5G for cooperative & connected automated MOBIlity on X-border corridors

D6.2

Plan and preliminary report on the business models for cross border 5G deployment enabling CAM

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Authors

Authors in alphabetical order		
Name	**Organisation**	**Author or Co-Author**
Akrivi Kiousi	Intrasoft International SA	1.3, 4.3, 5, 6.
Carmela Canonico	ERTICO – ITS Europe	4,5,6,7
Daniel Jáuregui Cortizo	CTAG	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8
David Fidalgo	AEVAC	3.3, 3.4, 3.5, 3.6, 4,5,6,Annex 2
Dr Chris Hobbs	Satellite Applications Catapult	2.3 , 4, 5
Edwin Busem	KPN	4.1, 5
Emanuel Sousa	CCG	4.4
Evangelos Mellios	Satellite Applications Catapult	2.3, 4, 5.
Hugo Mendes	NORTE	4.1
João Ferreira	CCG	3.1, 3.2, 3.7, 3.8
Joel Puga	CCG	4.4
Jorge Alfonso Kurano	UPM	4.1
José Manuel Menéndez	UPM	4.1
Luxshiya Ariyanayagam	Fraunhofer IIS - Fraunhofer Center for Applied Research on Supply Chain Services SCS	2.1, Annex 1
Maija Federley	VTT Technical Research Centre of Finland	Annex 1
Marijn van Overveld	NOS	4.1, 5, 6
Nazlı Güney	TURKCELL	3.9, 4.1
Nuno Gonçalves	NOS	4.1, 5, 6
Olga E. Segou	Intrasoft International SA	1.3, 4.3, 5, 6.
Pedro Llorens	AEVAC	3.3, 3.4, 3.5, 3.6, Annex 2
Ricardo Dinis	NOS	4.1, 5, 6
Tahir Sarı	Ford Otosan	1.4, Executive Summary, 2.1, 3.10, 7, Leading editor of deliverable
Thomas Donnelly	Satellite Applications Catapult	4, 5

Control sheet

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ABBREVIATIONS

Abbreviation	Definition
AV	Autonomous Vehicle
AMQP	Advanced Message Queuing Protocol
BMC	Business Model Canvas
CAV	Connected Autonomous Vehicle
CBA	Cost Benefit Analysis
CBC	Cross-border Corridor
CAM	Connected and Automated Mobility
CEDR	Conference of European Directors of Roads
C-ITS	Cooperative Intelligent Transport System
C-V2X	Cellular Vehicle to Everything
DoA	Description of Action

E2E	End to End
EC	European Commission
eMBB	Enhanced Mobile Broadband
ETPC	European Truck Platooning Challenge
EU	European Union
FAB	Semiconductor **Fab**rication plant
GA	General Assembly
ICT	Information Communication Technology
KPI	Key Performance Indicator
MEC	Mobile Edge Computing
mMTC	Massive Machine Type Communications
MNO	Mobile Network Operator
NRA	National Road Authorities
NSaaS	Network Slicing as a Service
OEM	Original Equipment Manufacturer
PESTLE	[P]olitical, [E]conomic, [S]ocial, [T]echnological, [L]egal, or [E]nvironmental
QoS	Quality of Service
RAN	Radio Access Network
RIO	Road Infrastructure Operators
SLA	Service Level Agreement
SME	Small and medium-sized enterprise
SOC	Silicon on Insulator
TRA	Transport and Road Authorities
TS	Trial Site
TSL	Trial Site Leader
UC	Use Case

UCC	Use Case Category
URLLC	Ultra-Reliable Low-Latency Communication
US	User Story
VNM	Value Network Model
WP	Work Package
WPL	Work Package Leader
X-border	Cross-border

EXECUTIVE SUMMARY

This document is the deliverable D6.2 "Foster adoption new business models for 5G & CAM" and part of "WP6 Deployment Enablers". The main objective of this deliverable is to provide detailed analysis of 5G-CAM stakeholders, revenue streams between these stakeholders and new business opportunities from 5G-MOBIX use cases perspective. 5G-MOBIX use cases can be found in D2.1 "5G-enabled CAM use cases specifications".

Currently, many EU funded projects related with 5G and CAM services exist. According to our project examination and experience, value network model is effective to show business related interactions between stakeholders. Business model canvas method also helped us to define customer segments, value proposition, key partners and possible revenue stream models.

With emerging 5G-CAM technologies, we also expect new business models where stakeholders could be responsible for several duties. For example, road site operators could be 5G-CAM service providers and also take part in the 5G deployment, meanwhile automotive OEMs providing vehicles as traditional way, they can also provide 5G-CAM services.

Motivation of stakeholders are also listed in this deliverable. According to our study, stakeholders are aware that 5G-CAM services are emerging technologies, but current unclear specifications, regulations, revenue sharing models etc. decrease stakeholder's motivation. Additionally, drivers in logistics sector fear losing their job, because of the latest improvements in vehicle autonomy, e.g. SAE L4/5 vehicles do not need drivers. Lack of trust in automated vehicles, ethical and legal issues in the development of crash algorithms, unclear way of ensuring protection of consumers' rights and difficulty in determining accountability in cases of accidents are also other open points. We use the PESTLE approach to define these business-related gaps to understand what should be completed in the future to enable 5G-CAM services.

We recommend determining the best use of public funds for 5G infrastructure, upgrade skills & create a highly specialised workforce, fostering job creation and entrepreneurship, defining a clear path by governmental bodies to increase penetration of 5G-CAM services and creating a data economy to clarify easily revenue sharing, having open discussions about machine ethics.

We will publish a second version of this deliverable (D6.6) at the end of the 5GMOBIX project. In that deliverable, we will update our initial findings presented in D6.2 according to our trial demonstration results and answers to our questionnaires that are prepared in D6.2. Questionnaires will be directed to stakeholders in and out of our consortia.

1. INTRODUCTION

1.1. 5G-MOBIX concept and approach

5G-MOBIX aims to showcase the added value of 5G technology for advanced Connected and Automated Mobility (CAM) use cases and validate the viability of the technology to bring automated driving to the next level of vehicle automation (SAE L4 and above). To do this, 5G-MOBIX will demonstrate the potential of different 5G features on real European roads and highways and create and use sustainable business models to develop 5G corridors. 5G-MOBIX will also utilize and upgrade existing key assets (infrastructure, vehicles, components) and the smooth operation and co-existence of 5G within a heterogeneous environment comprised of multiple incumbent technologies such as ITS-G5 and C-V2X. 5G-MOBIX will execute CAM trials along cross-border (x-border) and urban corridors using 5G core technological innovations to qualify the 5G infrastructure and evaluate its benefits in the CAM context. The Project will also define deployment scenarios and identify and respond to standardisation and spectrum gaps.

5G-MOBIX will first define critical scenarios needing advanced connectivity provided by 5G, and the required features to enable some advanced CAM use cases. The matching of these advanced CAM use cases and the expected benefits of 5G will be tested during trials on 5G corridors in different EU countries as well as in Turkey, China and Korea. The trials will also allow 5G-MOBIX to conduct evaluations and impact assessments and to define business impacts and cost/benefit analysis. As a result of these evaluations and international consultations with the public and industry stakeholders, 5G-MOBIX will identify new business opportunities for the 5G enabled CAM and propose recommendations and options for its deployment. Through its findings on technical requirements and operational conditions 5G-MOBIX is expected to actively contribute to standardisation and spectrum allocation activities.

1.2. Purpose of the deliverable

This deliverable aims to define possible new business opportunities that 5G-CAM will create. Other projects can take this deliverable as a reference in the future with its full of content. Deliverable contains but not limited to related other current and previous 5G and CAM projects. Business model canvas is used to show possible business opportunities and value network model also is used to explain relation between stakeholders.

In the Section 3, business model analysis of each cross-border user story examined. In this examination, we defined possible service flows, stakeholders of each user story, value proposition of user story and current market products, projects related with user story. Other purpose of the document is the definition of the motivation of the stakeholders. We wanted to define why a stakeholder should invest on 5G-CAM. Even though, most of the stakeholders are aware about emerging 5G technology, but importance of the 5G-CAM services have not clear for them completely, yet.

To motivate more the stakeholders, current business- related gaps must be closed. Current deliverable also defines these gaps with the help of the PESTLE analysis. With this approach, we look political, economic, sociological, technological, legal and environmental perspective of the gaps. To close defined gaps, we placed a recommendation section that may help related governmental bodies and other stakeholders to understand possible action points.

1.3. Intended audience

The dissemination level of D6.2 is public (PU) and is meant primarily for (a) all members of the 5G-MOBIX project consortium, and (b) the European Commission (EC) services. Intended audience is all 5G-CAM stakeholders that are at least but not limited to automotive industry, telecom industry, policy makers, research organisations, governmental bodies, standard developing organisations and insurance companies.

1.4. Task activities modifications due to COVID-19 pandemic

Due to COVID-19 pandemic, planned face-to-face business model related workshop has been turned into virtual with narrower attendance from various 5G-PPP projects. Additionally, most of the contributor partners started to work part-time from their home and this has been delayed their contributions that have been previously planned. Hence, delivery of the first version of D6.2 has been shifted from April 2020 to October 2020.

2. METHODOLOGY

For this deliverable, we use Business Model Canvas (BMC) and Value Network Model (VNM) to define and show interaction between stakeholders. We have also examined other related projects as a benchmark to understand how we can create a solid document. After that with the help and perspective of the BMC and VNM, we focused on each user story in our cross-border s. PESTLE approach is used to define business related gaps in front of the 5G-CAM service deployment and finally we provide some recommendations to solve defined gaps.

2.1. 5G-MOBIX Business Model Methodology

The Business Model Methodology supports innovators in conveying their complex business functions in a less complex, graphic and easy-to-communicate and easy-to-share way.[1] One of the well-known and widely used business modelling tools were developed by Osterwalder and Pigneur (2010). Their innovative and manageable paper-based tool to draft and communicate a firm's business model strategy is called Business Model Canvas (BMC). [2]

2.1.1. Business Model Canvas

According to the authors a business model "*describes the rationale of how an organization creates, delivers and captures value*".[3] Building upon the understanding that a business model functions as a firm's building plan for its business operation, the BMC comprises the following nine building blocks [4]:

1. **Customer segments** describe the target audience that a firm intends to address and serve
2. **Communication, Distribution & Sales Channels** describe how and in what way an organization communicates and reaches its target audience
3. **Customer relationships** refer to what kind of relationship a firm establishes with its target audience, in order to reach, sustain and grow its customer base.
4. **Value proposition** refers to the core of the BMC and any business is general. The formulation of the value proposition is the starting point and affects the remaining building blocks. Value proposition is the value that is created for a specific target audience with a firm's product or service
5. **Revenue stream** represents how and the amount of monetary value a firm generates from its customer base in exchange for its products and services.
6. **Cost Structure** describes the expenses inherent to a firm's business model.
7. **Key resources** outline the relevant and needed core assets for a business to operate and fulfil its value proposition
8. **Key activities** describe the essential activities needed to deliver the expected value proposition
9. **Key Partnerships** refer to the partnerships a firm needs in order to deliver the proposed value proposition .

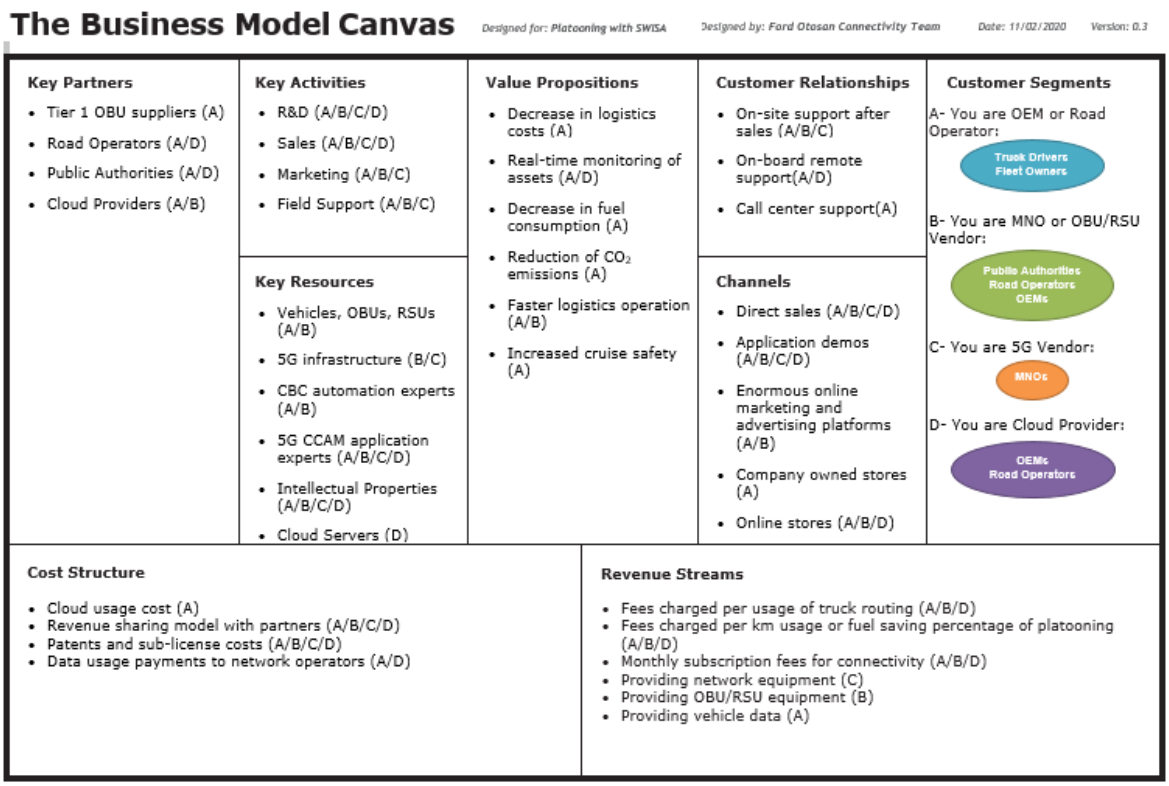


Figure 1: BMC example from 5GMOBIX User Story: Platooning with See What I See

As the nine building blocks highlight, the BMC is particularly characterized by its holistic approach that enables a visual thinking and allows easy to comprehend storytelling [5] of an organization's operational and physical form [6].

Moreover, Osterwalder's motivation to propose the BMC was rooted the impact he saw with the emergence of Information Communication Technologies (ICT) and its effects on the way business would operate. He predicted that ICTs would promote business to "*work in partnerships, offer joint value propositions, build-up multi-channel and multi-owned distribution networks and profit from diversified and shared revenue streams*". [7] Foreseeing the complexity of these value networks, he identified the need to create an innovative and manageable tool to communicate business models, which resulted in the BMC [8].

Against this background and the given context of 5G, BMC was chosen as one of the adequate methodologies to capture the innovative business models each stakeholder within the 5G-CAM ecosystem intended to pursue with their products, services and innovations.

In order to get first insights into each stakeholder's business' intention and mode of business operation, each user story owners were initially asked to fill out a BMC for their own user stories. As a difference from traditional BMC, we divided all BMC sections according to each stakeholders' perspective and grouped with capital letters A-B-C-D (Please see Figure 1 for details). As an example, if stakeholder is an Automotive OEM, it stated with 'A' and its customer segment, key sources, value proposition etc. are also stated with '(A)'. Building upon these insights, a more detailed questionnaire based upon the nine building blocks of the BMC were prepared and distributed (see appendix).

2.1.2. Questionnaire

The aim of the questionnaire is to capture and understand each business model and be able to gain further insights into the value exchanges, motivation of stakeholders, understand the gaps, possible new revenue streams in 5G-CAM complex networks and ecosystem.

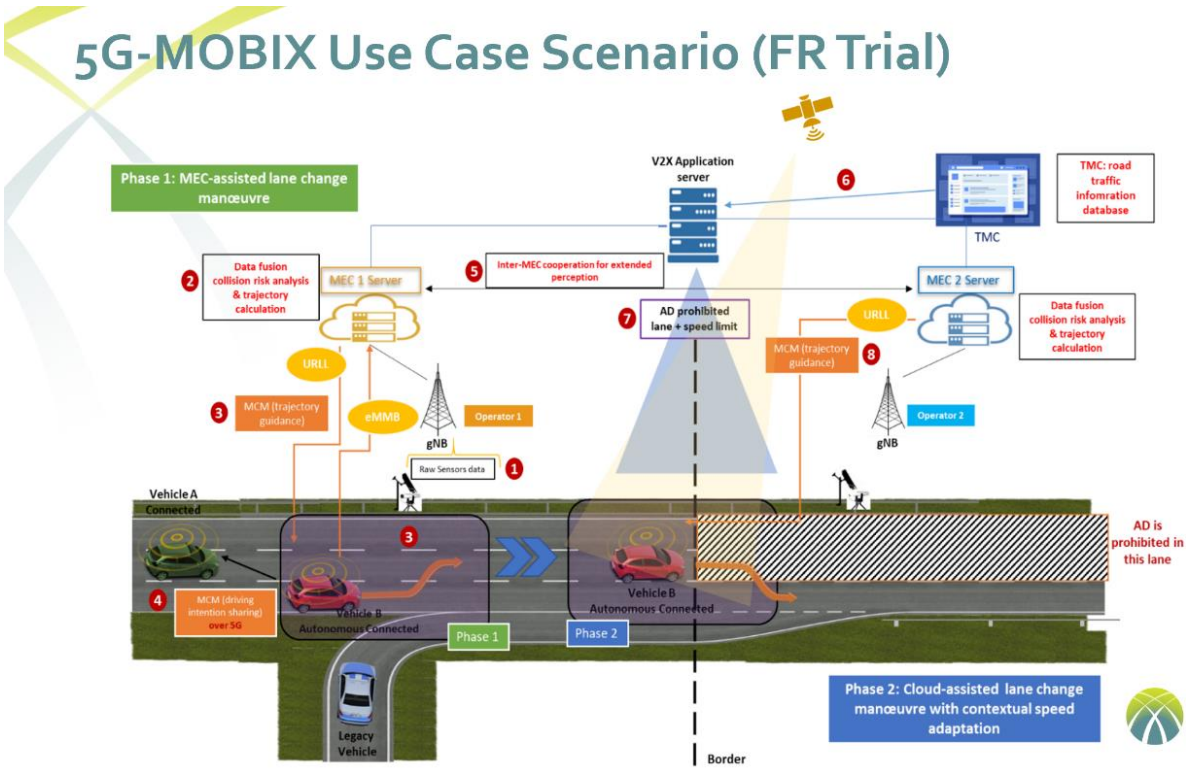
Answers of the stakeholders to prepared questionnaires will be analysed in the second version of this deliverable, which is D6.6.

2.1.3. Value Network Model

In addition to BMC, Value Network Model is also prepared for this deliverable to understand connections between organizations interacting with each other to benefit the entire 5G-CAM. A value network allows stakeholders to buy and sell products as well as share information. Prepared Value Network Model could be seen in Section 2.3.

2.2. 5G-MOBIX Partners and Value Network Model

We have established the Value Network for 5G-MOBIX by adapting the generic model of the SCOOP@F Value Network Model, into ones that fairly and accurately reflect the implementation at one of the shared borders. The example we shall share here is for the France-Spanish Border. To develop the right Value

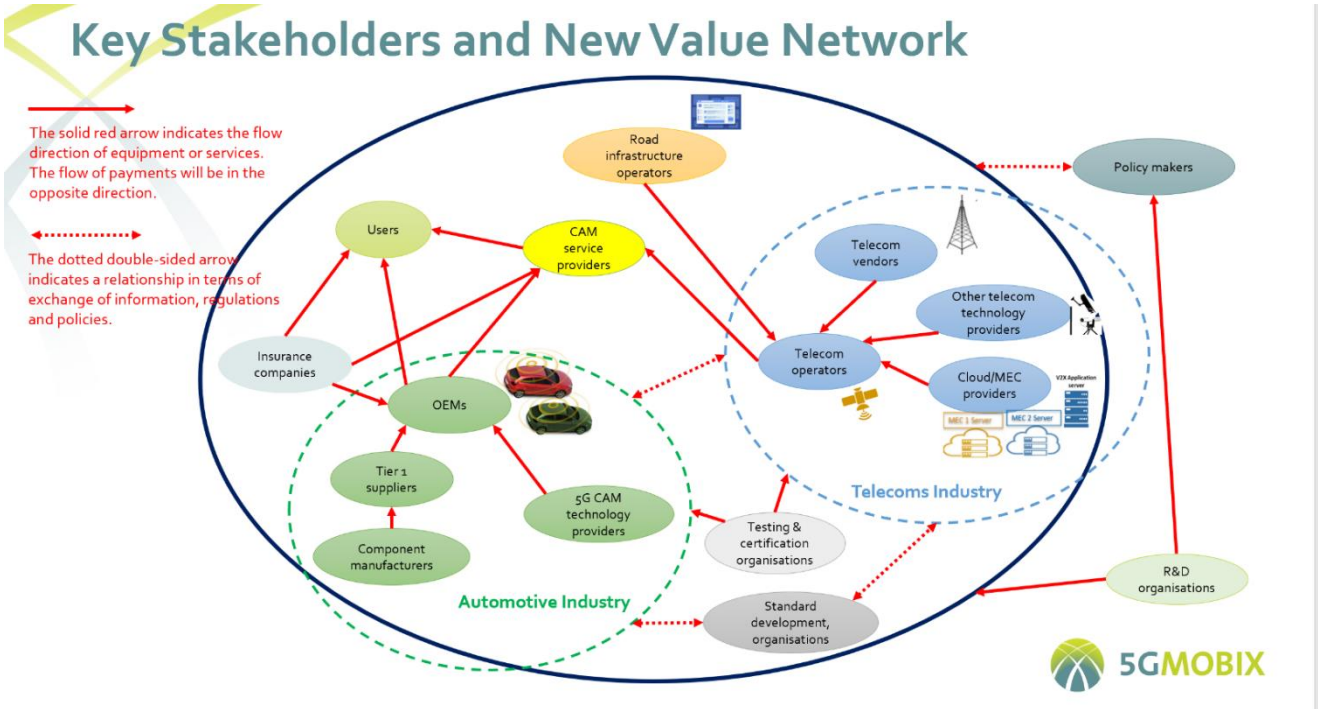


Network, it is important to understand how the technology plays it part in the transition of the vehicle from one side of the border to the other. This is best described by the diagram below:

Figure 3: FR Trial Site User Story

It is shown how the route of one vehicle entering from a side road affects another already en-route to the border and thus all of the connectivity that is already in place for routine operation well away from the border itself and for as it is approached. We have used the scenario above at the French-Spanish (FR) border to the derive where data/information flows to and from, and this then in turn provides us with a Value Network when we transition that flow into the flow of monetary transactions to facilitate these operations.

Our Value Network looks like this for the specific FR example scenario; it shows the flows of data, be they unidirectional (from one party to another; one gives an one takes) or bi-directional (in both directions between these entities; both give something and received something else from each other). We also distinguish between monetised relationships (solid arrows) – where monetary exchange is associated with the transfer of data/information - and non-monetary exchanges (dotted arrows) – where there is "free" exchange of data/information.



We have then established, of this example, where each partner within 5G-MOBIX sits, and two examples are shown below the generic plot.

Figure 3: 5GMOBIX Value Network Model

2.2.1. Value Network Model – Automotive Industry

Within the traditional automotive industry, the component manufacturers supply the Tier 1 companies, which in turn integrate these components into higher-level components and supply directly the OEMs (vehicle manufacturers). For Connected and Autonomous Vehicles (CAVs), this chain is extended to include the providers of 5G CAM-related technology to the vehicle OEMs. Examples are the HD map providers, and the providers of on-board sensors and telecom units. This category includes all the hardware and software suppliers, together with all the relevant supply and logistics chains. The automotive industry collaborates closely with the telecoms industry to design and develop technologies that meet the necessary 5G CAM requirements.

Table 1: Automotive Industry Consortia Partners

Role:	Who
OEMs	Ford Otosan, CNHTC, SENSIBLE4; NEVS, PSA and Renault (represented by VEDECOM),
5G CAM Technology Providers	TÜBİTAK, A-to-BE, DATANG, HERE, KATECH, SA Catapult, TNO, VALEO, VEDECOM, VICOMTECH, WINGS

2.2.2. Value Network Model – Telecom Industry

The traditional telecoms industry consists of the telecom operators, which include the Mobile Network Operators (MNOs) that deploy and operate the 5G and 4G networks, and the telecom vendors, which provide the necessary physical equipment to the MNOs such as the base-station antennas and the associated hardware (i.e. core network and Radio Access Network (RAN) infrastructure providers). Here, in the category of telecom operators we also included the Satcoms operators. For 5G CAM deployments, cloud and MEC infrastructure providers will also be needed to supply the local and central datacentres providing the storage, processing and networking resources.

Other 5G CAM-related telecom technology providers include the providers of any other necessary telecom devices and software (road-side C-V2X and sensor units are also included in this category here).Due to the high CAPEX and OPEX costs for deploying and operating CAM services, it is likely that MNOs will decide to share infrastructure, spectrum and/or core network resources. In order to ensure seamless CAM service delivery to the end-user, this will require various agreements (at technology as well as policy and regulatory level) between MNOs within the same country and of different countries for cross-border corridors. The automotive industry have embraced the GSMA Embedded SIM (eSIM) cards technology. The eSIM cards are fixed, allow remote provisioning, and can store multiple MNO profiles making it easy to switch between different MNOs.

