5GMOBIX

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

D6.6

Final report on the business models for cross border 5G deployment enabling CAM

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Control sheet

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ABBREVIATIONS

Abbreviation	Definition
5GAA	5G Automotive Association
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

NEP	Network Equipment Provider
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 "D6.6 – Final report on the business models for cross border 5G deployment enabling CAM". The deliverable's purpose is to provide an update of the work done in task T6.2, reported in the deliverable "D6.2 – Preliminary report on the business models for cross border 5G deployment enabling CAM" which was aiming to define 5G for CAM stakeholders, stakeholder interactions and their motivations. Main 5G for CAM stakeholders are listed below:

- MNOs,
- Automotive OEMs,
- SW / Service providers,
- MNO vendors,
- OBU/RSU providers,
- Road operators,
- C-ITS centres,
- R&D institutions,
- End users (individuals, drivers)

In D6.2, business model of all 5G-MOBIX user stories was analysed by using the business model canvas tool. Business related gaps were identified, and recommendations were given to solve the defined gaps. Additionally, a set of questionnaires was prepared in D6.2 to use in this deliverable D6.6, to understand what the 5G for CAM business model understanding according to stakeholders.

In section 3 of this deliverable, customer exploration map tool is used to help 5G for CAM stakeholders to identify problems and challenges of their customer, user or stakeholder and to explore possible solutions for identified problems. To have such study, we collected answers from expert 5G-MOBIX partners. According to MNOs, the biggest challenge on 5G-CAM deployment is to try and find justification for the capital expenditure associated with the network rollout to support all these 5G-CAM functionalities. The biggest unknown for MNOs when it comes to 5G-CAM to leverage their network infrastructure is the unknown customer. Where can the MNO compensate the cost of increasing coverage and capacity. For Automotive OEMs, the main challenge is the standardization of an 5G-CAM application. OEMs know how to implement standardized and regulative applications such as AEBS (Advanced Emergency Braking System), LDWS (Lane Departure Warning System), but it is unknown to them how to implement a safe, secure, and interoperable 5G-CAM application. Common unknowns for all stakeholders are what kind of services might be preferred by customers and what will be the related market penetration rate. These unknowns hinder the private sector investments. Additionally, most of the stakeholders want to have a definition of liability borders of a 5G-CAM service, to have safer and accident-free operations.

In section 4, a recommendation rating study is presented. In this study, 15 recommendations identified in D6.2 were classified by four different categories: Cross border corridor recommendations, human centric recommendations, deployment and investment recommendations and legal recommendations. Afterwards, these recommendations were asked to project partners from various stakeholder groups. We collected 10 answers from various stakeholder groups in our project. Then each recommendation rated from cost and utility perspective, according to the responses by the interviewed stakeholders. The most important recommendations according to 5G-MOBIX expert partners are listed in this section. According to answers to cross border corridor related recommendations, large-scale validations were consistently rated

as the most important recommendation in terms of utility, as well as the most costly one in effort. The variety of studies that target a good understanding of the business ecosystem and the driving forces behind the market was considered especially useful as well, with a much lower cost. In human-centric recommendations section, "upgrade of current skills" recommendation is clearly considered the most important recommendation in terms of utility, its final score being the lowest of the four recommendations due to its being also the one considered the most costly. In deployment and investment related recommendations section, responses show that the most important recommendation regarding utility was Investment on Software Architectures, SOC and AI Development, though it was also the recommendation rated with the highest cost. On the other hand, the Cooperate for 5G Deployment was, by a significative margin, rated the lowest in cost. Though its utility was rated the lowest of the Deployment and Investment recommendations, it was only by a small margin, so it is also the recommendation with the best utility to cost ratio. According to answers to legislative recommendations, from the utility perspective the highest average value of the score is attributed to the "Creating a data economy" recommendation, with a very low deviation of both scores (utility and costs) between the partners. Furthermore, the highest ratio of utility score is marked by the data economy recommendation. From the cost perspective, the recommendation of "Determine the Best Use of Public Funds for 5G Infrastructure" has the lowest score, which makes it the most accessible recommendation from the economic point of view.

Questionnaires that were prepared in D6.2, were asked to various stakeholders and answers were analysed in section 5. In total, we collected 63 responses to our questionnaires. Questionnaires were created from the business model canvas pillars. These pillars can be defined as "Value Proposition", "Key Resources", "Customer Relationship", "Key Partners", "Cost Structure" and "Revenue Streams". Firstly, we asked the stakeholders what the most valuable border crossing 5G-CAM service for their organization is. As it can be seen in Figure 1, advanced driving is the most valuable one.

