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Implementation of platooning concept from business perspective

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Abstract

Platooning is a way of how different transport companies could reduce fuel consumption and increase efficiency and safety. Concept implies that group of vehicles is driving in a convoy or string on the highway with close distance at particular speed with a help of driving assistance technologies, such as adaptive cruise control or cooperative cruise control.

Several projects describe how platooning can be used from technical perspective and are less focused on how platooning could be implemented from business perspective, as well as who would be making decisions for creating platoons. Even though some projects have mentioned this step, there is still lack of information and detailed business model.

This thesis gives a review of what kind of studies are done in this field and how platooning is defined by variety of researches. The aim of this paper is to propose different approach towards platooning implementation from business perspective. This paper implies that freight forwarding companies or 3PL service providers are the ones, who should organize several trucks in platoon.

Study is done with theoretical and practical approach, where theoretical approach includes several project review as well as academic literature review and practical approach is done by designing experiment and conducting interviews with industry representatives.

Key words: *platooning, transportation, logistics, heavy-duty vehicles, cooperative driving, road trains.*

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Yulia Puplaka
24.05.2016

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1 Introduction

1.1 Background

Transportation has a big impact on environment, since it is the major consumer of energy and has a biggest contribution to global warming. According to Schroten (2012) transport is responsible for 25% of green gas emissions. Especially essential is road transportation, since about 60% of all freight transportation is done on roads (Alam et al., 2015). Besides, ecological concerns, transportation companies also face economic challenges. For example, fuel costs for the Heavy-Duty Vehicles (HDV) represent a third of the total operational costs of an HDV that is why it is understandable why companies are eager to reduce these costs (Larsson et al., 2015). However, not only economy and ecology are the main issues in this field. Traffic flow and safety have great impact on society and industry as well (Halle and Chaib-Draa, 2005).

There are several approaches to address transportation problem. Improvements could be done from infrastructure's perspective with constructing more highways or making them more efficient. Additionally, there are such initiatives as switching from road transportation to railway transportation or redirecting polluters from the city centers.

However, this approach does not help to reduce the impact from HDV on the environment. Besides, more and more vehicles are produced every year. That is why this problem should be also addressed from vehicle perspective. A solution which is becoming more popular is development of intelligent transportation systems (Halle and Chaib-Draa, 2005). There are many components for ITS, however high attention nowadays earns cooperative driving, which can play a big role in achieving previously mentioned goals (Nieuwenhuijze et al., 2012). As Alam et al. (2015) states, the integration of information and communication technologies to transportation systems enables the development of cooperative methods to enhance the safety and energy efficiency of transportation networks.

One of this methods is platooning - cooperation of several vehicles which form a string by using advanced sensing and communication technologies in order to reduce fuel consumption and improve safety (Alam et al., 2015). According to some researches vehicles in platoon could reduce from 9% till 25% of fuel consumption and since fuel consumption is decreased, CO^2 emissions are reduced as well (Patten et al., 2012).

As stated in many studies platooning contributes to decrease of CO^2 emissions, because of the air drag that allows to save the fuel. It also helps to increase of safety on the roads and increase efficiency of the drivers, since they use advanced technology, such as Cooperative Adaptive Cruise Control (CACC). Which means that platooning not only influences transportation industry in particular, allowing to reduce several types of costs, but also has impact on society in general. That is why it is important to do research on this concept.

Platooning has a long history, dating back to 1950s when studies on dynamics of vehicles driving in formation in one lane were performed (Alam et al., 2015). One of the most influential research projects was PATH project in San Diego, California, in 1997, where a platoon of eight passenger cars was performed (Alam et al., 2015). This demonstration of the possibilities of platooning had impact on many researchers and many based their study on the results of PATH project.

Though platooning has long-standing history, it was mostly discussed from a technological perspective. Yet it has other aspects which should be considered. Only quite recently different organizations and even countries came together to collaborate and describe platooning not only from technical side, but also to develop business model for successful implementation of this concept.

The SARTRE Project - Safe Road Trains for the Environment - is collaboration by several companies or organizations from different countries, such as Spain, Germany and Sweden. This is another well-known project, besides PATH. Moreover it aimed “to develop strategies and technologies to allow vehicle platoons to operate on normal public highways” (Jootel, 2012).

Current level of technologies allows to perform a safe platooning on public motorways (Alam et al., 2015). This is proved by recent successful journey from Gothenburg in Sweden to Rotterdam in Netherlands done by Volvo’s truck convoy within the framework of EU Truck Platooning Challenge (Sjöberg, 2016). However business aspect remains insufficiently investigated, even though SARTRE and other projects raised the issue of the platooning implementation from business perspective, since it has big influence on society.

1.2 Research aim and research questions

It was previously mentioned that platooning has big impact on industry and society because of potential it has to reduce fuel consumption and increase efficiency of many activities. There are several articles and projects written about platooning, as well several business models described.

The aim of given research is to investigate the academic literature and project reports, review current state of platooning realization and propose a different approach towards platooning implementation. However, this could be challenged by the fact that all the researches have different understanding of what is platooning, which could lead to misconceptions. That is why in order to reach this aim, several research questions were formulated:

1) How platooning is approached and defined in academic literature and variety of related projects?

2) What are the current opportunities and challenges in implementation of platooning?

This paper focuses on several steps in order to answer these questions:

- Selection and analysis of the different practical projects to get general understanding of integrated approach towards platooning;

- Selection and analysis of academic literature to get insights of used approaches towards platooning;
- Review and analysis of known platooning implementation business models;
- Design of another possible business model and its evaluation;
- Design of the experiment and interviewing industry representatives.

This paper contributes not only to academic society, since it reviews relevant to platooning articles and project reports. It also provides different approach to the already described business models. Thus this paper can be interesting to the transportation industry representatives, such as freight forwarders, hauliers, shippers and others. Thesis outlines conducted studies and suggests new approaches towards research of platooning concept.

1.3 Outline of the paper and limitations

The outline of this paper is following: chapter two describes used methods, reasons for choosing particular methods, as well as detailed description of the research process. In turn chapter three discusses theoretical background of this paper, as well as provides with review on technological and economic review of platooning projects. Possible business model for platooning implementation is also suggested in this chapter. Chapter four describes empirical data gathered by previously mentioned methods. Chapter five concludes this study and chapter six provides discussion for further research.

There are also some limitations in this paper that should be mentioned. First limitation is related to the number of selected articles for academic literature review. Since large amount of articles address platooning, only those which could contribute to this study were selected. However, there is slight possibility that some potential articles might not be included. Time limitation plays important role as well.

Another limitation is related to the fact that this paper focuses on specific actors of supply chain – freight forwarders and 3PL providers. Relationships between hauliers and forwarders are mostly described in this study and perspective of the forwarder is primarily taken into consideration. This paper also focuses on HDV, since they are used for freight transportations and have big impact on environment. However other vehicles are also mentioned, though in relation to other projects.

2 Methodology

2.1 Introduction in research methods

Different methods are used in this paper in order to answer previously mentioned research questions. First part of the methods or, in other words, first approach - theoretical - consists of reviewing and analyzing already available information. The second approach – practical - is needed to obtain information from the industry representatives.

Theoretical approach is also divided in several steps. First step consists of platooning related project review. Several projects, such as The SARTRE Project, TNO Innovation project, COMPANION Project, Peloton and others are reviewed and compared. This is done in order to get insights of how platooning is approached, how it is studied and what are the suggestions for its implementation. The tendency shows that platooning is becoming more and more promising and many countries are conducting research on this topic.

Next step consists of reviewing several academic papers and articles, which addressed platooning from different aspects. Moreover there is wide range of papers on platooning that is why one of the main challenges in this paper was to select optimal number of relevant articles. Nevertheless selected articles were compared and specific aspects of them, such definition of the platooning or used methods, were compared. More detailed description of this process is available in the following chapters.

Second approach is needed to support theory chapter of the paper, which is based on theoretical analysis of the projects and articles. An experiment was initially conceived, where two heavy-duty vehicles follow each other on the route from Helsingborg to Gothenburg at the desired speed with specific inter-vehicle distance using adaptive cruise control. However, after police representatives reviewed details of proposed experiment, it was concluded that conditions for conducting this experiment are hard to fulfill.

As the other option interviews with industry representatives were conducted. Several forwarders and logistics representatives shared their perspective on proposed business model. Detailed description of the process is given in the following chapters.

As alternative method and/or for further research a case study can be proposed. For the case study observations, surveys, focus groups and simulations can be used. However, in order to answer research questions of this paper, case study is not necessary and used methods are optimal. Yet for further research which could focus on perception of the platooning by vehicle drivers or employees of transportation company case study can be effective method to conduct a research.

One of the biggest challenges of this paper is selection and review of available articles on platooning. The number of articles on the topic is quite high and described aspects are highly diverse, there are other drawbacks as well. Since it was not possible to review all articles on this topic, limitation of the amount of articles was used. Another example of the drawbacks is availability of some research papers: some of them was harder to attain rather than the others. As another challenge can be mentioned the amount of given time for this research. Consequently less amount of interviews were conducted than it could be.

Nonetheless used methods provide with right amount of the data in order to answer research questions and make reviews, thus allowing to make a suggestion for business model.

2.2 Project review

Several projects from different parts of the world address platooning. In order to get insight of how different projects address platooning from practical side, theoretical analysis of the projects is done.

First and general search was done with the help of searching engine google.com. With this such projects as SARTRE project, PATH and Peloton Technologies were found. Additionally author asked for consultation and advice from industry expert, who suggested to look for projects, such as TNO platooning project or The Companion. KONVOI and CHAUFFEUR II projects were added after conducting literature review.

In order to analyze all projects, comparison table was made, where projects were studied, using parameters, such as what is the country or organization, that made particular project and in some cases project description; who are the actors who will be using platooning; definition of platooning; some of the used terms; restrictions of the project; timeline; implementation plan; necessary technology; business value and costs of the implementation; business model; impact on society; advantages; challenges; source of information. Those factors were mostly chosen while getting acquainted with projects.

After that different reports from selected projects were studied in order to find information for each parameter. During this process parameters were changed and standardized for most projects. However, not all reports had necessary information. Besides some projects were added during gathering data for other analysis.

After finishing this step, projects were divided into two groups: first group consisted of projects KONVOI, SARTRE, TNO and COMPANION and other group consisted of the rest of the projects - PATH, CHAUFFEUR II and Peloton. The reason for dividing projects was uneven amount of information for each project, as well as projects from first group had more similarities between each other. In order to simplify comparison, they were put together.

For the next step author excluded some factors and simplified the table, by reformulating most statements from reports, used in the previous table in order to unify information. At this point there were three tables: initial one, table for group one and table for group two. Altogether seven projects and ten parameters were selected.

Selected ten parameters included the organizations or companies, which conducted platooning projects, as well as timeline, definition of platooning, description of technology, business model and costs, advantages of platooning and challenges, as well as impact on society and additional information.

Short conclusions about each parameter and for each group were done and compared in the table once again. Basic description of found patterns or differences is provided after the table.

All those steps allowed to systemize big amount of information from different projects and unify it in order to compare and analyze. This also helped to find what are the similarities and differences in approaches towards platooning, as well if there is lack of any information. Thus review conclusions could be done.

It can be noted that project data analysis was done twice: first it was done before academic literature review was conducted and second time after doing business model review. This was done in order to supplement the initial analysis, since at the beginning not all projects were found. Thus from four projects this review expanded till seven projects and several other were mentioned, but not reviewed.

2.3 Academic literature review

2.3.1 Selection of the articles

The purpose of the literature review is to investigate articles related to platooning, summarize them, and make categories and conclusions about information which is available on this topic. Other purpose of the literature review is to analyze how platooning is defined in different scientific papers and formulate a general definition. Due to the lack of similar academic reviews, author used following strategy.

In order to access scientific articles, online citation indexing service - Web of Science - was used. Initial aim was to cover as many related articles as possible, however since the number of found articles was too big, it was necessary to do sorting and selection of suitable sources. That is why author used words “platoon” AND “vehicle” OR “platoons” AND “vehicle” and refined by language - only English - and search areas, such as engineering, transportation, robotics, etc. Only articles were chosen for this literature review. This choice is determined by the fact that word “platoon” could be related to variety of areas, such as biology, transportation or engineering. In order to eliminate non related articles author used word “vehicle”. In addition second set of words was done due to the fact that in Web of Science not always all searches included word “platoons”, if only word “platoon” is searched. That is why in order to obtain a full list of necessary articles, this step was done, resulting by finding around three hundred fifty articles.