Table 2: Telecom Industry Consortia Partners

5G-MOBIX Project Partners		Role
Telecom Operators	COSMOTE (Deutsche Telecom), KPN, Telefonica, Turkcell – Associated partners: SES, TELIA, CUSJ	Providers of network
Telecom Vendors	ERICSSON, NOKIA, DATANG	Providers of 5G and 4G core network and RAN infrastructure
Other Telecom Technology Providers	TÜBİTAK, INTRASOFT, SA Catapult, SIEMENS, WINGS, VICOMTECH – Associated partners: NXP, Technovation	Providers of C-V2X and sensor Road-Side Units (RSUs), integration of different technologies.
Cloud/MEC Providers	AKKA, DDET, SNET ICT, VEDECOM	Providers of Cloud/MEC infrastructure and relevant software tools for data storage and processing.

2.2.3. Value Network Model – Road Infrastructure Operators

The Road Infrastructure Operators are national or regional entities in charge of the deployment, operation and maintenance of physical road infrastructure. They can be public entities or private companies. The Road Infrastructure Operators may provide infrastructure to the MNOs for the 5G network deployment (e.g. masts, fibre, cabinets, etc). The road operators provide geo-coded information to facilitate autonomous driving (e.g. traffic management information). Some Road Infrastructure Operators may decide to deploy and/or operate their own 5G networks and, acting as MNOs, directly provide the necessary coverage for CAM services.

Table 3: Road Infrastructure Operators Consortia Partners

5G-MOBIX Project Partners		Role
Road Infrastructure Operators	AENL, INFRAPT	Provide and manage the trial sites

2.2.4. Value Network Model – Policy Makers

The Policy Makers include the International, European or National authorities that define the legal framework and policies for the whole ecosystem of stakeholders. From a 5G CAM perspective, the relevant policy makers can be divided in two broad categories:

- Road and transport authorities
- Telecom regulators (including ITU and national spectrum regulators)

Here, in this category we also include the various city authorities.

Table 4: Policy Makers Consortia Partners

5G-MOBIX Project Partners		Role
Transport authorities	DGT, IMT – Advisory board: FTA, HMIT, LVM, TRAFI	Authorise, regulate and support deployment for trials
Telecom authorities	Advisory board: BTK, LVM, YME, FICORA	
Cities	Helmond, Vigo – Advisory board: Berlin, Espoo	

2.2.5. Value Network Model – Standard Development Organisations

The Standard Development Organisations include International, European and National entities that define the standards that will be adopted by the 5G industry. Example organisations that define the telecoms-related technical standards include: 3GPP, ETSI, IETF/IRTF, IEEE, NGMN, IIC, 5GAA, AECC). For safety-related 5G CAM applications pertinent standards developing organisations such as ISO may also be relevant.

The Standard Development Organisations consider the regulations set by the Policy Makers and work closely with the 5G telecoms and automotive industry, particularly for CAM applications where high levels of safety are imperative.

2.2.6. Value Network Model – Testing & Certification Organisations

The testing & certification organisations offer testing and evaluation services that aim to ensure that equipment and products achieve the necessary quality while complying with the relevant national and international performance, safety and operational standards and regulations. These organisations may have a focus on the automotive industry, the telecoms industry or both (for 5G-CAM related equipment and products).

Table 5: Testing & Certification Organisations Consortia Partners

5G-MOBIX Project Partners		Role
Testing & Certification	DEKRA, TASS	Set requirements, collect and evaluate results of trials

2.2.7. Value Network – CAM Service Providers

The CAM Service Providers might be the MNOs, the car OEMs, the Road Infrastructure Operators or other service providing companies. The CAM service provider receives a fee from the end user for the provision of 5G CAM services and pays a fee to the network operator for the supply of connectivity products and added-value services.

2.2.8. Value Network – End Users

The end users can be the vehicle drivers, owners or passengers who enjoy the 5G CAM services. Here, we also consider as end users not only individual vehicle owners but also national or private road transport operators that own vehicles equipped with 5G CAM technology. The end users buy the vehicle from the OEM, pay the CAM Service Provider following a pay-per-use model, a one-time payment model or a recurring-subscription fee model, possibly at different prices for different levels of CAM Service Level Agreements (SLAs).

Table 6: End User Consortia Partners

5G-MOBIX Project Partners		Role
Users (Transport Operators)	ALSA – Associated partners: AMBER	Provide public transport vehicles

2.2.9. Value Network – Insurance Companies

The insurance companies are now connected not only to the users but also to the CAM service providers and the car OEMs. For Level 4/5 autonomous driving, where the driving of the car relies completely on technology, the user may not have any relationship with the insurance company at all.

2.2.10. Value Network – R&D Organisations

R&D organisations such as academic institutions and private or public research companies and centres work closely with the whole ecosystem during the design, development and deployment phase of current and next generation CAM-related technologies and applications. Here, we have also included consulting companies in this category.

Table 7: R&D Organisations Consortia Partners

5G-MOBIX Project Partners		Role
R&D Organisations	AALTO University, AEVAC, CCG, CTAG, DALIAN, ERTICO, ETRI, Fraunhofer, GTARC, ICCS, ISEL, IT, KATECH, LIST, SA Catapult, SHANDONG, TIS, TNO, TU Berlin, TU Eindhoven, UL, UMU, VICOMTECH, VTT	Develop requirements and methodologies, coordinate tests, establish international collaborations, assess impact, disseminate and roll out development of project results

2.2.11. Value Network Disclaimers and Next Steps

This example value network is based on the 5G-MOBIX use cases, and the 5G-MOBIX partners have been categorised here solely based on their role within the project. It is also perfectly possible for some partners to be part of more categories than those listed here.

We designed this value network assuming that the entity that benefits and is positioned at the centre of the network is the end user of the connected and autonomous vehicle, who pays for and enjoys "CAM as service". Different value networks can be designed assuming other entities (such as the telecom operators or the OEMs) at the centre of the network.

This is only an example value network. The roles and responsibilities of entities such as the Telecom Operators (MNOs), the vehicle OEMs, the Road Infrastructure Operators and the CAM Service Providers are not fully defined and may dynamically change. Hence, different ecosystems and value networks are perfectly viable.

Some associate partners, supporters and advisory board members of those listed in the 5G-MOBIX project proposal have not been included here. We are now in the process of establishing what each of the data flows involves, so we can identify what transaction is taking place, what its value between the involved parties is to routine operation at the border and thus what monetary exchange may (or may not) be needed to facilitate that to happen. That is the focus of our next stage of the work. The field trial will ensure that we can detail example numbers for a TRL7-based demonstration.

3. 5G-MOBIX USER STORY BUSINESS MODEL ANALYSIS

3.1. Business Models Analysis for US – Complex Manoeuvres– Lane Merge

US1, Complex manoeuvres in cross-border settings, explores advanced driving maneuvers in the autonomous mode. This maneuver includes the lane merge and overtaking. As a requirement, these maneuvers should be performed in a vehicle's and infrastructures' connected context, where vehicles' data are shared through an internal communication unit or radars, placed on the road infrastructure, and detects non connected vehicles. The data is shared through a 5G communication network. The lane merge maneuver is characterized by the management of a situation where automated vehicles are in a lane merge scenario. Success of maneuvers is defined by the capability of an autonomous vehicle in:

1) Identifying nearby vehicles, including their lane position, acceleration, speed, size, etc.

2) Determining the best merge manoeuvre according to the current situation.

3.1.1. Current Market Situation for US – Complex Manoeuvres– Lane Merge

The number of autonomous vehicles (level 5) available on the market is limited. However, the overtaking feature is already provided in vehicles with mid-levels of autonomy (level3).
The Lane merge manoeuvre is a feature that should be incorporated in autonomous vehicles launched on the market. Actually, the lane merge is still a problem that automotive makers are trying to solve. The provided solution is still not safe enough to be used without precaution. Most of these problems could be related to the interaction with non-connected vehicles: the lane merge manoeuvre is performed based on the information provided by vehicle sensors. However, in the near future, this feature will be improved and will be integrated as a default feature in full autonomous vehicles.

3.1.2. Stakeholders of US – Complex Maneuvers– Lane Merge

This section list US stakeholders and relations among them (Figure 4).

- **5G Infrastructures Providers:** These actors include all elements related with the development, implementation and delivery of 5G communication equipment. This may include Original equipment Manufacturers and Tier 1 suppliers, vendors and other suppliers of technical solutions or products, involved in the deliverability of a 5G communication related infrastructure. This group of stakeholders will develop and provide the equipment needed to assemble the network infrastructures. Nokia-PT and Nokia-SP will be vendors of the equipment to MNOs (RR5), Road operators (RR4) and C-ITS stakeholders (R6).
- **5G Mobile Network Operators (MNOs):** These actors play an important role in the maintenance of the telecommunication infrastructure. This stakeholders group includes Telecommunication Operators and Service operators, Telecom vendors, Cloud providers and other Technology providers such as edge devices providers, software developers, etc. NOS and Telefonica will provide the communication service to Road infrastructures Operators (R8), C-ITS stakeholders (R9), R&D organizations (R14) and Transport Operators or End Users (R15).
- **Automotive Industry:** These actors provide a technological platform, such as vehicles and related components, or services to support autonomous driving or connected vehicles. This category of stakeholder includes car OEMs (car manufacturers), component manufacturers, Tier 1 suppliers, CAM service providers, HD map providers and other automotive-specific technology providers. Automotive actors will provide autonomous mobility solutions to Transportation Operators or End Users (R13).
- **Cooperative Intelligent Transport Systems (C-ITS):** These stakeholders manage the infrastructures and provide the information received and sent by connected vehicles that are on the road. This category includes local or national entities. These stakeholders, that could relate entities that manage the traffic and infrastructure, such as Infrastruturas de Portugal (IP) Direção Geral de Tráfego (DGT), or technologic companies that develop technological solutions, such as A-to-Be, Instituto de Telecomunicações (IT), CTAG or CCG. These actors will manage the traffic, having relation with Infrastructure Operators (R7). This is a bidirectional relation: Road Operators can be clients or data suppliers to a C-ITS centres. These infrastructures can even be managed by the Road Operators. R&D Organizations (R10) will develop, update and maintenance the C-ITS centres. The communication will be by the MNOs (R9). The transport Operators and End Users will be the final clients (R12).
- **Road Infrastructures Operators:** Correspond to entities that are in charge of deployment, operation and maintenance of physical road infrastructure. This includes the agents that are involved in managing road traffic operations, own or operate the toll system, etc. This includes public entities, governmental institutes and departments, and private companies that manage private or public road infrastructures and third-party maintenance companies. In public infrastructures, such as public roads, infrastructures operators can manage the equipment and provide access to the data that are available on the roadside units or ITS Centres. This data can be used by a third-party agent to develop a service (free or paid) for end users. Private road infrastructures operators can provide this service for all their clients (e.g.: Payed roads infrastructures). Road Infrastructure Operators, such as Infrastructures de Portugal (IP) and Direção Geral de Tráfego (DGT) will require equipment from 5G Infrastructures Providers (R4) and the network

service from MNOs providers (R9). They will even provide the requirement or the data to C-ITS (R7), as a bidirectional relation.

- **Transport Operators:** This section joins the final transport operators and suppliers of mobility solutions to the end user. Actors such as local, national and European transport companies that manage vehicle's fleets and related service providers. This includes transport of goods and passengers. Transport Operators, such as Alsa, public transports, or renting companies, will required network service from 5G NMOs (R11) to access the service provided by C-ITS (R12) o by a R&D Organization (R11). Automotive Manufactures will provide the vehicles operated by these companies (R13).
- **Transport and Road Authorities:** This section includes Local, National and European authorities and regulators that are directly involved in the regulation of traffic and organizations responsible to define and execute legal framework and policies, such as road and transport authorities or telecom regulators. These stakeholders include regulators and policy makers, actors that provide the highest authorities and regulate the relationships within the whole ecosystem. They have the responsibility to manage the access to the technological solution. These stakeholders, such as European Union Organizations, Portuguese and Spanish Government, Autoridade Nacional de Segurança Rodoviária (ANSR) or Director General (da Dirección General de Tráfico) will provide the legal framework to regulate the service, from the infrastructure point of view (R3), C-ITS (R2) and autonomous vehicles through automotive industry (R1).
- **Researches and Developers Companies:** This group of stakeholders include researchers, Research Centres, Universities, Developer centres and other R&D stakeholders related to the automotive industry. These entities can develop the sensors and to be implemented on Road Side Unities (RSU) and radars. These entities will be involved in the exploration of the data that are collected on site and use it to improve the lane merge algorithms for the automotive industry and related stakeholders. Researches and Developers, such as Instituto de Telecomunicações (IT), Centro de Computação Gráfica (CCG), Centro Tecnolóxico de Automoción de Galicia (CTAG), Instituto Superior de Engenharia de Lisboa (ISEL) and A-To-Be will provide the technological solutions to develop the C-ITS and deployment of the service (R10) or use the data from C-ITS to provide the service directly to end users (R11).
- **End User:** End users could be drivers, vehicle owners and vehicle passengers. This group of stakeholders would benefit from technological advances, using it daily. They represent a key role in the technology acceptance, as owners or passengers of an autonomous vehicle, such as users of autonomous driving related services. Users will benefit from these technologies or provided service, improving safety of a lane merge manoeuvre. The end users will benefit from the mobility solutions provided by Automotive Manufactures (R13) or transport Operators. The service will be provided by the transport operators, R&D organizations (R11) or directly by the C-ITS (R12). The 5G MNOs will provide the communication service (R15).

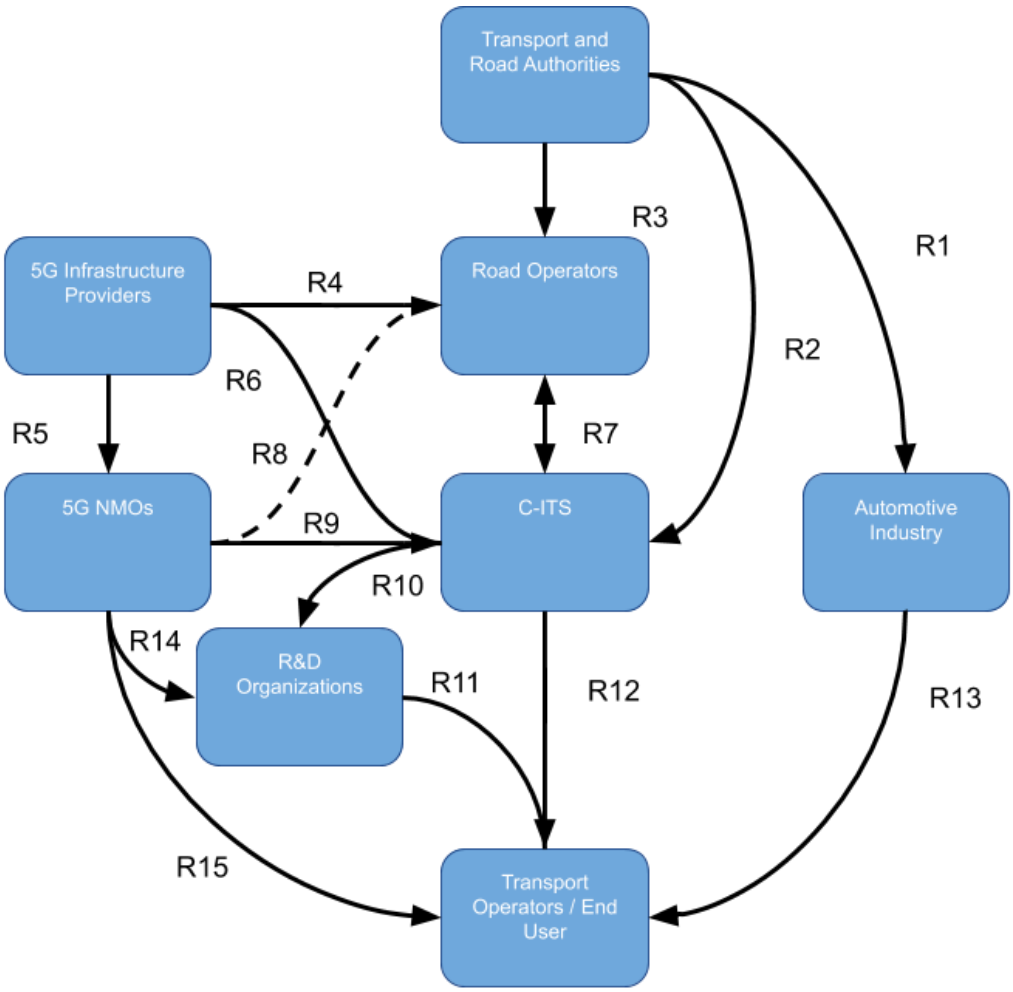


Figure 4: Schematic of Relations between Lane Merge Stakeholders

3.1.3. Value Proposition and Business Impact of US – Complex Maneuvers– Lane Merge

This product will improve safety on lane merge scenarios. These products will extend the capability of a lane merge algorithm provided by automotive manufacturers. The product can extend the sensor data provided by the vehicle's sensor systems, by adding information about other vehicles that are in the region but are not detected by vehicle sensors. The infrastructure can provide a solution optimized for each acceleration path or road entrance. Compared to generic solutions provided by competitors, an optimized solution can improve performance and safety.

3.1.4. Customer Focus of US – Complex Maneuvers– Lane Merge

Table 8: Customers of Lane Merge

Service and/or Technology Provider	Customers
Transport Operators	Passengers
Road Infrastructure Operators	Automotive OEMs, R&D Organisations, Transport Operators, Drivers, Fleet Owners
Automotive OEM	Transport Operators, Drivers, Fleet Owners
Mobile Network Operators	Road Infrastructure Operators , Other MNOs, R&D Organisations
5G Mobile Infrastructure Providers	Road Infrastructure Operators, C-ITS Centres, MNOs
R&D Organisations	Transport Operators, Road Infrastructure Operators, Drivers, Fleet Owners
C-ITS Centres	Road Infrastructure Operators, Transport Operators, Drivers, Fleet Owners

3.1.5. Financial Analysis of US – Complex Maneuvers– Lane Merge

A lane merge maneuver can be split into three main services:

- **Service 1:** Infrastructure Operators provide a lane merge service as an add-on to vehicle lane merge. Road infrastructure operators manage the infrastructure that can support the lane merge manoeuvre, such as sensors, radars and CAM service. These road infrastructure operators sell a lane merge service, optimized for each entrance. This service is an add-on to the lane merge system provided by the automotive manufacturer. The service can be provided as an extra to all clients of a paid infrastructure (road with tools), or as a standalone service available in infrastructures that support this service. Clients are road users, vehicle owners, private or companies that manage autonomous fleets. The service can be provided as a service with a single sale for a specific entrance, or as a weekly, monthly or annual subscription. The infrastructure cost and service management are supported by the profit of these spellings or subscriptions.
- **Service 2:** Road Operators Provide data required to perform lane merge and a third-party company provides the lane merge manoeuvre as a service. Road infrastructure operators manage the infrastructure that can support the lane merge manoeuvre, such as sensors, radars and CAM service. These road infrastructure operators sell the data to other stakeholders. The infrastructure cost is supported by the profit of these sales. A second stakeholder, from a technological area or vehicle manufacturers, provides the lane merge manoeuvre as a paid service. This service can be paid by vehicle owners, private or companies that manage autonomous as a weekly, monthly or annual subscription or a paid service only applicable for a location (e.g. highway entrance). The service is available as an alternative to autonomous vehicle lane merge algorithms. The data can even be sold to Research centres related to universities or automotive industries. These data can be used to improve the lane merge algorithms and to develop

alternative products. These final products can be sold to infrastructure operators, technology related companies, transport fleet management companies or to automotive manufacturers.

3.2. Business Models Analysis for US – Complex Maneuvers– Overtaking

Complex manoeuvres in cross-border settings, explores advanced driving maneuvers in the autonomous mode. This maneuver includes the lane merge, overtaking and HDMaps. As a requirement, these maneuvers should be performed in a vehicle's and infrastructures' connected context, where vehicles' data are shared through an internal communication unit or radars, placed on the road infrastructure, and detects non connected vehicles. The data is shared through a 5G communication network. The overtake maneuver is characterized by the integration of data from all road users, shared by other vehicles or infrastructure, and extending the autonomous vehicle perception about the actual situation, improving the safety of overtaking maneuver. Thus, the sensor's range of an autonomous vehicle will be increased by the data shared through the network, especially in occlusion scenarios.

3.2.1. Current Market Situation for US – Complex Maneuvers– Overtaking

The number of autonomous vehicles (level 5) available on the market is limited. However, the overtaking feature is already provided in vehicles with mid-levels of autonomy (level3). This feature will be provided by the automotive manufacturers. The overtaking is supported by the sensors data available on the vehicles. Actually, this feature is still in the development stage. However, some brands reported that are able to perform an overtake in urban scenarios, where the overtaken vehicles are stopped.

3.2.2. Stakeholders of US – Complex Maneuvers– Overtaking

The stakeholders involved on this US Business model are common to stakeholders involved in US – Complex Maneuvers– Lane Merge. Stakeholders and relation between them are listed and described in the section "Stakeholders of US – Complex Maneuvers– Lane Merge". Figure 4 presents the relation between stakeholders.

3.2.3. Value Proposition and Business Impact of US – Complex Maneuvers– Overtaking

This service will improve safety on overtake scenarios. The C-ITS will enable a CAM platform, being possible to share messages related with vehicle positions. These messages will extend the vehicles sensor systems by adding information about other vehicles that are in the region but not detected by vehicle's sensors. Connected and autonomous vehicles will perform a overtake manoeuvre considering the information about other's vehicles position and actions. These information enables a more reliable and safety manoeuvre, avoiding a possible collision with vehicles that are at front or are coming in the overtake lane.

3.2.4. Customer Focus of US – Complex Maneuvers– Overtaking

Table 9: Customers of Overtaking

Service and/or Technology Provider	Customers
Road Infrastructure Operators	Automotive OEMs, R&D Organisations, Transport Operators
Automotive OEM	Road Infrastructure Operators , Drivers, Fleet Owners
Mobile Network Operators	Road Infrastructure Operators , Other MNOs, Drivers, Fleet Owners
5G Mobile Infrastructure Providers	Road Infrastructure Operators, C-ITS Centres, MNOs
R&D Organisations	Transport Operators, Road Infrastructure Operators, Automotive OEMs
C-ITS Centres	Road Infrastructure Operators, Transport Operators, Drivers, Fleet Owners

3.2.5. Financial Analysis of US – Complex Maneuvers– Overtaking

- **Service 1:** Overtaking Edge computing solution: The infrastructure provides a service that can handle the control of an autonomous vehicle to perform an overtaking manoeuvre. The system can be an SW installed in MECs. The associated costs are the C-ITS service, MEC and HW and SW upgrades and maintenance. The service can be managed by the infrastructure operators. The service is played as a mensal or annual subscription or included as an add-on to paid road clients.
- **Service 2:** Warning assistant: The infrastructure provides the warnings and recommendations that can be used as auxiliary/assistant to an overtaking algorithm. The system can be a SW installed on MECs. The associated costs are the C-ITS service, MEC and HW and SW upgrades and maintenance. The service can be managed by the infrastructure operators. The service can be played as a mensal or annual subscription or included as an add-on to paid road clients.

3.3. Business Models Analysis for US – Complex Maneuvers– HD maps

The third user scenario within Complex manoeuvres in cross-border settings that explores advanced driving manoeuvres in the autonomous mode, is HD Maps. As a requirement, these manoeuvres should be performed in a vehicle's and infrastructures' connected context, where vehicles' data are shared through an internal communication unit or radars, placed on the road infrastructure, and detects non connected vehicles. The data is shared through a 5G communication network. The HD Maps US is characterized by the capability of autonomous vehicle and roadside units, to detect changes in the road. Lasers, cameras and traffic radars information can be fused with D-GPS and HD Maps data, in order to determine changes in the stored information. This information can be measured in terms of length of the event, changes in road description (number of lanes, width of the lanes), dangerousness of the situation, etc.

Finally, obtained data is shared with the ITS-Centre in order to be stored and shared with other vehicles, ensuring the information reaches all the relevant vehicles.

3.3.1. Current Market Situation for US – Complex Maneuvers– HD maps

HD map data is used to identify the position of vehicles, road signs and other elements relevant to driving. This capacity has been in the market for more than ten years. Car manufacturers have been selling navigation systems that used roadmaps in DVD format. In the best case, there is a new release of the maps' library once a year. Navigation systems, usually based on a 2D vector database, could be supplemented with local traffic events information transmitted via RDS.

Actually, some technological companies provide the HD maps service. TomTom [9], HERE [10] and Carmera [11] are just a few examples. These companies come from the navigation, GPS providers and computer vision background. Autonomous driving requires more information and much more updated, ideally in real time, otherwise vehicles should switch to manual driving under certain circumstances.

