a young theme in the area of information technology, this affects the existing literature. As the literature often is written with pure software development projects in mind, this affects the results of the articles and books, as this area is younger with newer structures than the area of logistics and freight transport. When applying this theory onto freight transport, there are at times differences in the outlook of information technologies and their configuration compared to how they are considered in freight transport. This can possibly affect the outcome of the project, as software is constantly evolving and the view of the area in freight transport is a more constant technology.

7.1 Further research

During the project several areas of possible future research was identified. First of all, it is of interest to further investigate the possibility of software ecosystems within freight transport with pilots or tests in real world examples. This study was mainly focusing on the theory of software ecosystems, which usually is conducted in the area of software and software development, which colours the case studies. As information sharing and transparency is of interest in order to improve the current situation of information asymmetry in freight transport, software ecosystems could be a possible solution.

Moreover, it is of interest to further investigate the possibility of opening up governmental projects and pilots of software within freight and logistics. As the rules and legislations affects the projects and often affect how the systems can be built, it would be of interest to see if the results would be better if other actors than pure governmental would be involved in the documentation of requirements for a software, for instance.

Finally, further projects within the area of information asymmetry and the possible solution of information transparency would be of interest. As this factor affects the freight buyer, and the market for freight transport is steadily growing, the transport buyer should have the possibility of gaining knowledge in the transport they are investing in.

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Appendix I – Interview template

How do companies within the freight transport domain view sharing of data and information?

Do you believe the actors active today within the domain to be willing to share information with each other?

How do you think the future will look within the freight transport domain regarding digitalisation and information sharing?

Do you think it is possible to apply the concept of software ecosystems in the freight transport domain?

What benefits of data sharing do you see within the freight transport domain today?

Do you believe the benefits overcome the drawbacks for the actors? All actors? If not, which actors?

If the benefits do not overcome the disadvantages, what do you think is required?

What are the general barriers towards digitalisation and information sharing today?

Do you experince particular barriers against digitalisation and information sharing within the freight transport domain?

What kind of barriers? Technical or social?

What do you think it takes in order to lift the existing barriers against the sharing of informaiton and digitalisation within the domain today?