However, other searches were done as well in order to broaden list of articles. Second search included such words as “platoon” AND “vehicle” and “highway” OR “platooning” with almost two hundred results, yet many of those results were already included from previous search. Additionally author searched for “platoon” AND “vehicle” AND “cooperative driving”, “platoon” AND “heavy vehicle”, “platoons” AND “vehicle” AND “strings”. Thus adding more articles to the list, although in last three searches approximately half of articles were already included

While doing searches and selection author focused on titles and abstracts of the articles. Point of interest on this stage were particular combination of words related to platooning, such as autonomous vehicles, cruise control, flock of the vehicles, vehicle-to-vehicle communication, vehicle following/ leading, string of vehicles, intelligent transport systems (ITS) and other, excluding pedestrians, bikes or bicycles, underwater vehicles, buses. This selection resulted with almost four hundred results.

Previously mentioned actions are considered to be primary search and selection of the articles. Next steps were considered to be secondary search and sorting process. In order to systematize all selected articles, new point of interest was chosen. In this stage author focused on finding the aim of each paper stated in the abstracts of particular articles. While looking into what authors of papers wanted to say, prove or answer in their works as well as how those questions and findings were related to platooning, criteria of four groups were formulated.

First group included articles with main object of interest is platooning as a string of vehicles following each other by using some kind of technology, for example, cruise control system or autonomous system. Meaning that aims of research stated in the abstracts of the papers would include word “platoon” or “platooning”.

Second group included articles, which describe platooning and some other concept or method. In this case focus is shifted from platooning to something else. However, platooning was still important, because “something else” is connected to it.

Third group focused on some other concepts, methods or technologies, however platooning was still mentioned and somehow related to the main question.

Last group included articles where platoon or platooning were mentioned in another context, not as defined previously, or not mentioned at all. Here were articles which were selected because of synonyms to platooning or similar ideas. It also included articles which consisted of the word “platoon” or “platooning”, however they were not related to this topic.

Shortly these groups could be described as following:

1. “Important” group - main focus is on “platooning” which includes several vehicles with autonomous cruise control system driving in the string/ flock.

2. “Medium” group - focus is shifted from platooning to something else, but platooning is still important, since “something else” could be mainly done/ performed in connection with platooning.

3. “Not important” group - focus is on something else and platooning is mentioned as example, alternative or option.

4. “Not platooning” group - platooning is mentioned in another context (not as defined for group 1) or not mentioned at all.

Since the reviewing is a continuous process, approach towards categorizing has slightly changed. That is why factors which influence decision have changed as well. Before it was mainly the factors described above, where question “what is the role of platooning in particular article?” later this approach changed to “how the particular article can contribute to the previously done project review?” Thus some articles were discarded faster than others with the aim to narrow down list of necessary for this research articles. However, the number of picked articles in category important” was 45 articles and this list did not include 77 previously picked articles. Besides there was still category “medium” which included quite needed articles as well. As the result, the number of articles which looked like should be included in the review was 237 out of 373 articles. Thus a new approach in sorting was implemented.

The main problems with further categorizing was concluded in the difference of understanding of what are “platoon” or “platooning” between different authors, including author of this paper. Other problem was that platooning itself includes many aspects that could be researched, so it is hard to limit which ones were needed and which could be avoided. Last factor is that articles had different directions and a lot of findings that is why there were difficulties in unified summary for each.

Articles from first “important” category were reviewed and the ones which author considered particularly important were saved separately in additional group.

All articles were saved in the online EndNote service. Following figure shows how it looked like.

Figure 1. EndNote list with first sorting categories

However, new approach was applied, where an Experimental Study on the Fuel Reduction Potential of Heavy Duty Vehicle Platooning by Alam et al. (2010) was taken as an example of search. That is why similar general articles, which overview platooning as a “convoy of vehicles which are using ACC and V2V communication” or similar, were searched. Thus 9 articles including aforementioned experimental study were selected in this new category. Other new categories were as following:

“CACC, ACC, V2V” category included articles on this topic, describing the ways how those systems could function or could be used in platooning separately or together.

“Not automated platooning” category included articles which described platooning without using cruise control or similar technologies.

“Safety category” - all articles and papers that included description of string stability, braking systems, changing lanes safely and other aspects of safe platooning.

There was also category of articles, to which author did not have access and thus was not reviewing them. New categories start with “I” and are shown in figure 2.

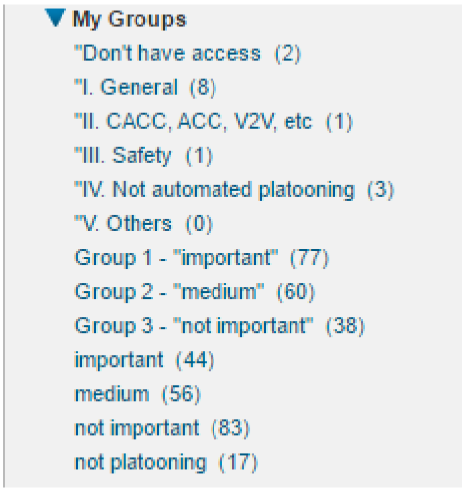

Figure 2. EndNote list with new categories

Articles from each category were reviewed in separate excel tables and after that combined in one table for comparison.

There might be other ways of systematizing articles, making more precise and detailed categories, however this was not the aim of this literature review. The aim of this literature review was to look into academic papers on the particular topic and provide the review on where is the lack of information, how platooning is approached and defined.

While doing new categorization previously mentioned categories slightly changed. To the category “general” were added more articles, making all together 13 articles. Next category was named CACC, ACC and V2V, where the main idea was to collect papers related to technologies, which are able to support modern platooning. However, author noticed many articles related to such parameter, called “controller”, so articles on this topic were separated. There was also category “safety” which included articles on how to ensure safety of a platoon, however main subjects of the articles were connected to stability, so this category mostly consists of those articles. There is also category, where different papers related to platooning or related slightly were combined, named “different topics”. Author also separated some general articles on platooning from the articles in “general”, since those articles described platooning, where cruise control or other systems were not used.

Author went through previous categories “important” and “medium”, adding articles in new categories. In its turn articles from categories “not important” were combined and left without categorization, since previously author concluded, that articles there are slightly related to the topic of this paper and cannot contribute to the current research. Separate category is left where subject is not related to the discussed platooning and this term is used in other context or not used at all.

However, that was just rough division of the articles, so new round of categorization was made. From category “CACC, ACC, V2V” author picked articles only related to those topics, selecting 25 articles. However this was still too many papers, since technological aspect is not the major one in this research, thus this area should be limited, even though other articles could provide additional data and perspective on platooning concept. This resulted to the selection of 13 articles on the topic, which was named “II. CACC”. From category “not automated” author selected two articles, and from category “controllers” four articles. Rest of the articles in that category were combined with articles from previous category “CACC, ACC, V2V, etc.” and renamed to “technology”.

From rest categories author selected 10 articles in category “Safety and stability” and 9 articles for “Different”. While doing so, author made two rounds of the selection, the same as in previous category “CACC”: firstly more rough selection of articles, resulted with around 20-25 articles and after that more specific selection of articles, which are mainly describing platooning in connection with particular category.

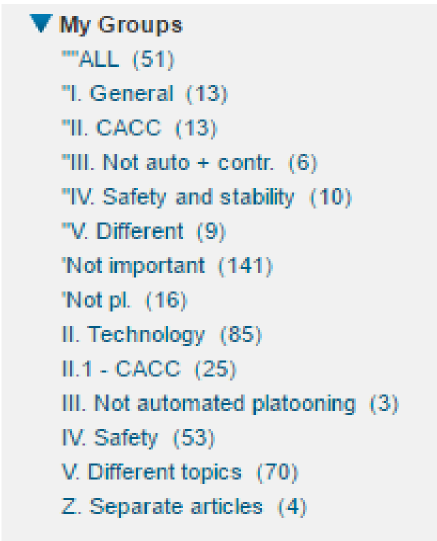

Figure 3. EndNote final version of categories

Finally, all selected articles were also added in category “all”, ending up with 51 articles, which were reviewed and compared. Final version of all categories is shown in figure 4.

During overview some articles were removed, since they did not suit purpose of this review.

2.3.2 Data overview and comparison

In the article comparison table were gathered 49 articles which describe different aspects of platooning. Main data gathered from each article consists of: authors, title, year, where it is published, definition of platoon or platooning according to particular paper, air or purpose of each article, used methods, mentioned terminology, described or mentioned technology to ensure platooning, automation level based on technology and paper's keywords.

In data gathering step papers were viewed in separate categories mentioned in method chapter, however their analysis was done by comparing all articles without dividing them into previously mentioned categories.

Level of automation in this paper is combination of the one described in the "Handbook of Intelligent Vehicle" by Azim Eskandarian (2012), where vehicle's control functions are described by three level of automation: active safety systems, semi-automated functions and fully automated vehicle control and the one described in TNO project review, based on SAE International standard's (2014) six level of automation. Together this looks as following:

- **No automation** - full control by the driver;
- **Semi-automation**, which is divided to:
- **Low-tech** automation - driver's assistance/ partial automation or active safety systems, such as anti-lock braking system (ABS), traction control, stability enhancement system, rollover control and collision warning, avoidance systems.
- **High-tech** automation - high level of automation, using ACC or CACC or even higher level technologies. Even though ACC and CACC use quite available technologies, not all transportation companies use them.
- **Full automation** - system replaces driver. For example, Google's automated cars.

That is why terms used are following: no auto, low-tech, high-tech, full auto.

All parameters in the table are divided into primary and secondary types of data. In primary group included definition of platoon or platooning, used methods, technology, aim of the research and automation level; in the secondary all others. Such parameters as authors, title and keywords were not analyzed, since they are not crucial for this comparison.

In order to analyze data in parameter "definition of platoon(ing)", all definitions were copied in separate working list and content analysis was used. Each definition was divided into four groups: what is platoon/ platooning; what actions are done; what are the conditions for platooning to happen and what are the additional words used. In other words in each definition "subject", "action", "condition" and "others" were found and marked each with different color. Some words were also counted to see general picture of how many times some words were used. In each group words were analyzed and divided once again. Thus some patterns were found which helped to formulate new definition based on obtained data.

Similar actions were done to the parameter of "aim of the research", however in this case this process was simplified during the analysis. Only sentences, which described main focus areas were marked and later copied in the table separately. However after that they were reduced to shorter phrases and after that divided into the groups.

Other parameters were reviewed in different way. Parameter with used methods were reviewed by percentage: how many researchers use particular method. Technology level was marked more roughly since it does not contribute to the aim of this paper. Same was with the automation level. However the number of articles were counted in this case as well. Secondary data was also reviewed, but in a less precise way, since this analysis is done additionally. Nevertheless publishing year, source of the paper and terminology were shortly described in that part of the chapter.

As for year and source, the quantity of the articles for specific year and journal was calculated, which allowed to make some conclusions. In the end short conclusions were made for each point of the analysis.

2.4 Practical research methods

2.4.1 Experiment design

Previously described methods were theoretical, since they included analysis of published data. However practical approach should also be implemented in order to increase validity of research. Thus experiment of platooning was developed

Experiment was designed to test platooning in the working conditions and measure what are the changes for vehicles with platooning and without it. In order to do that two heavy duty vehicles would do several round trips driving in platoon and in regular way between Helsingborg and Gothenburg. However several requirements should be followed:

- In order to limit variations same vehicles should be used;
- Same drivers should participate, since difference in driving behavior could influence the results;
- Vehicles must be equipped with minimum adaptive cruise control in order to avoid dangerous situations;
- Vehicle basic data, such as fuel consumption, should be easily accessed;
- Distance between vehicles should be 2 seconds and vehicles should have constant speed.

It is also necessary to have access to vehicles historical fuel consumption to be able compare data. Weight of load should be measurable. Every step should be measured from beginning of the trip and end of it.

For data recording special form was created, that consisted of such data items: date of the experiment, direction, e.g. in this case Helsingborg - Gothenburg, duration of the trip, environmental conditions, traffic conditions, road conditions, vehicle description, loads description, trip description, ACC notes, who were doing recordings.

