Aalto University Department of Communications and Networking

ELEC-E7830 Value Network Design for Internet Services

Case: Indagon

How to use GPS/RTK-positioning for platooning?

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Abstract

Automotive industry and related transport sector is facing huge disruption with the emerging technologies and requirements, which driving to evolve new services. One of such service in this ecosystem is platooning. In this report, we examine the RTK/GPS technology usage for platooning service case for the Indagon company. Our target was to define the new market for platooning services and creating new business model for Indagon in future mobility sector. To develop this, we used three methods in this case study. First, we have used scenario planning. Next, we have built the value network configurations. And finally, a business model canvas is presented.

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1. Introduction

The associated challenges with current huge scale automotive industry is familiar to the most. With respect to the same, the human errors associated with driving is the cause for accidents, one of the large contributor to the carbon footprint is fossil fuels used in it, traffic congestion and lower utilization of roads are the challenges in general. In recent times, the autonomous driving cars have been developing by tech giants Google and Tesla are drawn much more attention by majority of the people than the efforts made by leading truck companies towards platooning services.

As per ACEA (The European Automobile Manufacturers' Association) definition, truck platooning is the linking of two or more trucks in convoy, using connectivity technology and automated driving support systems. The vehicles in the truck platooning maintain a set, close distance between each other and responds to the changes needed in their journey with the connected services needed for it. The first vehicle in the convoy acts as a leader, remaining vehicles in the platoon follows the leader by reacting and adopting the changes of leader. The advanced technologies facilitates more advantages with autonomous truck platooning than the manual truck platooning in achieving fuel efficiency and safety [Tsugawa et al. 2016] [Axelsson, 2017]. The energy savings in the platooning service heavily depends on distance maintained between the vehicles, it is about 13% with 10 m gap and 18% with 4.7 m gap [Tsugawa et al. 2016]. The platooning service is able to maintain without cutting-edge technologies (keeping driver assistance systems) but the human behavior and experience heavily matters such as workload, trust, sleepiness, performance, control and other unexpected incidents [Hjälmdahl et al. 2017].

Platooning is promising service in near future mobility sector. It is offering many benefits and the help of required technologies such as vehicle-to-vehicle communication, sensors, controllers, cellular, Wi-Fi, GPS/RTK, firmware, hardware and other. As our case company Indagon is turnkey solutions provider for professional positioning requirements with GPS/RTK technology. Hence, in this case study we are

envisaged the future scenarios, value network configurations and business canvas for future platooning service with keeping importance to the GPS/RTK.

The rest of the document organized as follows. We introduce the methods used in the report in section 2. Then we explain the case and technology involved in platooning in section 3. The methods implementation about case analysis is explained in section 4. At last, we draw conclusions and recommendations in section 5.

2. Methods used in the report

In this chapter we will give some brief overview about the used methods, which are the Scenario Planning analysis (Schomaker, 1995), which give detailed information of the used Scenarios, the Value Network Configuration analysis (Casey et al., 2010), which can represent in the given scenario the relationship between the different actors and represent the roles of each actors. The Business Model Canvas (Ostenwalder, 2010), which aim to represent and clarify the business model. The last method is Porter's five forces framework (Porter, 2008). It helps identify the attractiveness of an industry in terms of five competitive forces. With these tools, we will plan and represent the case company's strategy and analyse the business concept and fields.

2.1. Scenario Planning Analysis

Scenario planning, invented by Pierre Wack, is a disciplined method for imagining possible future. Wack's principle was to identify predefined elements that revealed real uncertainties. Predetermined elements are results that have already occurred and can reasonably be predicted (Chermack, 2015), and in this task, scenarios have shown their usefulness.

Each scenario is intended to describe how different elements are interconnected, with the help of these relationships it will be possible to develop qualitative models in the future. A main objective of the scenario design is to help the designer avoid both underestimation and overestimation of change, which are the two most common mistakes. (Schoemaker, 1995)

The scenario planning method consists of ten phases, of which we only used the first five in this work. The first task is to define the time frame and scope of analysis. Secondly, identify the main stakeholder groups that can affect the organization's operations and objectives. Key stakeholders include employees, shareholders, suppliers and the community from which the company uses its resources, etc. Thirdly, basic trends are identified using the PEST framework as help. After that, uncertainties are identified, that is, events whose outcome is uncertain and can have a major impact

on the outcome. And in the last step, based on collected information can construct initial scenario.

2.2. Value Network Configurations

The Value Network Configuration (VNC) is an analysis method, which support the value creation logic, when a new business is started to plan. With this tool we can present different business cases, and represent the connection of the actors and their responsibilities, so it can show the whole process of the value creation logic.

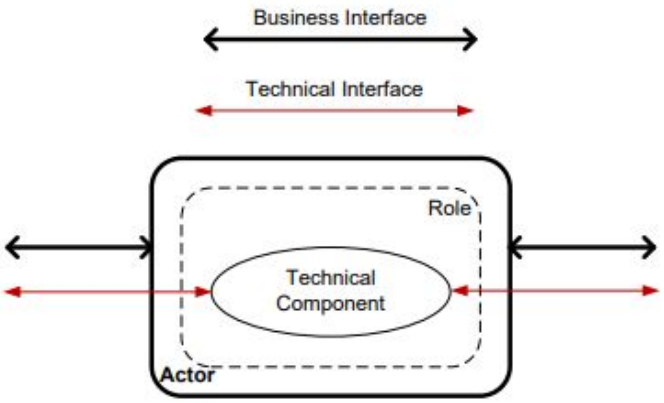

Figure 1: VNC object regarding to Casley notation (Casey et al, 2010)

A VNC model build up from actors, who are the companies, who produce or provide services for another actors. The actors have roles, which are the responsibilities of the technical components. These are the business model, these are the resource, which are offered to the other actors. If two companies share the resources with each other, so two technical components are connected on the model we mark it as a technical interface, which is delineated with red arrow. The technical interface can be a protocol, which makes possible the value creation in the network. Non technical connection is the business interface, which represent the connection between two actor. This connection can be a contract which contains the main principles between the companies, represent the requirements of the value flow.