HD Map companies provide several layers of information: a base map, road signs, traffic information, etc. This information is regularly updated. This update do not include traffic events like traffic jams, road works, lane closings, accidents, hazardous events, etc. that require to be updated in the HD map to maintain its accuracy and to allow autonomous cars operation without reducing its functionality.

Traffic events information could be provided by road operators and/or road authorities or captured by the vehicles using the road. These updates can be large and be very demanding on bandwidth, coverage and availability, especially if they include geometry information. The quality of HD mapping data would increase with the number of sensing vehicles, but this increases the load on the radio network. The updates information should be available across multiple networks and seamlessly beyond national borders.

The HD map information is localized for the surroundings of the road users and made available to vehicles by regular downloads for non-urgent information or pushed to vehicles for major changes, highly urgent or emergency information for a road accident or similar. This localized character makes MEC infrastructure very useful to host HD map information relevant for the area, reducing the demand for large downloads and providing fast, reliable and efficient access to relevant local map data. Cloud providers could host map content less localized and not so frequently updated.

HD Maps change detection and update capability should be integrated in autonomous vehicles but there are some aspects that have to be further developed and standardized like the type of sensors used on vehicles (cameras, LiDAR, radar etc.), the type of data updated, etc. The main HD Maps providers are making great improvements optimizing the information sent back from the vehicles to the ITS centers, reducing the bandwidth requirement while sensors providers are making important price reductions thanks to mass production so we can expect big changes in the near future.

Summarizing, there is a significant number of companies that are providing the technological solution for HD maps. However, the map coverage and data available is still limited and has a standardization problem related with formats.

3.3.2. Stakeholders of US – Complex Maneuvers– HD maps

This section lists US stakeholders and relations among them. Transport and Road Authorities (TRA) and Road Infrastructure Operators (RIO) collect and provide traffic events information including, road conditions, adverse weather, road works, lane closings, traffic jams and accident information among others. They also receive traffic events information they use to update its data, so the flow or information is bidirectional. That information supplements the map data that automotive OEMs acquire from HD Map providers. That communication is done via ITS platforms (C-ITS centers). So, data flows from TRAs (D1) and RIO (D2) to C-ITS centers. Operators will require equipment from 5G Infrastructures Providers and the network service from MNOs providers.

5G Mobile Network Operators (MNOs) provide the connectivity services for all the infrastructure related stakeholders (transport and road authorities -R1-, road infrastructure operators -R2, C-ITS stakeholders -R3, MEC and cloud services providers -R4) and vehicles and their drivers (R5) including transmitting location-based map information. MNOs will use technologies like network slicing and MEC to provide seamless cross-border implementation. In this US, vehicles are connected to MEC (D3) that acts as a gateway to the ITS platform (D4). MEC will be a significant value-added used to keep and provide localized and changing traffic information updated to vehicles crossing national borders and between MNOs coverage regions. Similarly, there will be an opportunity to for Cloud service providers to host less localized map data and less changing map information.

5G Infrastructure providers develop, implement, delivery and maintain 5G communications equipment to MNOs (R6), MEC/Cloud providers (R7), road infrastructure operators (R8) and C-ITS stakeholders (R9). Automotive OEMs provide an HD maps service to End users/Vehicle owners (R10) as part of an autonomous mobility solution. OEM provides and integrates the on-board equipment required and the connection to the infrastructure. The OEM contracts map information from HD Maps providers (R11) and supplements it with the dynamic information received from TRAs and RIOs (R12).

Cooperative Intelligent Transport Systems (C-ITS) manage this US. C-ITS communicates with:

- Transport and road authorities (D1) and road infrastructure operators (D2): They exchange traffic events information. This data flows are bidirectional, so TRAs and RIOs can either be clients or data suppliers to C-ITS centres.
- Vehicles/end users: C-ITS sends HD Map data and traffic events information and receives on-board sensor data. In this scenario, vehicles do not use V2V communications, so they do not share information directly and they neither access the C-ITS directly but through MEC that acts as a gateway. Vehicles exchange data with MEC (D3) and the MEC provider exchanges data with the C-ITS (D4).

- HD Maps provider: The C-ITS sends to the HD maps source the updated map data obtained after processing the vehicles sensor data and receives the updated HD map updates to distribute them to the other autonomous vehicles (D5).

The ITS platform has two roles:

- Monitoring the vehicles during the use case.
- Processing the data uploaded from the vehicle in order to generate a new map segment that will update the whole map source. Then, this map source will update the vehicles' maps.

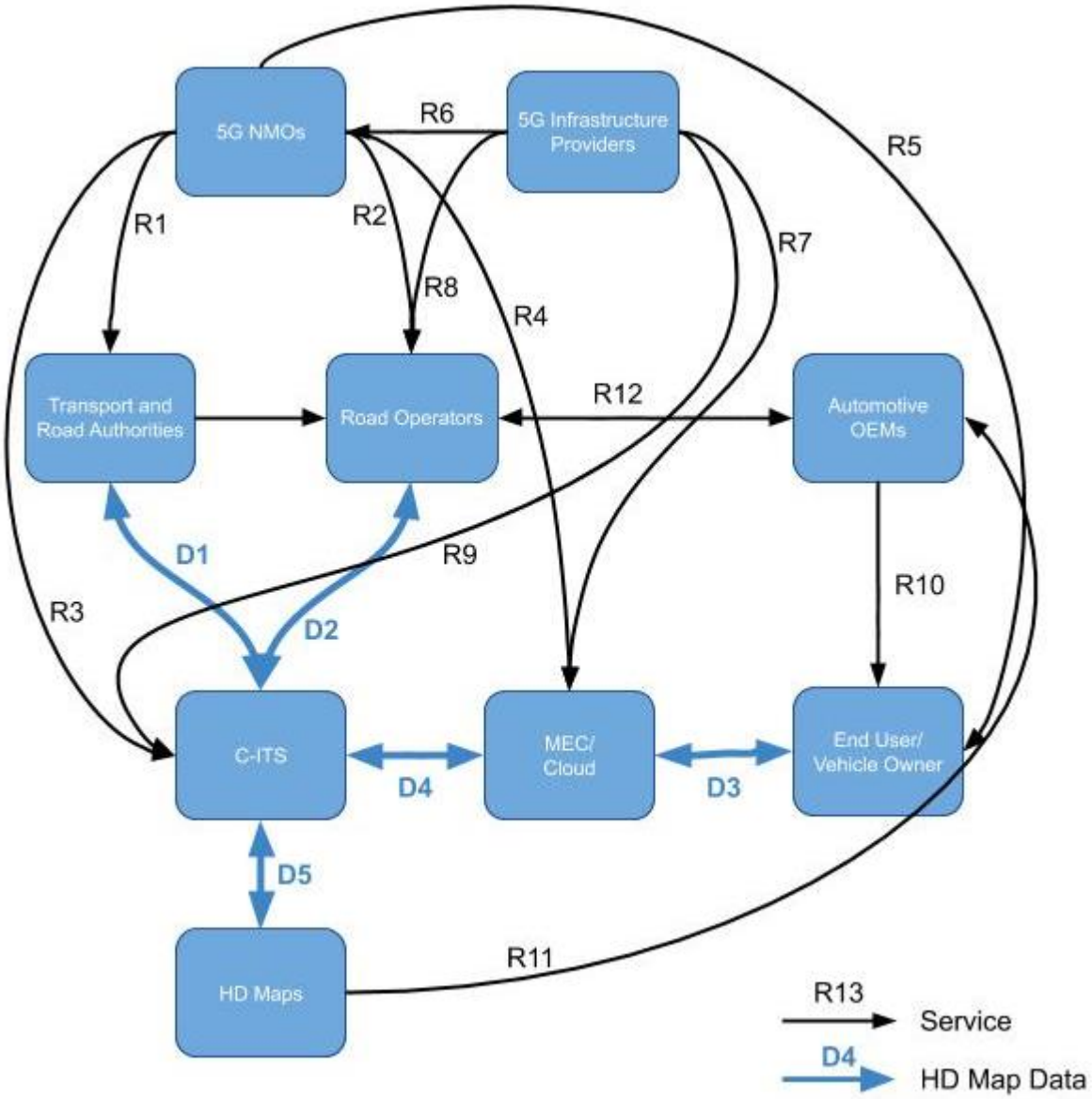


Figure 5: Schematic of Relations between HD maps Stakeholders.

End Users in this scenario are drivers and vehicle owners who use or contract the OEM's HD Maps service (R10).

3.3.3. Value Proposition and Business Impact of US – Complex Maneuvers– HD maps

- **Reliability:** HD maps are a reliable source of information to use to expand vehicles sensors. Reliable information is critical in autonomous driving scenarios. Merging information from different sources of information (redundancy) will guarantee information reliability.
- **Information updated in real time:** HD maps enables information updated in real-time. The user will have access to the actual conditions of the road, traffic and events.
- **Resource management:** a real time update of information enables a prompt reaction to an event and improves resource management from the infrastructure operators and safety related organizations.
- **Standardization:** A generalization of HD maps usage leads to the development of standards to support HD maps information. Simultaneously, this is a requirement for HD maps implementation. However, the generalization of a tool or a technology highlights the necessity of developing standards to increase the possibility of interoperability between solutions developed by different stakeholders.
- **Safety:** Safety is the main benefit of the usage of HD maps. A HD map updated in real time with reliable information can decrease the risk of accidents and improve the safety.

3.3.4. Customer Focus of US – Complex Maneuvers– HD maps

Table 10: Customers of HD Maps

Service and/or Technology Provider	Customers
Road Infrastructure Operators	Automotive OEMs, R&D Organisations, Vehicle Owners, Drivers
5G Infrastructure Provider	Road Infrastructure Operators, MNOs, C-ITS Centres
Automotive OEM	Drivers, Transport Operators, Fleet Owners
Mobile Network Operators	Road Infrastructure Operators , R&D Organisations, Other MNOs
R&D Organisations	Road Infrastructure Operators, Transport Operators, Vehicle Owners, Drivers
C-ITS Centres	Road Infrastructure Operators, Vehicle Owners, Drivers

3.3.5. Financial Analysis of US – Complex Maneuvers– HD maps

- **Service 1:** Road Operators provide HD maps. The Operator manages the infrastructure, such as radars, roadside units and CAM service, enabling an updated HD map service. These operators sell the HD maps service for their roads. This service is an add-on to the installed in the vehicle. The service is an extra to all clients of a paid infrastructure, or as a standalone service available in infrastructures that support this service. Clients are road users, vehicle owners, private or companies that manage connected or

autonomous fleets. The service has a weekly, monthly or annual subscription. The profit is used to support the costs of the infrastructure.

- Service 2: Road Operators supply the data to be used to others third-party organizations that develop the HD maps solutions. The operator manages the infrastructure, such as radars, roadside units and CAM service, enabling an updated HD map service. A third-party company, involved in the development of a HD Map service, buy the data provided by road operators. These technology organizations can provide HD Map service focus on a specific road, route, limited to a region, or national territory. Vehicle owners and users can use this service as add-on to the regular HD map installed in the vehicle. The clients are road users, vehicle owners, private or companies that manage connected or autonomous fleets. The service is provided against payment of a subscription, weekly, monthly or annual and focuses on geographic area. The infrastructure are supported by profit from the sale of data. The end users pay the development of HD maps service.
- Service 3: Vehicle owners provide information to update the HD Map. HD maps can be updated using vehicle data collected by sensors such as radars, LIDAR, cameras and inertial sensors. In this business model, the vehicle owner can select the amount of information provided to the road infrastructure or HD map service provider. The vehicle owner's payment are related with the amount of information that they share to the network. The payment is in function of the amount of data that is shared (e.g. per megabyte) or per type of data (e.g. LIDAR, cameras or other sensor). Services profits can amortize the investment in vehicles or sensors. The road infrastructures and HD maps providers can pay this data to have updated data in routes without roadside units or related infrastructures. Using this model, these stakeholders can guarantee an updated HD Map without fixed expenses related to infrastructure. This third service can be explored as an additional to others previous services.

3.4. Business Models Analysis for US – Public Transport – 4K video surveillance

The objective of this use case is to provide the public transport vehicle that connects the cities of Vigo and Porto with a 4K Camera in order to be able to remotely access the video stream for Control Centre management and monitoring tasks.

Added to this, in vehicle sensor data will be sent to the ITS Centre in order to update the HD maps of other vehicles around, helping to improve the execution of autonomous driving manoeuvres in terms of safety and comfort. The 4K Front camera will be connected to the communication unit, opening the stream channel from the bus to the ALSA Control Centre and the ITS Centre. ALSA, as the public transport operator, will have the remote connection to the 4k camera stream in order to visualize the image of where the vehicle is passing by.

3.4.1. Current Market Situation for US – Public Transport – 4K video surveillance

Currently, some public transport companies already provide certain internet services in their fleets. However, these services are often limited for users, and have reduced capacities in terms of bandwidth and latency. In the specific case of bus surveillance, it is common for buses to have surveillance systems. However, these systems are often revised ex-post, as it is not possible to transmit them in real time.

3.4.2. Stakeholders of US – Public Transport – 4K video surveillance

This section lists US stakeholders and relations among them. Transport and Road Authorities (TRA) regulate the solutions provided by CAM technology providers from automotive industry (R1), used by Passenger Transport Operators (R2), Road Infrastructure Operators (R3) and C-ITS (R4).The main use of the monitoring solution studied in this scenario is internal for the Passenger Transport Operator, but Road Operators might be interested to have access to the monitoring video and that surveillance could be transferred to a C-ITS (R5). 5G Infrastructure providers develop, implement, delivery and maintain 5G communications equipment to road infrastructure operators (R6), MNOs (R7), MEC and C-ITS stakeholders (R8).

5G Mobile Network Operators (MNOs) provide the connectivity services for all the infrastructure related stakeholders (road infrastructure operators -R9-, C-ITS stakeholders -R10-, control center -R11-) and the buses (R12). In this scenario, any communication between the bus and the control center or the C-ITS is done through MEC.The bus is monitored from the Transport operator Control Center (R15) but there could be other models where other stakeholders undertake that task and it is done in a C-ITS, providing that service to the transport operator (R13) or transferring some tasks or information from the Control Center to the C-ITS (R14). Automotive Industry provides the on-board equipment: 4K camera and on-board communication units for the bus (R16).

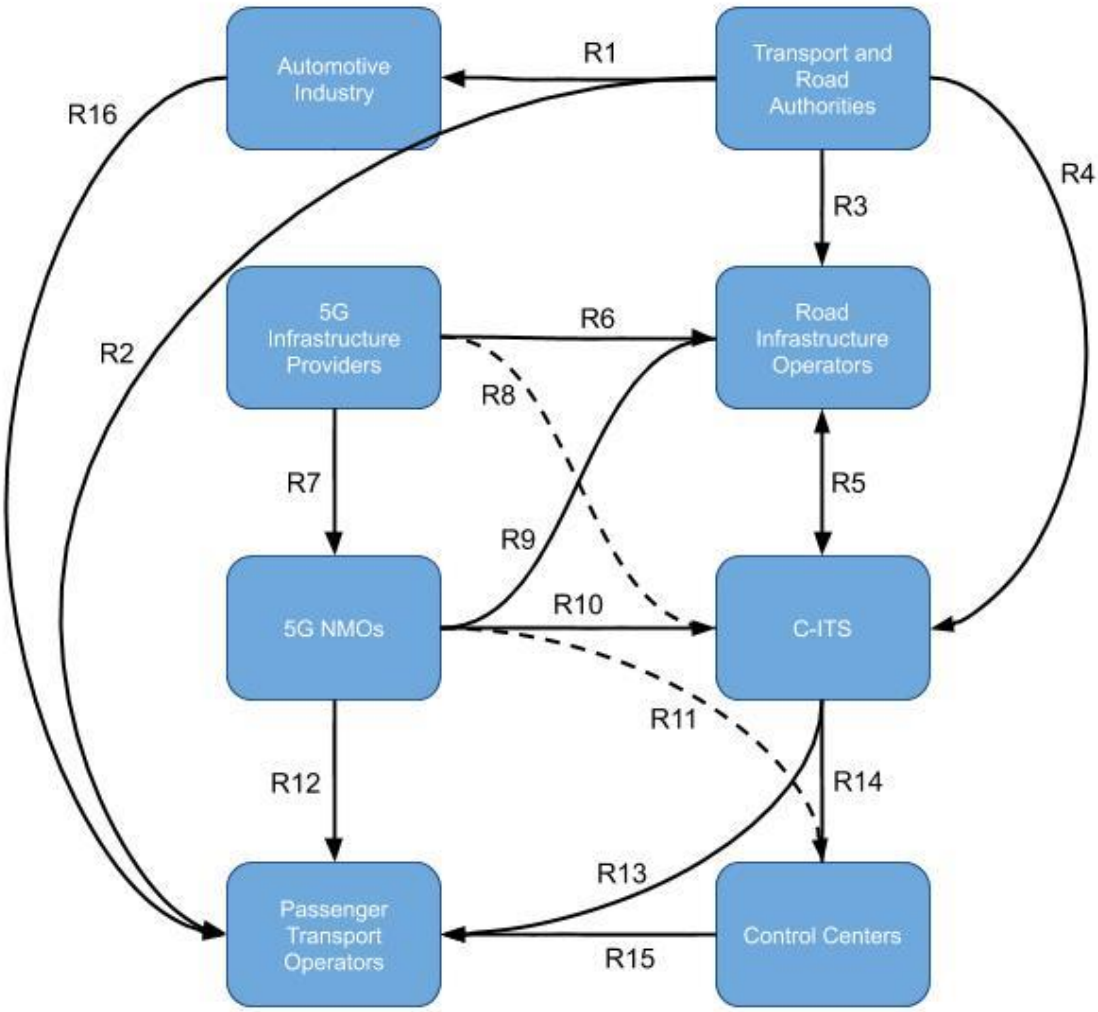


Figure 6: Schematic of Relations between 4K video surveillance Stakeholders

3.4.3. Value Proposition and Business Impact of US – Public Transport – 4K video surveillance

The case of use of 4K video surveillance aims to take advantage of the large capacities of 5G in terms of bandwidth and low latency, to improve the surveillance system of a fleet of buses, so that not only surveillance videos are recorded, but can also be consumed in real time from a location outside the bus itself, as a hypothetical security and comfort department of the bus company.

This use case aims to carry out a pilot test, which establishes the frames on which further improvements can be made, such as the detection in real time of risk situations, or the external action on some component of the vehicle (for example, speakers).

For road operators, additional monitoring capacity could be provided to enhance safety.

3.4.4. Customer Focus of US – Public Transport – 4K video surveillance

Table 11: Customers of 4K video surveillance

Service and/or Technology Provider	Customers
Transport Operators	Passengers
Road Infrastructure Operators	C-ITS Centres
Automotive OEM	Transport Operators
Mobile Network Operators	Road Infrastructure Operators , Transport Operators, C-ITS Centres
5G Mobile Infrastructure Providers	Road Infrastructure Operators, C-ITS Centres, MNOs
R&D Organisations	C-ITS Centres
C-ITS Centres	Road Infrastructure Operators, Transport Operators

3.4.5. Financial Analysis of US – Public Transport – 4K video surveillance

- **Service 1:** In a first approach, the monitoring service is internal for the passenger transport operator, so it is not a source of income, but the service involves acquisitions, connection fees, staff expenses and maintenance. The passenger transport operator (fleet owner) installs a 4Kcamera, a communications OBU and a 5G Wi-Fi router to link the camera and the OBU, paying the acquisition, installation and maintenance to the CAM technology provider. Data communication requires a 5G infrastructure along the bus route. The fleet owner deploys a control center connected to the bus through MEC. This involves setting up the control center, its applications, communications infrastructure and fees, and staff.
- **Service 2:** In case the road operator is interested in the monitoring activity or the information collected, there would be an opportunity for the fleet owner to get some revenue from the developed infrastructure.

3.5. Business Models Analysis for US – Public transport with HD media and video surveillance - HD maps (ALSA)

This user scenario could be considered a specific case of US – Complex Maneuvers– HD maps. In this scenario, mobile sensors are mounted on a public transport road bus (in this case a bus belonging to ALSA,

the passengers transport operator partnering in 5G MOBIX). The bus is used as a sensors platform that provides HD maps updates to other users of the road. The bus is driven manually so it is not an autonomous vehicle that could be a target user of the captured data, but it has sensors and a communications unit like an autonomous vehicle. As a requirement, these manoeuvres should be performed in a vehicle's and infrastructures' connected context, where vehicles' data are shared through an internal communication unit or radars, placed on the road infrastructure, and detects non connected vehicles. The data is shared through a 5G communication network.

The HD Maps (ALSA bus) US is characterized by the capability of the bus and road side units, to detect changes in the road. Lasers, cameras and traffic radars information can be fused with D-GPS and HD Maps data, in order to determine changes in the stored information. This information can be measured in terms of length of the event, changes in road description (number of lanes, width of the lanes), dangerousness of the situation, etc. Finally, obtained data is shared with the ITS-Centre in order to be stored and shared with other vehicles, ensuring the information reaches all the relevant vehicles.

3.5.1. Current Market Situation for US – Public transport with HD media and video surveillance - HD maps (ALSA)

This US has some similarities with US Public Transport – 4K video surveillance where a bus from a passengers' transportation operator was used to capture and transmit 4K video but, in this case, the bus is used to capture HD map data updates. Streaming data for surveillance there is some use cases already available on the market. First one is centred on the police and authorities [12]. These stakeholders use video cameras installed in their vehicles to stream images. These images are used to spot danger or critical situations. These images are only used for internal and security purposes. Apart from this use of the bus platform the rest of the market analysis is the same as in US – Complex Maneuvers– HD maps. Please visit that subsection if further information is needed.

3.5.2. Stakeholders of US – Public transport with HD media and video surveillance - HD maps (ALSA)

The stakeholder analysis is the same (same stakeholders, same roles) as in US – Complex Maneuvers– HD maps except by the presence of a new element, the bus, and a new stakeholder, the fleet owner.

There are also three new relationships between the fleet owner and other stakeholders:

- The transport operator sells the map data updates service to the HD Maps provider (R12) or to the C-ITS center (R13).
- The transport operator requires connectivity services from the MNOs (R14).

The bus detects and captures changes in the HD map and sends it to the C-ITS center via MEC (D6). The bus detected changes are processed in the C-ITS and then the localized HD maps are updated just as changes detected by autonomous vehicles in the area or changes detected by the TRA and the RIO.

The differences between the stakeholder "End user/Vehicle driver" and the bus are:

- The bus is not using the HD Maps updated data as it is driven manually, not autonomously.
- The bus is not cooperating with other autonomous vehicles, but it is selling its capacity to capture map updates as a business.
- The connectivity fees charged by the MNOs in US – Complex Maneuvers– HD maps were usually paid by the OEM and included in the subscription fees paid by the end users but in the bus case the MSP pays those fees directly to the MNOs.

The end users are the same as in US – Complex Maneuvers– HD maps, Vehicle owners and drivers who pay for the HD maps update service.

Next figure shows the relationships between the stakeholders in this scenario. Please note that the figure is the same as in US – Complex Maneuvers– HD maps but adding the Passenger transport operator, its data flow with the MEC/Cloud provider (D6) and its relationship with the HD Maps provider (R12).