Several items were divided more specifically and places in tables, where different parameters could be described. Such as:

- Weather conditions: Ambient temperature, Humidity, Wind speed, Wind direction, Precipitation, Description

- Slope angle: Going up, Going down, Going straight, Other;
- Vehicle parameters: Type/ model, Length, Weight, Engine, Rolling resistance, Gear box;
- Trip description:
    - Start (from terminal till highway): Speed, Fuel consumption, Notes;
    - Motorway (driving without slipstreaming): Speed, Fuel consumption, Notes;
    - Motorway (driving with slipstreaming): Speed, Fuel consumption, Notes;
    - End (from highway till terminal): Speed, Fuel consumption, Notes.

It was assumed that such parameters as weather, trip or vehicle conditions could influence the behavior of the vehicles in the platoon that is why it was important to note every step. For example, rain could influence the speed, slope angle could influence fuel consumption and depending on vehicle model results could have changed. Therefore in order to receive more valid results, it would be needed to conduct several similar experiments.

The experiment could be conducted with the help of local logistics service provider which often carries out similar trips. However due to legislation issued this experiment could not be conducted without obtaining consent from police representatives.

2.4.2 Interviews

Before any agreement with logistics company was done and experiment could be carried on, it was necessary to conduct interview with a senior traffic police officer. That is why request for the experiment together with the description was sent to police representatives. Results of this interview are described in the relevant chapter.

Additionally several interviews with industry representatives, such as freight forwarders or logistics company representatives were also carried out in order to receive opinion on platooning itself and on suggested business model that is described in this paper.

Several requests for the interviews were sent to different freight forwarders and logisticians, however only some of them were available to share their opinion. Interviewees represent variety European Union countries, such as Bulgaria, Latvia and Sweden. Besides they are employees of the different sized companies. Total number of interviews together with police officer interview is four interviews.

Conducted interviews were semi-structured and open-ended. Interviewees received short description of the thesis, summary of the discussed questions and suggested business model. There was also list of general questions, such as:

- From a perspective of the freight forwarder what does interviewee think about suggested model?
- What would be the conditions or factors that could make platooning possible?
- What would be the challenges?

Nevertheless interviewees were free to share their opinion and comments on everything which was related to the business model and platooning itself. Thus some complimentary information was obtained. Author also received additional information about hauliers and their approximate costs and revenues, however this data was not included in the research, since it was not related to the topic of the paper and could not supplement this research.

Besides necessary information about the topic and business model, interviewees were informed about the reason for this research, as well as that obtained data will be anonymised.

2.4.3 Ethical considerations

Conducting any type research where human subject is involved, it is necessary to fulfill several points that support ethical research (Silverman, 2013). Shortly most important and relevant to this research points can be formulated in the following way:

- Subject that is participating in the research should do it voluntary.
- Subject should be informed about important information of the research, e.g. purpose.
- Confidentially should be respected (Silverman, 2013).

All interviewees participated in the research voluntary. They were also fully informed about the paper as well as how their responses will be used. Their confidentiality is also respected. The only information available is their general position and place of residence. Nevertheless their answers are important part of this study.

Another ethical aspect is executed in this thesis. Specifically sources and authors of the particular theories or ideas are indicated in all cases.

3 Theoretical background

3.1 Introduction to the theory

In this chapter summary of several projects: The SARTRE Project, TNO Innovation project, COMPANION Project, Peloton Technology, PATH Project, KONVOI and CHAUFFEUR II project are summarized and reviewed from two different points of view.

First is technology review mostly from SARTRE and TNO projects. Six-level automatisation ladder from SAE standard is compared with 3 levels of automatisation from the book “Handbook of Intelligent Vehicle” by Azim Eskandarian (2012). This review allowed to combine both approaches and use it in academic literature review.

Next is business model review of projects SARTRE, TNO, KONVOI and Peloton Technology, because several business models are addressed and discussed in this projects. This enabled to propose different model for platoon implementation for logistics service companies. Before model is introduced, description of freight forwarders functions and difference from 3PL providers is given. This chapter conclude suggested business model design tool Business Model Canvas and evaluation instrument SWOT analysis.

3.2 Analyzed projects

The SARTRE Project - Safe Road Trains for the Environment - is collaboration by several companies or organizations, such as Idiada and Robotiker-Tecnalia of Spain, Institut for Kraftfahrwesen Aachen (IKA) of Germany, SP Technical Research Institute of Sweden, Volvo Car Corporation and Volvo Technology of Sweden. The aim of this project is “to develop strategies and technologies to allow vehicle platoons to operate on normal public highways” (Jootel, 2012). Project was funded by the European Commission under the Framework 7 Programme and covered time period between 2009 and 2012.

Project mainly focuses on three issues: environment, safety and congestion. Main consideration was based on how vehicles in platoon could interact between each other as well as how platoon vehicles could interact with non-platoon vehicles on the highways (Jootel, 2012). Project was also considering financial aspect of the concept, offers different possible business models, and considers legal issues, which might arise while implementing this concept.

Basic concept of platooning in SARTRE project is as following: vehicle platoon is a group of vehicles which are led by professional driver and where different types of vehicles (cars and trucks) are driving on public motorways. Except for leading vehicle other vehicles are driven fully automatically by the system, which allows other driver to do tasks, which usually are prohibited, such talking on the phone, reading, etc. (Jootel, 2012). Despite the fact that many issues were identified and considered during the SARTRE, Project there are still a lot of questions which should be resolved and new strategies developed and tested.

TNO Innovation project on truck platooning done by the Netherlands Organization for Applied Scientific Research. Some research and developments were already done before 2015 and next step for the project is to do wide scale tests. The aim is to achieve first commercial application by the year 2020 and broad commercial application by the year 2030 (Janssen et al., 2015).

The main definition of platooning according to TNO experts is formulated as “two trucks driving less than 1 second apart, made possible by wireless vehicle-to-vehicle communication.” (Janssen et al., 2015). TNO focuses on two-vehicle truck platoon, since many vehicles, especially trucks, in one platoon could make disturbances to other drivers, for example, block exit from the motorway.

Projects puts a lot of attention is on challenges of implementation - list of risks and barriers consists of 32 factors. Supply chain and all the stakeholders, who might be interested in platooning concept are thoroughly described and analyzed. Project also suggests new type of service provider - Platooning Service Provider, which would be neutral third party and which role would be to match trucks from different hauliers (Janssen et al., 2015).

Costs and savings from deployment of platooning are also significant and are explained in the whitepaper of the project. Used calculations are mostly similar to the ones which are described in The SARTE Project, which is not surprising, since TNO platooning project uses data from SARTRE as a source of information additionally to the data from LZV research on trucks and case studies with such companies as Peter Appel Transport, De Winter Logistics and Europe Container Terminals (Janssen et al., 2015).

Another interesting project which ends in 2016 is COMPANION Project - cooperative mobility solution for supervised platooning. COMPANION is European research project and includes such actors as Volkswagen Group Research, Stockholm’s Royal Institute of Technology KTH, Oldenburger Institut für Informatik (OFFIS) in Germany, IDIADA Automotive Technology in Spain, Science & Technology in the Netherlands and the Spanish haulage company Transportes Cerezuela (Eilers et al., 2015).

COMPANION Project is focusing its research on business implementation of platooning, since benefits of this concept are clear, especially after research done in SARTRE and TNO. Main aims are to develop necessary technologies, create dynamic system and suggest regulations for successful implementation (Eilers et al., 2015).

In this project platooning is defined as “trucks interconnected through Vehicle-to-Vehicle communication running at a very close distance” (Eilers et al., 2015). On the webpage of the project are published some deliverables, mostly describing technological side of the project. More information will be published this year.

The common thing in previously mentioned projects is the fact that they are done in Europe. However it is also interesting to look for similar experience in other parts of the world, for example, in United States.

Peloton is an automated vehicle technology company in USA, which is developing technology for platooning. Trucks with necessary technology are coordinated by Network Operations Center, which makes sure that vehicles are driving in safest mode. Main aims are to reduce accidents and provide fuel savings (Peloton_Technology, 2014). However one of the earliest projects in United States was PATH project, which was driven by the need to produce an increase in the capacity of a highway lane, as well as to increase safety, so that there would be no need to significantly change the infrastructure (Bergenhem et al., 2012). However project implied some slight changes in highway infrastructure, such as in-vehicle magnetometers sensed magnets, which were buried in roadbeds (Thomas and Martinez-Perez, 2015). Nevertheless this project gave impetus for other projects on automated highway systems, including platooning projects.

According to PATH research, driving in platoons up to 10 vehicles could increase the capacity of car lanes. It was considered that all vehicles would be automated in platoon in order to avoid accidents caused by human error (Bergenhem et al., 2012). Successful demonstration of the results of experiments in 1997 showcased 8-car platoon driving in particular speed (Thomas and Martinez-Perez, 2015). It attracted big audience and almost one thousand people took part in demonstration rides. All maneuvers were done with the help of different sensors and controllers, as well as with V2V communication technology (Bergenhem et al., 2012).

Coming back to Europe. Two German projects KONVOI and CHAUFFEUR I/II discuss platooning as well.

CHAUFFEUR I was conducted between 1996 and 1998 and was focused on developing so called "tow bar" - vehicle guidance function which represents a very advanced driver assistance system (Benz, 1999). The aim was to develop a system, which would increase the density of freight traffic while preserving safety and allowing better road usage (Benz, 1999). In turn CHAUFFEUR II was based on first project, but was focused on platoons of vehicles.

German project KONVOI, funded by Germany's Federal Ministry of Economics and Technology, aimed to realize and analyze the use of electronically regulated truck convoys on the road. It provided not only technological perspective on platooning, but also considered economical value from microeconomics and macro economical point of view (Kunze et al., 2011).

There are also other researches being done on platooning or similar concepts and technologies, such as SAFESPOT Integrated Project, CVIS Project (Cooperative Vehicle-Infrastructure Systems), Grand Cooperative Driving Challenge (GCDC), national ITS project by Japanese Ministry of Economy, Trade and Industry, SCANIA-platooning etc. However in this paper those projects are only mentioned, not reviewed, since focus mostly will be on the projects that focus on different aspects of platooning.

3.3 Technology review

Idea of automated vehicle dominates modern society and it seems that it is not a future, but already a present. It is clear that many developers and manufacturers have two general objectives: either to provide an integrated vehicle automation or to automatize separate modes of vehicles driving, e.g. parking, driving in traffic jam, highway driving, etc. A lot of research and development of necessary equipment that allows vehicles to drive autonomously is done. Google self-driving car is one of the quite successful examples of the first objective (Suslinnikov, 2015).

One of the most important questions related to technologies in platooning is what technology is needed and what technology already exists (Suslinnikov, 2015). In order to answer second question, first question should be considered.

The question “what technology is needed” is not specific. But it represents the idea that with so many researches done and technology described there is a needed to unify the understanding of technology levels, so that everyone can address that issue to the same extent. As an example could be mentioned SAE International levels of driving automation, which was described in TNO Project.

SAE International’s new standard J3016 describes six levels of automation from “no automation” till “full automation”. The aim is to “provide a common taxonomy and definitions for automated driving in order to simplify communication and facilitate collaboration within technical and policy domains.” (SAE International, 2014). Levels are also divided in two parts: in first free “human driver monitors driving environments” and next three “automated driving system monitors driving environment” (SAE International, 2014).

Standard reviews automation from several parameters, for example, “monitoring of driving environment” or “system capability (driving modes)”. Level of automatisation is related to who is in control in all those parameters. In no automatisation human driver is responsible for execution of all actions and in full automation all actions mentioned in the description are performed by the system (SAE International, 2014). TNO project not only includes SAE international standard, but also compares those six levels with ones developed by the Germany Federal Highway Research Institute

(BASt) and approximately corresponds to those described by the US National Highway Traffic Safety Administration (NHTSA) in its ‘Preliminary Statement of Policy Concerning Automated Vehicles’ of May 30, 2013 (Janssen, 2015). The comparison in the table is shown in figure 4. According to TNO, platooning requires level 2-4 from this standard.