With more VNC models, we can clearly analyze the business field, clearly appear, that from one business case which actor can benefit the most. It helps to understand

how can the given business case affect to the business market. Moreover, it clarifies for the given company from which business case can it benefits the most, what are the roles and the technical requirements, that they have to meet. So the company with the support of the VNC models can plan, which are those fields, where they can work and they can make sure if the business market allow to work on the given field.

2.3 Business Model Canvas

The Business Model Canvas consists of nine building blocks. These blocks are Customer Segments, Value Propositions, Channels, Customer Relationships, Revenue Streams, Key Resources, Key Activities, Key Partnerships and Cost Structure.

Customer Segments define the profitable customers enterprise aims to reach and serve. The customer need is satisfied with Value Proposition, which caters the requirements of each Customer Segment. Value Proposition creates value for a Customer Segment. These values can be quantitative or qualitative.

Building block for Channels solves how to deliver this Value Proposition to each Customer Segment. Channels have five phases: awareness, evaluation, purchase, delivery and after sales. Playing important role in customer experience, channels can be indirect partner channels or direct inhouse channels.

A business model can involve two different types of Revenue Streams: transaction revenues from one-time customer payments and recurring revenues from ongoing payments. Pricing can be predefined or the prices can change depending on market conditions. Predefined prices based on static variables is called Fixed Menu Pricing. These can be list prices, product feature dependent, customer segment dependent or volume dependent. Changing dynamic pricing can base on negotiation, yield management depending on inventory and time of purchase, real-time market where price is established based on supply and demand or auctions where price is determined by bidding outcome.

Most important assets required for the business model are described in Key Resources. Key Resources can be physical, financial, intellectual, or human. The resources can be owned by the company or acquired from key partners. These resources together with Key Activities allows the enterprise to achieve its Value Proposition. Categories for Key Resources are Physical, Intellectual, Human and Financial. Key Activities describes company actions for the business model to work. Key Activities consists of three categories: production, problem solving and platform/network.

Key Partnerships describes the network of suppliers and partners. Partnerships can be distinguished to four different types: strategic alliances between non-competitors, cooperation, joint ventures and buyer-supplier relationships. Motivations for partnerships can be optimization and economy of scale, reduction of risk and uncertainty, azuisition of particular resources and activities.

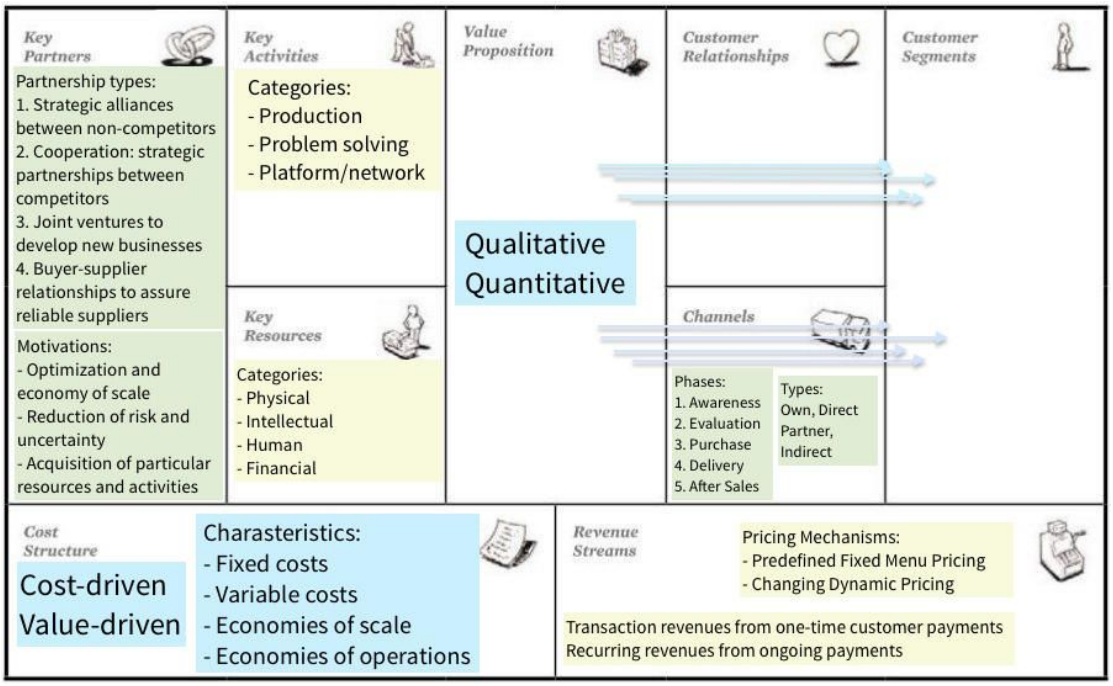

Figure 2: Business Model Canvas methods (Ostwalder & Pigneur, 2010, p. 44)

Most important costs are described in Cost Structure building block. Costs can be calculated after defining Key Resources, Activitities and Partenrships. Cost model can

be divided to cost-driven and value-driven and a cost structure can have following characteristics: fixed costs, variable costs, economies of scale and scope. (Ostwalder & Pigneur, 2010, pp. 20-41)

2.4 Porter Five Forces

Using Porter Five Forces supports understanding the structure of the industry an enterprise is acting in. It makes the company more profitable and less vulnerable for possible attacks. The four competitive forces are customers, suppliers, potential new entrants and substitute products. These forces affects the todays direct competitors. (Porter, 2008)

Figure 3: Michael Porter's Five Forces (Porter, 2008)

3. Case description

The case was introduced briefly in the introduction, here more detailed explanation is provided about the case company and the technology involved in platooning.

3.1 Company description

Indagon is a 16 year old company in providing custom middleware for the system integration between terminal and end user application for the professional positioning requirements. These positioning solutions majorly based on GPS/RTK technology with the help of their varied product portfolio. Currently, Indagon is looking and expanding opportunities in intelligent transportation systems with involving in many pilot projects. Few pilot projects are automated vehicle testing in Aurora smart road, intelligent transportation systems(ITS) solutions with ITS Russia and 5G network based on smart light poles - LuxTurrim5G.