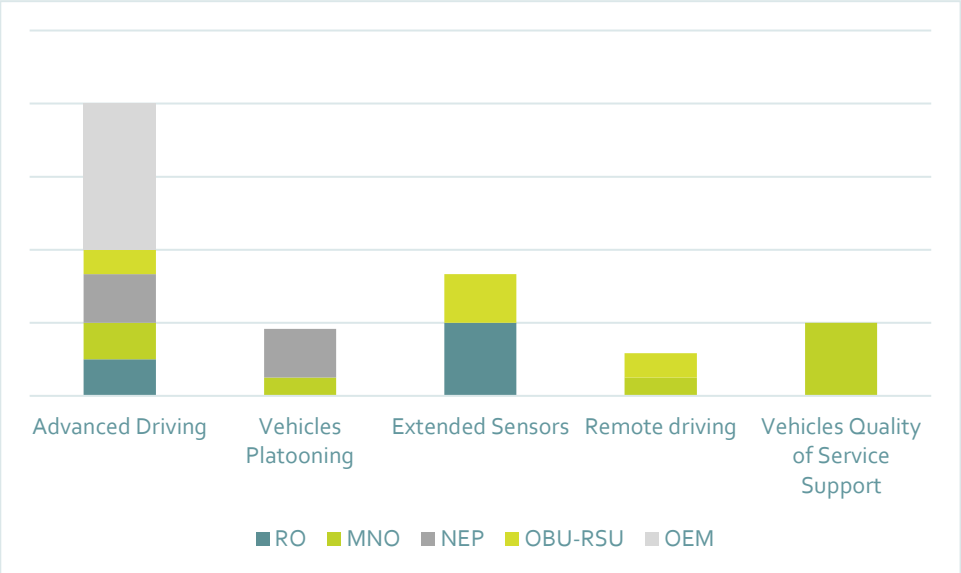

Figure 1: Value of border crossing 5G-CAM Services

After that, we asked question considering the difficulty to integrate 5G for the CAM services in each stakeholders' operations, especially while border crossing. Advanced Driving seems to be difficult to be integrated in the operations for all stakeholders but road operators. Another question we asked the stakeholders is which 5G-CAM services will bring changes to their relationship with their customers. MNOs

indicate that all services will change their relationship with their customers, but network equipment providers consider that none of the proposed services will strongly change their relationship with customers. Afterwards, we wanted to learn who is the key partner for stakeholders. Government is always a key partner for almost all stakeholders' groups and road operators also play a huge role. About the obstacles and challenges related question to have 5G-CAM services addresses the most topical challenges for each stakeholder in its operation. To summarize, we can say that for MNO, the main challenges are Roaming handover, Cross-border operations, standardization, and low-coverage areas for 5G-CAM applications. For OEM, the main challenges are Standardization, Accuracy of geo-positioning and low-coverage areas for 5G-CAM applications. For NEP, the main challenge is MNO handover, but RAN optimisation and cross-border operations are also challenging.
Considering OBU/RSU, the main challenges are MNO handover, connection loss while cross border operation, latency and Data and application-level protocol interoperability. Road operators have totally different concerns, and their main challenge is cybersecurity, and service providers consider that packet loss caused by congestion is their main challenge.

We asked these questionnaires also to end users such as drivers and passengers. In total we had 27 responses. As summary, the use of 5G-MOBIX service will mostly increase their feeling of safety in traffic and their travel comfort, as well as decrease their stress while driving. But when we ask them if the 5G-CAM services would affect their choice of travel mode, they all responded that they would use public transport, passenger car, walk or bicycle and taxi services as often as today, so the availability of 5G-MOBIX service will not affect their choice of travel mode. They are also somewhat concerned by the price of 5G-CAM services, but they are not afraid of their need to learn new skills or change their routine.

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 has demonstrated the potential of different 5G features on real European roads and highways, creating and using sustainable business models to develop 5G corridors. 5G-MOBIX has also utilized and upgraded existing key assets (infrastructure, vehicles, components) allowing 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 executed a series of CAM trials along cross-border (x-border) and trial sites using 5G technological innovations to qualify the 5G infrastructure and evaluated its benefits in the CAM context. The Project has also defined deployment scenarios and identified and responded to standardization and spectrum gaps.

Firstly, 5G-MOBIX has defined critical scenarios requiring advanced connectivity provided by 5G, and the associated features to enable selected advanced CAM use cases. The matching of these advanced CAM use cases and the expected benefits of 5G was tested during trials on 5G corridors in different EU countries as well as in Turkey, China, and Korea.