Level	Name	Narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)	BASt Level	NHTSA Level
***Human driver* monitors the driving environment**								
0	No automation	The full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	N/a	Driver only	0
1	Driver assistance	The *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	Partial automation	The *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes	Partially automised	2
***Automated driving system* ('system') monitors the driving environment**								
3	Conditional automation	The *driving mode*-specific performance by an automated *driving system* of all aspects of the *dynamic driving task*, with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes	Highly automised	3
4	High automation	The *driving mode*-specic perfomance by an automated *driving system* of all aspects of the *dynamic driving task*, even if a human driver does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes	Fully automised	3/4
5	Full automation	The full-time performance by an automated *driving system* of all aspects of the *dynamic driving task*. under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**	·	

Figure 4. SAE International levels of automation in comparison with BASt and NHTSA

However, this is not the only way of how to describe level of automatisation. In the "Handbook of Intelligent Vehicle" by Azim Eskandarian (2012) vehicle's control functions are described by three level of automation:

First level is called "active safety systems" - automated systems are activated only in emergencies, otherwise driver is still in full control. In this level such technologies, as anti-lock braking system (ABS), traction control, stability enhancement system, rollover control and collision warning, avoidance systems, etc.

Next level "semi-automated functions" besides driver assistance systems also includes ACC and active front steering. In this level vehicle controls specific functions and system is manually activated. Platooning could be mentioned as an example for this level.

Last level is "fully automated vehicle control" - system replaces the driver in conducting driving functions (Eskandarian, 2012).

This system compared to the one reviewed in TNO Project is more general and simplified, however at some point this simplicity is its strength, because it is easier to understand and use such model. But it does not include no automation level. On the other hand, SAE International standard is more detailed and thorough, which at some point makes it easier to apply for many cases. Both levels of automatisation are equally useful, however author of this paper suggests that simplified 3-level model is more effective for this paper, since this paper focuses on business side of platooning and not technical part. Nevertheless, it is important to understand on what level of automation is required for platooning in general and in order to answer previously mentioned question "what technology does already exists".

Modern platooning requires usage of technologies as well, since vehicles could communicate between each other and following vehicle could drive in at least half automated way. In some projects ultimate ambition is to let technology take full control of all vehicles without any driver involvement (Janssen et al., 2015).

Many articles and researches describe possible options of how to make it work. However main general idea is to use automated driving (AD) technology and wireless communication. AD technologies allow vehicles drive autonomously and close to each other, as for wireless communication its main task is clear by its name - allowing vehicles to communicate between each other.

In TNO project AD technology consists of Adaptive Cruise Control (ACC), Lane Keeping Assist (LKA), Autonomous Emergency Braking (AEB), Automated parking (parking assist). Together with Vehicle-to-Vehicle communication (V2V) ACC technology makes Cooperative Adaptive Cruise Control (CACC) - this technology allows using platooning in more efficient and effective way. The advantages of using technology, such automated driving, are, for example, the possibility to adjust speed and position faster than the driver, as well as being able to hop-on, hop-off from the platoon on-the-fly (Janssen et al., 2015). Figure 5 represents a simplified scheme of technologies necessary for platooning.

Next step in this chapter is to review in more detailed way what technologies are needed, so that several vehicles could safely drive in a platoon. At first it seems that advanced technologies are necessary, however, many of them are already used in modern vehicles and generally are quite simple.

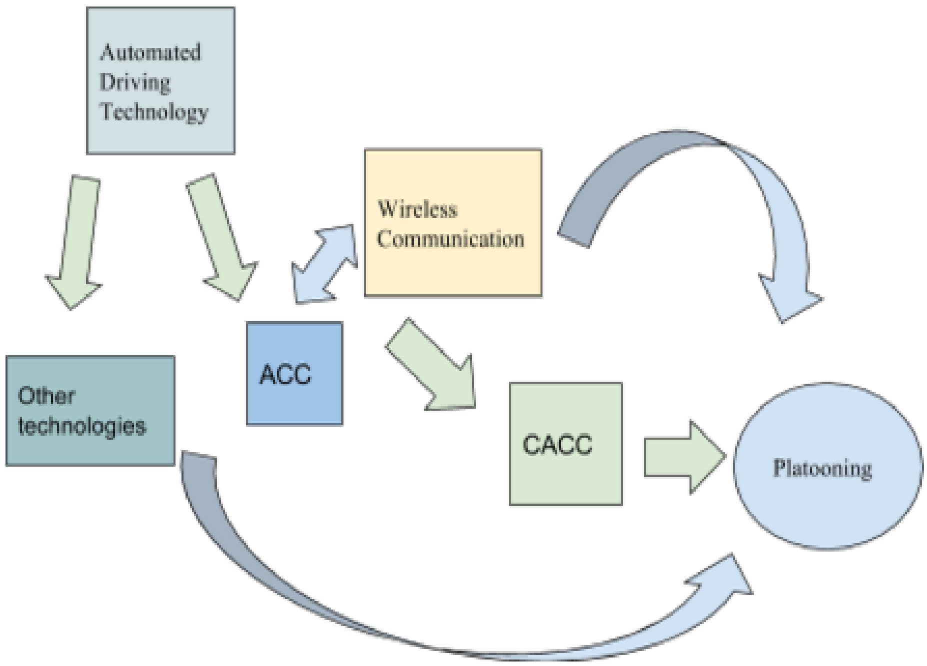

Figure 5. Technologies in platooning

Adaptive Cruise Control (ACC) is not a new technology for many companies, e.g. ACC from Scania assists to maintain a time gap between vehicles and warns if distance suddenly closes. It analyses road, speed, and data from engine; has Scania Retarder and wheel brake assist. However, this technology never takes over completely and is used only to assist to driver (Scania, 2016). ACC system uses: radar, lidar, camera, position determination devices, such as GPS or INS (Janssen et al., 2015).

Radar is needed to determine precise position of other objects and distance to them and their speed. Radars are particularly good to use in bad weather conditions. In turn lidar or laser radar can scan environment and created 3D picture of the environment. Camera determines traffic signals and recognizes moving objects. GPS and INS are good to detect vehicle's exact position, which makes easier to orient (Suslinnikov, 2015).

Cooperative Adaptive Cruise Control (CACC) is extension of ACC technology. It allows vehicles to communicate by using a specific Wi-Fi standard - IEEE 802.11p. This is an extension of commonly used Wi-Fi standard, but it adds support to ITS - Intelligent Transport Systems (Janssen et al., 2015).

Automated vehicles technologies allow not only in driving vehicles in particular speed or distance, but could also help with other functions, such as docking and parking. As for example, other innovations, which could be related to platooning: Stop-and-Go Support; Blind Spot mitigation; Cooperative Autonomous Emergency Braking (C-AEB), etc. (Janssen et al., 2015). Other possible innovations could be included.

3.4 Business model review

As it was mentioned before, one of the research question of this paper is how platooning can be implemented in logistics service provider companies. There are several business models, presented in platooning projects discussed before. In this chapter business models from projects SARTRE, TNO, KONVOI and Peloton Technology Company will be discussed and reviewed. Shortly about each project's business model.

In SARTRE project's commercial viability report different potential customer groups are described as well as benefits for them from using road trains or in other words platoons. Report mentions such customers as long distance and professional truck drivers, trucking fleets, truck/ car makers, communication and telecom companies and society, which is affected indirectly. However, there is also another way of perceiving customers - as lead vehicle, following passenger and commercial vehicle. As for effects of platooning reports lists such benefits: safety, reduced fuel consumption, increased productivity, extra income and others. In this project such terms are used: lead vehicle - vehicle at the front of the platoon; user - driver in a following vehicle, following vehicle - vehicle that is part of the platoon which follows lead vehicle (Brännström, 2013).

SARTRE project also suggests several product solutions of how platooning could be used. Since it provides fuel consumption reduction, commercial vehicles could be the first one who could use it. Moreover, for the following vehicles arises opportunity to perform other tasks, thus increase the efficiency or decrease workload. Besides this model could be quickly implemented, especially for this types of vehicles (Brännström, 2013).

As for the model that could be applied firstly also to passenger vehicles - monthly subscription of road train usage is suggested. This model implies, that users or their companies pay monthly fee to participate in road train lead by professional truck driver. However, the availability of the technology will be limited at the beginning, so this model could be used for specific area or road as first step in implementation of platooning (Brännström, 2013).

Another model suggested that payment is done for specific distance or route and is called "pay-as-you-go for joining the road train". This could be more suitable for long distance users, however in order for the model to be effective, it is necessary to have large amount of lead vehicles. So this solution could be implemented in later steps of the process (Brännström, 2013).

"Free service based on "sponsored" benefits" model explains the benefit system for the buyers of the vehicles capable of platooning, thus encouraging the spread of technology. This would broaden the market and attract more users and later increase the number of lead vehicle drivers. Benefits could be issued by the government and as number of users grows, benefits can be adjusted to different groups of drivers (Brännström, 2013).

Previous model implied that users who value their time would pay to lead vehicle drivers for joining platoon. In next model vehicles could be both users and lead vehicles. This solution suggests that user could be a lead vehicle for one time, and then a following vehicle for so many times, as how many following vehicles were in platoon, when he was a lead vehicle. However, there are some challenges to this model, since for it will require for users to prove that they are skillful enough to lead a platoon. So trust issues come first. Moreover, big amount of users is necessary for this model (Brännström, 2013).

Last solution suggests that with time previously mentioned models could be used together (Brännström, 2013).

To sum up report provides solutions for different platooning implementation stages as well as different types of relationships between users. Report also provides costs calculations, however, it does not describes ways of how payments could be done, as well how joining or leaving platoons is going to be organized. Report also does not mentions who is going to organize commercial truck platoons. Nevertheless, SARTRE project provides solutions for different types of vehicles, both passenger and commercial vehicles (Brännström, 2013).

In its turn TNO project focuses more on different actors of the supply chain and how platooning is influencing them. As well as how these actors are influencing process of platooning and its implementation. There is four group of actors: developers, users, policy-makers and regulators. Role of each participant as well as benefits are also described.

According to executive summary of TNO project, user of platooning would be: shippers, carriers and Logistics Service Providers (LSPs) and Platooning service providers (PSPs). Although shippers are not direct users of platooning, however they have big influence on implementation, since they would choose carriers with platooning, because such carriers would provide lower prices and more sustainable approach. Carriers and LSPs have central position of the chain, since they are connected to shippers by transporting goods and to other supply chain actors, e.g. truck manufacturers by purchasing trucks equipped by necessary technology for platooning. In turn PSPs is a new type of logistics service. It is independent service provider who could organize platoons consisting trucks from several carriers. PSPs would be interested in increase of platooning users, since this would influence their fees (Janssen et al., 2015).

Benefits and all costs are also explained in TNO project, as well three business cases are discussed, based on logistics firms ECT, De Winter Logistics and Peter Appel Transport (Janssen et al., 2015).

To sum up, TNO project goes further than SARTRE project and not only explains the relationships between users on the road as well with governmental support, but also expands what are the other actors who could influence platooning customers. Besides project provides the solution of what actor could take a role of platoon organizer so vehicles from several carriers could be part of platoon. However, TNO is focusing only on heavy-duty vehicles and does not take into consideration passenger vehicles (Janssen et al., 2015).

Another project - KONVOI - explores scenario “Driver Organized Truck Platoons”, basic idea of which is that vehicles can create platoons within existing motorways, but with the help of a Driver Information System and necessary information (Kunze et al., 2011). KONVOI project offers two approaches: looking into platooning from microeconomic perspective - how would benefit freight forwarding companies from platooning - and from macroeconomic perspective - how country’s economy could benefit, thus motivating government to take actions (Kunze et al., 2011). In the first approach the initiative to form a platoon depends on driver, who has all necessary information to make a decision. The monetary effectiveness of the approach is evaluated with the Value Oriented Cost-Effectiveness Estimation method, also named as NOWS method, which combines the classical analysis of investment with so-called soft factors in the profitability analysis (Kunze et al., 2011).

An example with freight forwarding company is used. It is important to note that in this case freight forwarding company is company which operates own fleet of vehicles and all described costs are connected to this company’s fleet. According to KONVOI project based on their evaluation method, implementation of platooning in freight forwarding or carrier company is a positive investment (Kunze et al., 2011).

To sum up, KONVOI project focuses only on one company and does not consider passenger vehicles of vehicles from different owners.

Another approach provides Peloton technology. Peloton Tech is a company which provides necessary technology for heavy-duty vehicles, necessary to create a platoon. Drivers of trucks, who have equipment, decide themselves when and for how long to form platoon. Company offers usage-based managed service, charging a per-mile fee when trucks are in platoon and saving fuel. Fleets pay a one-time fee for System hardware and installation (Peloton_Technology, 2014). However, this model is limited only to customers of the company.

Even though there are also other projects done about platooning, such as PATH, GCDC, Chauffeur and COMPANION, yet they focus on other aspects of the platooning, e.g. technological. Thus they are not analyzed in business model review.