Indagon is created a startup company named Vediafi, with the focus in creating fairly priced services and products within the world of intelligent transportation systems. Together with Vediafi, Indagon would like to be part of rapidly growing future transportation ecosystem with creating new business models. However, Indagon is looking to create new opportunities in the mobility service sector, their existing product portfolio would help them to be part of major technology provider and new service provider. In this context, we analysed the methods and tried to provide solution that feasible to Indagon in the platooning service ecosystem with keeping their GPS/RTK technology in consent.

3.2 Technology

For autonomous driving, the Society of Automotive Engineers (SAE International) has provided a standard J3016, that describes six levels of automation from “no automation” to “full automation”. First three levels are human-driven, and last three automated driving-driven. Excluding the first level, platooning is possible in all the other five levels.

Apart from Automated Driving Technology, Adaptive Cruise Control (ACC), Cooperative Adaptive Cruise Control (CACC), Wireless Communication and other technologies are necessary for platooning. All the technologies are presented in the figure 4.

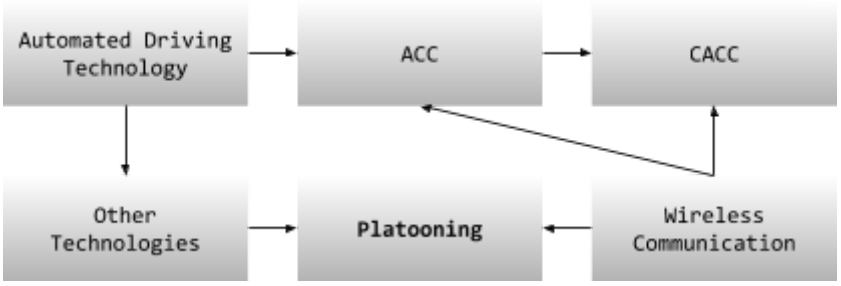

Figure 4. Technologies in platooning

ACC assists to maintain a time gap between vehicles. It analyses road, speed and engine data and warns if distancy closes. ACC system requires radar, LIDAR and GPS/RTK. Radar provides precise position of various objects, distance to them, their speed and helpful in bad weather conditions. LIDAR or laser radar scans and creates 3D picture of the environment. Camera determines traffic signals and recognizes all objects. GPS/RTK provides vehicles exact position to do easier orientation. Cooperative Adaptive Cruise Control (CACC) allows vehicles to communicate by using IEEE 802.11p standard, which adds Intelligent Transportation Systems (ITS) to the WLAN-standard. (Puplaka, 2015)

In our case study to understand the platooning service and technology used in it are understood from documents on various projects such as SARTRE - an European platooning project, PATH - a California traffic automation program, EU truck challenge and other. As mentioned in the introduction fuel savings can be achieved with less gap between vehicles, to create this gap and operate the vehicles without fail needs a sophisticated platooning architecture. The platooning architecture provided for level 2+ is considered in this report. (Bijlsma & Hendriks, 2017)

The level 2+ architecture is simplified for the purpose of analysis and designed for the requirement of platooning service structure which is shown in figure 5.