The trials also allowed 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 identified new business opportunities for the 5G enabled CAM and proposed recommendations and options for its deployment. They have been presented in previous deliverables of work package 6 which are D6.1, D6.2, D6.3 and D6.4. These documents can be found in project website: (https://www.5G-MOBIX.com/).

1.2 Purpose of the deliverable

This deliverable aims to elaborate possible new business opportunities that 5G-CAM will create. Other projects can take this deliverable as a reference in the future with its complete content. Deliverable contains customer exploration map tool that is used to show possible customer of each stakeholder, what are their customers likes and dislikes, jobs to be done, challenges, what we do not know about 5G for CAM, existing solutions and what would be game changing in the future. Details of this study can be found in section 3.

In the Section 4, recommendations are listed that are important to have a solid 5G for CAM business model and a rating study has been reported. Ratings show, which recommendation is the most important about cost and utility perspective. Audiences of this deliverable should consider these recommendations to achieve sustainable business.

In section 5, deliverable shows a questionnaire analysis. These questionnaires were prepared in D6.2 and disseminated after publishing D6.2 in the project website. Questionnaires aimed to understand business model development strategy and obstacles on the road. To achieve this, we asked stakeholders what is the

value proposition of 5G for CAM services, what are key resources and key partners of stakeholders, what are obstacles, challenges, cost structure of 5G for CAM, what are revenue streams and willingness to pay of stakeholders.

1.3 Intended audience

The dissemination level of D6.6 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 the automotive industry, telecom industry, policy makers, research organisations, governmental bodies, standard developing organisations and insurance companies.

Interested readers may also refer to:

- D6.1 - Plan and preliminary report on the deployment options for 5G technologies for CAM.
- D6.2 - Plan and Preliminary Report on the business models for cross border 5G deployment enabling CAM.
- D6.3 - Plan and Preliminary Report on the standardisation and spectrum allocation needs.
- D6.4 - Plan and Preliminary Report on EU Policies and regulations recommendations.

2. PLAN AND METHODOLOGY

2.1 Customer Exploration Map

The Customer Exploration Map tool helps stakeholders to identify problems and challenges of their customer, user or stakeholder and to explore possible solutions for this problem [1]. This document aims to identify what are the 5G-CAM customers, what they want, challenges and unknowns on the road to have successful 5G-CAM business model.

To achieve this, a set of questions listed below has been asked to stakeholders in 5G-MOBIX work group and each stakeholder perspective is reported.

MNOs, automotive OEMs, application providers, network equipment providers, OBU/RSU providers, road operators and end users are the related stakeholders in 5G-CAM deployment.

- Who are your customers / users / stakeholders?
- What are their likes and dislikes?
- Jobs to be done and challenges to achieve solid 5G for CAM business model
- What we do not know, what are our assumptions, black spots and why/when is something a challenge / a good experience etc.
- What are the existing solutions that are used or could be used instead of 5G for CAM services?
- What would be game changing, perfect solution, and experience that 5G for CAM promised?

Detailed analysis can be seen in section 3.

2.2 Questionnaires

Questionnaires that have been prepared in D6.2, has been used to analyse business model of 5G for CAM services. Questionnaire example that is used to understand MNO stakeholder perspective can be seen in Annex-1.

Five 5G for CAM use case category that are listed in 3GPP TS 22.186 [2] document explained at the beginning of the survey. These categories are advanced driving, vehicle platooning, extended sensors, remote driving, and vehicle quality of services support.

After this explanation, questions about 5G for CAM were asked. Questions were about the business model canvas tool that was used to elaborate business model opportunities in D6.2. Question categorized as value proposition, key resources, customer relationship, key partners, obstacles and challenges, cost structure, willingness to pay and revenue streams.

Details of the analysis can be seen in section 5.

2.3 Recommendation Evaluation

Recommendations that are used in this evaluation were listed before in D6.2. For the evaluation methodology, the approach of D6.1 was followed. We collected 10 answers from project partners. They rated 15 recommendations based on their utility and cost perspective.