After reviewing all projects that provide suggestions on how platooning could be commercially implemented or at least that mention the commercial benefit of using platooning, beside decrease of fuel consumption, it can be concluded that there is a lack of information on how platooning could be used within today's existing system. Some projects suggest new types of relationships or new types of organizations, however this would require additional actions for implementation, thus it complicates the whole process.

Some projects in their suggestions focus on platoons that consist of vehicles from one particular organization, which is responsible for equipping vehicles with the right technology. Thereby platooning is possible only for separate group of vehicles. Considering that platooning is a cooperative driving which requires cooperation of several vehicles, it should not be limited only for vehicles for one organization. Nevertheless such system is more possible at the present time. For example, recent Volvo truck convoy had a successful journey from Gothenburg to Rotterdam.

That is why it is not clear of who could make the decision to organize vehicles in platoons when drivers do not belong to one organization or vehicles are from different owners. Some projects attempt to describe relationships between different actors in supply chain which is influenced by platoons, however they do not provide detailed solutions on how this new system could function.

Projects also include cost calculation for platooning implementation, such as costs for technology, communication, maintaining the system or driver training. Yet situation when different carriers are participating in platooning could lead to conflict of interests: who would be the lead vehicle and who would be following vehicle; how cost saving will be distributed between them; which route will be used; how long vehicles would be in platoon. Thus this decision making process could not be left to the drivers themselves. At least on the initial stage of platooning implementation.

This requires a participation of neutral side. In TNO project is mentioned new type of service provider called Platooning Service Provider. Since it is new type of service, for present companies it might be confusing of what type of actions this new company could do. This could increase a level of uncertainty for shippers and carriers and other participants, thus slow down the implementation of platooning and decrease the positive perception of platooning.

A possible business model for platooning commercial implementation is described in next chapter.

3.5 Suggested business model

3.5.1 Logistics service providers

As it was mentioned in previous chapter main users of platooning could be shippers and hauliers. In order for them to successfully use platooning in their business activities, a mediator or third party is needed. TNO project suggests to create a separate organization - platooning service provider. However, there is no necessity to create new type of organization, since current service providers with additional training could manage mentioned in project functions. And such service providers are freight forwarding companies and/or 3PL companies.

Freight forwarders are often called “The Architect of Transport” because of their ability to organize shipments according to customers’ requests with different means of transport (Schramm, 2012). Since there is different approach towards understanding functions of forwarders in this paper will be used following definition from business dictionary: freight forwarder - firm specializing in arranging storage and shipping of merchandise on behalf of its shippers (Business Dictionary, 2016). Freight forwarding companies can use their own transport or warehouses, but many decide to outsource these functions (Wang, 2014). According to a brochure of the FIATA, freight forwarders gives advices to their customers about packaging, clearance or transportation, as well as gives insurance, chooses best route and carriers, provides necessary documents and many other functions (Schramm, 2012). For those shippers who do not want or cannot organize shipment themselves, freight forwarders are indispensable allies.

There are also 3PL or third-party logistics providers which seem to have similar functions as freight forwarders that is why they are also mentioned for suggested business model. However 3PL have wider range of services and logistics solutions and are more like a partners for shippers rather than suppliers (Vasiliauskas, 2007). The main difference is that beside freight forwarding functions, 3PL might also operate distribution centers or provide value-added services, such as re-packing (Christopher, 2011). Basically, freight forwarders are mostly responsible for transportation of shipper’s freight and 3PL providers are responsible for managing shipper’s logistics operations (Transportation Insight, 2016). However in this paper platooning business model will be suggested for freight forwarding companies rather than for 3PL providers.

As it was mentioned before many freight forwarders decide to outsource some of their activities to hauliers. It is done to avoid excess costs for maintaining own fleet, besides if the forwarding company is very big and has many customers, it will require to have larger amount of vehicles. Thus buying transportation service is more convenient and cost efficient. However some forwarding or 3PL companies can still use their own fleet for most profitable routes or for most important customers. This strategy is called "cherry-picking" (Wang, 2014). Own fleet can also be used for combined cargos, where goods from different shippers are put in one vehicle in order to reduce costs and have efficient transportation.

Nevertheless the most important question is how payment to hauliers is done. There are two possible options for making payment:

1. One-time contracts imply price for particular load. Price depends on negation process of haulier and forwarder and can be quite flexible.
2. Dedicates contracts have fixed tariffs. Price is calculated beforehand based on type of cargo, weight, dimensions or distance (Wang, 2014). It can be fixed pick up or delivery zone, fixed distance or fixed space in the vehicle.

According to one of the interviewee forwarders are more interested in second option rather than first one. Reasons for that are: assurance in freight, since there are trusted or specified relationship with supplier and predefined costs for transportation, paid every month. For example, some forwarders pay to hauliers fixed amount per kilometer. Moreover there is agreement that per each month there is minimal amount of kilometers. For hauliers more kilometers mean more profit. On the other hand one-time contract could lead to unexpected costs for forwarder and loss of profit.

Freight forwarding business is quite competitive, that is why companies look for different ways of gaining competitive advantage without lowering the price (CATAPULT, 2015). According to one interviewee in some cases prices from customers are not even negotiable and forwarders are forced to work for low income. Forwarders are pressured to improve profitability and reduce costs as points out Wang (2014), so they can still have profit.

Another issue that was mentioned by interviewed forwarders is efficiency of the transportation. Some loads have expiration date, which means particular shipment is delivered by two drivers in order to deliver as fast as possible. It is known that according to legislation, drivers are allowed to drive limited amount of hours and after that should take a break. Second driver replaces the first one, thus continues uninterrupted driving. Proposed business model for platooning could provide solution for both issues.

3.5.2 Description of the model

Proposed model suggests that since freight forwarders choose hauliers and obtain more information about shipments and possible combinations of trucks, they could make decisions about the following actions:

- Based on the route and distance, which vehicles combine in one platoon and how long vehicles are driving in platoon;

- Based on information about the haulier, e.g. driver's experience and knowledge, which vehicle is going to be leader and which is going to follow;
- Other organizational questions related to platooning.

In this way not only goods can be consolidated, but also vehicles. All actors in this chain benefit from this solution:

- Hauliers are able to reduce fuel consumption and increase efficiency;
- Freight forwarders are able to reduce costs for transportation, ensure safety for the cargo and increase their profit;

Important issue for platooning implementation for hauliers is decrease of operating costs, which consist of fixed costs, such as capital investment, obsolescence, insurance, registration fees and variable costs, such as fuel, fuel taxes, oil, tires, depreciation, maintenance and repair, crew wages, travel time, paid parking and tolls (González-Calderón et al., 2013). According to the data, obtained from one of the hauliers, largest costs for them are maintaining costs as well as costs for drivers since in Sweden salaries for drivers are quite high. This is why for hauliers partial reduction of some costs can be good motivation to participate in platooning.

In order to illustrate this model, simple example of freight forwarding company with several subcontractors with dedicated contracts is used. Some hauliers have a fixed distance tariff per month. Hauliers profit is calculated by subtracting revenues and operating costs. For forwarder paid amount to haulier is the cost that needs to be reduced in order to increase a profit. When two trucks are combined in platoon, they are both able to reduce fuel consumption. According to some researches vehicles in platoon could reduce from 9% till 25% of fuel consumption (Patten et al., 2012). Proposed model suggests that haulier and forwarder agree to decrease fixed tariff paid by forwarder. In this case forwarders get to reduce their costs to increase the profit. However for haulier that could lead to decrease in profit. That is why haulier and forwarder could agree on bonus system or some other ways of getting benefits. For example, that haulier could be selected to perform transportation of goods more often, since he agrees to be leading vehicle. However, this haulier should have balanced proportion of driving roles.

Another benefit is that when hauliers with such agreement are driving in platoons as followers, they can rest during that trip, which means there is no need for second driver and for long breaks. Driver will be still driving, but getting paid less for that. Thus for freight with fast expiration date one driver in platoon could more beneficial rather than two drivers.

With increased efficiency of hauliers, forwarders are able to increase amount of orders and thus increase profit. It is also good strategy to promote themselves as sustainable business.

However, there are drawbacks as well, since carriers are forced to invest in platooning technologies. Platooning equipment should be also universal and work with all vehicles. Moreover drivers could disagree to be part of platooning and could perceive platooning negatively. One more drawback is legislation which does not allow for drivers to drive with small inter-vehicle distance as well as exceed driving hours.

Some of the drawbacks could be eliminated by freight forwarders, e.g. they could motivate hauliers to participate in platooning by prioritizing vehicles who agree to be part of the platoon. However, some limitations can be reduced only by cooperation of the government.

3.5.3 Evaluation of the model

In order to illustrate suggested business model, Business Model Canvas is used. It is a good strategic tool to design a business model and evaluate its parts (Osterwalder, 2013). In the table nine building block are used, which made four pillars of business model: product, customer interface, infrastructure management, financial aspects. This model is reviewed from perspective of freight forwarding company.

Canvas shows that main customers for freight forwarding company are different type of shippers, such as manufacturers, distributors or retailers and relationship between them are direct through internet, telephone or meetings. Key activity is combining vehicle in platoons thus increasing safety of goods, providing sustainable solutions and cost reduction. Key partners are transporting companies and government, since its support is necessary to adjust legislation to platooning situation. Knowledgeable forwarders as well as necessary technology, e.g. software, are main resources. For the financial aspect with this model costs are related to trainings and technologies, however transportation costs are decreased, thus increasing profitability. Besides platooning can be seen as competitive advantage for customer attraction.

<table>
<tr>
<td rowspan="2">Key partners
Carriers, government</td>
<td>Key activities
Combining vehicles in platoons</td>
<td rowspan="2">Value proposition
Increased safety for goods, sustainable solutions, cost reduction</td>
<td>Customer relationships
Direct</td>
<td rowspan="2">Customer segments
Manufacturers, distributors, retailers, etc</td>
</tr>
<tr>
<td>Key resources
Knowledgeable and experienced employees; necessary technology</td>
<td>Channels
Direct channels (webpages, specialized web portals, meetings, telephone, etc)</td>
</tr>
<tr>
<td colspan="3">Cost structure
Decrease in costs for transportation;
Costs for employee training;
Costs for technology</td>
<td colspan="2">Revenue stream
Profitability increase
Competitive advantage</td>
</tr>
</table>

Table 1 Business Model Canvas for freight forwarders

However it is not enough with only design of the model. SWOT analysis is also done in order to evaluate strong and weak sides, as well as opportunities and possible threats. Possible strategies are proposed.

SWOT analysis is a familiar and useful technique to summarize strengths, weaknesses, opportunities and threats of the company/ organization, product, service or even business model.

Strengths: Availability of necessary technology; Successful experiments; Emergence of new projects in different countries	**Weaknesses:** Lack of research; Legislation; Necessity of investments
Opportunities: Interest from industry and society; More sustainability; Increase in safety; Potential for new services	**Threats:** Discontent of transport companies; Impending of government; Lack of interest from industry; More accidents

Table 2. SWOT matrix for proposed business model

After all parts of the matrix are filled, several strategies can be proposed in order to enhance the strengths, eliminate the weaknesses, use the opportunities and avoid threats.

For this business model these strategies can be applied:

Strength & opportunity - with available technologies and successful experiments interest of industry and society is growing. New projects give new information of possible benefits.

Strength & threat - Successful experiments and projects could influence government and industry. Thus discontent of transport companies could be also reduced. Necessary technology reduces the threat of more accidents.

Weakness & opportunity - with more interest from industry, more research will be available, besides this can help to change the legislation and adjust it to platooning situation. Decrease in costs and new services outweigh the necessity to invest.

Weakness & threat - if society, government and industry are not interested, it could lead to bigger lack of information. If legislation is not changed, there is less possibilities of changes.