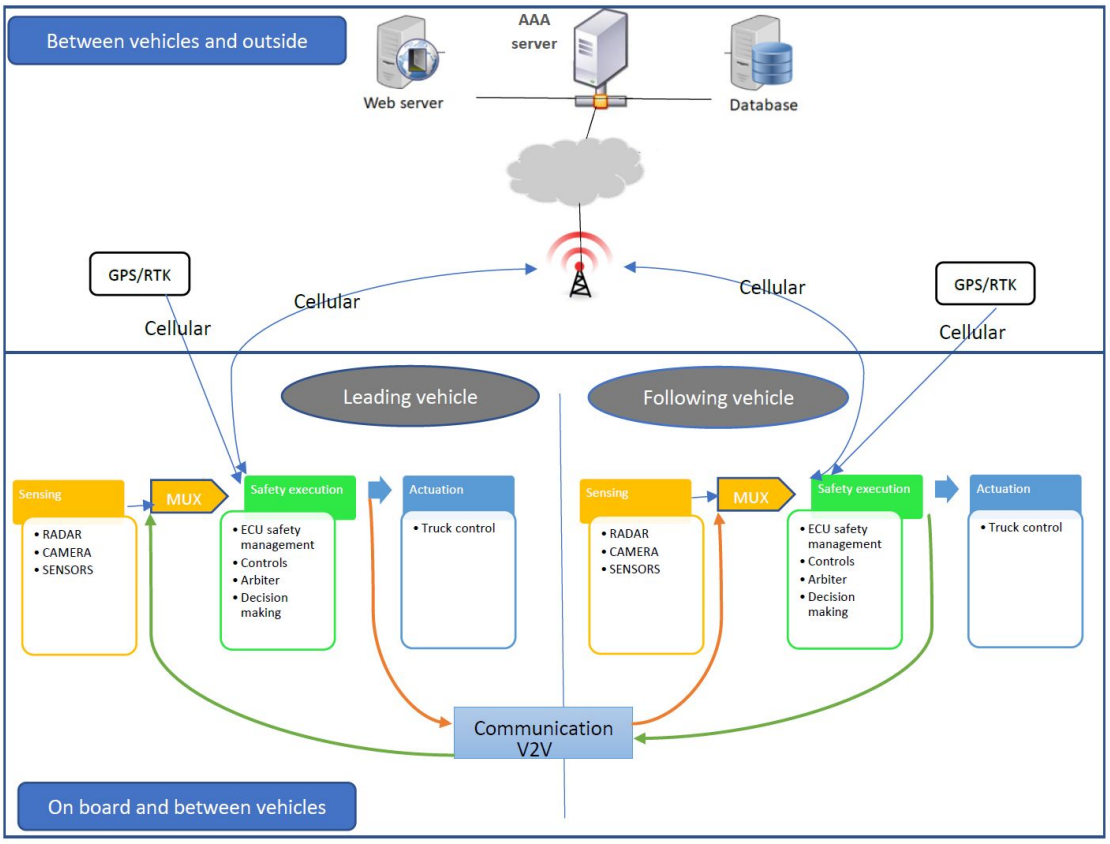

Figure 5: Platooning system architecture

In abstract level, the architecture contains homogeneous function blocks for leading and following vehicles. The functions of main system are differentiated, depending on sensing of truck internal changes and its environment, deciding the actions need to take by thinking, exchanging the messages between distributed components by communicating and acting the trucks accordingly. The leader vehicle senses the environment by their sensors, acquired position from GPS/RTK and instructions from platooning controller are gathered and multiplexed before sending it to the safety execution block. In safety execution block electronic control unit (ECU) performs safety management and control operations by arbiter sending the control to select the channel from which the actuation output should be forwarded with the decision making. The selected channel actuates the truck where to move right or left, to operate

brakes or accelerator and other truck actuating functions. The details about actuation are sent to following vehicle multiplexer mechanism along with required sensing data of leading vehicle via V2V communications (IEEE 802.11p). The explained procedure continues in following vehicle and the safety execution controls forward to leading vehicle.

The technologies used in automated driving are extensive. The adoptions are varies in manufacturer varies for example Uber self driving uses LIDAR for getting 3D images of surroundings. Whereas, Tesla autopilot uses processing of radar signals to create the similar application use as LIDAR, this helps to navigate better in low visibility conditions. However, in these cases GPS/RTK navigation is used to get the precise location data, limiting the vehicle speed when no signs are present and optimal route to its navigation given distance. In case of platooning, GPS/RTK provides all the features and also helps in knowing the position of the trucks that would like join in platooning along with approximate time estimation to join.

The competition in the platooning service market is not there at this moment and this is in evolving stage. All the projects are currently in pilot stage in developing the technology, standards and required infrastructure needed. These projects are highly driven by truck manufacturing companies.

4. Case analysis

4.1 Scenario Planning

In this chapter we will present the scenario analysis. The time frame and scope of analysis for Indagon platooning solutions is 7 years (2018 - 2025) which is bounded to geographic location to Nordic and Baltic countries.

Autonomous cars need a lot of new technology and that is shaping the automotive industry. Apart from the consumer market, particularly through a B2B approach, some manufacturers also eye on the transportation and logistics domain. Truck platooning is an IoT application into autonomous trucks. Political decision-makers also support research and development at domestic and European level since the automotive industry has a strong economics position in southern and central Europe.

The main partners in these research projects are vehicle manufacturers, transportation and logistics companies, geospatial technology providers, research companies like VTT and other academia, communications technology providers and solutions and service providers.

Protecting the environment through fuel consumption and reducing emissions has both economic and political impetus. Other key trends include road safety, avoidance of congestion, efficient use of roads and green legislation in general.

4.1.1 Key Uncertainties

Political

U1: Legislation, regulations and Transportation planning

Considering the challenges of modern transport planning, making large and fast changes is a very long-term process. Building costs are high, planning with all the complaints takes a long time, and political parties may have a completely different

view of the importance of issues. In addition, a lengthy transition period is needed for new legislation.

U6: Suitability to fit the models in different geographical locations

Some terrain is better suited to the use of platooning than others. Multi-lane motorways built on a flat land are the optimum terrain. The steep hilly and winding roads, as well as the narrow roads, are not well suited to the use of platooning, because the tracking of the driver close enough is too difficult.

Social

U2: Reliability and safety of services

Adverse weather conditions have been one of the major problems of self-driving cars. Rain and moisture can make car sensors unreliable and often snow cover the roadway paintings used for navigation. At an early stage, even one such accident caused by this kind of error can bring the car manufacturer a great amount of liability and so much bad reputation that the business will suffer greatly.

U5: Reduction in energy consumption and emissions

Platooning can cause resistance amongst other road users, as long truck queues are difficult to bypass. Also, shipping companies can't be sure of promised fuel savings based on tests alone (Tsugawa, 2016). Costly investments may turn out to be unnecessary.

Economical

U3: Timeframe to develop fully functional system

Slow political decision-making causes economic pressure on all stakeholders, the implementation may be delayed even if the system is otherwise ready or the development of technology may turn out to be slower and costly than expected.

Technological

U4: Open interfaces, standardization and interoperability

In the worst case, the solutions of different car manufacturers are not compatible. Standardization may endure and end up being a bad solution for some manufacturer. Without open interfaces, only car manufacturers can develop systems.

U7: Research development

Research and product development can end up in a dead end. It may not be possible to develop a sufficiently safe and cost-effective solution for platooning.

4.1.2 Initial Scenarios

Based on the two greatest uncertainties questions, Whether legislation and regulations that facilitating to platooning or not?; Is safe and cost efficient solutions provided?; we construct the initial scenario matrix by crossing them.