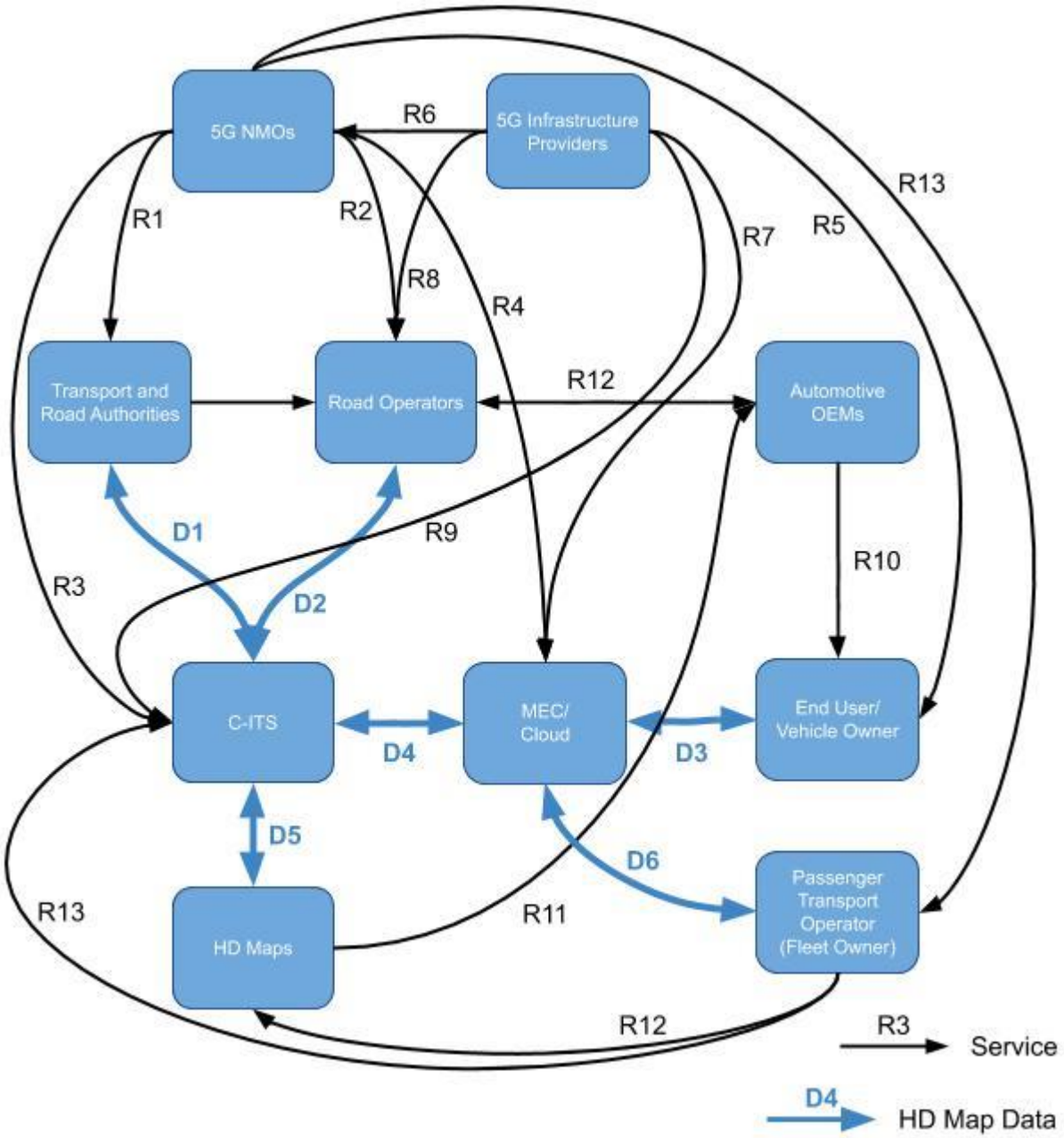


Figure 7: Schematic of Relations between HD maps (ALSA) Stakeholders

3.5.3. Value Proposition and Business Impact of US – Public transport with HD media and video surveillance - HD maps (ALSA)

Apart from the value proposition and business impact already described in US Complex Maneuvers– HD maps Complex Maneuvers– HD maps, it should be added a new offering for service providers.

- **Service provider:** Sensor data from the bus could be sold by the transport operator to HD mapping providers or C-ITS platforms with a subscription-based model. Considering that public road passenger transport usually uses regular routes, using the same roads, there could be some interest from road infrastructure operators to have a regular flow of map data updates.

3.5.4. Customer Focus of US – Public transport with HD media and video surveillance - HD maps (ALSA)

Table 12: Customers of HD maps (ALSA)

Service and/or Technology Provider	Customers
Transport Operators	Passengers
Road Infrastructure Operators	Automotive OEMs, R&D Organisations, Transport Operators
Automotive OEM	Transport Operators
Mobile Network Operators	Road Infrastructure Operators , Other MNOs, R&D Organisations
5G Mobile Infrastructure Providers	Road Infrastructure Operators, C-ITS Centres, MNOs
R&D Organisations	Transport Operators, Road Infrastructure Operators
C-ITS Centres	Road Infrastructure Operators, Transport Operators

3.5.5. Financial Analysis of US – Public transport with HD media and video surveillance - HD maps (ALSA)

The Passenger transport operator sells the bus sensor data to the HD Map data providers or C-ITS centers on a subscription basis.

This service coexists with the other services described in US Complex Maneuvers – HD maps Complex Maneuvers– HD maps, that describes the end users demand of HD maps change detection and update services like that offered by the transport operator.

3.6. Business Models Analysis for US – Public Transport – HD media services for passengers

The objective of this user story is to provide real time connected services to the public transport fleet that connects the cities of Vigo and Porto. According to this approach, users will be able to enjoy different multimedia services while travelling in the public transport, including high bandwidth data consumption applications as well.

The user story can include a multimedia device which will be used as user interface, allowing users to make use of the multimedia application installed on this device. Another option is to allow users to connect their own devices through a Wi-Fi connection which will be connected to the high capabilities mobile network.

3.6.1. Current Market Situation for US – Public Transport – HD media services for passengers

Currently, some public transport companies already provide certain internet services in their fleets. However, these services are often limited for users, and have reduced capacities in terms of bandwidth and latency. Specifically speaking of multimedia services, at present most companies opt to consume content hosted locally on the bus itself. While those public transports that give free access to Internet, usually limit the bandwidth that the user can consume.

3.6.2. Stakeholders of US – Public Transport – HD media services for passengers

Transport and Road Authorities and Road Infrastructure Operators may seem not so important in this scenario but if MNOs do not deploy the required radio access network, maybe private road operators should share the investment. In any case, the huge potential offering entertainment services not only to passengers of public transport but in the future to drivers and passengers of autonomous level 4 and 5 cars, and considering that many entertainment platforms are linked to MNOs and those streaming services are one of their main products, it does not look that RAN deployment should be an issue.

5G Infrastructure providers deploy 5G communications equipment for MNOs (R1), MEC providers (R2) and road infrastructure operators (if needed) (R3). 5G Mobile Network Operators (MNOs) provide the connectivity services to MEC providers (R4) and to public transport vehicles (R5). MNOs would service passengers in case they cannot or do not want to access the bus Wi-Fi and want to use their own devices 5G connectivity (R6). MEC acts as a gateway giving access to multimedia services from content providers (R7) to the bus operator (R8).

Multimedia and gaming content providers like Movistar+, provide contents that the transport operator (R9) makes accessible to its passengers. In case passengers were accessing freemium or pay per view content, then content provider would be servicing directly the passengers (R10). Automotive Industry 5G CAM technology providers supply communication equipment for the bus (R11): A 5G communication unit and a 5G Wi-Fi router.

End Users in this scenario are the passengers of the bus who would benefit from the access to entertainment services via Wi-Fi without consuming 5G data (R12). The initial approach included studying the option of letting passengers connect their own devices to the bus Wi-Fi.

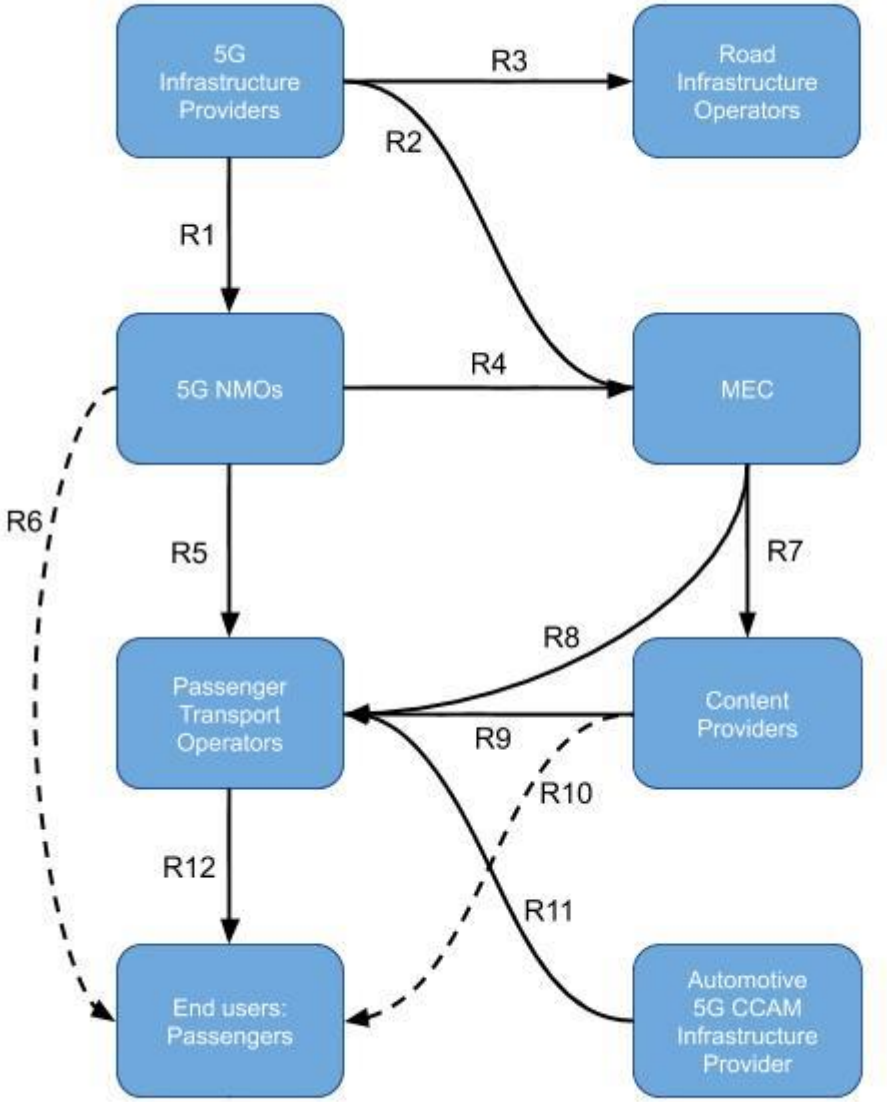


Figure 8: Schematic of Relations between HD media services for passengers Stakeholders

3.6.3. Value Proposition and Business Impact of US – Public Transport – HD media services for passengers

It is expected that passengers of connected cars, either in private or public transport will be able to access their entertainment services seamlessly on the road. This includes films and series from streaming services, that require big bandwidth, and online games from gaming platforms, that require low latency. Users will also expect fast and efficient access to their own contents or those related with their work.

This scenario studies the access to multimedia services from the bus, equipped with multimedia devices like tablets connected to HD multimedia services (like Movistar+) and the access to the passengers' own contents or services with their own devices connected via WIFI. Entertainment companies see a huge potential for these services not only in public transport but also in level 4 and 5 autonomous vehicles where the driver will expect those services while his intervention is not required.

3.6.4. Customer Focus of US – Public Transport – HD media services for passengers

Table 13: Customers of HD media services for passengers

Service and/or Technology Provider	Customers
Transport Operators	Passengers
Road Infrastructure Operators	C-ITS Centers
Automotive OEM	Transport Operators
Mobile Network Operators	Road Infrastructure Operators , C-ITS Centres, Transport Operators
5G Mobile Infrastructure Providers	Road Infrastructure Operators, C-ITS Centres, MNOs
R&D Organisations	C-ITS Centres
C-ITS Centres	Road Infrastructure Operators, Transport Operators
Multimedia Content Providers	Transport Operators

3.6.5. Financial Analysis of US – Public Transport – HD media services for passengers

The passenger transport operator (fleet owner) installs a 5G communications unit and a 5G wife router to give access to the, paying the acquisition, installation and maintenance to the 5G equipment provider. Data communication requires a 5G infrastructure along the bus route including MEC, but we can expect that MNOs deploy it expecting return on investment from the access to content services. The passenger transport operator contracts the multimedia services (films and series streaming, TV live channels, gaming, etc.) with a license for public exhibition and includes a connection fee in the price of bus tickets. There could be options as offering passengers a package closed without options or including most of the content free and some content like film premieres and sports in a pay per view model or in a freemium model. Transport operators should decide which extent of access would allow to passengers using their own devices, maybe a limited speed connection.

3.7. Business Models Analysis for US – Remote Driving Across borders – Remote Control

In this scenario the EV autonomous vehicle is driving following a predefined route, and suddenly an obstacle appears in its path blocking the original route. In this situation, an operator is alarmed, and he/she is able to remotely take the control of the EV autonomous vehicle or issue a set of new navigation commands in order to handle a new route. The operator is in a control centre, monitoring one or several autonomous vehicles.

3.7.1. Current Market Situation for US – Remote Driving Across borders – Remote Control

The interaction between Cross-border cities has a relevance from the point of socio-economic development of regions. Cross-Border Municipalities developed mobility solutions to improve the mobility between international cross-border s regions. In the case of SP-PT cross-border municipalities, Valença and Tui, have a touristic bus that crosses the historic centre of these two cities. The service is operated by a driver. The train circulates between the two cities with a defined frequency. The service has a touristic purpose. In the European context, Tourism is the main reason for people to visit two cities from neighbouring countries. However, shopping for goods or services or work are other reasons to cross a border.

3.7.2. Stakeholders of US – Remote Driving Across borders – Remote Control

This section list US stakeholders and their relations (Figure 9).

- **5G Infrastructures Providers:** These actors include all elements related with the development, implementation and deliverable of 5G communication equipment. This may include Original equipment Manufacturers and Tier 1 suppliers, vendors and other suppliers of technical solutions or products, involved in the deliverability of a 5G communication related infrastructure. This group of stakeholders will develop and provide the equipment needed to assemble the network infrastructures. Nokia-PT and Nokia-SP will be vendors of the equipment to MNOs (R6), Road operators (R5) and C-ITS stakeholders (R7).
- **5G Mobile Network Operators (MNOs):** These actors play an important role in the maintenance of the telecommunication infrastructure. This stakeholders group includes Telecommunication Operators and Service operators, Telecom vendors, Cloud providers and other Technology providers such as edge devices providers, software developers, etc. NOS and Telefonica will provide the communication service to Road infrastructures Operators (R8), C-ITS stakeholders (R9 and Transport Operators (R11) and Control Centres (R10).
- **Automotive Industry:** These actors provide a technological platform, such as vehicles and related components, or services to support autonomous driving or connected vehicles. This category of stakeholder includes car OEMs (car manufacturers), component manufacturers, Tier 1 suppliers, CAM service providers, HD map providers and other automotive-specific technology providers. Automotive actors will provide autonomous mobility solutions to Transportation Operators (R14).

- **Cooperative Intelligent Transport Systems (C-ITS):** Cooperative Intelligent Transport Systems (C-ITS): These stakeholders manage the infrastructures and provide the information received and sent by connected vehicles that are on the road. This category includes local or national entities. These stakeholders, that could relate entities that manage the traffic and infrastructure, such as Infrastruturas de Portugal (IP) Direção Geral de Tráfego (DGT), or technologic companies that develop technological solutions, such as A-to-Be, Instituto de Telecomunicações (IT), CTAG or CCG. These actors will manage the traffic, having relation with Infrastructure Operators (R4). This is a bidirectional relation: Road Operators can be clients or data suppliers to a C-ITS centres. These infrastructures can even be managed by the Road Operators. R&D Organizations will develop, update and maintenance the C-ITS centres and use the data for Research (R13). The communication will be by the MNOs (R9). The transport Operators (R12) and Control Centres (R19) will be the final clients.
- **Road Infrastructures Operators:** Correspond to entities that are in charge of deployment, operation and maintenance of physical road infrastructure. This includes the agents that are involved in managing road traffic operations, own or operate the toll system, etc. This includes public entities, governmental institutes and departments, and private companies that manage private or public road infrastructures and third-party maintenance companies. These entities, already identified in previous US, require equipment from 5G infrastructure providers (R5), use the network operated by 5G NMOs (R8) and manage or the C-ITS (R4), or contract the service from other stakeholders.
- **Transport and Tour Operators:** This section joins the final transport operators and suppliers of mobility solutions to the end user and Tourism Operators. Actors such as local transport companies that manage vehicle's fleets or local tour operators. Transport Operators, such as Alsa, public transports, or renting companies, will required network service from 5G NMOs (R11) to access the service provided by C-ITS (R12). Automotive Manufactures will provide the vehicles operated by these companies (R13). Municipality institutions will regulate or act as clients of this transportation service (R16). In some cases, the municipality institutions can be the transport operator. The remote and control centres will provide the service of monitoring and remote controls to transport Operators (R17). In some cases, remote centres will be managed by the transport operators.
- **Transport and Road Authorities:** This section includes Local, National and European authorities and regulators that are directly involved in the regulation of traffic and organizations responsible to define and execute legal framework and policies, such as road and transport authorities or telecom regulators. These stakeholders include regulators and policy makers, actors that provide the highest authorities and regulate the relationships within the whole ecosystem. They have the responsibility to manage the access and the use of the technological solution. These stakeholders, already identify in previous US, will regulate the solutions provide by Automotive Industry (R1), actions of Road Operators (R2) and C-ITS (R3).
- **Municipality Institutions:** This section includes municipality institutions, such as city hall and related companies from the cross-border regions. These institutions are engaged in developing mobility solutions and cross-border cooperation action. These actors can assume a role of facilitators, providers and clients of a remote shuttle service. These stakeholders, that in or special use case can be Valença

Municipality and Tui Municipality, will regulate and contract the service to Transport Operators (R16). In some cases, these stakeholders will have the role of transport operators.

- **Control Centres:** These stakeholders have the function of monitoring the vehicle and control it when necessary. These actors, from a technologic background, will provide the service to transport operators (R17). In some cases, transport operators have their own Control centres. R&D Organizations will develop these Remote centres (R18). The Control centres will require data from C-ITS (R19) using the 5G service provide by 5G MNOs (R10).
- **Researches and Developers Companies:** This group of stakeholders include researchers, Research Centres, Universities, Developer centres and other R&D stakeholders related to the automotive industry. These entities can develop the sensors and to be implemented on Road Side Unities (RSU) and radars and other technological solutions. Researches and Developers, such as Instituto de Telecomunicações (IT), Centro de Computação Gráfica (CCG), Centro Tecnolóxico de Automoción de Galicia (CTAG), Instituto Superior de Engenharia de Lisboa (ISEL) and A-To-Be will provide the technological solutions to develop the C-ITS and deployment of the service (R13). These actors will develop the control centres (R18).
- **End User:** End users could be tourists or users of a mobility service between two cross-borders cities. This group of stakeholders would benefit from the provided service, using it daily or punctually. They represent a key role in the technology acceptance, as passengers and users of the service. They will benefit the service provided by transport operators (R15).

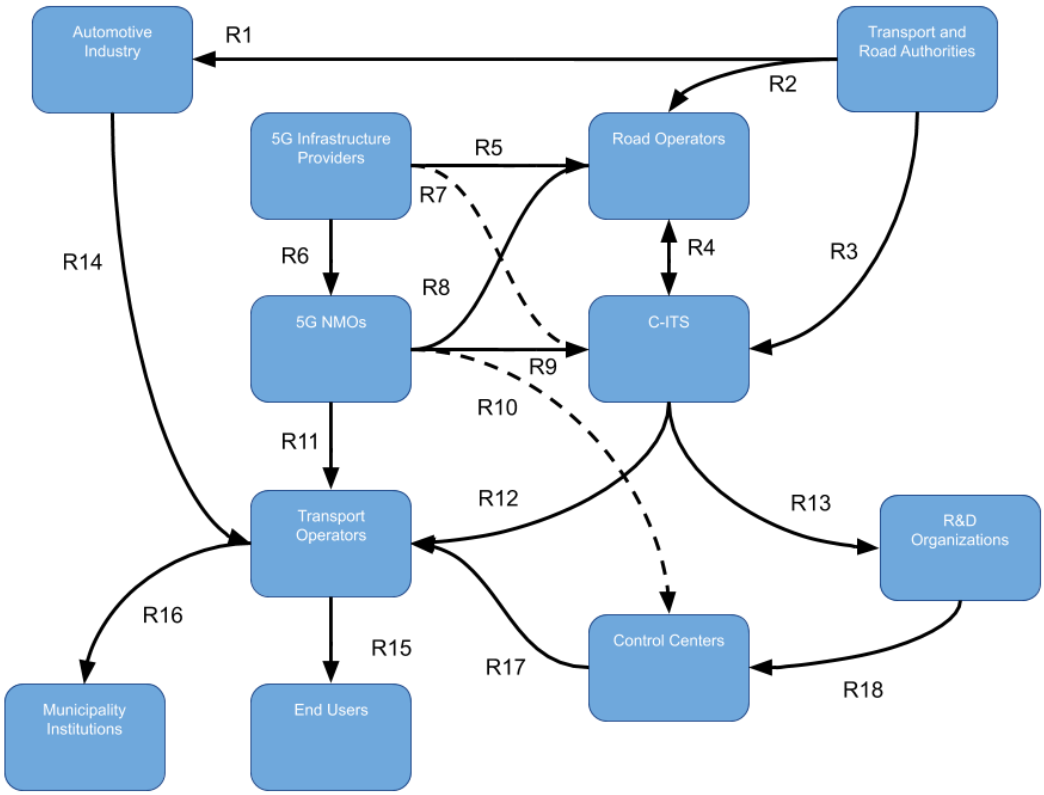


Figure 9: Schematic of relations between Remote Control stakeholders

3.7.3. Value Proposition and Business Impact of US – Remote Driving Across borders – Remote Control

The Costs reduction will be the main impact of this service. A single operator can monitor and control multiple vehicles; Increase the possibility to develop an autonomous fleet in different spots, inside the same cross-border region or in multiple regions.

3.7.4. Customer Focus of US – Remote Driving Across borders – Remote Control

Table 14: Customers of Remote Control

Service and/or Technology Provider	Customers
Transport Operators	Municipalities, Passengers, Tourists
Municipality Institutions	Public Transport Passengers
Automotive OEM	Transport Operators
Mobile Network Operators	Roadside Infrastructure Operator , C-ITS Centres, Transport Operators, Control Centres
Roadside Infrastructure Operators	C-ITS Centres, Municipality Institutions
5G Mobile Infrastructure Provider	Roadside Infrastructure Operators, MNOs, C-ITS Centres
C-ITS Centres	Roadside Infrastructure Operators, Transport Operators, R&D Organisations
Control Centres	Transport Operators
R&D Organisations	Control Centres

3.7.5. Financial Analysis of US – Remote Driving Across borders – Remote Control

- **Service 1:** Transport Operator has autonomous vehicles fleet with remote control option. Transport Operators that manage an autonomous vehicles fleet with the option of having a remote-control option available. The clients will be other transport operators, tours operators or municipality institutions. The service has potential to extend for urban or highway context. The associated costs are the autonomous vehicle, the control room and the communication infrastructure. The service can be paid by an optional subscription to regular autonomous vehicle rent.
- **Service 2:** Autonomous fleet Operator provide the service to Transport Operators. An Operator provides the service to Transport Operators that have autonomous vehicles. The associated costs are the control room and the communication infrastructure. The service can be paid by a mensal subscription. Transport operators, tour Operators or other actors that manage a transport fleet are the main clients. The service has potential to be extended to urban or highway contexts.

3.8. Business Models Analysis for US – Remote Driving Across borders – Coop. Automated Operation

Last mile EV Automated shuttle vehicles will play an important role in the near future of European cities. The cooperation of these vehicles with VRUs (Vulnerable Road User) in order to increase comfortability and safety of these users, as well as the fact of having an alternative solution when the path of these vehicles becomes blocked, suppose a valuable advance in connected cities. 5G technology will enable these developments even in cross-border areas or close to country boundaries.

The capability of sharing information related with position and motion, from the all road users is the key feature of this context. A communication unity, connected to a 5G Network, enables an autonomous shuttle to transmit his position and movement related data as receive information related with pedestrians and vehicles on the surroundings. VRUs connected to the 5G network, also called connected VRUs, use smartphones, wearables or communication units, to share their position and information related to their motion. Pedestrian Radars, installed as Road Side Units, detect non-connected VRUs. The flow of information enables a safer interaction between autonomous vehicles and VRUs in an urban scenario and cross-border scenario.

3.8.1. Current Market Situation for US – Remote Driving Across borders – Coop. Automated Operation

The interaction between Cross-border cities has a relevance from the point of socio-economic development of regions. Cross-Border Municipalities developed mobility solutions to improve the mobility between international cross-border s regions. In the case of SP-PT cross-border municipals, Valença (Portugal) and Tui (Spanish), have a touristic bus that crosses the historic centre of these two cities. A driver operates the service. The train circulates between the two cities with a defined frequency. The service has a touristic purpose. These two cities are part of pilgrim route of Caminhos de Santiago. A high number of pilgrims, beyond the local pedestrians, crosses this route daily. The interactions between vehicles and pedestrians are considerable. Apart from conventional traffic signs, there is no other form of signage.

3.8.2. Stakeholders of US – Remote Driving Across borders – Coop. Automated Operation

This section list US stakeholders and their relations (Figure 10).

- **5G Infrastructures Providers:** These actors include all elements related with the development, implementation and deliverable of 5G-communication equipment. This may include Original equipment Manufacturers and Tier 1 suppliers, vendors and other suppliers of technical solutions or products, involved in the deliverability of a 5G communication related infrastructure. This group of stakeholders will develop and provide the equipment needed to assemble the network infrastructures. Nokia-PT and Nokia-SP will be vendors of the equipment to MNOs (R6), Road operators (R5) and C-ITS stakeholders (R7).