The evaluation criteria objective is to understand the impact that recommendations have and provide a prioritization level base in colours (red, yellow, green as presented in chapter 4). The recommendation evaluation study assesses each recommendation based on two factors:

Utilization:

The utilization value measures the level of how critical each criterion is, ranging from 1 to 5. With 1 having a minimal impact and 5 a critical impact. These recommendations are assessed based on the

Table 1: Utilization Cost Impact Matrix

			UTILITY SCORE(Higher is better)							
			Minimal	Low	Average	High	Critical			
		Scoring System	1	2	3	4	5	WEIGHTS	SCORE	WEIGHTED SCORE CALCULATION
1	Impact	Has user value	Has no user value	Has little value, brings awareness to a specific gap	Has average value somewhat limits an existing gap	It has the potential to simplify 5G for CAM adoption	Has great user value - will greatly help adoption of 5G for CAM	0,17		0,00
2	Impact	Has business value (for Europe?)	Has no business value	Has little value, brings awareness to a specific gap	Has average value somewhat limits an existing gap	It has the potential to increase investment or the creation of new products and services, or mitigate known gaps	Has great business value - this recommendation can improve investment in 5G for CCAM and will help create new products/services/business models, or solve known gaps	0,17		0,00
3	Impact	Has technical value	Has no technical value	Has little value, brings awareness to a specific gap	Has average value somewhat limits an existing gap	It has the potential to mitigate or circumvent a technical gap	Has great technical value - this recommendation bridges a significant technical gap	0,17		0,00
4	Impact	Has operational value	Has no operational value	Has little value, brings awareness to a specific gap	Has average value somewhat limits an existing gap	It has the potential to improve operational procedures	Has great value in terms of improving operational procedures - it can bring multiple operational benefits	0,17		0,00
5	Impact	Has standardisation value	Has no standardisation value, does not utilise or validate an existing standard	Has little value, brings awareness to a specific gap	Has average value somewhat limits an existing gap	it has the potential to drive standardisation efforts or support an existing standard	Solves a significant standardisation gap or is based on existing well known, industry accepted standard	0,17		0,00
6	Criticality	This recommendation is time critical	not time critical	2021-2035	2021-2030	2021-2025	Recommendation is time critical and should be applied within 2021-2023	0,17		0,00
							SUM SHOULD BE EQUAL TO 1	1	TOTAL SCORE	0,00

Lifecycle cost:

The lifecycle cost analyses the cost of acquisition and the recommendation's utilization by defining the acquisition cost of the research, development, deployment and integration of the solutions. The cost of utilization is defined as the cost to operate, train, maintain and deploy these solutions.

Table 2: Lifecycle Cost Impact Matrix

		Just put an "x", ONLY one 'x' per row							
		Very Low	Low	Medium	High	Very High			
	Lifecycle Cost factor	1	2	3	4	5	ANSWERS	WEIGHTS	WEIGHT* SCORE
Acquisition	Cost to research		x				2	0,1	0,2
	Cost to develop	x					1	0,2	0,2
	Cost to deploy		x				2	0,1	0,2
	Cost to integrate			x			3	0,1	0,3
Utilisation	Cost to operate				x		4	0,1	0,4
	Cost to train			x			3	0,2	0,6
	Cost to maintain			x			3	0,1	0,3
	Cost to dispose		x				2	0,1	0,2
							SUM OF WEIGHTS is 1	1	2,4	Cost Score

The average between the utilization and the lifecycle cost will provide us with the level of prioritization of the recommendations. The prioritization is weighted from 1 to 5, with 1 recommendation having a very low importance and with 5 a very high criticality.