4 Empirical data

4.1 Project review results

Parameters/ Projects	Comparison between KONVOI, SARTRE, TNO, COMPANION	Comparison between PATH, CHAUFFEUR II, Peloton
Who did this project?	Basically collaboration of different countries and/or organizations. Countries that show interest in platooning are: Germany, Netherlands, Spain, and Sweden.	Two US projects, one European collaboration.
Timeline	All projects go one after another from 2005 till nowadays.	90s, 00s, current time.
Definition of platooning	2 projects: name it “road trains”; most mentioned usage of technology (from ADAS to V2V communication).	Group of vehicles that are linked together.
Technology	Wireless communication; different sensors, such as radar, lidar, camera, etc); GPS, etc.	Two of them mention V2V communication. Different sensors and controllers.
Costs	3 mention costs for training drivers; costs for technology/ devices. Generally costs 2000 - 3500 euro.	Mostly no information, except for Peloton, since it sells its technologies.
Business model	Different models where decision for platoons are done by: drivers themselves or third party. Payment system varies.	Mostly no information, except for Peloton, since it sells its technologies.
Advantages	Increase in safety, reduced fuel consumption, optimization of traffic flow, new service opportunities, competitive advantage, increased efficiency, etc.	Fuel savings, increase of capacity.
Challenges	Mentioned: technical challenges, perception of society, legislation.	Two of them have different challenges: either safety or technical issues or legislation.
Impact on society	Environmental benefits, increase in safety, higher road capacity.	Safety, increase in road capacity.
Additionally	Potential users: freight forwarders, carriers, government, society.	Different aims, different users.

Table 3. Project data comparison

Countries that show interest in platooning are: Germany, Netherlands, Spain, Sweden and USA. Most of the project in Europe are done by collaboration of different organizations and countries. Even though Peloton also used studies from other organization, research and development is mostly conducted by one company. Collaboration of many actors, especially in the European Union, is reasonable, since platooning could be implemented in many countries or organizations, besides EU countries have similar legislation.

Timelines of the projects show continuous process of research, starting from 1994 and still being the process of research.

Every project has its own definition of the platooning. However generally projects from first group name platoons as “road trains” that uses some kind of technology. In turn projects from other group describe platoons as “connected to each other group of vehicles”. The SARTE Project defines platooning as road train of vehicles without specifying which vehicle is mentioned - truck or car, since project focuses on both types of road vehicles. In contrast other projects are focusing on two or more trucks, because platooning could be more beneficial to hauliers and truck drivers. Most definitions are also using term “vehicle-to-vehicle communication”, since this how vehicles are able to connect and drive in one platoon.

As for technology although projects use different descriptions, most projects suggest similar technologies, where vehicles use wireless communication and different systems to “sense” the environment (Janssen, 2015). According to COMPANION and Peloton necessary technology coordinates trucks in order to create and maintain platoons and ensure that vehicles are driving in the safe mode.

Both The SARTRE and TNO presented similar costs of implementation of platooning, as well savings in different suggested models. Other projects, however, did not include this kind of information. Moreover, Peloton Company mentioned that this information is only given to the customers and other related actors. According to the first two mentioned projects costs include investment into technology and communications, costs for training drivers and additional service and annual costs. KONVOI project also mentions driver training int their costs analysis. According to Peloton Technology, initial costs include one-time fee for system installation. However, they did not provide information about other possible costs.

Next issue discussed in projects from first group is business model for implementation platooning. There is difference in who is going to make a decision to form a platoon. Some projects suggest that it could be decision of drivers, since they know more about their own position and whether they need to drive in platoon or not. However some suggest that it could be third party that decides which vehicles will form a platoon. SARTRE project offers different models, suitable both for trucks and cars. TNO project also provides different models, however main suggestion is third neutral party, called Platooning Service Provider. COMPANION project suggests an online central coordination platform to manage platooning at European level (Eilers et al., 2015). And Peloton suggests creation of Peloton Network Operations Center.

All the projects describe advantages of platooning. However some of researches are more focusing on detailed description and others on general. Mentioned advantages include fuel savings, pollution reduction, increase of safety, decrease of congestion and others. Both

SARTRE and TNO describe advantages from the perspective of different stakeholders, as well as focus separately on the impact of platooning in society.

From the other hand according to most projects platooning implementation will meet a lot of barriers and challenges, such as legislation, public acceptance, and technological challenges, etc. TNO project has a made a list of 32 barriers and challenges, however report provides a summarized version of that list. Some projects describe challenges in more elaborate way than advantages. As the main reasons of why implementation of platooning has some obstacles are mentioned public perception of the idea, legislation, encouragement to buy and use and technological unreliability.

And the last factor was additional, where various information was provided, for example, how the research in each project was conducted. SARTRE Project is considered to be the first one project on this topic, followed on TNO project, which made elaborate version of SARTRE with additional case studies. And as potential users are mentioned in all projects hauliers, manufacturers and others.

Generally speaking platooning is becoming more and more popular for the industry, since projects appear one after another. This also means that there are too many issues that need to be discussed and studied in order to successfully implement platooning. However it is already clear that in order to form a platoon vehicles need to use some kind of technology which allows them to communicate and that with the help of platooning safety could increase, as well as road capacity and work efficiency. Besides one of the major advantages is fuel consumption reduction.

4.2 Academic review results

Each definition was divided in 4 parts: what is platoon/ platooning, what actions are made, what the conditions and what are the additional words used.

In first part all the descriptive words are put, as well as synonyms, such as “cluster”, “string” and “convoy”. Not all synonyms describe platoon as the group of vehicles, but more focus on other processes, such as usage of autonomous systems.

Almost every definition used word “vehicle” or “vehicles”, however some used more specific words as “heavy-duty vehicle”, “cars” or “trucks”. Many definition consist of description of quantity of vehicles from general “group” or “many” to more specific “two” or “ten”. Some papers also used descriptive words, e.g. “participating, leader, automated” or indicated position of the specific vehicle, e.g. “lead”, “first”, etc. To sum up according to variety of papers, platooning consists of group of vehicles, where is a leader vehicle and follower vehicles.

Next part describes actions of the vehicles, which are divided in “active” and “passive”. Most actions are active, such as “move”, “drive”, “travel”, however in some descriptions are used passive forms, such as “are packed”, “are organized”, etc. Mostly used actions are “follow” and "travel". To sum up platooning is a group of vehicles, with leading vehicle that is followed by other vehicles, travelling somewhere.

Next part is the biggest one, since it describes the conditions that make platooning happen and separate this process from others. There are three types of conditions: what technology is mentioned, how actions are done and what are the general conditions to that. Mostly used words in first type is "communication". In the second group is hard to note specific word used mostly, however many articles stressed word "close". As for conditions, then a lot of articles mentioned "small inter-vehicle distance" and "desired speed". Many used word "lane", however it is hard to stress specific description of the lane. To sum up aforementioned, platooning is when a group of vehicles, consisting of leader and followers, travelling with small inter-vehicle distances with desired speed and communicating with each other by the means of specific technology.

In the last part included all the rest of the used words in definition of platooning. There is almost no connection between the words in this group, however mostly used word here is "platoon". Additionally some sentences represent the positive impact of the platooning.

Some words were not included in this analysis, however those words do not influence the definition of platooning and are used as connection between the parts.

What is platoon/ platooning?
General: vehicles, Cooperative Adaptive Cruise Control (CACC); **Synonyms**: cluster, string, convoy, chain, fleet train, unit, formation, interconnected systems, road train, clustered formation, electronic coupling, single file, autonomous driving control, car-following state; **Number**: many, group, two, multiple, several, group of ten, all, multiple trucks; **What type**: HDV, identical, consecutive, other, participating, leader, follower, automated, large-scale, driving, autonomous, predecessor, automatic, platooned, automatically controlled, semi-automated, constituents, flexible, dense; **Position**: ahead, first, lead, preceding, in front, non-leading, closely spaced, between the cars, longitudinally adjacent.
What actions are done?
Passive: Are packed, are organized, are separated, are synchronized, are defined, are equipped; **Active:** follow, travel, drive, move, keep a distance, are capable, use, are close, guide, maintain, cooperate, merge, change lanes, communicate, reduce, include, suppress, adapt, coordinate, organize, make use, operate, control, allow, share, form, consist of.
What are the conditions?
Technology: With the aid of an adaptive cruise control (ACC) system, with technologies that already exist (e.g. distance controller, vehicle and vehicle-infrastructure communication, lane keeping and driver information system), with interconnected dynamics, using CACC,

make use of V2V communication, based on reliable communication systems, using inter-vehicle wireless communication in addition to onboard sensors, using automatic control systems, with the existence of wireless radio communication, with specialized sensors and wireless communication systems, where communication and automation techniques are used; **How**: manually by a professional driver who has received appropriate training, automatically with a very short headway, safely, smooth, utilizing a 4-s time gap instead of time headway (front axle to front axle), autonomous and cooperative, with a high level of safety, maintaining string stability, close to each other at particular speed; **Conditions**: at/ by/ with close/ short/ small/ relatively small/ very small inter-vehicular/ inter-vehicle/ constant distances/ spacing, at a given intermediate distance and velocity, at the same speed, within each lane, on highways in closely spaced groups, on the road, over a couple of lanes, in a single lane in close proximity, speed to the speed of its predecessor in order to keep a minimum distance from its predecessor, with desired speed/ distance between the vehicles, on freeways in small convoys, on regular highway lanes, at high speeds, very close to or very far from, for a small time headway, a similar itinerary over a period of time.
Additional words used
Platoon, method of, within/ into/ between a platoon, concept entails, aiming at increase in safety and road capacity with flexibility, often (but not necessarily), to reduce air resistance, thereby potentially improving road throughput, steady state.

Table 4. Words used to define “platooning”

Results of the content analysis of the definition of the platooning are seen in the table 4.

Next step in this analysis is to review used methods in all chosen papers. It is necessary to clarify that in this paper theoretical analysis is used to refer to analytical modeling and theorems description.

A little bit more than 80% papers mention theoretical analysis as their method, however, only 10% used only this method; majority supplement it with either simulation or experiment. Almost 25% of the researchers use theoretical analysis and experiments; a bit more than 25% use it together with simulations and 12% use all three methods. One paper uses theoretical analysis and case studies and one uses it together with field tests, simulations and case studies.

Experiments without theoretical analysis are used by 14%, however 4% use it with another method. Out of all papers only one paper use case study for their research and one literature review with study scenarios.

Described technology was also reviewed, however it was done roughly, since this is not the main aim of the paper. There were articles that did not have the description of the technology or that technology was not used in the vehicles, but, for example, in the highway infrastructure. Many articles describe the architecture of the controllers, including CACC, ACC or platoon controllers and were considered mostly as low level technologies. Some articles mentioned communication protocols; variety of sensors and actuators; radar, lidar and other devices, as well as computers and wireless communication devices.

According to described technology author used particular terms to describe automation level mentioned in each article. Half of the papers describe technology in category high-tech, which includes description of technology on the level of adaptive cruise control or even cooperative adaptive cruise control. Quarter of papers describes the low level technology, mostly different type of controllers and another quarter describes platooning without using technologies, such as ACC, CACC or other. Results are seen in table 2.

Automation level	**Number of papers**
No automation	12
Low-tech	12
High-tech	25

Table 5. Automation level in papers

As the last part of the primary data analysis, aims of the researches will be reviewed. This step is made in order to understand main ways of perceiving platooning. It is important to understand what the focus of those researches was and whether there is a gap in information on this topic.

There are variety of aspects of platooning that are considered in the articles. Some articles describe fuel saving potential of the platooning; some articles focus on safety issues, presented in table 6.

Separate group of articles describe control functions and laws as well as controllers used in platooned vehicles.

Aims/ topics of the articles
Fuel: fuel reduction potential of heavy duty vehicle platooning; fuel-saving potential as offered by platooning; amount of fuel saved by platooning;
Safety: collision avoidance in HDV platooning scenarios; the stability of the platoon; platoon control problem, the parameter uncertainties, disturbances; string stability/instability caused by disturbances or maneuver of a lead vehicle; string stability; safety of highway vehicle platoons; behavior of drivers in emergency-braking situations.

Table 6. Topics about fuel saving and safety of platoons

Other technological and engineering articles are combined in the corresponding group in table 7.

Aims/ topics of the articles 2
Controllers/ control: decentralized controller for HDV platooning; control design; corresponding dynamic control law; lateral control for the platooning; system of distributed controllers; unified control strategy for the single lane control laws; integrated control system; study of vehicular platoons using identical controllers; fundamental limitations on the longitudinal and lateral control performance of a platoon; software architecture of automated vehicle control system;
Engineering: multiagent system to the platoon architecture; dynamics of a VANET enabled platoon under traffic disturbance; impact of packet loss rate (PLR) and beacon sending frequency (BSF); a modification to the time headway policy; new approach for small inter-vehicle distances; calculating optimal longitudinal forces using the road inclinations; ad hoc vehicle platooning; automated health monitoring system for all the sensors and actuators; cooperative awareness protocols for platooning; vehicle/gap distributions under two variations of the free-agent (vehicle-following) rule; introduction of cooperative vehicle technologies; improved algorithm that ensures the functionality of the CACC system.