- **5G Mobile Network Operators (MNOs):** These actors play an important role in the maintenance of the telecommunication infrastructure. This stakeholders group includes Telecommunication Operators and Service operators, Telecom vendors, Cloud providers and other Technology providers such as edge devices providers, software developers, etc. NOS and Telefonica will provide the communication service to Road infrastructures Operators (R8), C-ITS stakeholders (R9) Transport Operators (R11) and Vulnerable Road User (VRU) (R10).
- **Automotive Industry:** These actors provide a technological platform, such as vehicles and related components, or services to support autonomous driving or connected vehicles. This category of stakeholder includes car OEMs (car manufacturers), component manufacturers, Tier 1 suppliers, CAM service providers, HD map providers and other automotive-specific technology providers. Automotive actors will provide autonomous mobility solutions to Transportation Operators (R19).
- **Cooperative Intelligent Transport Systems (C-ITS):** These stakeholders manage the infrastructures and provide the information received and sent by connected vehicles that are on the road. This category includes local or national entities. These stakeholders, that could relate entities that manage the traffic and infrastructure, such as Infrastruturas de Portugal (IP) Direção Geral de Tráfego (DGT), or technologic companies that develop technological solutions, such as A-to-Be, Instituto de Telecomunicações (IT), CTAG or CCG. These actors will manage the traffic, having relation with Infrastructure Operators (R4). This is a bidirectional relation: Road Operators can be clients or data suppliers to a C-ITS centres. These infrastructures can even be managed by Road Operators. The communication will be by the MNOs (R9). They will share data with transport Operators (R12) and R&D Organizations. The transport Operators and Vulnerable Road Users will be the final clients (R14).
- **Road Infrastructures Operators:** Correspond to entities that are in charge of deployment, operation and maintenance of physical road infrastructure. This includes the agents that are involved in managing road traffic operations, own or operate the toll system, etc. This includes public entities, governmental institutes and departments that manage public road infrastructures and third-party maintenance companies. In public infrastructures, such as public roads, infrastructures operators can manage the equipment and provide access to the data that are available on the roadside units or ITS Centres. Road Infrastructure Operators, such as Infrastructures de Portugal (IP) and Direção Geral de Tráfego (DGT) will require equipment from 5G Infrastructures Providers (R5) and the network service from MNOs providers (R8). They will even provide the requirements to C-ITS (R4), as a bidirectional relation.
- **Transport and Tour Operators:** This section joins the final transport operators and suppliers of mobility solutions to the end user and Tourism Operators. Actors such as local transport companies that manage vehicle's fleets or local tour operators. These stakeholders will buy technological capable vehicles form Automotive Industry (R19) and operate the transportation fleet. Their vehicles will process data provided by the C-ITS (R12) using the 5G service provided by the 5G MNOs (R11).
- **Transport and Road Authorities:** This section includes Local, National and European authorities and regulators that are directly involved in the regulation of traffic and organizations responsible to define and execute legal framework and policies, such as road and transport authorities or telecom regulators.

These stakeholders include regulators and policy makers, actors that provide the highest authorities and regulate the relationships within the whole ecosystem. They have the responsibility to manage the access and the use of the technological solution. These entities are represented by European Union and National and local Institutions such as Autoridade Nacional de Segurança Rodoviária (ANSR) or Diretor Geral da Dirección General de Tráfico. These institutions will provide the legal framework to regulate the service, from the infrastructure point of view (R1), C-ITS (R3) and autonomous vehicles through automotive industry (R2).

- **Municipality Institutions:** This section includes municipality institutions, such as city hall and related companies from the cross-border regions. These institutions are engaged in developing mobility solutions and cross-border cooperation action. These actors can assume a role of facilitators, providers and clients of a remote shuttle service and in the design of technological solution for Vulnerable Road User. These actors can be Municipality entities, such as Valença and Tui Municipality. They will require the infrastructure provided by the Road Operators (R16). They will require and guide the implementation of the theological solution, contracting the R&D Organizations (R17). In some cases, the Municipalities entities will share the role of Road Operators.
- **Researches and Developers Companies:** This group of stakeholders include researchers, Research Centres, Universities, Developer centres and other R&D stakeholders related to the automotive industry. These entities can develop the sensors and to be implemented on Road Side Unities (RSU) and radars. Researches and Developers, such as Instituto de Telecomunicações (IT), Centro de Computação Gráfica (CCG), Centro Tecnolóxico de Automoción de Galicia (CTAG), Instituto Superior de Engenharia de Lisboa (ISEL) and A-To-Be will provide the technological solutions to develop the C-ITS and deployment of the service (R13). These actors will provide the technological solution to connect a Road User to the CAM service (R18). Municipality Institutions will regulate and contract R&D Organizations (R17) to develop the technological solution to Venerable Road User (R18).
- **Vulnerable Road Users:** This section of stakeholder includes all the pedestrians and all users of soft mobility solutions (e.g. bicycle, scooters, wheelchair) that interact with autonomous vehicles in urban and cross-border contexts. These actors will contribute to the acceptance of this technological solution. These actors will use the technological solution provided by R&D Organizations (R18) that make them a connected road user. When connected, will share data with the C-ITS (R14). The interface with the C-ITS will be supported by the 5GMNOs (R10).
- **End User:** End users could be tourists or users of a mobility service between two cross-borders cities. This group of stakeholders would benefit from the provided service, using it daily or punctually. They represent a key role in the technology acceptance, as passengers and users of the service. They will be the client of the Transport Operators (R15).

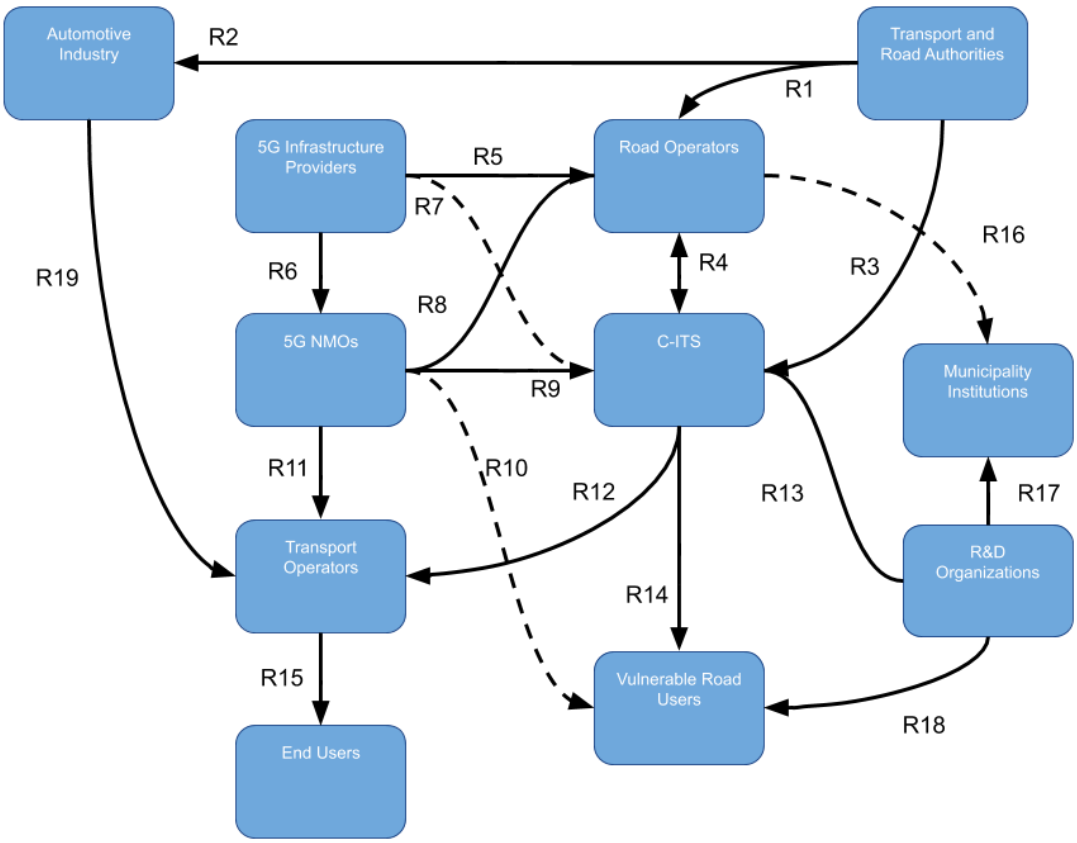


Figure 10 Schematic of relations between Coop. Automated Operation stakeholders

3.8.3. Value Proposition and Business Impact of US – Remote Driving Across borders – Coop. Automated Operation

- **Safety:** This technological solution leads to safer interaction between autonomous vehicles and VRUs in urban scenarios. Connected VRU or VRU detected by sensors extend the autonomous vehicle sensor range having impact on the safety of interaction between vehicles and other road users. A two-way communication channel, based on CAM communication system, by the implementation of warnings for VRU users, enables the development of more inclusive urban areas.
- **Differentiation factor:** Automated vehicles can attract more tourists and other people such as technological enthusiasts. This technological solution for city centres or for a cross-border context has a Wow factor that can be used by Municipality authorities as a trigger for the development of tourism, or even as a differentiating element in small cross-border s areas.
- **Environmental impact:** An autonomous vehicle has referred to as having better energy conservation performance and pollution reductions, when compared with manual operated vehicles. The CAM system can empower the environment impact by anticipating the velocity adjustments or decreasing the breaking behaviour.

- **Costs:** The autonomous vehicles reduced paid driver costs and potentiate an exhaustive operation only limited by the vehicle energy.

3.8.4. Customer Focus of US – Remote Driving Across borders – Coop. Automated Operation

Table 15: Customers of Coop. Automated Operation

Service and/or Technology Provider	Customers
Transport Operators	Passengers, Tourists
Automotive OEM	Transport Operators
Mobile Network Operators	Roadside Infrastructure Operator , C-ITS Centres, Transport Operators, Control Centres
Roadside Infrastructure Operators	C-ITS Centres, Municipality Institutions
5G Mobile Infrastructure Providers	Roadside Infrastructure Operators, MNOs, C-ITS Centres
C-ITS Centres	Roadside Infrastructure Operators, Transport Operators, R&D Organisations
R&D Organisations	Municipality Institutions, Vulnerable Road User

3.8.5. Financial Analysis of US – Remote Driving Across borders – Coop. Automated Operation

- **Service 1:** Autonomous shuttle that is used as public transportation between two cross-borders cities. Implementation of an infrastructure to enable connected VRU or Road side units that can detect them. The system can be developed by road infrastructure operators, network operators or even municipal institutions. Passengers and tourists will be the users of this kind of transportation. The costs can be supported by multiple sources. The service can be paid by ticket sold by the operator. Passengers paid for a ticket, one trip only or a set of it. There is the possibility to integrate the transportation systems with cultural events, where the ticket is part of a cultural ticket or initiatives. For a free service, the costs can be feed by cross-boards municipalities, or from regional or European founding programs related with mobility, cross-border s Corporation or culture.
- **Service 2:** Development of a Warning system based on CAM communication. An application that is running on the MEC is prepared to anticipate critical events such as a collision or a run over event. These events will trigger a warning that will be received by the shuttle and VRUs involved in the event. The warning service can consider the mobility condition (e.g. without limitations, senior mobility constraints), activity (e.g. walking, running) or disability (e.g. blind, deaf) of the VRU. The warning system can be improved by a historical of critical events, shuttle and VRU profile. This system can be developed by technological companies, telecommunication or infrastructure operators, national or municipal institutions and other actors related with mobility. The VRUs transport operators and other mobility

related actors are the potential clients. The service can be paid by transport operators as an additional measure for an autonomous fleet; by municipality institutions as part of an inclusive mobility solution for the cross-border region; or by VRUs as a subscription of the warning service.

3.9. Business Models Analysis for US – Assisted Zero-Touch Border-Crossing

This user story is specifically designed for the borders that exhibit a « hard-border » nature in the sense that there exists actual physical borders between two territories that are governed by different administrations and authorities, which must approve leaving the occupied zone to pass to the other. Depending on the rules of the *from* and *to* territories, certain checks are performed to basically identify the vehicle, the driver and the possible passengers as well as the cargos that are being carried in the vehicle that will do the crossing of the border before any clearance can be granted to the vehicle, which should be considered as a group from the point of view of authorities. The aim of this user story is to explore mechanisms that will expedite passing from one side of the border to the other by designing a scenario, where the 5G-capable equipment on the vehicle, at the border zone and the customs personnel will feed certain information to the cloud applications that also use data from the authorities to make automatic crossing decisions. The vehicle-based information serves to identify the group, whereas the border zone 5G-enablement is included for enforcing the vehicle to stop in case of a detected possible threat or an additional control deemed necessary by the cloud application. The custom personnel are the vulnerable road users of this user story, who will be protected by sending a *stop* signal to the vehicle if a collision a detected.

3.9.1. Current Market Situation for US – Assisted Zero-Touch Border-Crossing

Within 5G-MOBIX, the user story will be trialled at the GR-TR cross-border corridor, which is situated at the south-eastern region of the European Union constituting a challenging geo-political environment due to the transport of goods essential for the European economy, and is further characterized by rigorous border checks that worsens the already heavy and heterogeneous traffic, especially during the high touristic seasons. According to a recent study [13], a large portion of the time of international transport is wasted at European border crossing in south-east Europe, significantly raising the cost and delivery time of goods and contributing to the segmentation of international logistics. The study has shown that on average most border crossings take between 30 and 60 minutes but can easily surpass 90 minutes depending on traffic conditions and other factors (counting both waiting and procedural times). The largest portion of this delay is attributed to inefficient flow of information regarding the necessary documentation (33.4%), custom agent's inefficiency (21.9%) and lack of necessary infrastructure and equipment (21.3%). Since border control cannot be alleviated due to security and smuggling concerns, improving the average control time by addressing the weak points of the process can significantly benefit the transport and logistics industry, and can greatly reduce both the time and cost of international transportation of goods.

In order to decrease the time spent at the borders and to avoid lines of trucks, which can extend up to a few kilometres, a new system will be deployed at the borders of Turkey as confirmed by the Trade Minister Ruhsar Pekcan [14]. The goal is to equip customs administrations with technological facilities, which will

result in uninterrupted and quicker international trade operations at the customs. To serve this purpose, "Transit Vehicle Tracking Program" is designed, which will allow the border gates and customs administration to get quick information on trucks and incoming vehicles beforehand, cutting the times spent at the gates. Through an early effective risk analysis, it will be possible to intervene the vehicles that are likely to be involved in smuggling or have already been involved in other illegal acts much more quickly. This will also ensure an effective usage of the personnel. Despite the ongoing efforts to solve the issues observed at the border gates as this example demonstrates, there are no measures yet to include automated and connected mobility in the system designs or cooperate with other countries, organisations or authorities to share information about possible suspects that might require closer inspection at the borders by the customs personnel. However, the "Transit Vehicle Tracking Program" of Turkey supports the market need for a service such as the one envisioned in the "Assisted Zero-Touch Border-Crossing" user story.

3.9.2. Stakeholders of US – Assisted Zero-Touch Border-Crossing

The analysis in this subsection builds on the Value Network Model introduced in Section 2.2 to identify the key stakeholders of the user story and subsequently depict their relationships in Figure 11 below.

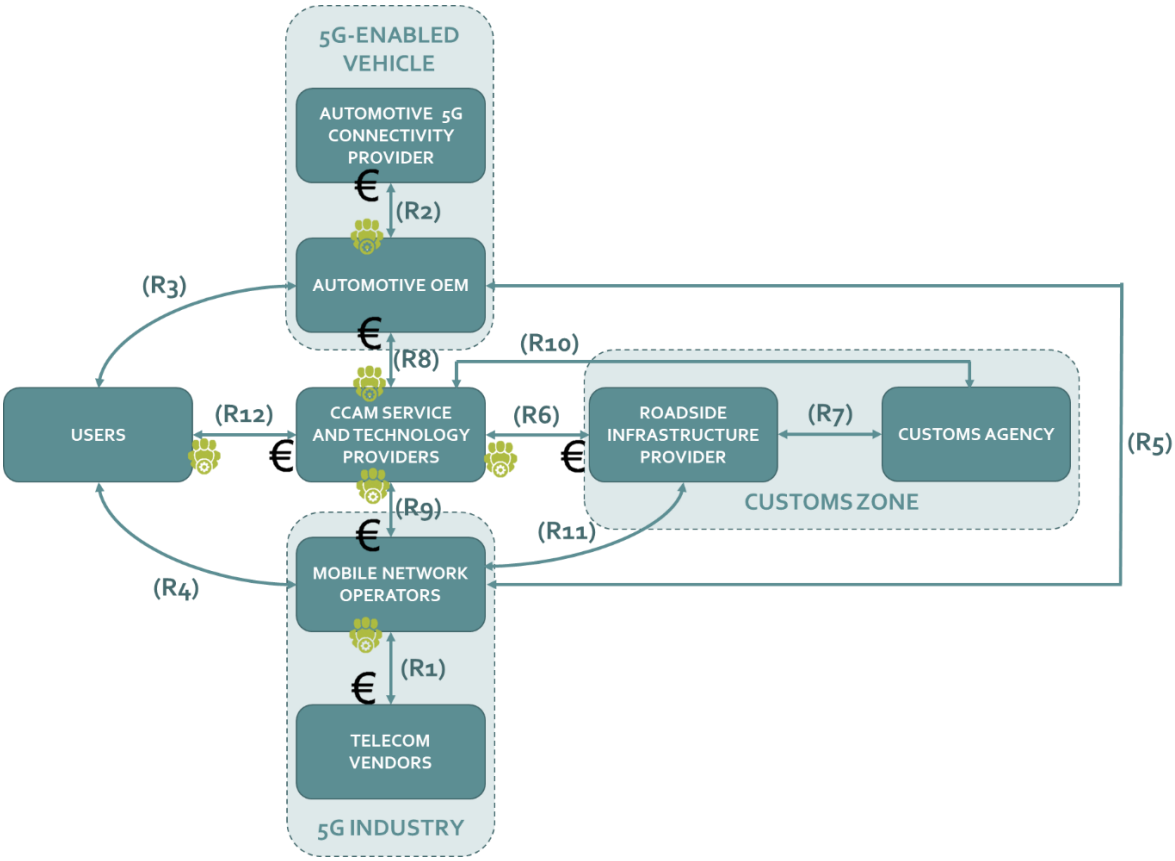


Figure 11: The key stakeholders for the "Assisted Zero-Touch Border-Crossing" user story

- **Mobile Network Operators:** Receive services from *Telecom Vendors* (R1) for deployment of the telecommunications infrastructure, and with the network they operate, give services to *Users* (R4), *5G-enabled Vehicles* (R5) and *CAM service and technology providers* (R9).
- **Telecom Vendors:** Sell telecom infrastructure to *mobile network operators* (R1).
- **Automotive OEMs:** Benefit from the technology of the *automotive 5G connectivity providers* (R2) to sell connected vehicles to *Users* (R3) and possibly share information with the *CAM service and technology providers* (R8).
- **Automotive 5G connectivity provider:** Develop the necessary technology to offer connectivity to *automotive OEMs* (R2).
- **CAM Service and Technology Providers:** Receive services from (possibly) *automotive OEMs* (R8) and *mobile network operators* (R9) as well as *roadside infrastructure providers* (R6) to offer the assisted zero-touch border-crossing application to users (R12). Need an approval procedure or agreement with the *Customs Agency* (R10).
- **Roadside Infrastructure Provider:** In cooperation with the *customs agency* deploy roadside infrastructure within the customs zone (R7) and use *mobile network operator* services (R11) to *CAM service and technology providers* (R6).
- **Customs Agency:** Allow *roadside infrastructure providers* access to the customs zone (R7) and the *CAM service and technology providers* the right to offer the assisted zero-touch border-crossing service to users (R10).
- **Users:** Buy *5G-enabled vehicles* (R3) and 5G services from *mobile network operators* (R4). Receive assisted zero-touch border-crossing service from the *CAM service and technology providers* (R12).

3.9.3. Value Proposition and Business Impact of US – Assisted Zero-Touch Border-Crossing

- **Cost reduction:** The decreased waiting times at the border gates, together with the extra level of efficiency and security added to the whole operation will have profound effects on the transport and logistics sector. First of all, the costs associated with waiting will decrease, and also the duration of the transportation will be more predictable. The time saving will likely translate to indirect reduction of transportation costs, as well, which will eliminate the need to exercise extra protective measures on the goods being transported because of the undesirable situations that excessively extend the time spent during the transport.
- **Better driver experience:** The drivers employed by the logistics industry will suffer less at the gates, and thus taken from the point of view of an end-to-end driving experience, they will be more comfortable on their duty.
- **Customs personnel and pedestrian safety:** The risky driving behaviour that is caused by extensive waiting at the gates will be overseen by the cloud system, which will automatically stop the

dangerous vehicles. This ensures the safety of the customs personnel as well as the other pedestrians in the customs zone.

3.9.4. Customer Focus of US – Assisted Zero-Touch Border-Crossing

Table 16: Customers of Assisted Zero-Touch Border-Crossing

Service and/or Technology Provider	Customers
Telecom Vendors	Mobile Network and Road Operators
Automotive 5G Connectivity Provider	Automotive OEM
Automotive OEM	End Users, CAM Service and Technology Providers
Mobile Network Operators	End Users, CAM Service and Technology Providers
Roadside Infrastructure Provider	CAM Service and Technology Providers, Road Operators
CAM Service and Technology Provider	End Users

3.9.5. Financial Analysis of US – Assisted Zero-Touch Border-Crossing

- **Service 1 – CAM Service and Technology Providers to End Users:** The drivers will be able to seamlessly pass from one side of the border to the other, with the condition that they are not involved in any illegal affairs. This service will be provided by the CAM service and technology providers to the end users that agree to deploy the sensors and modules required in the user story to transmit the necessary information about the vehicle and the cargo it carries. The end users will be charged each time they pass the border.
- **Service 2 – Automotive OEMs to CAM Service and Technology Providers:** The devices and modules to be positioned on the vehicle are manufactured by the automotive industry. The CAM service and technology providers will be bundling this equipment to the service they offer to the end users. The devices can be sold or rented for a fixed term.
- **Service 3 – 5G Industry to CAM Service and Technology Providers:** The 5G connectivity is the main enabler for the zero-touch service to the end users. The 5G Industry powers all types of connections, which includes those of the roadside infrastructure and the ones generated by the vehicle and its devices. The 5G services will require regular subscription. It is likely that the CAM service and technology providers will be compensating for the 5G data consumed by the roadside infrastructure and the vehicles for this particular service (i.e., users, automotive OEMs and roadside infrastructure providers do not appear as receivers of 5G services).
- **Sales:** Three types of sales are shown in Figure 11:
  - (1) Telecom Vendors → Mobile Network Operators

(2) Automotive 5G Connectivity Provider → Automotive OEM

(3) Roadside Infrastructure Provider → CAM Service and Technology Provider

The analysis made above assume that the CAM service and technology provider will be taking on the market risk of the assisted zero-touch border-crossing service, where it is liable towards the automotive OEMs, the mobile network operators and the roadside infrastructure providers. In another scenario, the associated risk of introducing the service to the market might be shared by one or more of the actors shown in Figure 11.

3.10. Business Models Analysis for US – Platooning with "See What I See" Functionality in Cross-Border Settings

This use story contains three different application. First one is platooning application through hybrid 5G connected cloud and PC5, as second, See What I See application to stream video of 4K camera at the leader vehicle to follower vehicle to reduce anxiety and increase safety and as third, autonomous truck routing application in hard border customs area to complete autonomy of a L4 vehicle when there are lots of checkpoints and paperwork exist. Main focus of the user story is the showing 5G capable platooning, real-time high-quality video streaming with 5G while moving and showing that with the help of the 5G connected RSUs and Cloud, routing a connected but not autonomous vehicle in complex fenced environment like a L4 vehicle. With the help of the selected scenarios, 5G limits such as service continuity, roaming, handover, throughput, latency will be also tested. During trials, platoon that has See-What-I-See application will reach to Turkish border gate and then platoon will be dissolved. After that point, Autonomous truck routing application will be enabled. With the help of the sensors (CCTVs, LIDARs) located on the border, truck will move through checkpoints autonomously without need of a human intervention.

3.10.1. Current Market Situation for US – Platooning with "See What I See" Functionality in Cross-Border Settings

Today, the most of the known truck OEMs tried their own platooning cases. Additional to this individual trials, seven big truck OEMs (DAF, Daimler, Iveco, MAN, Scania and Volvo Group) join the ENSEMBLE project that is also referred in Section 2.1. Main communication protocol of all these projects is DSRC, and there isn't any video stream or such advanced autonomous maneuvers for hard borders. About patents, AGVERDICT, INC., San Francisco, CA (US) has a patent [15] namely, "Systems and Methods for Cloud-Based Agricultural Data Processing and Management". This patent is received for agricultural industry but similar to our autonomous truck routing architecture, sensor data and GPS data is fused in cloud and then, this fused information is sent back to a control centre to check status of agricultural fields, when to harvest, which equipment will harvest etc. Additionally, Scania CV AB, Södertälje (SE), hold another patent [16] and name of it is "Device and Method for Increasing Road Safety in Vehicle Platoons". Daimler in 2016 demonstrated the platooning with see through capability [17], but video quality was limited, frame rate was low, and latency was high. These patents and studies cover some bases of Platooning with See What I See

Application user story, but none of them commercialized and neither fully capable of what 5GMOBIX user story promised about connectivity continuity, border crossing, video quality, latency etc.

3.10.2. Stakeholders of US – Platooning with "See What I See" Functionality in Cross-Border Settings

Interaction between stakeholders is quite similar with other GR-TR user story, Assisted Zero-Touch Border-Crossing. For stakeholder relation please see Figure 11 that is also shown in section 3.7.2.