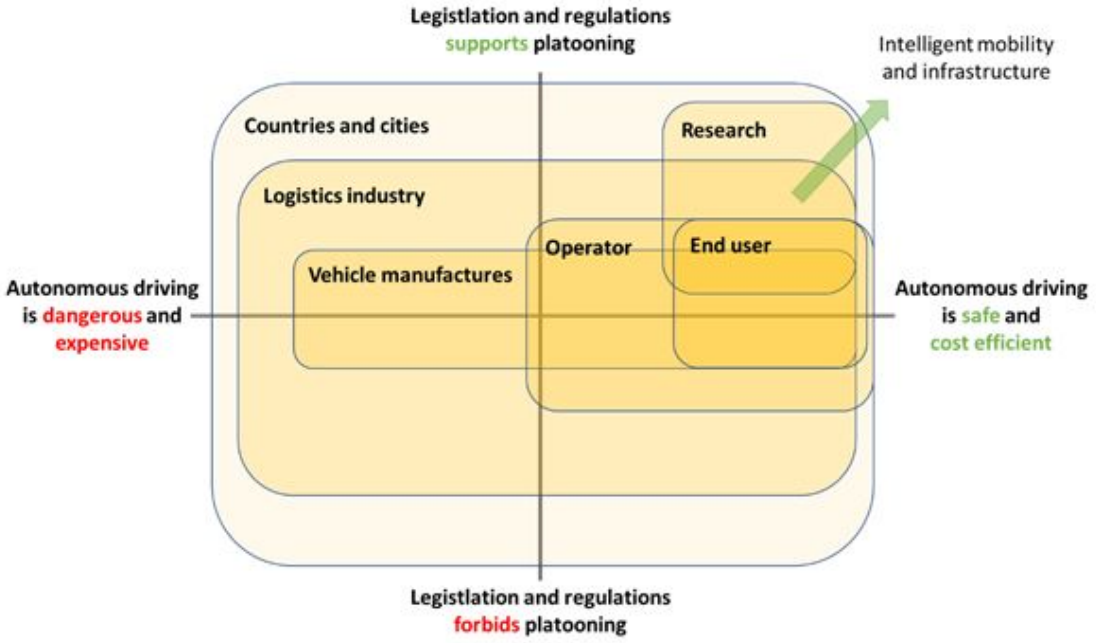

Figure 6. Initial platooning scenario matrix.

However, this scenario matrix is mapped with the various stakeholders that bounds in the suture scenarios and shown in figure 6. The possibility of truck platooning with semi-automated driving or fully automated driving is possible only when the services are provided at low prices and safe with the supportive legislations and regulations are provide. Where it creates platform to the end users to use the services. The scenario planning serves us further analysis of value network design and business canvas methods.

4.2 Value Network Configurations

The following models describes different VNC models, that can emerge in the fields of Indagon. Every model approaches the platooning in different way, the models shows which company, actors can benefit the most from the platooning. We developed three models, which are the following: Vehicle Manufacture Driven model, Logistic Company Driven model and Platooning Operator Driven model. In the next chapters we will discuss about these VNC models.

4.2.1 Vehicle Manufacturer Driven VNC Model

Our first model is the Vehicle Manufacture Driven VNC model, which aim to represent a case, when the platooning is mainly managed by the company, who produce the vehicle. In this case the main actors are vehicle manufacturer, logistic company and navigation operator.

The first actor is the vehicle manufacturer, who sells vehicles, which are equipped with all the necessary sensors and communication devices. The sensors gather all the data from the vehicle's environment and pass it to the Embedded Control Unit (ECU). It collects all the sensor data and manage the vehicle regarding to the collected data. The ECU has various technical interfaces to keep contact with the elements (ethernet/CAN inside the vehicle and 4G/5G outside). In this case the vehicle manufacture maintain database, which aim to provide more information for the vehicles. It can provide information about another platooning convoy or any city, environment related notifications. Moreover with the database vehicle company can

maintain which vehicles can connect to a convoy, thus those vehicles can just join, whose meet the requirements and if it is necessary can check if the vehicle has license. So it can act like an authentication, authorization unit.

The next actor is the navigation operator. As we earlier introduced in the platooning environment the accurate positions, navigation data are essentials for vehicles. In our case this actor is our case company, the Indagon. The Indagon provides the RTK infrastructure and the navigation data as a service. The vehicles can connect to the operator through mobile network (4G/5G) and they can get accurate position data, if they subscribe for the service. This contract is signed between the manufacturer and the operator (business interface), thus the end user, logistic company is not responsible for handle the contract, subscription.