Table 7. Engineering topics

Last group named "general" consist of variety of articles, including CACC description and general framework for platooning. It is presented in table below.

General: platooning phenomenon on two-lane two-way highways; traffic operation on two-lane highways; future freight transportation system; the traffic flow as a congestion game; platoon control methodology; organizing vehicles into platoons; platoons organized as part of a CDS; cooperative driving of automated vehicles; flexible automated platooning; estimate the driving condition and vehicle dynamics in an intelligent convoy of vehicles; cooperative driving system; CACC system and competition vehicle; different components that are needed to participate in the GCDC; new control system design and implementation; aerodynamic effects, especially the drag reduction; CACC system; results of the performance of the ATeam heavy-duty truck during the GCDC; leader state available to the other members of the platoon; quantify the effect of rainfall on following behavior; new semi-autonomous systems; freeways dedicated to road-trains; principles of cooperative adaptive cruise control (C-ACC) and platooning; ongoing standardization activities; new framework for vehicle coordination and control.

Table 8. General topics on platooning

As for the secondary data such parameters are reviewed: year, source of information and terminology. Those are considered as secondary, since they cannot provide enough information to make objective conclusions. However they were still reviewed as additional sources of information.

In this research used papers are dated from 1997 until 2015. Most papers are quite recent - from 2015 and 2014, which could be explained by increased interest in the platooning in the last years. Quite many articles are dated by 2012 and this could be explained by the fact that

SARTRE project ended that year (was coming to an end). Other articles are spread through rest years.
Around 25 journals are sources of chosen papers. A lot of journals are connected to engineering, communication and transportation. Almost third of the articles were published in the journal “Ieee Transactions on Intelligent Transportation Systems” - journal that publishes articles connected to Intelligent Transportation Systems (ITS). Since platooning is connected to ITS in many ways, it is not surprising that many articles from that journal are used in this research. Other two journals are Ieee Transactions on Vehicular Technology and Ieee Transactions on Control Systems Technology. Respectively 5 and 4 articles in each journal.

The main terms used in articles are: cruise control, adaptive cruise control, cooperative cruise control, air drag, string stability, Intelligent Transportation Systems, Automated Highway System, controller, longitudinal and lateral control, wireless communication, inter-vehicle, distance, heavy-duty vehicles and others. Thus the analysis of the literature review is finished.

4.3 Experiment and interview results

As it was mentioned previously, several interviews were conducted for this study. One interview was done with police officer on platooning experiment. This interview provided the information whether platooning could be already used in public motorways.

In order to answer interview questions police officer discussed this issue with his colleagues and together they evaluated if experiment is possible. As a result they came to conclusion that to conduct described platooning experiment between Helsingborg and Gothenburg, four factors should be taken into account:

1. Speed of the vehicles;
2. Skills and experience of drivers;
3. Technology:
    a. Braking systems;
    b. Conditions of the tires;
4. Weather conditions and road conditions.

With allowed speed 80 km/h, reaction distance between vehicles is supposed to be 25-30 meters. Drivers should be experienced and skilled enough to be able to react quickly and correctly. All vehicles and every part should have working braking system and all tires should be in good condition. Besides weather and road conditions should also be safe. Thus conduction experiment is allowed, however it was not possible to comply with all conditions.

Such experiment is possible in same extra cases. For example recent Volvo journey from Gothenburg to Rotterdam was done as exception, since company Volvo could provide right and tested technology, as well as skilled and experienced drivers.

Since it was difficult to meet all conditions to conduct the experiment, focus switched on industry representatives. Several freight forwarders and logisticians from European Union were introduced with described business model and asked for their opinion on it. Below is short summary of each interview;

First interviewee stated that if platooning technology is consistent and reliable, then platooning can offer benefits for many actors in supply chain. Yet it would work best for large companies and for longer distances. There are several reasons for that, such as:

- Time slots for loading and unloading. Since trucks that do not move are a loss of money for customers, vehicles that participate in platoons should have same loading/ unloading time slots, so that they do not stay idle.
- Close distance between loadings. This reason is related to first one and as it was mentioned before vehicles should have similar unloading time slots and if they have large distance between loading/ unloading points, it could mean that one truck is forced to wait for another or trucks arrive to early/ too late for loading/unloading.
- Capacity of the warehouse or distribution center. Companies with bigger warehouses are able to load/ unload more trucks and can be more flexible.

Another concern expressed by the interviewee was related to drivers. If platooning technology is not reliable, then driver being too relaxed could be dangerous. However if it is reliable, then the opportunities of refueling less than usually and being able to rest while driving seem very appealing.

Yet one of the biggest challenges regarding platooning implementation is administration of the whole process. Since in this industry scheduling is often non reliable, controlling and organization of the platoons can be very challenging, especially for freight forwarders.

According to second interviewee platooning can be more beneficial for hauliers, but it could also benefit freight forwarder, which has own fleet of vehicles.

Interviewee mentioned several positive aspects of platooning, such as eco-friendliness of the concept, which could attract customers who are interested in sustainable service. Another aspects: easier localization of several trucks, thus better control of them; easier orienteering in the new territory for the inexperienced drivers, help of the other driver in case of unexpected events.

However there were some challenges mentioned as well, such as additional investments for technologies; shippers and receivers within short distance should be found for platooning trucks and difference in types of goods, thus difference in delivery time. Besides, since haulier is the one who pays for the fuel, for freight forwarder it could mean no benefits at all.

Third interviewee expressed opinion that from platooning could benefit companies, whose several trucks are going in the same direction. Thus it could be more beneficial for bigger companies, rather than from smaller ones, which have small fleet and vehicles are driving in several directions. One more condition for implementation - drivers should be interested in the system. It was also mentioned that for organizing platoons a special person should be arranged. And last, but not least technical parameters of the vehicle should be taken into consideration when platooning technology is implemented.

After comparing answers it becomes obvious that all interviews have some similar points, but mostly their responses were different, thus they complimented each other and provided bigger perspective on the concept.

All interviewees mentioned that platooning could be beneficial for bigger companies, either those, who own and organize vehicles, such as hauliers and freight forwarders or for those, who sends and receives goods, e.g. shipper or receiver of the goods. Majority mentioned close distances between senders and receivers as an important factors, since it allows avoid idle time.

Drivers' behavior and attitude towards platooning is another common discussed question, since drivers will be primer users of the platooning. Table with comparison of benefits and challenges, mentioned by the interviewees is below.

	I interview	**II interview**	**III interview**
Benefits	Fuel economy; More resting time; More suitable for bigger companies.	Eco-friendliness; Better control of the trucks; Better orientation; Mutual help of the drivers; Competitive advantage; Better for those with own fleet/ haulier.	Better for bigger companies.
Challenges	Distance between loading/ unloading sites; Importance of time slots; Drivers' safety; Administration.	Distance between loading/ unloading sites; Difference of the delivery conditions; Additional investment.	Drivers' attitude Technological conformity; Administration.

Table 9. Comparison of benefits and challenges from interviewee perspective

Overall it seemed that interviewees have moderate attitude towards suggested model. They saw the potential of the system, however there are several challenges that need to be discussed and addressed before platooning as a system could be widely used. Nevertheless these interviews gave insights that in society there should be more discussion on this topic, so that industry representatives are more familiar with the idea and could start to think about how it could benefit them.

5 Conclusions and discussions

The aim of given research was to investigate the academic literature and project reports, review current state of platooning realization and propose a different approach towards platooning implementation.:

- How platooning is approached and defined in academic literature and variety of related projects?
- What are the current opportunities and challenges in implementation of platooning?

In order to answer first question academic literature review was conducted, where from almost four hundred articles fifty most relevant were chosen. Even though articles were addressing different aspects of platooning, for example, technology part through variety on controllers and advanced drivers support systems, e.g. adaptive cruise control. Some articles described platooning without using technologies. Some focused on safety and string stability. Several papers addressed platooning directly, proposing to solve all possible issues.

After conduction content analysis, definition of platooning concept could be formulated as follows: platooning is travelling by the a group of vehicles, consisting of leader and followers, following each other with small inter-vehicle distances with desired speed and communication with each other by the means of technology.

Majority of papers used such methods, as theoretical analysis, simulations and experiments separately or altogether. In the papers were reviewed a lot of technologies, however most of the papers described high level technologies, such as CACC. Half of the vehicles described high level of automation, another half equally describe low-level technologies, such as controllers or did not describe technology at all.

The aims and thus the topics for the papers were very broad, starting from general discussion of platooning and ending with description of particular controller. Majority of the articles are published in “Ieee Transactions on Intelligent Transportation Systems” journal in 2014 and 2015.

Overall, academic literature provide variety of technical approaches towards platooning, such as possibility to drive in platoon safely and with the help of different technologies. However literature almost does not address other issues, for example, business strategies.

This is why project review was also carried out to get insights on how platooning is addressed practically by different countries and organizations. Project reports were studied and data was gathered and unified in order to make a comparison. Seven projects out of more than ten were selected since they provided information about costs of implementation platooning. Several projects addressed the organizational issue, however did not provide with explicit description and/or business model.

It can be concluded that even though platooning is becoming more studied, there is still lack of information about important questions: who would organize vehicles into platoons and how costs and revenues are going to be distributed in supply chain.

Not only provides this study with analysis of several projects and approaches, but also focuses on describing possible business model for implementation of platooning. Model suggests that vehicles in platoons can be organized by freight forwarders, which already function as middlemen between shippers and different transportation companies, hauliers. Even though third-party logistics providers are mostly managing their customers' logistics functions, they could also organize vehicles into platoons.

Used approaches in this thesis are mostly theoretical, however experiment on platooning was also designed and several interviews with industry representatives were conducted. Though experiment was allowed by police representative, yet conditions to perform it were considered hard to fulfill. Thus experiment was not carried out. In turn some logistics representatives and freight forwarders shared their opinion and their concerns towards platooning. Moreover interviews helped to design proposed business model, yet motivated to look into platooning implementation more critically.

As it was mentioned before, one of limitations of this study is focus in specific player in the supply chain, specifically on freight forwarder. Forwarders perspective on platooning was addressed, thus losing sight on other participants of the supply chain and their needs.

In order to enhance this research more interviews with industry representatives could be conducted. Other methods, such as observations or case study could be used to gain broader perspective.

Regarding business model, experiment or case study in freight forwarding company could be carried out in order to practically secure the idea and provide more details to the model.

Even though many projects focus on transportation companies that own vehicles as on those who could gain more benefit from platooning, however their opinion is nowhere stated. Thus future researches could explore separately all benefits of platooning for all supply chain participants, as well as describe new type of relationship that might appear after implementation of platooning.

However before that one of the important issues should be noted. In his book "Diffusion of Innovation" Everett M. Rogers describes cases when objectively more convenient technology is not used by majority instead objectively inefficient one is used. Rogers describes and explains why some innovations are implemented faster and why some innovations take longer time to get used. It is already proved by many studies that platooning has numerous advantages, such as fuel reduction, safety on roads, driver's efficiency increase, traffic optimization, etc. Yet this concept could also have the fate of those convenient technologies which are not implemented that quickly. New researches on how to avoid that could be carried out.