- **Mobile Network Operators:** Receive services from *Telecom Vendors* (R1) for deployment of the telecommunications infrastructure, and with the network they operate, give services to *Users* (R4), *5G-enabled Vehicles* (R5) and *CAM service and technology providers* (R9).
- **Telecom Vendors:** Sell telecom infrastructure to *mobile network operators* (R1). In the future, this might be extended by selling telecom infrastructure directly to Road Operators or Custom Agencies.
- **Automotive OEMs:** Benefit from the technology of the *automotive 5G connectivity providers* (R2) to sell connected vehicles to *Users* (R3) and possibly share information with the *CAM service and technology providers* (R8). Additionally, MNOs provide network connectivity to vehicles (R5).
- **Automotive 5G connectivity provider:** Develop the necessary technology to offer connectivity to *automotive OEMs* (R2). They are Tier-1 supplier of OEMs.
- **CAM Service and Technology Providers:** Receive required data from *automotive OEMs* (R8) and *mobile network operators* (R9) as well as *roadside infrastructure providers* (R6) to offer the Platooning with See What I See and Autonomous Truck Routing applications to users (R12). Need an approval procedure or agreement with the *Customs Agency* for Autonomous Truck Routing application (R10).
- **Roadside Infrastructure Provider:** In cooperation with the *customs agency* deploy roadside infrastructure within the customs zone (R7) and use *mobile network operator* services (R11) to *CAM service and technology providers* (R6).
- **Customs Agency:** Allow *roadside infrastructure providers* access to the customs zone (R7) and the *CAM service and technology providers* the right to offer the autonomous truck routing service to users (R10).
- **Users:** Buy *5G-enabled vehicles* (R3) and 5G services from *mobile network operators* (R4). Receive Platooning with See What I See and Autonomous Truck Routing services from the *CAM service and technology providers* (R12).

3.10.3. Value Proposition and Business Impact of US – Platooning with "See What I See" Functionality in Cross-Border Settings

As in BMC document of this user story stated, main value propositions are listed below:

- **Cost reduction at logistic operations:** Platooning is a cost saving function. According to literature researches platooning provides up to 24% fuel consumption reduction depending on position of

platoon, distance between vehicles, platoon speed, vehicle load, total trip distance and road topology [18]. Fuel consumption is the second largest operational cost of ownership after personnel cost. Hence, reducing fuel consumption is a quite important value proposition especially for truck drivers and logistic fleet owners.

- **Decreasing environmental effects:** If we talk about reduction on the fuel consumption, it is obvious that CO_2 emission will be also reduced and this will affect environment positively. According to Schroten's "Marginal abatement cost curves for Heavy Duty Vehicles, Background Reports" study [19], vehicles account for 20% of the total carbon emission of which a quarter comes from heavy duty vehicles. Platooning can help this CO_2 emission reduction.
- **Increasing safety and reducing stress:** In a platoon, if an emergency brake situation occurs, follower vehicles can react and brake faster than a human brake. With the help of the V2x connectivity, information could flow faster than human brain decision mechanism. In addition to this, with the help of the See What I See application, follower drivers will be more aware about environment. As an example, just before leaving the platoon on highway exit, follower vehicle driver will be able to know whether it is safe to take that highway exit or not. Since platoon vehicles follow each other quite close distances, follower drivers see only a big trailer in front of them. Seeing through also helps to reduce stress level of follower drivers.
- **Faster logistic operations:** With the help of the Autonomous Truck Routing application, while drivers doing their paperwork, truck moves autonomously from one checkpoint to another. Addition to this, X-ray checks will be done with an AI based application and there will not need a human to check X-ray images. These two features will reduce border crossing time per truck.

3.10.4. Customer Focus of US – Platooning with "See What I See" Functionality in Cross-Border Settings

Customer focus of each stakeholder can be seen on the table below:

Table 17: Customers of Platooning with "See What I See" Functionality in Cross-Border Settings

Service and/or Technology Provider	Customers
Telecom Vendors	Mobile Network and Road Operators
Automotive 5G Connectivity Provider	Automotive OEM
Automotive OEM	End Users, CAM Service and Technology Providers
Mobile Network Operators	End Users, CAM Service and Technology Providers
Roadside Infrastructure Provider	CAM Service and Technology Providers, Road Operators
CAM Service and Technology Provider	End Users

3.10.5. Financial Analysis of US – Platooning with "See What I See" Functionality in Cross-Border Settings

- **Service 1:** For Platooning application and See What I See application scenario, end user pays an extra money when purchase the vehicle to have 5G-CAM services, because vehicle OEM pays to its Tier-1 suppliers (5G connectivity and see through camera supplier). End user connects Platooning and/or See What I See servers to get advantage of the 5G-CAM services. For this connectivity, end user pays subscription money periodically (e.g. monthly, yearly etc.) or per usage (e.g. per km) to CAM service and technology providers. Data usage cost may be covered in subscription or may be paid by end user to MNOs.
- **Service 2:** For Autonomous Truck Routing scenario, as first option, truck driver pays money to CAM service and technology provider according to his/her subscription method. This could be per usage, if driver use the same road so often, then it could be a periodical subscription. CAM service and tech provider share this paid money with road operators. Service pays MNOs to get network connectivity. As second option, truck driver pays to road operator at the entrance of the autonomous truck routing capable road and this money is shared between road operator and CAM service provider. Required data cost should be covered by truck driver or road operator and paid to MNOs in this case. As third option, truck driver pays both CAM service provider according to his/her subscription method and road operator at the tollgate once or if used so often then an advantage package could be created by road operator. Required data cost should be covered by CAM service provider and road operator and paid to MNOs. For all options, revenue sharing percentage between road operators and service providers would be decided according to a contract that is signed at the beginning.

For all services, drivers will get 5G-CAM advantages such as relaxing while driving and have time for secondary tasks like phone call, eating, reading emails etc. Advantages and their cost should be balanced.

4. MOTIVATION OF STAKEHOLDERS

4.1. Introduction of 5G-CAM Deployment Motivation

In this section, we look for answers why stakeholders should invest on 5G-CAM. The analysis of the motivations of the various stakeholders within the 5G/CAM ecosystem should begin by investigating first what is of value for the customers that would incite them to pay for connected and autonomous driving products and services. In this context customers are considered to be either individual vehicle drivers, owners or passengers, or national and private road transport operators. Research evidence so far has demonstrated that those end users of 5G/CAM technology firmly believe that the cost for such services is worth the benefits of [20]:

- *Safety.* The potential of 5G/CAM technology to dramatically reduce the frequency of road accidents has been one of the most important driving forces for the development and adoption of connected and autonomous vehicles. Assistive driving features such as forward collision and lane departure warning systems, side view assistance, and adaptive headlights have already started to have an impact in reducing the number of crashes and fatalities on the road. Given the fact that the vast majority of accidents are a result of the drivers' fault, wide adoption of fully autonomous vehicles (levels 4 and 5) are expected to reduce accident statistics even further. This will be evident also in cross-border situations, where the low latency of 5G will enable the quick handover of information, and as a result enabling the seamless continuation of the service without any kind of disruption. As a result, safety will increase with respect to the current situation.
- *Comfort.* Drivers and passengers of fully autonomous vehicles will be able to engage in altenative, more beneficial, work or entertainment related activities whilst travelling. This factor might also make people willing to commute longer distances to and from work, and hence locate further from densely over-populated urban areas improving their quality of life helping to revitalize rural areas at the same time. Although this might result in an increase in the total time and distance of travel, even leading to more congestion in some cases, the quality of time spent inside a vehicle will be increased significantly. This may even lead to increased emissions that will be compensated by other benefits (see environmental sustainability below).
- *Additional services.* In addition to the alternative activities mentioned in the previous paragraph, fully autonomous vehicles will enable many services to increase investment in economic activity through additional business models like micropayment, last mile delivery of essential products to these vulnerable regions that are key to the European Union.
- *Mobility for those unable to drive.* Level 4 and level 5 autonomous and connected vehicles that do not require a human driver would enable mobility for people who are disabled, too young, too old, or unwilling to drive. The benefits for those people with regards to independence, reduction in social and physical isolation, and access to healthcare, shopping and other essential services will be significant. . 5G connectivity in CAVs can also provide swift help to vulnerable users in stress situations such as medical emergency, physical attacks, etc.

- *Environmental sustainability*. Fully autonomous and connected vehicles will be able to optimise travel speeds, distances and times, thus improving significantly road capacity and reducing fuel consumption. This increased efficiency will not only be beneficial for reducing harmful for the environment emissions, but will also result in lower fuel costs for the consumers. Furthermore, the ability of fully autonomous vehichles to drive and recharge themselves when not in use would enable the wider use of electricity as an alternative fuel, and therefore will play an important role in reducing pollution.

Many governments, public authorities and policy makers have also realised how revolutionary those potential benefits of wide adoption of connected and autonomous vehicles are for the economy, the society and the environment in the long-term, and therefore are determined to facilitate, support and promote the development and deployment of 5G/CAM technology.

Questionnaires that are prepared for this deliverable (See Annex) will guide us to understand stakeholders' motivations in more detailed perspective. Answer to these questionnaires will be analyzed second version of this deliverable, D6.6, which will be published at the end of project.

4.2. Motivation of MNOs

The wireless communications business encounters significant depreciation in revenues especially for the traditional services, where the average revenue per user (ARPU) constitutes the best-known metric in this domain. The report by PWC's Strategy& demonstrates that the ARPU figures experienced by telecom operators steadily declined over the ten-year frame 2006-2016 across all geographies considered in the analysis [21]. The rationale for this trend is attributed to the commoditization of the services offered by telecom operators, which also translates to a convergence of the prices and market shares of the operators in the market. In particular, the evolution from 1G to 4G focused on coverage and capacity improvements for mobile users, which receive basic voice and data services from the MNOs on similar devices, and hence the actual value offered to customers is limited to performance differences between the operarors.

4.2.1. New Differentiation Ways

Differentiation is the key to increase competition, and thus prevent the effects of commoditization in a stagnating market. 5G will not be a commodity: It is expected to create a new wave of socio-economic transformation by enabling smart environments and automated industries. There will be a vast heterogeneity in number of use cases, diverse requirements, end devices of all kinds and ecosystem players to significantly increase the customer base for the MNOs that can meet the requirements and challenges of their subscribers earlier than the competition.

MNOs will enable a new business environment, within a large and growing ecosystem. This dynamic ecosystem, particularly in relations to Verticals and cloud providers, will create and demand a large variety of flexible business and operational models with great diversity in the value chain. MNOs will be in unique position to create and distribute value, and thus obtain additional revenue streams. They will provide a fully integrated solution that encompasses networks, platforms and services, with dynamic customisation, end-

to-end management, carrier-grade security and efficient spectrum use. The softwarisation, orchestration and exposure of network functions enable an efficient and real time allocation of network resources and capabilities. The role as a connectivity provider enhances with a variety of partnerships to provide services to end users. The strength in providing a customised service enabling platform with intelligence all the way to the edge and lifecycle management is delivering value to Verticals, while integrating telco services, including security, knowledge, context and others. The dedicated network-as-a-platform will give the MNOs the ability to form and contribute to a variety of different business models and partnerships, including cloud providers and the Verticals.

4.2.2. Expected 5G Services by Other Stakeholders

The road transportation industry is expected to provide efficient, safe, environmentally –friendly and comfortable transportation, especially by exploiting the potential of artificial intelligence, to achieve connected and automatic driving through perception, decision and control. The 5G system will enable this by supporting, amongst others:

- Transmission of high quality video of images of road conditions and roadside facilities to help navigation, remote and automatic driving, as well as identification of blind zones and other vulnerabilities for vehicles;
- Real-time communication among vehicles and road infrastructures, coupled with precise positioning and local (edge) computing capabilities, enabling identification of potential dangers, which can help decision-making including route planning and updating, emergency braking and intelligent car collision avoidance;
- Connectivity of sensors and collection of data from vehicles and roadside infrastructure, supporting building models of the road environment and business applications such as advanced road-use charging;
- Remote maintenance through download of software updates to vehicles and the reporting of status information to vehicle manufacturers.

Advancement and progress in development of several key 5G enablers include the specification of the service/technology specific categories of service offerings embodied in the eMBB, mMTC and URLLC typologies, of which a number of solutions are already identified as being of interest in the context of 5G-MOBIX and transport/mobility field in general.

MNOs have a crucial role to play in the ecosystem as 5G for CAM is the key driver to enhancing road safety for all types of road users whilst combining the capabilities of the technologies to increase efficiency of road use again for all types of road users. Even though the more advanced applications as may be used in road vehicles will not lead to short term revenue potential for the MNOs, the necessary upgrades to road-side infrastructure are already in early stages of deployment and as such offer a need for MNOs to move now in order to keep up with market speed. Similarly the use of 5G for CAM in vehicle classes other than cars and trucks (e.g. bicycles, mopeds, scooters, micro-mobility vehicles etc) but also vehicles used outside the public

road infrastructure (e.g. various vehicles for use in logistics chains) may offer shorter term opportunities for MNOs as the development (and type approval) cycles for these vehicle classes tends to be a bit shorter.
5G for CAM in this respect also opens up new market potential for MNOs above plain connectivity only. As more advanced usecases within the realm of 5G for CAM will rely on the low latency component that the 5G networks will be able to offer, hosting third parties for computing tasks close to the end user in the edges of their networks offers the MNOs a host of new opportunities that legacy wireless technologies were not able to offer them. It is however crucial for MNOs to consider these opportunities in the designs and architecture of their roll-out plans up front to avoid having to address these opportunities as an after-thought in their operational networks.

4.2.3. Other Motivational Points

Additional to all stated above, 5G CAM services are important for MNOs for a host of other reasons (the order of importance may vary from operator to operator):

- The "critical 5G CAM services" respresent one of the most prominent drivers for the investment in a 5G-URLLC infrastructure (this is the incremental investment needed to make a 5G-eMBB network ready for URLLC services), because this market segment has some unique characteristics:
- The total addressable market in the long run is large
- The value created per subscriber is substantial which should help MNOs to recoup the investments made for such services.
- There is no technical alternative / substitution for the connectivity necssasary for such services, which further reduces the risk of malinvestment.
- It is in the interest of MNOs to ensure a consistent service across borders in a similar way that customers can use their mobile data seamlessly as they travel. Some of the infrastructure will be common to that used for other services like mobile data, needing only a capacity increase.
- Provision of the 5G for CAM is likey to become a 'hygeine factor' where its absence puts a particular MNO at a disadvantage to competitors who are providing the service.
- An opportnity will exist, to use owned hardware to provide a service to smaller competitors that do not make the investment. Agreement around policy, regulation and technology will be needed and will need to operate within and between countries for cross-border corridors. This represents an additional revenue stream.
- It is not a question of "if", but more a question of "when" the demand for such services start to appear. Although the last point (timing / adoption curve) is a positive in the sense that it is easier to decide to invest in a market that surely will exist, the "when" question is still relevant. Even with a low cost of capital (by historical standards), it is still important for MNOs to get the timing of investment right: investing too early leads to significant opportunity costs whereas investing too late can lead to long lasting loss of market share.
- The "non-critical 5G CAM services" (eg. In car entertainment) provide a space into which MNOs can extend their existing consumer services in a seamless manner (eg. Premium Cartoon TV subscription). Whereas initially such services are mainly focused at passengers (eg. Kids), in time (as AD moves to

Level 5) they will soon also target the former driver, representing a long term growth opportunity. Such services will require 5G-eMBB connectivity and are the closest to "business as usual" from the perspective of the MNO.

- Business customers are expected to use the data from their connected fleets in their mandatory quests for efficiency (eg. Digital Transformation initiatives). MNOs can add value to such customers providing reliable and secure connectivity within private networks. Connecting fleets directly to Corporate backends without traversing the public internet greatly reduces security risks. From a pure network perspective, these services will mostly require 5G-eMBB networks, though there may be some usecases for 5G-mMTC as well. However, the main question for MNOs is not on the network side. The main question is until what extents MNOs have the ambition and ability to orchestrate end-to-end services. For this MNOs need to be part of ecossystems together with OEMs, device suppliers, platform providers and integrators.

Arguably, the value opportunities listed above are still subject to many unknowns (notably regarding business models, adoption curves, and regulation). But, even for a more cautious MNO, it is probably clear that ignoring the potential of 5G CAM services would be a significant business risk. Securing the option to participate in the 5G CAM services market partially explains why MNOs are willing to bid significant amounts in 5G spectrum auctions, especially when it comes to the lower bands.

A number of strategies and roadmaps have already been proposed to the mass deployment of mobility and transport services making use of 5G technologies in different scenarios, and this would be a critical moment for MNOs to position themselves in the explosion of user and service-driven solutions that will require the most from network and cellular networks and their operators.

4.2.4. Market Researches

In order to substantiate the discussion above, we reference a number of reports by Nokia that explore the answer to the question of exactly where new subscribers will come from, and which 5G services will most spark their desire: Research results performed by Nokia with more than 3,000 consumers in markets where 5G is already deployed such as the US, the UK and South Korea demonstrate the following [22]:

1. They want 5G when they understand it
2. They're willing to pay more for 5G
3. Engaged users will switch provider to get 5G
4. Opportunities abound for MNOs to expand beyond connectivity

The same report mentions that the majority of vehicle owners are interested in enhanced connectivity in the car, especially for road safety and enhanced navigation. 73% of vehicle owners found the idea of vehicle connectivity appealing, making connected vehicles an interesting use case for MNOs, particularly in markets with higher vehicle ownership. For the enterprise domain, of organizations that use vehicles, 74% find 5G appealing, but the level of appeal varies depending on the way vehicles are used. Higher interest for 5G is

found among the organizations where the vehicle is being used for safety and security purposes and for transportation of non-employees [23].
In a nutshell, within the connected vehicle market the opportunities for the MNOs are summarized to be [24]:

- Increased value of connectivity
- New subscription models
- Bundled vehicles and service packages
- Automotive security support
- Mobility as a service (MaaS)
- New data and analytics services

4.3. Motivation of Automotive OEMs

The autonomous driving market is expected to reach a sheer size in the near future, with estimates of generating $560 billion in revenues by 2035 representing 17% of the global automotive market[25]. The main products that will contribute to these revenues can, in general, be grouped in the following categories:

- *Fully autonomous and connected vehicles*. Several types of self driving vehicles are expected to be designed including, for example, large vehicles for transporting goods or people; simpler vehicles and taxis for commuting and short trips; luxurious vehicles for premium travel experience; and drones for improved road capacity and speed. These self driving vehicles will be able to connect to each other and form platoons with fixed distances and speeds, or swarms giving control to a real-time automated traffic flow management system. 5G technology will support the swift and wide roll-out of these vehicles' activities by offering low latency services and seamless handovers, even for cross-border transport of passengers and goods.
- *New Autonomous Driving Architecture*. Autonomous driving represents the biggest change in software architecture in the automotive industry since the last 100 years. The current vehicle architectures do not have enough computation power to perform in a safe manner Level 4 & Level 5 . Also in order to provide the drivers and the vehicle with sufficient information to make decisions the vehicle architecture needs to be supported for a digital infrastructure that allows the vehicle to take decisions and share information and the driver to enjoy a digital experience in the car. For these reasons the automotive industry would need to redesign their architecture to include a more powerful domain controller that allows them to perform in a safe manner L3 and L4 functionality and SOTA. Also the automotive OEMs would need to rethink and redesign their Enterprise architectures to cope with the large amount of data and the new digital business models. This category would include all on-board accessories especially a on-board connectivity modem that enable high level of driving automation, such as assisted driving, auto pilot, navigation, automatic parking, etc. Both hardware and software aspects of those accessories are included in this category. 5G will improve performances of the special equipment in terms of availability (through coverage and reliability), accuracy (through positioning) reliability (through low

latency and reliable services), and responsiveness (through low latency and higher bandwidths), while at the same time cutting costs by using widespread technologies.

- *Mobile apps*. It is forecasted that by 2035 autonomous driving systems will free up 5 trillion minutes of idle time for vehicle passengers, most of whom will be in possession of a smart phone or tablet. Smart phone and tablet apps will enable drivers and passengers to enjoy access to multimedia and information for entertainment or work purposes while travelling without the risk of causing an accident. Apps will also allow consumers to control various features of their cars remotely, as well as integrate their vehicle with their smart home and program their home from the car and vice versa. Apps can also be utilised to improve insurance policies and offer better legal protection, especially in cross-border situations, where insurance policies may differ per country.
- *Infrastructure*. New road-side infrastructure that enables seamless and ubiquotous connectivity for autonomous vehicles needs to be deployed in motorways and cities and complement existing infrastructure. This would include, for example, 5G core network and RAN for wireless connectivity, cloud and MEC datacentres for data storage and processing, road-side C-V2X and sensor units, platforms for automated traffic control, and more.

Undoubtedly, connected and autonomous vehicles will disrupt the existing automotive industry in an unprecedentent way. Today, the value for an average vehicle is 90% hardware and 10% software. In future, it is expected that the value of the hardware will fall to 40% and most of the vehicle's value will be dominated by software (40%) and content (20%). The concept of connected mobility will blur the distinction between connectivity and mobility creating new forms of competition, while generating opportunities for the provision of new services. The current value chain in the automotive industry, which has traditionally been formed as an one-way pyramid with the OEMs sitting at the top and the various component suppliers and integrators at the lower levels, will be replaced by new value network models with complex interdependencies between previously unrelated stakeholders, as discussed in detail in Section 2.3. This is because the various stakeholders, from multi-billion giants in the automotive, telecoms and online technology industries to specialist hardware and software SMEs and start-ups, have realised that if they want to play a leading role in this rapidly evolving autonomous driving market they will need to join forces and establish powerful partnerships and ecosystems.

OEMs will find themselves in the position of being the platform supplier for the multiple services, or content, that emerge as the technologies evolve. They will need to develop the skills needed to offer their customers an integrated suite of digital serices that aligns with their brand, which will also evolve as a result of the changes. This is a process that has already started with integrated phone capability and other services like e-call and navigation. Failure to offer these services to their customers would put an OEM at a disadvantage when compared to competitors. New business models will be needed to distribute revenue from a single point to the multiple hardware, software and content providers involved. Access to many of the services will only be feasible if the vehicle is autonomous and customers will expect seamless delivery across land borders.

4.4. Motivaton of Third-party SW/HW suppliers

Based on the point of view of SW/HW suppliers the main motivation for new investments in 5G/CAM lies on the development of new business opportunities such as, development of new partnerships, reaching out to new segments/verticals, improvement of existing products and services or development of new ones, the motivation can be affected by many internal and external factors. Internal factors refer to the company's strategic goals, available infrastructures and resources, the company growth, marketing intensity or even the capacity of decision makers to make informed decisions when novel technologies such as 5G CAM are concerned. External factors include the market dynamics such as market size, growth, competition intensity, restricting regulations and policies or existing standards and patents. This subsection details some enablers that can further motivate investment from SW/HW suppliers.

Creating a data economy around CAM can be a significant motivator to increase investment in 5G CAM deployments. In general, Big Data as-a-Service is estimated [26] to grow from USD11.3 billion in 2019 to USD 42.7 billion by 2024, at a Compound Annual Growth Rate (CAGR) of 30.5% during this period, according to recent analyses. This is an indication of the growing demand in industries to gain actionable insights from growing data. The wealth of data in 5G-enabled CAM makes it possible to offer Big Data as-a-Service as long as compliance with GDPR is maintained. This would enable third parties to create products and services on these data, to improve logistics, route planning, demand responsive transport, traffic management, environmental monitoring and many more. The existence of Secure and Ethical BDaaS can thus spur significant economic growth.

Autonomous Vehicle Architecture: The integration of the new autonomous functionality in the vehicle is key for the successful implementation of autonomy. Currently the vehicle architectures of most OEMs are not ready to perform in a robust manner due to inefficiencies based in the commodity centric approach of the classic automotive OEMs. New business models and companies had been created to displace some of the Tier1 that usually had the power and trust from the Auto industry to develop this architecture and a new figure called "systems integrators" has been growing in the last 3 years. Aptive, ARGO AI , Waymo are some examples of the new incumbents moving to this areas.

Validation and Certification: One of the biggest challenges and more expensive part of autonomous driving is the validation and verifications of the algorithm . In the last 3 years this challenges has generate a lot of new companies that provide solutions to ensure that the AI algorithms are validated following the automotive standards.

Simplifying decisions related to IPR and favouring standardisation over patenting: Decisions related to IPR can have significant impact on a product's success. Given a novel technology such as CAM, companies are faced with multiple possible options, e.g. keeping the technology proprietary, patenting the technology, standardising or a mix of those strategies. Significant benefits and drawbacks are also present in both cases as illustrated in Table 18

Table 18: Pros and cons of patenting versus standardization

	Patenting	Standardisation
Pros	Capitalising on IP through royalty fees Temporary exclusive rights Increases trust in investors and clients IP protections	A company can establish a dominant design as a de-facto industry standard and request royalty fees. Community standardisation and specifications such as the German DIN or European PAN are low cost alternatives.
Cons	High up-front cost Incurs additional litigation costs (e.g. to defend against infringements) Imitation of patents is hard to detect Difficult to create a patent that cannot be by-passed Duration of 1.5-3 years disadvantageous in rapidly growing markets	Competing companies pushing their designs can instigate a "standardisation war" (e.g. BluRay against HD DVD, Firewire vs USB etc.) and affect the sector significantly.