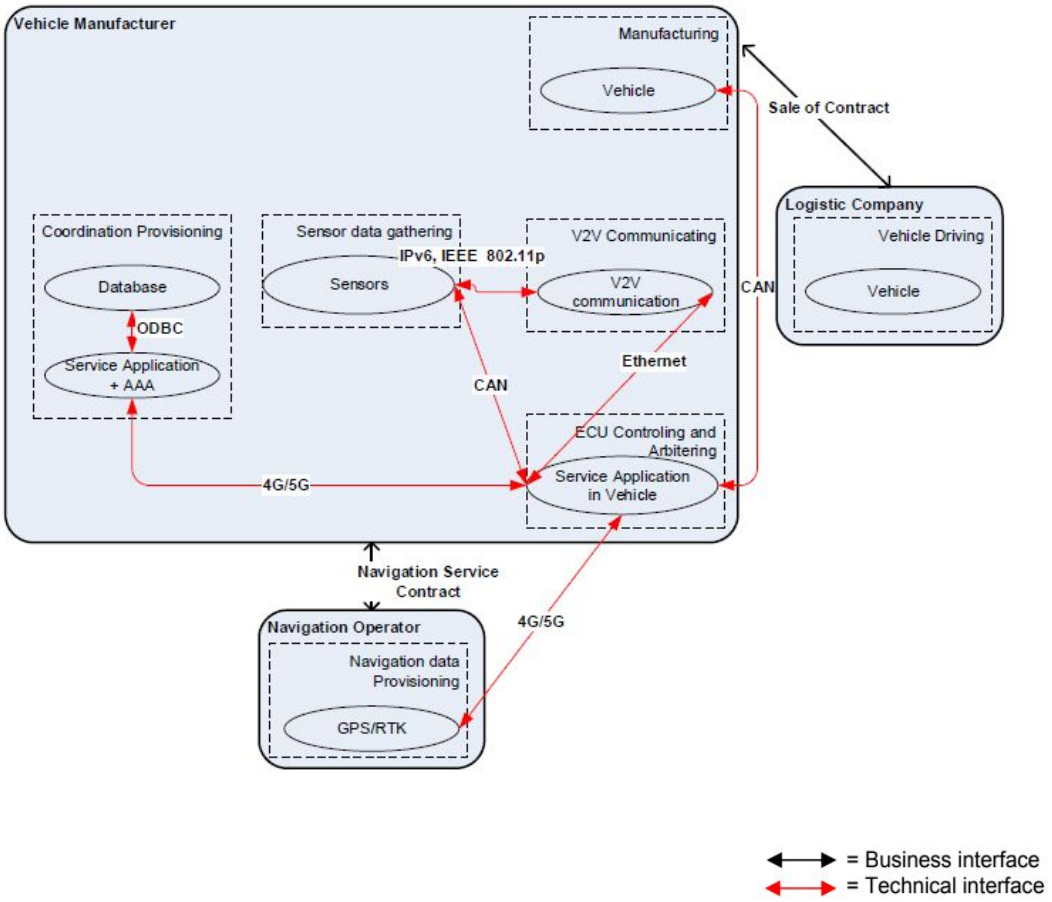

Figure 7: Vehicle Manufacture Driven VNC model

The last actor in this VNC model is the logistic company, who just buy the vehicle and make a contract, which is the business interface between the logistic company and the manufacture. The vehicle is equipped with all the necessary tools and services, so the logistic company need just a contract to buy it, the contract provides a vehicle, which is ready for the platooning.

So this case covers that case when the vehicle manufacture almost rule the whole market. The logistic company can benefit from this case, so it does not necessary to take care for the technical requirement of platooning, all the responsibility is on the manufacturer.

4.2.2 Logistics Company Driven VNC Model

Other possible VNC model is the Logistic Company Driven model, where the main actor is the logistic company. We can still find the vehicle manufacture and the navigation operator, but a new actor appears too, a platooning operator.

In this case the vehicle operator's only responsibility is the produce of the vehicle and sell it to the logistic company. So the only interface between these two actor a business interface, so a sell of contract. The logistic company buy new vehicles, a fleet and equip it with the required sensors and communication tools to use the platooning. All the roles, technical interfaces, which the logistic companies contains can be found in the previous chapter. But in this case the logistic company has two new technical and two business interface to the other two actors.

The first business interface is a navigation service contract to the navigation operator. The responsibilities and the technical interface are the same of the operator, but now the logistic company can handle the contract. So, the logistic operator can choose, which company can meet expected requirements. The new actor in this model is the platooning operator, so the authorization and the authentication process and to share any traffic, environment or convoy related information is now the new actor's

responsibility. This new actor in the platooning service is a 3rd party, who can interconnect the different vehicles, provide reliable information.

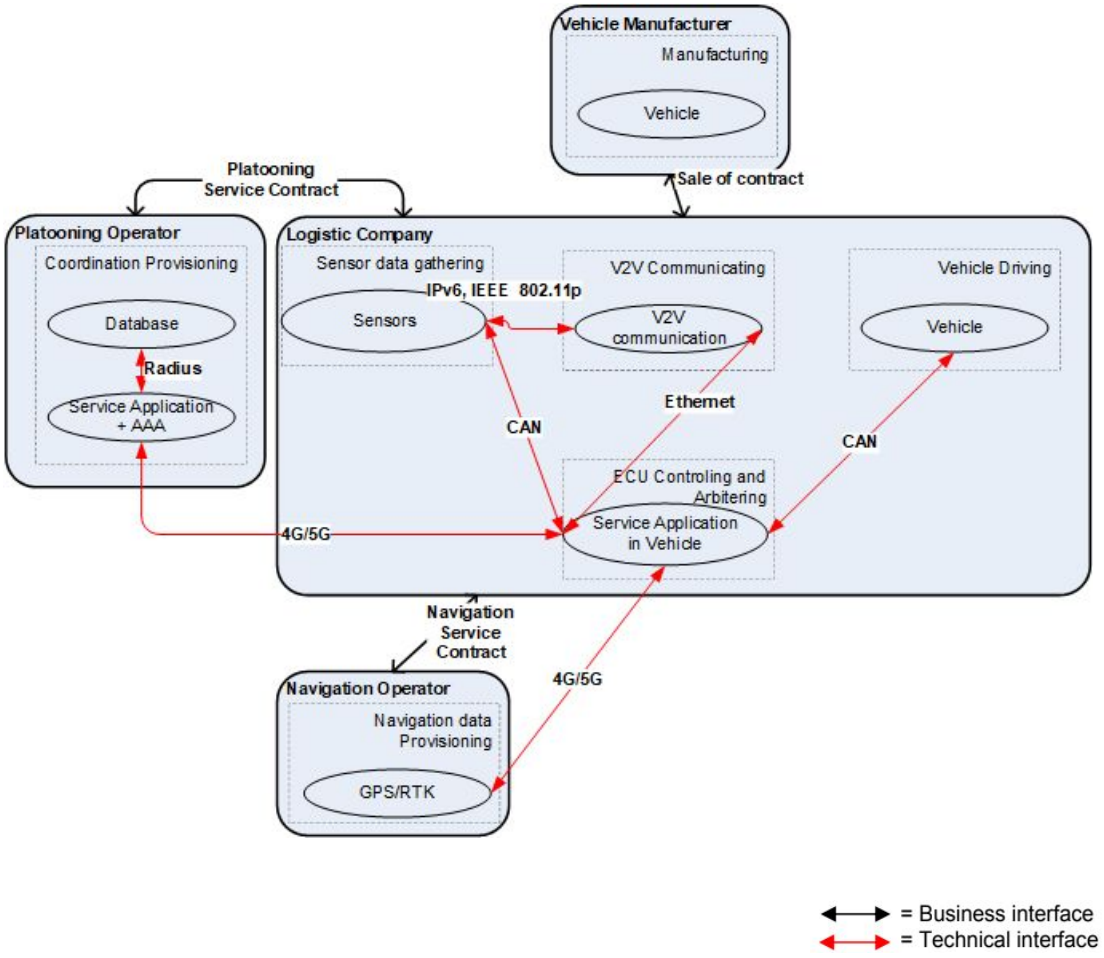

Figure 8: Logistic Company Driven VNC Model

This models advantage is the logistic companies have chance to choose, who they want to work with. They can find those actors, who provides the best required value for the money.

4.2.3 Platooning Operator Driven VNC Model

The next VNC model is the platooning operator driven VNC model, where the main actor is a third party, platooning operator. The actors are similar as the previous model

(logistic company driven model), but the responsibilities of the main roles now at the platooning operator.