3. CUSTOMER EXPLORATION MAP

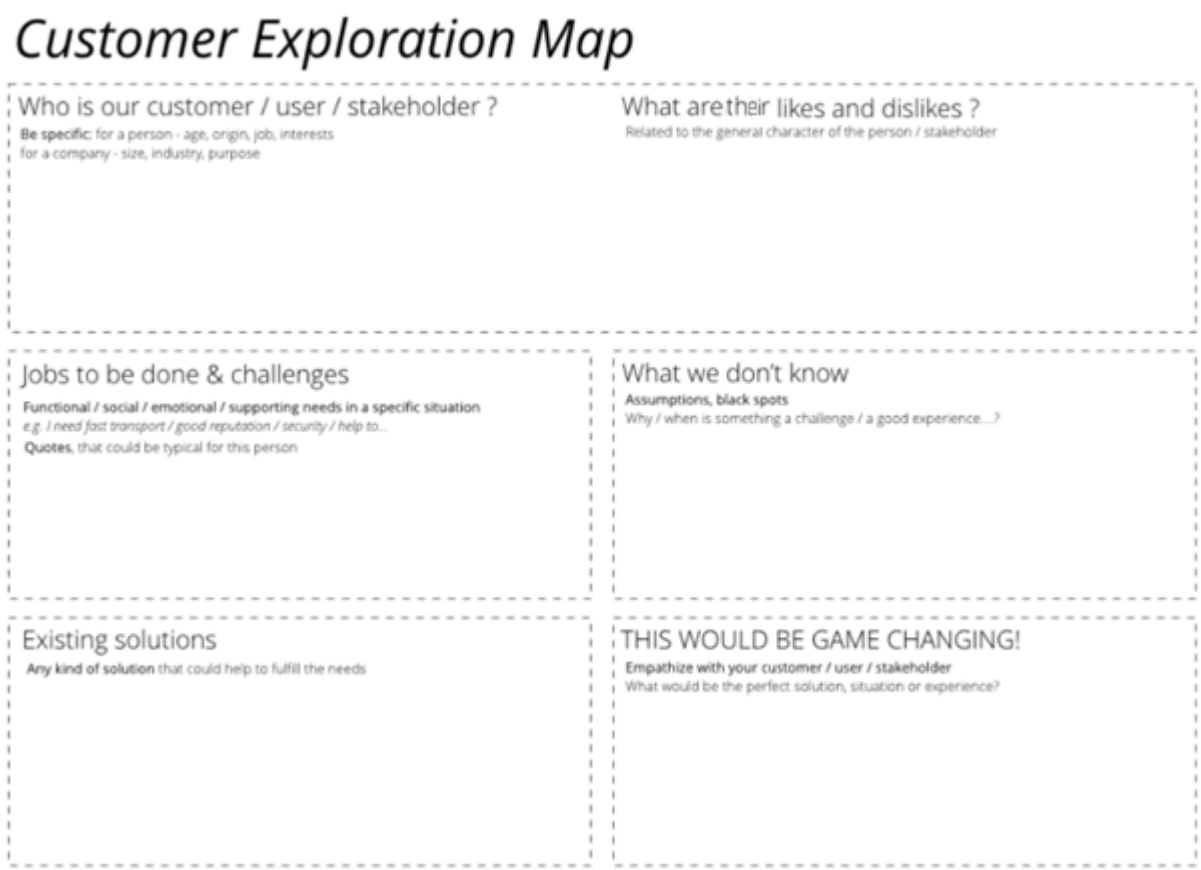

Figure 2: Customer Exploration Map example to fill by stakeholder

An example of the customer exploration map tool can be seen in Figure 2. Answers from the expert team in 5G-MOBIX project were collected according to this template.

Below we have presented the results for stakeholder groups MNOs, automotive OEMs, application providers, network equipment providers, OBU/RSU providers, road operators and end users.

3.1 MNO Perspective

3.1.1. Who are our customers / users / stakeholders?

Primarily, MNOs are looking at every person / legal entity or device as a (potential) customer. Translated into the context of 5G-CAM technology and use cases, the customers are individuals, automotive OEMs and infrastructure operators (government)

3.1.2. What are their likes and dislikes?

All customers are looking for efficient and safe travels. However, adding such features increases the cost of the vehicle as well as operation of the infrastructure. As such nobody is (currently) willing to take on the enhanced cost of 5G-CAM.

3.1.3. Jobs to be done and challenges

As 5G-CAM use cases are becoming more advanced and technology may be reaching maturity levels sufficient for broader roll-out, MNOs need to increase the coverage and capacity of their 5G networks. This includes the capabilities unlocked only through Stand-alone (SA) operation of the 5G network. As typically the existing customers for MNOs do not tend to accumulate in great numbers across the major road infrastructure networks, MNOs find themselves faced with discrepancies between past focus areas (urbanized areas with high concentration of personal / business users) for their network roll-out efforts and the now required focus on major roads (and border crossings).

The biggest challenge for MNOs is to try and find justification for the capital expenditure associated with the network rollout to support all these 5G-CAM functionalities. The business case is communal, and the value is in the absence of a transaction (accident). There is no business case today that can be monetized on the absence of a transaction.

3.1.4. What we don't know?

As indicated, the biggest unknown for MNOs when it comes to 5G-CAM to leverage their network infrastructure is the unknown customer. Where can the MNO compensate the cost of increasing coverage and capacity.

3.1.5. Existing Solutions

For CAM use-cases, a lot of time and effort has been allocated towards ITS-G5 technology in the past. For MNOs, this is not part of their connectivity offering and there is no business model associated with it for an MNO. But this technology suffers from the same challenges and unknowns; actually even more so as there are no opportunities to leverage these investments beyond their primary focus whereas for 5G connectivity it is merely a question of finding secondary uses to strengthen the business case. As most countries /

member states have introduced coverage obligations towards MNOs as part of their spectrum auctions, a basic availability will always be achieved ahead of the existing ITS-G5 requirements

3.1.6. This would be game changing!

For MNOs the biggest game changer will occur if some of the 5G-CAM technology would find its way into existing fleets under a governmental intervention requiring all vehicle and fleet owners to retrofit technology with connectivity, even if just for a single safety-related use. This would draw investments from MNOs to best serve this specific market.