ETSI has provided a tool [27] to help companies make an informed decision on whether a new and innovative development should be patented or standardised (Figure 12). However, formal standardisation by large communities of experts or even open specifications could lessen the barriers for market entry to new companies and lead to new products with higher degree of interoperability, leading to a more sustainable market.

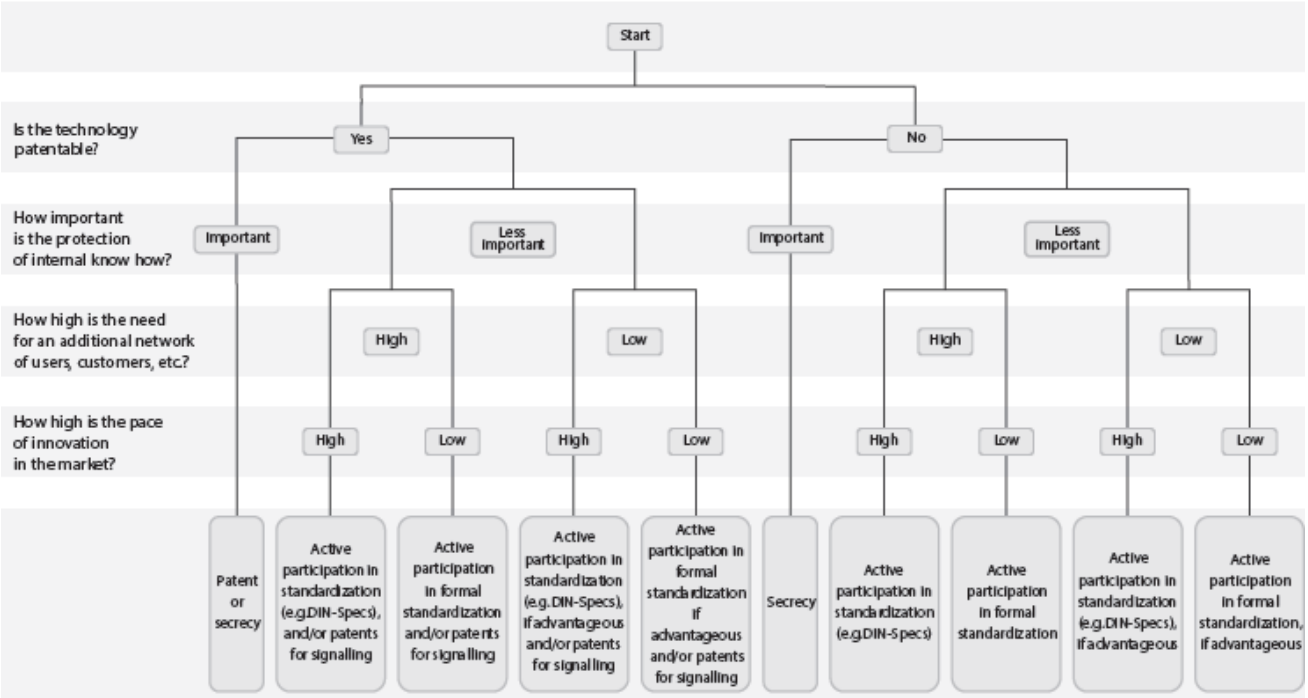


Figure 12: Decision tree provided by ETSI

4.5. Motivaton of Road-Operators

There is a need to provide road users with the infrastructure that they need for travel and transport and it is the operators' responsibility, whether private or public, to do so. It is also in the interest of the road operator to ensure that traffic throughput is efficient, this is not only important for toll roads where revenue can be maximized, but also to non-paid roads, where costs may be incurred by accident repairs (to roads and other infrastructure) and management of severe congestion. There may also be an argument that increasing throughput through traffic control using technology could delay or eliminate the need for capacity increase through road widening with the associated costs and delays. This is particularly important at border areas where responsibility and liability may be unclear.

For Road Operators is important to know all it is happen in highway and as sooner as he receives this information better to management decisions, information about meteorological conditions, traffic, incidents, and other information on entire highway are essential to make decisions and operate efficiently. Currently, operators only can obtain this kind of information with meteorological stations, CCTVs and phone calls of users. However, this method cannot cover entire highway operators always have blind spots with 5G communication from and to connected vehicles, operators can have fully control on entire road.

Another motivation is that with 5G communication, road operators can inform all users in entire highway if any incident is occurred. Currently, the only method the road operators have is PMV (Variable Message

Panel), but it is impossible to have it on entire highway. With the help of the 5G, road operators are able to send issue with more detailed, reliably and instantly to the connected vehicles at the any point of highway.

4.6. Motivation of C-ITS Centres

A similar motivation to the road operators – providing the infrastructure to ensure safe and efficient travel and transport. Use of 5G is a key contributor. Further opportunities may arise from the gathering and processing of driver and potentially passenger data. This might be useful in improving traffic systems both in the controlled area and elsewhere, as well as potential for data sales and use elsewhere. Legal and technical differences across the border will need to be accommodated and these organizations will be an important element here.

4.7. Motivation of R&D Institutions

R&D organizations such as academic institutions and private/ public research companies and centers work closely with the whole ecosystem during the design, development and deployment phase of current and next generation 5G-CAM-related technologies and applications. The main motivations for these institutions are:

Scientific advancement in network connectivity: R&D institutions are behind many of the advances that enable 5G connectivity. It is their goal to continue advancing the state-of-the-art, maturing the technology and making it more efficient and reliable. It is also their interest to understand the main hindrances and limitations currently opposing the wide ad of 5G technology, thus identifying future challenges and opportunities for scientific endeavor. Slicing and the limited range of 5G on some wavelengths are some examples of features and limitations of special interest.

Scientific advancement of CAM technology: 5G has for years been regarded as a fundamental enabling technology for CAM. From the vehicle point-of-view, it has the ability to provide a continuous flow of information that can complement the information provided by the vehicle own sensors, allowing the AD systems to make better informed decisions, ultimately enabling automation levels above L3. It also enables mobility use-cases that depend on precise orchestration of multi-vehicle motion such as platooning and integrated traffic management. It thus provides new challenges and enables innovative solutions in the fields of control theory, artificial intelligence, edge computing, traffic and transport system management and logistics, to name a few.

Acquire know how: R&D institutions will work closely with private and public organizations to implement 5G-CAM solutions and identify and explore new opportunities that this technology provides. Working on 5G-CAM projects give these institutions the knowledge and expertise they require to play their role in the overall ecosystem.

Understand economical and societal impacts of 5G-CAM adoption: CAM can have a profound impact on society by deeply transforming the current mobility paradigm. It can change the geographical perspective that makes us choose where to live and work and alter the premises that govern territory and urban planning. It has the potential to create new business ecosystems around people and cargo transportation. It can facilitate the mobility of physically impaired (either by disease or age) people, in effect increasing the number of transportation users. Research institutions on the field of economics and sociology aim to understand and predict these changes, while also addressing which factors can contribute to or hinder acceptability.

Increase awareness about 5G-CAM: R&D institutions are instrumental in the dissemination of developments in 5G-CAM. This is mostly done through publications in peer reviewed publications and international conferences, though other types of events involving nonacademic organizations is almost as essential.

4.8. Motivation of Transport Operators

Transport operators benefit from the following in terms of cost and efficiency and are likely to be willing to pay for the technology and services that enable them.

- Reduced cost of operation
- Reduced journey time
- Improved estimate of delivery time
- Reduced driver fatigue
- Reduced probability of accidents

Transport operators will also need to invest in vehicles with autonomous capability to gain these benefits if the total cost can be justified.

4.9. Motivation of End Users such as Transport and Passenger Operators and Individuals

End users such as transport/passenger operators and individuals will benefit from the advantages of safe automated mobility. Although the services are provided by several organizations it is unlikely that they would be willing to pay each provider individually and certainly not just for cross-border operations. There is a case for an 'aggregator' service provider that is a single point of contact, and payment, for the end users. That role could be taken by a new market entrant or possibly by the automotive OEM, again potentially via a market entrant intermediary.

5. IDENTIFICATION OF BUSINESS-RELATED GAPS

5G-MOBIX explores the barriers that hinder the development of new business models and deccelerate investment in 5G and CAM. For the purpose of this work, the **PESTLE** approach is adopted, where barriers are discussed in the [P]olitical, [E]conomic, [S]ocial, [T]echnological, [L]egal, or [E]nvironmental sense.

Table 19: PESTLE Approach

Barrier Type	Description
Political	**Difficulty in harmosing and coordinating policies and standardisation between different companies and countries:** Governments and major companies involved in the development and deployment of 5G-CAM technology have found it difficult to establish common protocols, with some supporting that strict regulations hinder progress while others claim regulations are not strict enough. The differences usually lie behind issues related to road safety (of drivers, passengers and pedestrians); environmental sustainability (e.g. seamless travelling between a country that allows exclusively electric cars and another that allows also biofuels will be significantly affected); cybersecurity (e.g. see the different approach of various countries towards the use of 5G telecom equipment from Huawei); data protection and privacy (e.g. GDPR rules in EU frequently prohibit the effective and efficient development of crucial data-dependent algorithms for CAM). **Different degrees of interest at a local level**: in some EU countries, decisions on CAM infrastructure are made at a regional level. Poor, underserved and remote areas can be less interested in deploying 5G-CAM technology, due to other needs (e.g. deployment and maintenance of the physical infrastructure) that are perceived as more urgent.
Economic	**Lack of motivation for investment in innovative research and development:** The development of a new product can incur high costs in CAPEX/OPEX especially when hardware manufacturing is concerned or when delivery of such a service or product may significantly impact network designs and architectures. Meanwhile, trust in innovative new products can be difficult to build, especially if long-standing contracts among major telcos/vendors etc. are in place. Additionally, there has been a lot of debate about whether the Governments should be paying for it (using tax-payers' money), the vehicle manufacturers, the telecom vendors and mobile network providers, or other stakeholders. As a result of the high CAPEX/OPEX costs, it is also likely that road infrastructure,

	spectrum and/or core network resources will need to be shared between competitive stakeholders, which will require various agreements at technological as well as policy, regulatory and political level. This breaks the momentum in the creation of new products and in investment in innovative R&D. **Lack of investment from sectors that might benefit greatly from 5G-enabled CAM:** CAM is poised to achieve great reduction in congestion and accidents in European roads. Multiple industries such as logistics/freight transport, ridesharing and Demand-Responsive Transport etc. stand to gain from 5G-CAM as costs incurred due to traffic collisions and delays will be minimised. However, the amount of direct investment in 5G-CAM from these industries is very low due to lack of motivation and trust of the near future.This effect may be further exacerbated due to the fact that most developments appear to be geared towards new vehicles and less on retrofitting existing vehicles leading to the perceived need of additional investments in the fleet. Lastly, in order to reap the full benefits of 5G for CAM, a significant portion of the nation-wide fleet of vehicles will need to have the technology fitted and so fleet (or individual vehicle) owners may be hesitant to invest in technology that may only yield the benefits after a majority uptake has been established. **Competitive nature of automotive OEMs:** Much of an OEM's brand is invested in the way a vehicle drives and OEMs will need to develop a new set of attributes that position their product favourably in the market. Under autonomous control the driver experience (or 'rider' experience) is likely to become somewhat standardised with silent powertrains (for EVs) and similar acceleration and handling charactristics across vehicles from different manufacturers. The resulting 'commoditization' of vehicles makes it difficult (though perhaps not impossible) for OEMs to differentiate their product. This could be a particular problem for makers of sports cars, and could mean that cars controlled by individuals rather than machines continue to populate our highways for many years to come. **New relationships and business models for insurance:** Insurance companies currently interact directly with end users however automation will require that new entities are involved. Risk pricing models will evolve as control of the car is ceded from driver to the vehicle and infrastructure. Complex chains of responsibility and liability will emerge, and insurance companies will need to recover losses from supply chain insurers rather than driver insurers in many

	cases. The process is likely to take time to shake out and develop new procedures acceptable to all participants. and operable across borders.
Social	**Public's lack of trust to automated vehicles:** Although automated vehicles are seen as key disruptors and part of the next "technology revolution", public distrust is still a barrier towards their adoption. Consumers find the idea of relinquishing control as unnerving and news of semi-AVs [28] that have crashed exacerbate this problem. A recent survey by AAA [29] discovered that 88% of respondents felt unsafe to ride in an AV. A poll by AIG discovered that 41% didn't want to share the road with driverless cars. **Concern around security of jobs dependent on driving as a profession:** Although CAM technology is expected to create economic growth and many new jobs in several sectors of the 5G/CAM ecosystem, many people such as taxi drivers, bus drivers, HGV drivers, delivery drivers, and others whose profession has traditionally been relying on the physical driving of vehicles, fear that fully autonomous vehicles will replace workers in these sectors. Many petitions and protests have been organised globally by trade unions and organised workforces. These are also sometimes joined by people who see driving as a passion and not as necessity, and fear that their joy in non-autonomous driving will be affected significantly. **Distrust in 5G technology:** The growing anti-5G sentiment throughout Europe can hinder the swift deployment of 5G/CAM solutions. Updated figures from GSMA (October 2020) show 221 attacks on telecom infrastructure by anti-5G groups globally. The intervention of the EC to mitigate these sentiments has been requested by a group of EU Member States in October 2020. [30][31] **Continuation of service for used car owners:** A significant proportion of private car owners purchase used cars. To avoid those customers being 'locked in' to pricing models developed for new car buyers it will be necessary to enable them to choose their infrastructure provider, (something that the original owner may also wish to do). This will avoid a semi-monopolistic system where only one provider can be used for a particular brand of car. The vehicle must enable a choice of provider, fostering competition and differentiation in the service available, and encouraging uptake by second, third and subsequent vehicle owners.
Technological	**Disparities in the capabilities of EU Member States:** EU Member States do not share the same adoption rate when it comes to technical innovations. Other

	disparities such as in the level of automation in ITS centres across the EU, local road infrastructure and GDP per capita can affect the adoption of 5G-CAM. **Ethical and legal issues in the development of crash algorithms:** Autonomous vehicles of level 4 and level 5 will inevitably need to make ethically difficult decisions in the event of an accident. For example, the majority of people wouldn't choose to buy a vehicle that doesn't prioritise the safety of the driver/passenger, but a crash algorithm that prioritises the safety of the driver or passenger may opt to crash the vehicle into pedestrians or bicycles instead of a wall. Developing ethical and legal crash algorithms that are widely accepted by the society is a complex task and is still unclear what the recommended approach is. **Stifling of Consumer Choice with Different Technology:** Currently most participants active in the 5G CAM ecosystem seem to expect that vehicles will have one OBU connected to one physical 5G cellular infrastructure. However, it is unlikely that all operators active in the "5G infrastructure layer" in a geography will invest in the same areas, at the same pace and using the same type of infrastructure and frequency bands. The resulting differences between the 5G infrastructure networks will have different impacts on each 5G CAM service. Infrastructure A may be superior for one use case (eg. Vehicle Guidance) while for another use case (e.g. In car infotainment) Infrastructure B may the best choice. Even if Infrastructure A is equally well suited for the other use case (In car infotainment), there may be differences in the service layer. For example, MNO/MVNO B, which exclusively uses infrastructure B, may offer a premium content (e.g. Premium Sports channel) at an exclusive basis or at a beneficial price. In both situations, the customer needs to make a choice (e.g. Between "The Best Vehicle Guidance" and "The best in car infotainment"). **System security:** Protection of user data is one issue that has been covered elsewhere however there is concern about the potential for hacking the complex systems that govern 5G-CAM. Public perception, whether justified or not, is that it might be possible for malicious actors to interfere with the safe operation of a 5G-CAM network, causing accidents and incovenience. A joined up regulatory framework that operates across national boudaries would go some way to allaying those fears.
Legal	**Unclear how to ensure protection of Consumer Rights:** it is highly important to protect Consumer Rights with specific guidelines and legislation. Many issues could arise, not only creating the potential for unfair business practices, but also

	creating liabilities for companies in the 5G-CAM supply chain. The introduction of M2M communications and its implications on cross-border scenarios requires clarifications or even possibly new legislation to ensure fair roaming charges for drivers, fair use policies, clarification on taxation policies, portability of data to avoid customer lock-in conditions, potential portability of numbering resources etc. **Difficulty in determining accountability in cases of accidents:** There is lack of a cohesive approach about how insurance companies will deal with accidents and define culpability for the different levels of accountability. This issue becomes particularly complex when one considers the various levels of vehicle automation, the different laws and legal approaches between countries, and the different policies between insurance companies. As a result, some OEMs have been slow, or even reluctant, to roll out connected and automated vehicles with level of automation above 3, so that they don't take full responsibility and the accountability remains with the driver. Similarly, MNOs are looking into the potential liability they may be incurring as vehicles become more dependent on the connectivity for performing their driving tasks in a safe way. As older generations of wireless networks were always based on a best-effort reliability and availability, 5G will necessitate a more pro-active role of the MNO in order to provide the guarantees required whilst at the same time assuming an inherent liability associated with non-performance. **Clear Standardization and Legislation Roadmap:** 5G deployment for Autonomous driving in the Eu has been lacking a clear roadmap and a framework that allow companies in the Eu to develop more standardization and testing of vehicles and functions in the european union. Due to this situation, stakeholders in EU are not able to define their next steps about 5G-CAM. Currently the USA and China has this framework develop and testing and validation of some of these key features has been developed as the legal and standardization framework has been putting in place.
Environmental	**Development of environmentally-sustainable but also economically-affordable vehicles:** Low emissions of connected and autonomous vehicles is a requirement of particular importance as it is likely that total travel distances and times will increase as a result of improved comfort for commuters. Manufacturers of connected and autonomous vehicles are obliged, by increasingly strict Government regulations and societal trends worldwide, to keep the environmental pollution footprint of their vehicles to as low levels as possible. On the other hand, the costs need to be kept low too in order to ensure

	that the autonomous vehicles are affordable for the mass market and are not only a luxurious product for the rich and privileged consumers. Car-sharing and ride-hailing will undoubtedly assist significantly in reducing the pollution generated by cars when level 4 and level 5 autonomous vehicles are widely available, but this will require the society to alter their mind-set with regards to car ownership. **Differences in geographical context:** The environments in which 5G for CAM can realize potential benefits differ very strongly across the entire EU-geography. Countries (or regions within a country) with a high population density may require a different deployment strategy compared to less dense areas. Similarly, the deployment in urbanised areas will require a different approch compared to more rural areas or mountainside border crossing points vs. plain border crossing points and hard borders like Greece – Turkey vs soft borders like Spain – Portugal. In order to avoid social exclusion, all circumstances will need to be considered but a one-size-fits-all solution is extremely hard (and costly) to achieve.

6. RECOMMENDATIONS

6.1. Recommendations for the Cross-Border Corridors

A strategic plan for the development of 5G for CAM in the Cross-Border Corridors, entails significant analysis on the factors that shape the business environment and facilitate or prohibit market entry or additional investment.

Create a Cost Benefit Analysis (CBA) for the critical corridors (in order to jumpstart 5G for CAM service adoption): In order to execute on the existing plans regarding the first critical corridors where 5G CAM services can be used, some public investment is necessary for those locations where private investment alone is not sufficient (or not soon enough). In order to create a CBA for such public investment, policy makers need to define inputs. For this to happen, ecosystem participants must provide policy makers with guidance on how certain parameters of policy requirements affect the necessary investment. This is an iterative process which requires investment of time and resources from all participants.

Perform a VRIO analysis for potential products and offerings, targeting the Cross Border Corridor environment and its specificities: Technical improvements are not sufficient to ensure the high innovation potential coming from the 5G-MOBIX CBC trials or the viability of future products and offerings coming from the CBCs. VRIO analysis assesses the (V)alue, (R)arity, (I)mitability, (O)rganisational support associated with a capability, in order to estimate its effect on the creation of competitive advantage. VRIO poses four important questions: (a) Is the offering **Valuable**? (b) Is it **Rare**? (c) Is it hard to **Imitate**? (d) Is there **Organisational** support to ensure its exploitation? When all requirements are met, long-term competitive advantages are created.

Perform large-scale validation to increase trust in the research results: Large scale data pilots are necessary to address the technology's readiness in near operational environments. Liaison with similar projects such as 5G CroCo and 5G CARMEN and exchange of information can strengthen our understanding of the effects of a growing number of connected vehicle when it comes to data volume, latency, reliability, availability etc. The availability of rigorous research results proving the viability of 5G for CAM (and their wide dissemination) can go a long way towards increasing trust in the technology, both for investors and for the buyers of 5G CAM services.

Regional market analysis should be performed to assess the potential for growth of 5G for CAM in the specific countries (e.g. Compound Annual Growth Rate). Additional analysis should be made to assess what is the buying power for 5G CAM in the area. Furthermore, there needs to be an assessment of the most sought-out services by the drivers in the region, as such selections might not be universal across the EU. Deployment plans can then be finetuned to the connectivity and latency requirements for the required services, optimising the potential for adoption of 5G CAM as well as the placement of investment in the Cross-Border Corridors.

6.2. Cooperation Enablers

Based on the barrier analysis already provided within Section 5, it is important to identify technologies, policies, and cooperation enablers that can help alleviate their negative impacts and act as business catalysts that boost 5G and CAM. The purpose of these recommendations is to increase EU competitiveness in CAM. In order to bridge the technological disparities among Member States, it is important to attract innovation and investment to increase the adoption rate of new technologies. The shaping of common policies in the EU as well as the shaping of policies on Member State level is a crucial factor to enable the creation of 5G CAM innovation hubs.

6.2.1. Upgrade Skills & Create a Highly Specialised Workforce

Although there is a large number of professionals active in the 5G, CAM, big data, cloud computing, computer vision, embedded devices, artificial intelligence and automotive markets, and EU academic and research institutes heavily invest in their education, the realization of the 5G-enabled CAM vision requires continuous education of young professionals with additional focus on the specificities of 5G and CAM. In order to alleviate the impact of the technical disparities among member states, there needs to be invested effort to improve education. Another important aspect is the upgrade of current skills in the existing workforce. For example, the increased automation in ITS centers requires personnel re-training. It is important to note that at the level of publicly funded projects, dissemination and communication activities are instrumental and should be intensified. The inclusion of academic and research partners in 5G CAM projects ensures that these activities will reach a large audience, with additional focus on students, early stage researchers and young professionals in the beginning of their careers. Commercial partners need to ensure that their knowledge reaches their employees and clients. The road-mapping activities, research papers, evidence-based best practices and recommendations to be published by many projects, can be considered a further step towards the effective dissemination of specialized knowledge.

6.2.2. Fostering Job Creation And Entrepreneurship

At the Member State level, a strong connection among high-tier research and academic establishments and the workforce should be established. Legislation could foster the creation of start-ups by ensuring tax breaks and protecting licensed or patented intellectual property. The Digital Single Market policies of the EU are a stepping stone for the creation of a viable ecosystem of highly innovative start-ups, however there are blocking factors when it comes to 5G/CAM. The creation of a data-driven economy where third parties can create added-value services on big data in the area of transport can greatly benefit from 5G CAM assuming that a level of protection personal data can always be enforced.

6.2.3. Creating a Data Economy

5G-enabled CAM in conjunction with smart infrastructures has the capacity to transform the economy by enabling third parties to create new data-driven services. The main challenge is to create ethical data proxies that can provide sanitised data to any interested third-party, in order to minimise risks to citizens' digital

rights and ensure GDPR compliance. This would be a key step to enable a data economy. The creation of industry-standard data formats is necessary as it would contribute to data interoperability as well as the creation of anonymization and sanitisation services that would facilitate multimodal transportation, providing a complete travel experience for passengers.

6.2.4. Legislating for the Future and Creating Clear Liability Borders

5G for CAM creates a complex ecosystem of actors, creating a web of B2B and B2C relations. There need to be clear definition of fair use policies, penalisation procedures, liability borders, consumer rights protections, as well as a clear understanding on the effects of such policies to billing, fees and taxation. Special attention should be paid to cross-border harmonisation of legislation linked to 5G for/and CAM solutions, to ensure a homogenous deployment throughout the EU and the maximum protection of EU citizens' rights.

6.2.5. Investment On Better Infrastructure Can Improve EU And Regional Competitiveness

Road infrastructure needs to be upgraded to meet the demands of the future, to ensure efficient and sustainable mobility and logistics, to enable digital services and to remain resilient to the effects of climate change and resource scarcity. Increasing EU Competitiveness needs to include investment, cost, price, and innovation in road infrastructure and traffic management and must satisfy industry and public authorities, as well as consumers/drivers in order to be sustainable. On regional level, investments in transport infrastructure have been shown to correlate with competitiveness, through enhanced accessibility of services and transport endowment, lower office rental prices, reduction in emissions and noise level, increased labour supply and productivity, increased new business density, increased number of enterprises in certain sectors, growth of FDI inflows, increased export of goods and services, etc. Many CAM-related services are also at the core of smart cities operational concepts which also correlate with regional competitiveness. Better infrastructure is especially needed both in remote regions, to help closing the economic, social and productivity gaps, and cross-border regions, to ensure the swift and safe deployment of 5G for/and CAM autonomous features of CAVs.