The vehicle manufacturer role is just to produce vehicles and sell it to the logistic company (business interface), regarding to the contract of sale. After logistic company can choose the appropriate platooning operator, which can meet the expected requirements.

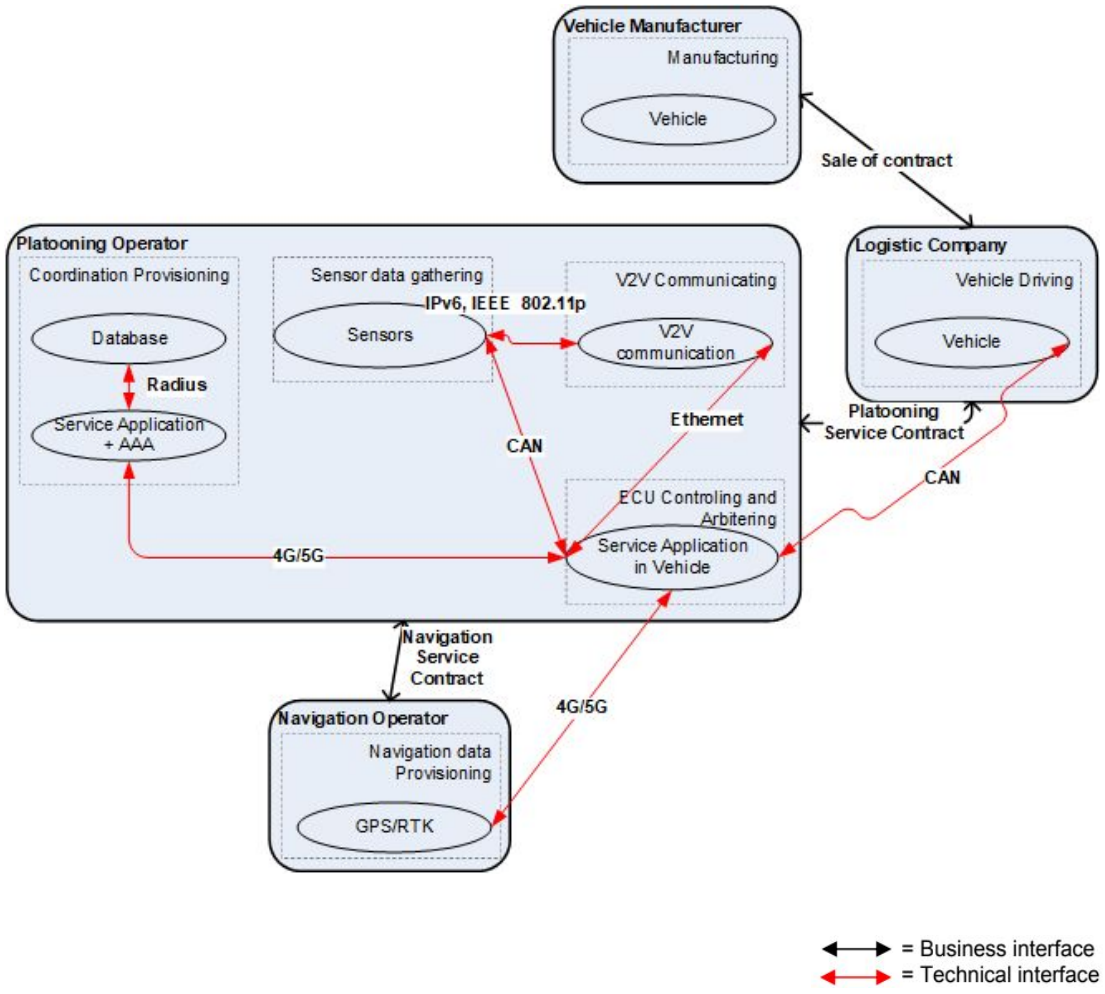

Figure 9: Platooning Operator Driven VNC Model

The logistic company according to the sales contract set up the vehicles with sensors and communication devices, which are detailed in the previous chapters (5.1, 5.2). The informational database and the authentication are the responsibilities of the platooning operator. Instead of the previous model, the navigation operator has a

contract, business interface with the platooning operator, which makes possible again the whole platooning system be available as a service for the logistic company.

In this case every roles, which are in connection to the platooning system belongs to platooning operator. The advantage of the model is that in this case the roles of the platooning are centralized in to one actor, which can concentrate only on this field. The aspect is similar to the first model (5.1), but in this case the actor's only role the platooning and no other, and the vehicle manufacturer's only role is the vehicle producing, so the roles can be separated obviously.

4.3 Business Model Canvas

The final proposition for the business model canvas is presented in Figure 7. This is based on the value network configurations that fits to the Indagon company that can provide platooning service. This business model canvas is basically based on platooning driven VNC model. We have defined the Customer Segments as road logistics industry, long distance public transportation and effective distribution channels. Common for all this is logistics industry. The solution will serve the logistics industry as a whole.

Indagon gives value to the customers by providing new technology while reducing the costs. There will be additional cost reduction when fuel saves are made. This has also a societal impact while a step towards autonomous driving is taken. Most road accidents are cost by human error, with autonomous driving, road safety increases.

Logistics industry is reached with partnering activities. Partnering is done with each target market territories. Awareness, evaluation, purchase, delivery and after sales is done directly to each customer.

Revenue Streams come from recurring revenues when pricing is dynamic and leasing hardware and software. At first, the hard- and software development is done with the customers to gain the trust from the industry, also the pricing is done dynamically.

Key Resources and Activities are provided to the Customers who are also related to the partners. Cost Structure of the company includes implementation and development of services and products.