3.2 Automotive OEM Perspective

3.2.1. Who are our customers / users / stakeholders?

Fleet owners, confined area (such as ports, mining, construction) operators, end users are the main customers of the automotive OEMs.

3.2.2. What are their likes and dislikes?

Low-cost operation is important for fleet owners and confined area operators. Low-cost operation could be achieved by decreasing number of employees, operation time, accidents that a human got hurt or an equipment damaged. Safety is also another important aspect for such customers.

End users (e.g.drivers, passengers) also look for comfortable, safe and fast travels.

Regardless of which group the end user falls into, 5G-CAM technology can contribute to addressing their concerns. Autonomous vehicles can be calibrated to optimise driving practices that can avoid aggressive or erratic driving that wears out tyres and brakes more quickly. Replacement of brakes and tyres are two of the major maintenance costs borne by fleets and drivers. Elimination of driving offences reduces costs and should help to reduce the driver risk element of insurance premiums.

Reduction or elimination of accidents and unexpected damage to the vehicle can result in significant savings, such as repair cost and provision of an alternative vehicle while out of service.

For fleet drivers in particular, automation can enable greater productivity as the 'driver' is free to carry out tasks that could otherwise be distracting such as making calls, reading messages or filling the necessary forms for crossing borders.

For the vehicle OEM it should be possible to ensure that Real Driving Emissions testing is more predictable, leading to closer alignment with WLTC results and giving the customer more confidence in stated fuel economy and CO_2 claims.

Where CAM is deployed in confined areas such as ports, greater productivity and predictability can result. In addition, removing some of the people from hazardous areas can contribute to health and safety and reduce costs incurred by protective measures.

3.2.3. Jobs to be done and challenges

Since customers desire low-cost, fast, comfortable, and safe operation/travel, an automotive OEM should focus on its 5G for CAM application developments to fulfil these requirements. For that purpose, related KPIs, such as reduced operation time, number of accidents prevented should be added to 5G-CAM application field tests.

Main challenge here is the standardization of an 5G-CAM application. Today, Automotive OEMs know how to implement safety applications such as AEBS (Advanced Emergency Braking System, a semi-automatic brake system designed to prevent collisions or limit their consequences) or LDWS (Lane Departure Warning System, that detects line marking on the road surface and warns the driver of unintentional lane departures), but these applications do not interact with any external infrastructure. Their operation is entirely contained within the vehicle. This is not the case for 5G-CAM applications. Network is another key pillar to achieve reliable, safe, and secure applications. And that is why regulatory bodies, standardization institutes should define related application requirements and test conditions, to have interoperability among all automotive OEMs and safe, secure applications.

The human element of the system cannot be underestimated, and OEMs will need to prepare and educate their customers for the arrival of automated vehicles. There might be some resistance to such radical changes in the way a vehicle operates, and the benefits should be clearly communicated. If an accident does occur, there is a danger that the OEM will be blamed, and a strategy for managing this would be wise.

Automation can also bring challenges from an OEM branding perspective. With automation bringing ever more standardised modes of operation, OEMs will need to seek alternative ways to differentiate their product (automated sports car?). This will be a challenge.

OEMs will also need to develop new business models that incorporate the connectivity element of automation, as well as the services delivered via the infrastructure. This should be seen as a benefit and an opportunity to generate repeating revenue throughout the life of the vehicle. It will need interaction with a new group of stakeholders which they previously may not have been in contact with, and familiarisation with a new industry.

3.2.4. What we don't know?

Which 5G-CAM application will be the first industry standard to deploy on vehicles, what will be the minimum requirements, who will liable if an accident occurred during 5G-CAM application active on cruise, how will the current business models evolve…?

3.2.5. Existing Solutions

It is possible to see 5G-CAM proof of concept application deployments on the market today, such as tele-operated (remote) driving, automated valet parking for AVs, Cooperative Manoeuvres etc. most of which were demonstrated in 5G-MOBIX and other H2020-ICT-18 projects [3], [4] ,but none of them deployable yet.

C-V2X PC5 and DSRC based CAM applications which are powered by ad-hoc and/or 4G-LTE communication, are early steps of 5G-CAM applications. 5GAA releases their findings about related fields in their website [5].