6.2.6. Investment on Software Architectures, SOC and AI Development

These areas are the major investment that the leading countries have made to win the race of 5G and autonomy. The EU must invest heavily in the development and promotion of more FAB development, AI and software otherwise the Chinese and American companies would dominate these areas and the stakeholders in Europe would be fully dependent on them to develop any autonomous vehicle and 5G hardware products. That would put Europe and the industrial ecosystems in a difficult positions as all the IP and the owner of the value add business for the European economy would be outside of the EU.

6.2.7. Aligning with the EU Digital Single Market

The Digital Single Market Strategy is built on three main pillars:

- **Pillar 1 - Access:** In the context of 5G-enabled CAM, this means better access for consumers and businesses to 5G, Automated Vehicles and CAM services across Europe. Novel services are usually adopted by larger organisations, working their way down to smaller organisations. SMEs/MEs have much the same transportation and supply chain needs and will be considerably assisted by the new services.
- **Pillar 2 - Environment:** The EU needs to create the right conditions and a level playing field for digital networks and innovative services to flourish. 5G and Edge computing will ease the communication and data path for CAM services. Seeing it in a wider context, an entirely new "data value chain" can evolve, comprising firms that support data collection, the production of insights from data, data storage, analysis and modelling.
- **Pillar 3 - Economy & Society:** In order to maximize the growth potential of the digital economy, CAM need to evolve into network solutions where you are trying to connect all actors on the network to improve collaboration and to get more access to data. For example, logistics companies want to give real time load/order information to customers because customers increasingly have an Amazon-type mind-set whereby if they order a book online, they can track where it is. Data from multiple CAM services can be aggregated and actors can start to provide analytics and operational insight on top of that data. Access to data can have a positive impact in multiple industries and can help them improve their provided services and support their efficiency. Businesses that build digital platforms on CAM-related data have a major advantage in the data-driven economy and could be motivated to invest in 5G-CAM.

6.2.8. Determine the Best Use of Public Funds for 5G Infrastructure

When it comes to private (unaided) investment in the 5G infrastructure necessary for 5G CAM services, roads can be divided (albeit somewhat artificially, as reality is more a continuum) into four categories:

1) In many roads (e.g. Urban areas) serving existing eMBB customers is a sufficient reason to heavily invest in 5G infrastructure (in extremis: even without expected revenue from 5G CAM services, the investment would still be made).

2) In other roads (e.g. Highways trough sparsely populated areas) investments in 5G infrastructure will be made, but at least initially there may be limits to some 5G CAM services:

- 5G coverage may not be continuous in some road segments
- 5G coverage may be continuous, but some segments not have the capacity for the CAM services that require most bandwidth (e.g. when a part of the road only has 5G coverage in a lower band, such as the 700MHz band)

- 5G capacity for all 5G CAM services may exist in normal traffic conditions, but may not be sufficient for more intense traffic scenarios, which incidentally may be when such services would provide most value (e.g. "Black Saturday" when many people travel to a holiday destination on the same day)

3) In road sections that cross a border, service continuity for 5G-CAM services that require low latencies will not be available initially in most cross borders. Once there is continuous 5G-URLLC coverage of throughout the country up to the border, then the next logical next step for MNOs will be to implement cross border service continuity.

4) Finally, for some roads (e.g. in remote rural areas) the business case for investment in 5G infrastructure is unclear and such investments may be delayed until more data has become available.

Undoubtedly aware of this reality, the EU has already signaled its intention to stimulate the development of 5G infrastructure covering some roads / corridors. Arguably, this was the most important step, but in order to implement such a plan a CBA should be made in order to decide where the benefits for the public good justify the usage of public funds to stimulate additional investment in 5G infrastructure. In order to make such CBA some inputs are necessary. Some of these inputs are somewhat objective (e.g. a table with the % of vehicles capable of using a certain CAM service per year). Other inputs represent implicit policy decisions (e.g. Is it acceptable that there is not enough capacity to provide all 5G CAM services when there is a rare traffic jam on a highway in a rural area? If it is not acceptable, this will greatly raise the necessary funds for 5G infrastructure. If it is acceptable, a selection of the most critical 5G CAM must be made).
This leads to a circular situation, which could become a barrier:

- The number of scenarios is nearly unlimited and only a limited number of CBA scenarios can be calculated with the necessary detail. Therefore, policy makers need to first define the inputs.
- In order to define sensible inputs, policy makers need to have some visibility on the respective cost implications. Therefore, participants of the 5G CAM ecosystem should first provide a CBA.

6.2.9. Cooperate for 5G Deployment

When a cross-border infrastructure is planned, it must be decided how the costs, benefits and responsibilities will be divided between the respective parties. Road operators, road authorities and mobile network operators should collaborate to create synergies for connectivity deployment along CAM corridors and cross borders, working together to develop end-to-end solutions for future mobility and transportation services.

There is a need for appropriate cooperation models to enable the initial deployment of 5G highways corridors. Infrastructure sharing will be a key lever to reduce cost and make 5G deployments feasible, accelerating private investments in 5G infrastructure along highways and cross borders. Providing the conditions for site sharing (towers, ...) and reuse of the existing transmission infrastructure along the

roads, most of the times owned by the road operators, will be an important way to reduce time to market and investment, facilitating the installation of the necessary 5G infrastructure.

6.2.10. Guaranteeing consumer choice

It is one thing when a consumer buys a particular vehicle which uses a cellular service from a particular MNO in order to provide services that are integral to the usage of the vehicle. It is another thing when the cellular service from this particular MNO limits the choice of which additional services can be used in the vehicle. Consumers should be free to choose which MNO/MVNO they want to use for such services (e.g. Infotainment)

6.2.11. Having Open Discussions About Machine Ethics

There are cases where a driver is required to make a moral choice, e.g. swerve and risk damage to the vehicle instead of injuring a pedestrian. A recent survey from MIT [32] showed that moral choices when driving are not universal. Although the EU has provided guidelines for Trustworthy and Ethical AI, there needs to be a comprehensive framework for the ethical programming of automated vehicles, and a close inspection of the moral choices involved in driving. Having moral safeguards can increase the public's trust in connected, cooperative and automated mobility and may influence the uptake of a novel and disruptive technology [33].

6.2.12. Improve Communication to the EU Citizens

To ensure a quick uptake of the 5G for/and CAM solutions in the European Union, citizens need to be informed on the advantage, safety and opportunities of connected and automated driving. Due to the growing fake news campaign against 5G technologies and the distrust for highly automated solutions, citizens need to have access to relevant trusted data, and need to be protected from misinformation. Although in the long run users will choose CAVs, preventing misinformation at this early stage could help ease the trust barrier from consumers.

7. CONCLUSION

This document describes in detail possible new business models that could come with 5G-CAM services. Document has been created also with examination of other global projects that are also contains business related deliverables. These projects can be found in "*D6.1 - Plan and preliminary report on the deployment options for 5G technologies for CAM*". Some of them have not publish the related deliverables, yet, but for second version of this deliverable, D6.6, we will follow closely to check what are the ideas of other projects and try to find the most suitable business model strategy. In the same deliverable, a general 5G-CAM deployment cost study has been created together with D6.2 partners. Section 6 - Recommendations, has been fed also other WP6 deliverables, i.e. D6.1, D6.3 and D6.4. PESTLE approach in Section 5, has been used as one reference for D6.1, D6.3 and D6.4 about current technical, standardization and legalization wise deployment gaps.

As methodology, after reviewing other projects, we determined to use both business model canvas and value network model. Business model canvas provides us key pillars in a business model i.e. key resources, key partners, key activities, customer segments, customer relationship and channels, value propositions, customer relations, revenue streams and cost structure of a business. On the other hand, value network model provides us business related connection between all stakeholders i.e. money and/or service sharing.

For detail business model analysis for every cross-border user story, we exploit these two tools and explained user story specific possible business scenarios and relationships. It is obvious that there is not only one method to share revenue or deploy 5G-CAM service on a border road. Contracts between stakeholders will determine revenue and service deployment. According to our study, stakeholder motivation points are listed and they are mainly around increasing market share and providing more elite services. Besides, stakeholders will face many struggles to develop, deploy 5G-CAM services and that could hold them back at the beginning of the technology readiness day. Business related gaps would be the main showstopper for 5G-CAM services, and they are listed in detail with the help of the PESTLE approach. We see that governmental bodies need to take action as soon as possible to solve main business gaps that are listed in section 5. After solving main gaps, motivation of the stakeholders could be increase. Possible solution to defined gaps also listed in recommendations section.

According to prepared questionnaires in D6.2, we will gather answers from various stakeholders in and out of our consortia. After that, we will compere these answers with our initial study in D6.2 and update required sections in D6.6. Additionally, we plan to organize various workshops with other ICT-18 and 53 projects to increase common understanding about new possible business model opportunities and how to foster them. These workshops could be enlarged with public attendance to increase awareness more. Results of these workshops will be also reflected in D6.6.

First workshop has been held on 26 March 2021, that is named "Workshop on the Deployment Methodology of 5G for CAM on Cross-Border Corridors " [34]. In this workshop, business model has been pointed as one

of the biggest challenge to realize 5G-CAM services and need of business model harmonization between stakeholders stated. Additionally, complexity of value network model has been discussed. Value network models become more complex with 5G-CAM. 5G for CAM application development needs to be more transparent for developers and if there are too many degrees of freedom among institutions, operators etc., it will be extremely complex and in the end, there is no guarantee that connectivity will be seamless. As recommendation, a central power such as national regulatory authorities have to control on rule of interactions and needs to start simply and reduce the number of interface to make interactions between stakeholders more manageable.

Furthermore, to foster innovation in addressing technical challenges, 5G-MOBIX will host a hackathon that will ask innovators to provide their solutions for one of the proposed technical challenges (orchestration and resource allocation, billing for CAM, and geodriven discovery). This one-day event that will be coordinated with WP7 leaders, and will aim at collecting innovative solutions for the proposed topics, consider innovators' new business models, and accelerate future innovation with new solutions. Other benefits will be the establishment of possible cooperations with project partners and ideas for new projects, the stimulation of local innovation and the gathering of more data from external stakeholders (innovators). To increase awareness, the winners will be invited to the ITS World Congress in October, and the results of the hackathon will be included in D6.6 findings.

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ANNEXES

Annex 1 – QUESTIONNAIRES

Questionnaires cover page and MNO related questionnaire are listed in sections below. We created questionnaires for also vehicle OEMs, end customers, road operators, cloud and MEC providers, network equipment providers and RSU providers. However, since other questionnaires of stakeholders are similar to MNO questionnaires, we placed only MNO questionnaire below.

Cover Page of Questionnaires:

About 5G-MOBIX

5G-MOBIX aims to showcase the added value of 5G technology for advanced Connected and Automated Mobility (CAM) use case categories and validate the viability of the technology to bring automated driving to the next level of vehicle automation (defined by the Society of Automotive Engineers (SAE) as Level 4 and above). To do this, 5G-MOBIX plans to demonstrate the potential of different 5G features on real European roads and highways and create and use sustainable business models to develop 5G corridors. 5G-MOBIX also utilizes and upgrades existing key assets (infrastructure, vehicles, components), and ensures the smooth operation of 5G within a heterogeneous environment comprised of multiple incumbent technologies such as ITS-G5 and C-V2X. 5G-MOBIX executes CAM trials along cross-border (x-border) and local corridors using 5G core technological innovations to qualify the 5G infrastructure and evaluate its benefits in the CAM context. The project also defines deployment scenarios and serves to identify and respond to standardisation and spectrum gaps. 5G-MOBIX consists of 55 partners from 10 countries from the EU and Turkey representing European ICT industry and cooperates closely with South Korea and China to bring forward advances in 5G for CAM. It is coordinated by ERTICO-ITS Europe.

Funding

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Scope and intended audience

Task 6.2 is about the analysis business model analysis of current market and future new business opportunities. We are defining business models for a significant group of 5G-CAM services use cases, to develop and evaluate new business opportunities for CAM and 5G, financing schemes, revenue allocation and procurement models. The following questionnaire is a research instrument and it will help to know what current stakeholders think about those services. The questionnaire explores the different areas and elements defining the use cases' business models. The results will provide feedback to refine the business models already outlined by 5G MOBIX project partners. The potential stakeholders have been grouped in

several categories including road operators, OEMs, MNOs, network equipment providers, RSU providers, cloud/MEC providers and end users/customers.

The results will be used internally in the elaboration of the deliverable D6.2 of 5GMOBIX which will be made publicly available in the project website, www.5g-mobix.com.

Benefits for participation

The results of this questionnaire will be provided to you via email if you leave your e-mail address at the end of the survey. In this case your address will be stored and used separated from your answers. The results will also be published in on the 5G-MOBIX website.
Your name or your organization name will not be shared in deliverable or in any other public area.

Contact

For more information about the project, you may contact the Project Coordinator Coen Bresser via email: c.bresser@mail.ertico.com
For more information on the questionnaire and your rights as a data subject, you may contact via email: Tahir Sari (Task Leader) tsari1@ford.com.tr, Luxshiya Ariyanayagam luxshiya.ariyanayagam@iis.fraunhofer.de or Maija Federley maija.federley@vtt.fi

1. MNO Questionnaire:

The emergence and rise of connected automated vehicle refers to both technological and industrial developments; in progressive yet rapid stages, it will become possible to safely confer more and more driving responsibilities to automated systems in road transport. These innovations involve personal vehicles, but also public transport and logistics/freight vehicles.
The objective is to take full advantage of technology's potential to deliver a renewed transport and mobility system with the following 5G-CAM service use case categories:

- **Advanced Driving**
  Advanced Driving enables semi-automated or fully-automated driving. Longer inter-vehicle distance is assumed. Each vehicle and/or RSU shares data obtained from its local sensors with vehicles in proximity, thus allowing vehicles to coordinate their trajectories or maneuvers. In addition, each vehicle shares its driving intention with vehicles in proximity. The benefits of this use case group are safer traveling, collision avoidance, and improved traffic efficiency.

- **Vehicles Platooning**
  Vehicles Platooning enables the vehicles to dynamically form a group travelling together. All the vehicles in the platoon receive periodic data from the leading vehicle, in order to carry on platoon operations. This information allows the distance between vehicles to become extremely small, i.e., the

gap distance translated to time can be very low (sub second). Platooning applications may allow the vehicles following to be autonomously driven.

- **Extended Sensors**
  Extended Sensors enables the exchange of raw or processed data gathered through local sensors or live video data among vehicles, RSUs, devices of pedestrians and V2X application servers. The vehicles can enhance the perception of their environment beyond what their own sensors can detect and have a more holistic view of the local situation.

- **Remote Driving**
  Remote Driving enables a remote driver or a V2X application to operate a remote vehicle for those passengers who cannot drive themselves or a remote vehicle located in dangerous environments. For a case where variation is limited and routes are predictable, such as public transportation, driving based on cloud computing can be used. In addition, access to cloud-based back-end service platform can be considered for this use case group.

- **Vehicle Quality of Service Support**
  Vehicle quality of service support enables a V2X application to be timely notified of expected or estimated change of quality of service before actual change occurs and to enable the 3GPP System to modify the quality of service in line with V2X application's quality of service needs. Based on the quality of service information, the V2X application can adapt behaviour to 3GPP System's conditions. The benefits of this use case group are offerings of smoother user experience of service.

The entire mobility and transport ecosystem will need to adapt to these upcoming changes, therefore we are interested in how each member of the potential 5G-CAM ecosystem operates.

PROPOSED QUESTIONS

1. Value Proposition

In regard to the development and deployment of connected automated vehicles, we see the following value propositions and business opportunities that may be relevant for MNOs:

1. **Aftermarket and tethered services models:**
   The aftermarket and tethered services models, via data services subscriptions, feature smart car devices and applications either embedded in a vehicle at the time of its manufacture or installed as an aftermarket product, creating opportunities for MNOs at different levels of the value chain. All three models represent opportunities for mobile network operators (MNOs), but ultimately each MNO must adopt a business model meeting the needs and requirements of its customer base.

2. **Vehicle diagnostics**:
   MNOs could provide with insurance providers and offer individualized insurance policies, where the connected car system offers features such as a safety score based on driving behaviour, vehicle diagnostics, emergency assistance. By offering these services, MNOs are able to develop data monetization solutions for fleets and insurance carriers in a wider ecosystem.

3. **Improved Road Safety & Efficient Traffic Management:**
   By cooperating with Road Operators, MNOs are able to approach the role of consultant or data provider for Efficient Traffic Management and Improved Road Safety. From a data point of view, vehicles' continuous broadcast of their location, speed, and other data would give cities' traffic management system real time data on traffic conditions that are more detailed and accurate than data available today. It will also enable the establishment of more efficient plans for road maintenance and traffic management.

1.1. What is the most valuable border crossing 5G-CAM service for your organization? (Please select one)

- Advanced Driving ☐
- Vehicles Platooning ☐
- Extended Sensors ☐
- Remote driving ☐
- Vehicles Quality of Service Support ☐

Please explain, why:

1.2. Please rate the value propositions for each 5G-CAM service category in regard to their relevance for your organisation, giving the most important value proposition grade 1, for the second grade 2, for the third grade 3 etc. (grades "1…7", or "0" if not relevant at all, can be used to as many as necessary)

Advanced Driving

Improve market share	_____	Improve quality of service	_____
New customers	_____	Reduce investment costs	_____
New (data-based) services	_____	Security	_____
Reliability	_____	Energy efficiency	_____

Vehicles Platooning

Improve market share	_____	Improve quality of service	_____
New customers	_____	Reduce investment costs	_____
New (data-based) services	_____	Security	_____
Reliability	_____	Energy efficiency	_____

Extended Sensors

Improve market share	_____	Improve quality of service	_____
New customers	_____	Reduce investment costs	_____
New (data-based) services	_____	Security	_____
Reliability	_____	Energy efficiency	_____

Remote driving

Improve market share	_____	Improve quality of service	_____
New customers	_____	Reduce investment costs	_____
New (data-based) services	_____	Security	_____
Reliability	_____	Energy efficiency	_____

Vehicles Quality of Service Support

Improve market share	_____	Improve quality of service	_____
New customers	_____	Reduce investment costs	_____
New (data-based) services	_____	Security	_____
Reliability	_____	Energy efficiency	_____

1.3. Please list further values that you expect through deployment of 5G-CAM services and rate them

Other kind of values:	Neutral		Somewhat important		Very important
_____	☐	☐	☐	☐	☐
_____	☐	☐	☐	☐	☐
_____	☐	☐	☐	☐	☐
_____	☐	☐	☐	☐	☐

2. Key Resources

2.1 Where is the focus of your portfolio? Please describe your core operations:

2.2 Please estimate how difficult the integration of 5G for the following CAM services is in your operations, especially while border crossing?

	Very difficult		Somewhat difficult		Not difficult at all
Advanced Driving	☐	☐	☐	☐	☐
Vehicles Platooning	☐	☐	☐	☐	☐
Extended Sensors	☐	☐	☐	☐	☐
Remote driving	☐	☐	☐	☐	☐
Vehicles Quality of Service Support	☐	☐	☐	☐	☐

2.3 In what areas is further expertise and/or substantial progress necessary for your organization to enable deployment of the following 5G-CAM services?
(Please tick the crucial areas)

	Technology	Legislation	Procurement	Revenue share	Data sharing solutions	Other, please specify
Advanced Driving	☐	☐	☐	☐	☐	_____
Vehicles Platooning	☐	☐	☐	☐	☐	_____
Extended Sensors	☐	☐	☐	☐	☐	_____
Remote driving	☐	☐	☐	☐	☐	_____
Vehicles Quality of Service Support	☐	☐	☐	☐	☐	_____

2.4 How important is the enablement of border crossing 5G-CAM services to your organisation?

Not at all important		Somewhat important		Very important
☐	☐	☐	☐	☐

3. Customer Segments

3.1 Please specify the respective target groups in reference to the use cases

	Authority	Vehicle drivers	Fleet owners	Vehicle OEMs	Road operators	Other, please specify
Advanced Driving	☐	☐	☐	☐	☐	_____
Vehicles Platooning	☐	☐	☐	☐	☐	_____
Extended Sensors	☐	☐	☐	☐	☐	_____
Remote driving	☐	☐	☐	☐	☐	_____
Vehicles Quality of Service Support	☐	☐	☐	☐	☐	_____

4. Customer Relationships

Please rate the changes that the mentioned 5G-CAM services will bring to your relationship with your customers:

	Completely				No changes
Advanced Driving	☐	☐	☐	☐	☐
Vehicles Platooning	☐	☐	☐	☐	☐
Extended Sensors	☐	☐	☐	☐	☐
Remote driving	☐	☐	☐	☐	☐
Vehicles Quality of Service Support	☐	☐	☐	☐	☐

5. Key Partners

5.1 What partnerships are essential for you as a MNO to support deployment of border crossing 5G-CAM services?
Please tick the required partners and **give an order of priority** from 1 (the most important partner) to the number of your total needed partners (the least important partner).

Partnerships	This partner is needed	Ranking (1 to x)
Government		
Fleet Owner		
OEM		
OBU Provider		
Cloud/ MEC Provider		
Road Operator		
Network Equipment Provider		
RSU Provider		
Software solution/CAM service provider		
Other, please specify:		

5.1 What steps are needed to form the cooperation between the above-mentioned partners?

	Technology	Legislation	Procurement	Revenue share	Other, please specify
Government	☐	☐	☐	☐	_____
Fleet Owner	☐	☐	☐	☐	_____
OEM	☐	☐	☐	☐	_____
OBU provider	☐	☐	☐	☐	_____
Cloud/ MEC Provider	☐	☐	☐	☐	_____
Road Operator	☐	☐	☐	☐	_____
Network Equipment Provider	☐	☐	☐	☐	_____
RSU Provider	☐	☐	☐	☐	_____
Software solution/ CAM service provider	☐	☐	☐	☐	_____
(Other, please specify _____)	☐	☐	☐	☐	_____

6. Obstacles and Changes

6.1 What are the most topical challenges in your operations as MNO?

- ☐ MNO handover
- ☐ manoeuvre coordination messages from a road infrastructure
- ☐ Cross border operations
- ☐ Connection loss while cross boarder operations
- ☐ Roaming handover
- ☐ Latency
- ☐ Low coverage areas for 5G-CAM applications
- ☐ Change of IP stack when switching networks
- ☐ Data loss while crossing boarders
- ☐ Accuracy of geo- positioning (GNSS)
- ☐ Network QoS when switching MNOs
- ☐ Data and application level protocol interoperability
- ☐ Geo-constrained information dissemination scheme
- ☐ Law enforcement entities
- ☐ Automation
- ☐ RAN (Radio Access Network) optimisation
- ☐ Security
- ☐ Standardization
- ☐ Other, please specify? _____

6.2. Which are from your perspective as an expert the main challenges related to the implementation of the introduced border crossing services?

6.3. What kinds of challenges do you see related to liability for the safety-related issues?

6.4. Please describe legal terms and other conditions that have to be established, so that you can enable 5G-CAM services, especially while border crossing:

The following questions in the section below, aim to obtain financial information. Due to the sensitive nature of the questions, they are not mandatory to answer and we fully understand if you hesitate to give any statements. However, by providing even some indicative information you would help us to precise our research results.

7. Cost Structure

7.1 Please estimate the expected increase in the following cost categories for supporting deployment of 5G-CAM services for the next 10 years:

	Negligible	Minor	Moderate	Significant	Major
Staff	[ ]	[ ]	[ ]	[ ]	[ ]
Equipment and materials, including maintenance costs	[ ]	[ ]	[ ]	[ ]	[ ]
Consulting/External Services	[ ]	[ ]	[ ]	[ ]	[ ]
Network/Cloud/Hosting	[ ]	[ ]	[ ]	[ ]	[ ]
Patent/Sublicense	[ ]	[ ]	[ ]	[ ]	[ ]
Others (please specify)	[ ]	[ ]	[ ]	[ ]	[ ]

8. Willingness to pay

8.1.How likely is your organisation to invest in supporting 5G-CAM services during the next 10 years?

Not at all likely		Somewhat likely		Already under preparation
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐

Advanced Driving
Vehicles Platooning
Extended Sensors
Remote driving
Vehicles Quality of Service Support

9. Revenue Streams

9.1. Please describe your each current revenue stream in the context of vehicles, infrastructure, logistics and cross-border operations:

9.2. Please evaluate expected impact in revenue for your organisation as a result of deployment of 5G for the following CAM services for the next 10 years:

	Impact Level:				
	Negligible	Minor	Moderate	Significant	Severe
Advanced Driving					
Vehicles Platooning					
Extended Sensors					
Remote driving					
Vehicles Quality of Service Support					

9.3. Please describe further opportunities to generate extra income or cost savings with 5G-CAM services which you can identify for the operations of your organisation or in the partner network:

10. Please write here if you have any other comments or suggestions with regard to business perspectives on border crossing 5G-CAM services:

THANK YOU FOR YOUR VALUABLE INPUTS FOR OUR RESEARCH!

Annex 2 – PRESENTATION

An example page for Platooning User Story can be seen below. The all user stories has been elaborated in this presentation to help survey attendants, if it is needed.