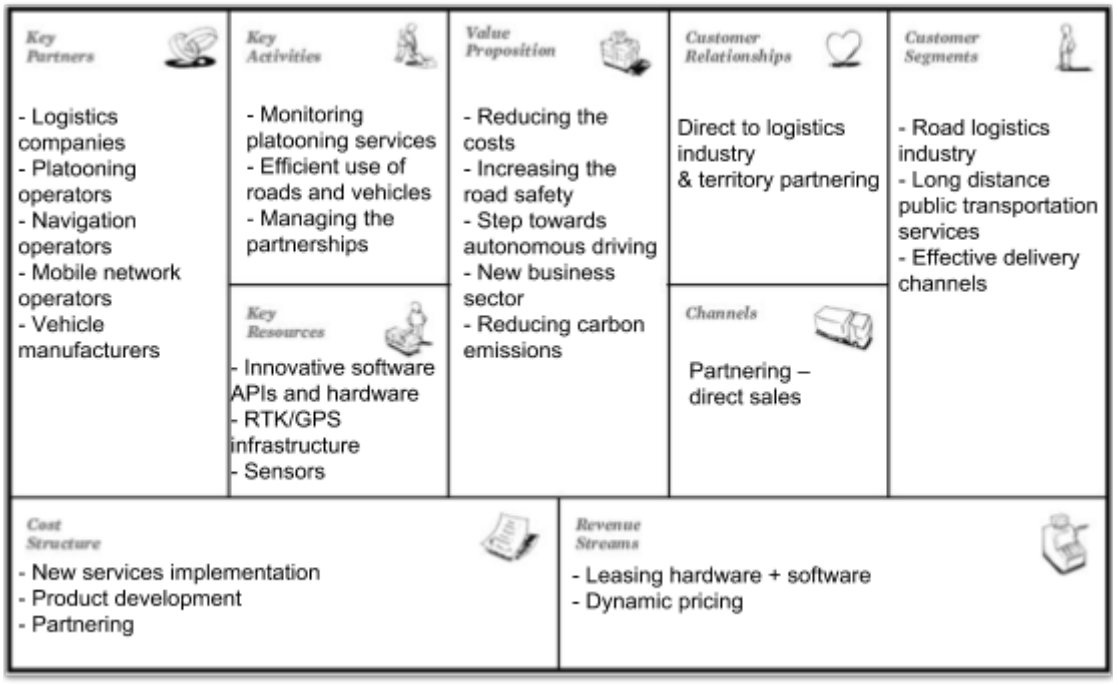

Figure 10: Business Model Canvas Case Indagon

4.4 Porter's five forces

As the industry is completely new in platooning service sector, Porter's five forces do a favor in finding the new entrants, bargaining power of suppliers and buyers,

substitutions to the service developed and rivalries. These elements of Porter's five forces are shown in figure 11 for platooning service model.

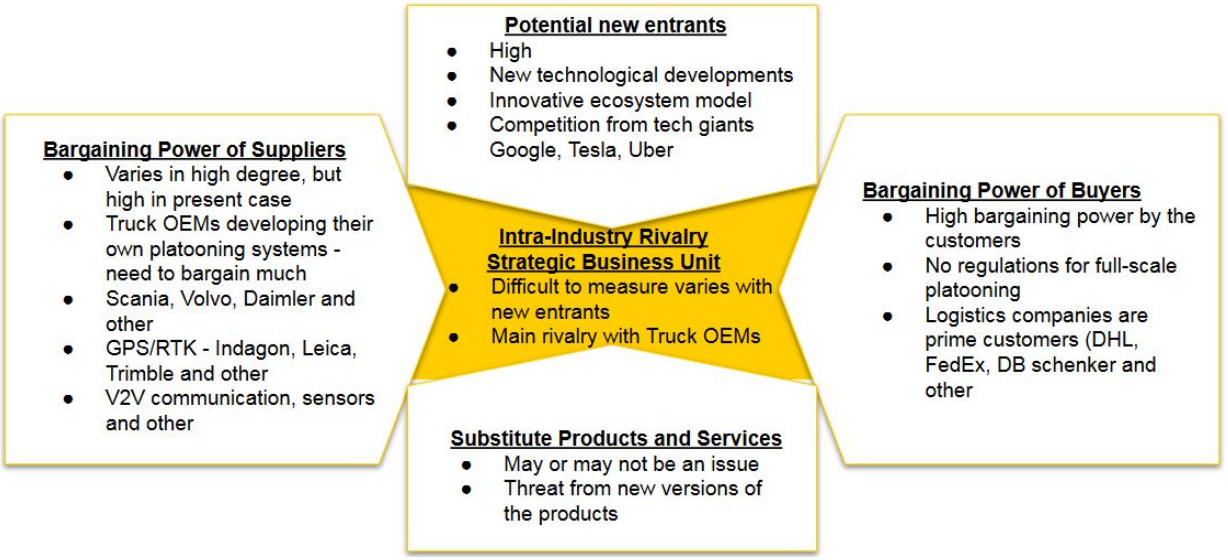

Figure 11: Porter's five forces for platooning service model.

5 Conclusions

In this report we have taken opportunity to look into the emerging platooning service in future mobility sector and in what areas Indagon could create their new business model. For this we have analysed the case with scenario analysis method, value network configuration method, business canvas model and porter's five forces .

We recommend Indagon to create a business model in platooning service as a service platform operator. As in future within the time period (2018-2025) of this case study multi brand truck platooning and logistics operations by the operators are mutually coordinated for better utilization of trucks, the operator for the platooning service is expected. The market in this ecosystem is not developed or no player is there at this moment. as the early entrant in this segment Indagon can get benefit and act as a major player at the time market becomes mature stage.

The major difficulty for Indagon is developing their own service platform in the critical autonomous driving platooning structure and where they can develop their solution platform. It may face strong competition from the big players such as Google, Tesla and Uber, who already developing various platforms towards autonomous driving.

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Feedback for the course

In this course the workload is on par with the hours needed to spend for 5 credits. The material given and course structure is very good. However, the structure for developing the value network configurations could be improved for example developing a VNC model together in a lecture for some example case. Our case was little tougher to fit into VNC method than the rest of the cases in the course. The required technology involved in the case is not matured in the market, which made us spend time on it then the required amount. Hence we lost time in developing the case according to the methods.