3.2.6. This would be game changing!

For confined area operators and fleet owners, removing drivers from the loop will be the main game changer since humans are one of the main expenditures of the operations and they are more error-prone than robotic systems. Whenever we see 5G-CAM applications common deployment on the market, it will be enable driverless operations.

3.3 Application Provider Perspective

3.3.1. Who are our customers / users / stakeholders?

Customers vary depending on the application, it could be targeted towards the vehicle owners/drivers, application providers or the telco/service providers. For example, cybersecurity services can be provided to all types of stakeholders, business/operational support services can be provided to the infrastructure providers (i.e. for billing, SLA assurance), etc.

3.3.2. What are their likes and dislikes?

According to the results of a recent public consultation [6] on Connected, Automated Vehicles, the vehicle owners require a feeling of **security and cyber-resilience**. Another significant trend is that of **data sharing**. About one third of vehicle owners would accept data sharing with public authorities in order to support the development of public-interest services, while a third would prefer restricted/conditional data sharing, and one third would decline all data sharing. The vast majority of respondents (75%) considers it very important to be able to **choose among different service providers**, independent from the vehicle manufacturer. Industry actors also agree on cybersecurity being essential (87.7%), and report "security issues introduced by 3rd party actors" as the most crucial issue. Furthermore, almost all industry actors (98%) see business potential for the re-use of non-personal vehicle data.

3.3.3. Jobs to be done and challenges

Although most industry actors claim the process collected data in accordance with EU data protection rules (69.9%), they also report (64.2%) that they do not have experience with implementing Article 20 ("Right to portability"). More than half industry actors (69.8%) believe that specific guidance on how to implement existing data protection rules. When it comes to automated vehicles, the rules of operation must be the same in all countries. This is necessary for all stakeholders like road operators, fleet managers, car manufacturers and MNOs.

3.3.4. What we don't know?

The business case for advanced 5G-CAM services is not very clear in many EU regions. It is not clear what kind of services might be preferred by drivers in each region and the related market penetration rate. This can hinder investment in this sector. The business case for ITS companies may be different to the public and private transport by cars or buses.

3.3.5. Existing Solutions

According to the results of the public consultation and based on industry respondents, among the most preferred solutions for accessing in-vehicle data and resources at short/medium term are:

- Extended vehicle model via OEM back-end servers,
- Neutral server model,
- Other solutions listed are: Secured Vehicle Interface+ "Open OBAP", OBD2 port, Secure Vehicle Interface (SVI) concept.

Furthermore, UNECE WP.29 is working on the definition of storage of data from CAVs.

3.3.6. This would be game changing!

Solutions for virtualised cybersecurity could be game changing, as this approach could make remote management easier for all parties involved. Furthermore, the introduction of data sharing services from a trusted intermediary with anonymisation, encryption, authorisation, authentication on the fly, can simplify the collection of data and its sharing among "data consumer" organisations.

3.4 Network Equipment Provider

3.4.1. Who are our customers / users / stakeholders?

Network equipment providers mainly target three customer segments with their hardware, software and services portfolio: Communications service providers (CSP), enterprise verticals and hyperscalers. Additionally, they focus on licensees in selected industries that benefit from the value of their innovations, primarily in the mobile devices, automotive, consumer electronics and emerging IoT industries.

3.4.2. What are their likes and dislikes?

CSPs nurture a more diverse supplier ecosystem based on open architectures. Their aim is to broaden their supplier options and increase competition to strengthen their pricing power towards the network vendors. We have seen the first examples of CSPs relying on hyperscalers to lead the transition to a cloud-based operational and business model. This introduces new players and increases competition for established network vendors. Lastly, geopolitics and environmental, social and governance (ESG) criteria influence investment decisions. Security and sovereignty have become important factors in the vendor landscape. Government-funded broadband initiatives influence the investments of CSPs, for example in rural areas and support the emergence of neutral hosts.

Within the enterprise verticals segments, the digitalization and automation of operations across verticals accelerates demand for critical networks. In transportation, the transition to software-centric operations and the adoption of industrial clouds and operational technology (OT) edge will further increase efficiency. Private wireless networks and mission-critical transport edge applications are key enablers. In transportation, vehicle automation and the assistance to vehicle drivers are the main concern because these networks should be deployed.

Hyperscaler are companies like Alphabet (Google), Amazon (Amazon Web Services), Microsoft and Meta Platforms (Facebook) that provide cloud solutions at a global scale, leveraging massive, connected data centers. Hyperscalers need optical networks and IP routing. Within optical networks, we foresee that data center interconnect (DCI) technology will be a strong driver. Hyperscalers assume an increasingly important role in the telecommunication domain and will become ecosystem partners and potential competitors. Hyperscalers target edge computing as the next growth engine for industrial automation workloads and low-latency applications.