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Appendix

Appendix 1: Data recording form for experiment on driver slipstreaming

Date:

Direction: Helsingborg - Gothenburg

Duration:

Environmental conditions:

Weather conditions	Ambient temperature	Humidity	Wind speed	Wind direction	Precipitation	Description

Notes:

Traffic conditions:

Road conditions:

Slope angle	Going up	Going down	Going straight	Other

Notes:

Vehicle description:

Vehicle parameters	Type/ model	Length	Weight	Engine	Rolling resistance	Gear box

Notes:

Loads description:

Trip description:

Start: from terminal till highway	*Speed:* *Fuel consumption:* *Notes:*
Motorway: driving without slipstreaming	*Speed:* *Fuel consumption:* *Notes:*
Motorway: driving with slipstreaming	*Speed:* *Fuel consumption:* *Notes:*
End: from highway till terminal	*Speed:* *Fuel consumption:* *Notes:*

ACC notes:

Recording done by:

Appendix 2: Project review table with group one

Project ->	KONVOI	SARTRE	TNO	Companion
Who did this project?	KONVOI consortium consists of industrial partners, institutes of the RWTH Aachen University and logistics companies and it is supported by public authorities and vocational schools. Partners: ika, IfP, IRT, isac, BUR, ZLW / IMA, MAN, WABCO, BASt.	Collaboration of different organizations: led by Ricardo UK Ltd; additional participating companies: Idiada and Robotiker-Tecnalia of Spain, Institut for Kraftfahrwesen Aachen (IKA) of Germany, SP Technical Research Institute of Sweden, Volvo Car Corporation and Volvo Technology of Sweden. Funded by the European Commission under the Framework 7 programme.	The Netherlands Organisation for Applied Scientific Research TNO.	COMPANION - European research project - includes Volkswagen Group Research, Stockholm's Royal Institute of Technology KTH, Oldenburger Institut für Informatik (OFFIS) in Germany, IDIADA Automotive Technology in Spain, Science & Technology in the Netherlands and the Spanish haulage company Transportes Cerezuela.
Timeline	September 2005 - November 2009	Start: September 2009; end: September 2012.	Until 2014 - early research and development preparation; 2015-2019 - wide scale tests, technical feasibility and upscaling; 2020 - first commercial application; 2030 - broad commercial application.	Start: October 2013. End: autumn 2016 (tests).
Definition of platooning	"trains on road". Electronically coupled trucks with the aid of Advanced Driver Assistance Systems, thus, trucks can keep short distances between vehicles of approx. 10 meters at 50 mph.	"It's a road train with vehicles, where vehicles are autonomously following a manually driven lead vehicle, driven by a professional driver".	"Two trucks driving less than 1 second apart, made possible by wireless vehicle-to-vehicle communication".	"trucks interconnected through Vehicle-to-Vehicle communication running at a very close distance."
Technology	The main components of the system architecture are the actuators (steering and power train), the sensors (object registration in close-up and far range, recognition of lane), the vehicle-vehicle-communication (WLAN), the automation unit (coordination of the different vehicle states), the control unit (longitudinal and lateral guidance) and the driver information system (human-machine interface, organization assistant, GPS and 3G). The longitudinal guidance of the ADAS is based on a LIDAR (Light Detection and Ranging) distance sensor, a Complementary Metal Oxide Semiconductor (CMOS) Camera and a RADAR-sensor.	Wireless communication through a technique based on 802.11p; combination of sensors (radar, camera, blind spot detection, electric power steering); for administration of the platoon - a software client.	Automated Driving technology: robotic systems to scan environment, uses sensors: lidar (light detection and ranging), radar, and cameras; for localisation - GPS (global positioning systems) and INS (inertial navigation systems), for wireless communication - a specific Wi-Fi standard IEEE 802.11p. Developing the Cooperative Adaptive Cruise Control (CACC).	Real-time coordination system, which creates, maintains and dissolves platoons according to an online decision-making mechanism. Communication (vehicles & the off-board platform) established via the cellular network (3G). Vehicles use an extended version of the ITS-G5 V2V communication. Vehicle controller controls the vehicle's speed according to the input of the platoon controller other ADAS systems and driver input.
Costs	The costs for the assembly of the devices and the signposting of the KONVOI-vehicles, the costs for the training of the driving personnel.	Initial investment for commercial transport: ~€3500, where €2000 - add-on cost for technology and communication; €1500 training cost for drivers; + annual cost of €300/year for services. For commuter: €2000 - add-on cost for technology and communication + annual cost of €300/year for services. Saving for both vehicles on average ~10%.	Two types of costs: tangible (payment for technology) and intangible costs (societal/governmental costs, e.g. time investment, possible adaptation of infrastructure and additional maintenance costs of infrastructure). Technology costs € 2,000 per truck; Service Provider + additional Annual costs = € 300 + Training drivers - € 75. Savings: ~ 10% fuel & labour.	No information
Business model	Several scenarios:Platoons Organized by the Driver; centrally organized platoons and platoons on a special truck lane. The creation of a platoon depends on driver who has the necessary data about time and place of meeting, the destination Several scenarios:Platoons Organized by the Driver; centrally organized platoons and platoons on a special truck lane. The creation of a platoon depends on driver who has the necessary data about time and place of meeting, the destination of his tour, as well as the required truck telemetric data (loading weight, engine power etc.). Besides in project two different views on the profitability have been identified: profitability of owners and users of platooning (microeconomic point of view); profitability of government (macroeconomic perspective).	Different business models: road trains for commercial vehicles; monthly subscription of road train usage; pay-as-you-go for joining the road train; free service based on "sponsored" benefits; taking turns in leading the road train; Different business models: road trains for commercial vehicles; monthly subscription of road train usage; pay-as-you-go for joining the road train; free service based on "sponsored" benefits; taking turns in leading the road train; open market for subscriptions, taking turns and pay-as-you-go.	Phased implementation of platooning: limited number of vehicles outfitted with the platooning technology and devices, limited widespread market penetration. In later stages platoons might are formed dynamically Phased implementation of platooning: limited number of vehicles outfitted with the platooning technology and devices, limited widespread market penetration. In later stages platoons might are formed dynamically on-the-fly by a specialised Platooning Service Provider (PSP) - new actor and neutral third party.	Implementation of an online central coordination platform to manage platooning at European level. Implementation of an online central coordination platform to manage platooning at European level.
Advantages	Road safety contribution amounts 428 million euro per year. With a portion of 45% on all distances the benefit amounts to 354,375 euro. If on 80% of all distances, then benefit would sum up to 630,000 euro. Other: improved vehicle occupancy, gained road space, optimization of traffic flow, reduction of fuel consumption, relief for professional drivers.	For long distance drivers and following passenger vehicles: safety, reduced fuel consumption, increased comfort; for trucking fleets: increased productivity; for professional truck drivers: extra income for leading the platoon; for vehicle manufacturers: new vehicle functionality and means to product differentiation; for communication/telecom companies and highway operators: new revenue streams, means of product and service differentiation; for following commercial vehicles: decreased fuel consumption, increased work efficiency.	For the truck manufactures: being the first manufacturer delivering platooning trucks, thus bigger market share; insights in the test requirements and type approval, and a positive effect on image and marketing. For other manufact.: opportunity for standardisation. Generally: opportunities for additional functions or services. For carriers: competitive advantage because of the lower price, driver productivity. For shippers: competitive advantage. For the PSP - management fee, since they do matching service. For Ministry of Economic Affairs: increase in competitiveness of The Netherlands. For local authorities: increase of the innovation in their region.	Lowered fuel-consumption, increased safety, higher road capacity.
Challenges	Technical adjustment; profitability for country's economy; law limits; no general agreement in the society	Challenge to identify an appropriate length of platoon; to encourage customers to buy vehicles capable of platooning; to encourage the professional drivers to take the additional licenses to lead a road train; to persuade drivers that it is safe.	32 potential risks and barriers for all the stakeholders divided in six categories: Business, Deployment/Timing, Legal/Conditional, Safety/Security, Technology and User Acceptance. Highest number - business and legal/Conditional. Main risks and barriers: digital tachograph and driving/resting times legislations, limited first mover advantages, prior earmarked budget constraints, road infrastructure constraints, driver-representation lobbies, public opinion backlash against platooning.	Lack of research on the actual creation, coordination, and operation of platoons. Other challenges: safe and efficient control of inter-vehicle distance; formation of platoons; user acceptance; business model; standardisation; legal solutions.
Impact on society	Increase in safety ; an optimization of traffic flow up to 9% and a reduction of fuel consumption up to 10% . Avoidance of 10% of all accidents on motorways.	Increased safety; reduced congestion & increased traffic stability; environmental benefits (decreased CO2 emissions by ~ 20%); increase in drivers comfort and efficiency.	Reducing transport costs, pollution (lower carbon emissions), accidents and congestion; lowering fuel consumption; better usage of truck assets and of existing infrastructure, safer traffic.	Increased safety, higher road capacity.
Additionally	Interest from freight forwarders and truck drivers. Aim: to realize and analyze the use of electronically regulated truck convoys on the road.	Project done by different case studies, road tests, calculations and analysis. Project focuses on both trucks and cars, driving on motorways (5 mixed type vehicles). Potential users of platooning: truck companies and long distance commuters.	Project based on The SARTRE Project, LZV and 3 case studies (Peter Appel Transport (PAT), De Winter Logistics (DWL) and Europe Container Terminals (ECT)). Project focuses on 2-truck platoon. Potential users: developers (Truck manufacturers, OEMs, Tier suppliers), users (Shippers, Carriers/LSPs, Platooning Service Providers), policymakers (Ministries, Local government) and regulators	Potential users Users of the COMPANION-System: Dispatcher, Truck Driver. Stakeholders of the COMPANION-system: Carrier, Consignor, Consignee, Truck Manufacturer, Information Providers, Society.

Appendix 3: Project review table with group two

Project ->	PATH	CHAFFEUR II	Peloton
Who did this project?	California Partners for Advanced Transportation Technology (PATH), a research and development program of the University of California, Berkeley.	Partners: PTV, Germany - REGIENOV, France - Renault, France - Clifford Chance Puender, UK - Iveco, Italy - Robert Bosch, Germany - Centro Richerche Fiat, Italy - TUEV Kraftfahrt, Germany - ZF Lenksysteme, Germany - Wabco, Germany - Centro Studi Sui Sistemi di Transporto, Italy - Daimler Chrysler AG, Germany - Central Research Laboratories Limited, UK	Pelaton - an automated vehicle Technology company in USA.
Timeline	Experiments in 1994 - 1997. Later in 2003 and in 2010-11.	Cahuffeur II: From 2000 to 2003	~2016: serious pilot program. ~2017 - large difference in fuel savings.
Definition of platooning	Vehicles travel in closely spaced groups (platoons) of up to 20 vehicles, with constant intra-platoon separations of the order of 15m	More than two trucks that are linked electronically. Platooning is direct extension of electronic towbar where leading vehicle is driven conventionally, both following vehicles follow as "trailers" in a very close following distance.	"Linking pairs of heavy trucks, by using vehicle-to-vehicle communications and radar-based active braking systems, which are always active and combined with sophisticated vehicle control algorithms to form close-formation platoons on the open road."
Technology	Trucks use V2V communication in addition to forward sensors to help maintain constant clearance vehicle following at very short gaps (tested from 10 m down to 3 and 4 m gaps).	System: platoon vehicle controllers, IR image processing system, 5.8 GHz vehicle-vehicle communication, electronically controlled drivetrain and steering system; integrated platooning components. Five prototype vehicles for study.	"Trucks with the Peloton System are connected to the cloud. Peloton's Network Operations Center (NOC) coordinates trucks to find linking partners on the road and enables cross-fleet platooning. Geo-fencing enables trucks to platoon only on safe roads, in safe conditions, and by safe drivers. NOC ensures that the trucks operate in the safest mode for the road and conditions."
Costs	No information	No information	Fleets pay a one-time fee for System hardware and installation so they can equip trucks at minimal upfront cost with a rapid payback period -- as quick as a few months.
Business model	No information	No information	System offered as a usage-based managed service, charging a per-mile fee when trucks are in platoon and saving fuel. The analytics and other functionality provide another, always-on, revenue stream.
Advantages	Potential of nergy saving; enabling a capacity of about 1500 trucks per lane per hour, which is twice the capacity achievable with trucks driven individually; fuel consumption savings in the range of 5% for the lead truck and 10% to 15% for the following trucks.	Up to 20% reduction in fuel consumption; improvement in traffic flow, reduction of transportation times, reduction in operating costs, increased safety; more flexibility to use; reduction of drivers workload even when driving alone.	Fuel savings for both the trailing and the leading truck.
Challenges	No information	Safety; platooning function realization on a longer time perspective.	Challenges: policy issues; keeping cars from going in and out between trucks; placement of the video screens to avoid confusing drivers; sharing fuel economy in a fair way; necessity of signage informaing about the platoon; public acceptance.
Impact on society	Decrease of fuel consumption, increase of road capacity	Decrease of fuel consumption and safety.	Decrease road accidents.
Additionally	Initial aim: to produce a significant increase in the capacity of a highway lane, so that increases in travel demand could be accommodated with a minimum of new infrastructure construction.	Based on Chauffeur I. Interest from freight forwarders and truck drivers. Aims: transformation of the product into a saleable product; to realize a fully operable truck platoon.	Project done with the help of The North American Council on Freight Efficiency. Potentional users of technology: Peloton's Network Operations Center (NOC), carriers, fleet managers.