3.4.3. Jobs to be done and challenges

Critical networks combine carrier-grade resilience, reliability, and security with web scale flexibility and elasticity. As we move ahead in an era of digitalization, critical networks will gain much more importance and reliability requirements will increase significantly. Network vendors need to position their solutions in the automotive sector, giving their automotive customers enhanced capacity and connectivity while offering greater energy efficiency and ease of deployment. Vendors also need to improve also with new radio features the scalability of the radio handovers for automated vehicles and for transport applications.

Solutions that provided by vendors need to progress to new sectors like transportation. Vendors need to drive the market in fiber and 5G fixed wireless access, and in optical networks to give customers increased performance and cost efficiency. These networks must be deployed throughout the border of the countries to provide continuity on the sensors network and automotive virtualized applications.

Cloud and Network Services provided by vendors will provide a new solution category that will enable on-premises processing of a host of transportation and industry 4.0 applications and help customers accelerate their digitalization plans. Vendors must launch new Software-as-a-Service products for their communications service provider customers, giving them more flexibility and ways to capture revenue from transport sector.

3.4.4. What we don't know?

Risks related to vendor strategy and its execution

- Vendor's ability to become and remain as a leading provider of technology, software and services in the industries and markets in which they operate.
- Trends, such as cloudification, open RAN/openness, virtualization and disaggregation with potential impact on vendor's portfolio of products and services, competitive landscape, business models and their margin profile.
- The degree vendor's investments, including venture funds, result in technologies, products or services that achieve or retain broad or timely market acceptance, answer to the expanding needs or preferences of our customers or consumers, or in breakthrough innovations, research assets, digitalization, and intellectual property that we could otherwise utilize for value creation.
- Vendor's ability and success in acquiring or divesting businesses and technologies, in integrating acquisitions, entering licensing arrangements, and in forming and managing joint ventures or partnerships.

Surrounding economic, financial, and competitive environment

- General economic and financial market conditions and other developments in the economies and industries where we, our customers and partners/suppliers operate.
- Duration of the COVID-19 outbreak, disruptiveness of the related measures to contain the virus and other prolonged impacts of the pandemic.
- The cyclical nature of the markets in which vendors operate, competitor behaviour, customer consolidation, customer purchase and spending behaviour, deployments and rollout timing.
- Accelerating inflation and our ability to pass increased costs to vendor's customers.
- Price erosion largely driven by competition challenging the connectivity business models of vendor customers.
- Vendor's dependency on a limited number of customers and large multi-year agreements.
- Competitiveness of or developments regarding pricing and agreement terms vendors offer, including developments with respect to customer financing or extended payment terms or credit lines that we provide their customers.
- Willingness of banks or other institutions to purchase vendors receivables.

3.4.5. Existing Solutions

There is a diversity of technology and enterprise with different approaches in the market.

The RAN market, including associated network management solutions and network services, is a highly consolidated market. All vendors offer similar solutions, such as 5G SA, NSA core and network infrastructure equipment. Deployment is currently limited.

Cloud and Network Services operates in a fast-moving marketplace characterized by numerous competitors that range from niche providers to global technology enterprises whose offerings span several technical capabilities. The competitive environment comprises networking companies, infrastructure and application software suppliers, services specialists, hyperscalers, cloud providers and a wide range of industry segment businesses.

3.4.6. This would be game changing!

Sensor's deployment in an efficient manner and interconnected between countries with low latency will create in Europe a global market size able to compete in the global market. So, roads must be covered with mobile connections.

The sensors network must be directly connected between the countries, not centralized in country/region isolated silos. So, fibre must be interconnected in the border of the countries.

This basic infrastructure along the roads will be the baseline for the full deployment of a pan-European automotive radio network.

On top of this network diversity of operators public or private could interconnect different radio layers with radio Slices supporting many different Use Cases.

3.5 OBU/RSU Provider Perspective

3.5.1. Who are our customers / users / stakeholders?

Car manufacturers, road operators, end users. OEM's, telecommunication companies, regulators, road authorities, insurance companies and end users.

3.5.2. What are their likes and dislikes?

Being able to enjoy comfortable and safe travel is one of the main challenges offered by autonomous mobility. Having technologies that minimize risks will facilitate their adoption by public entities and their exploitation by companies.

From the end user's point of view, being able to provide them with comfortable, entertaining and safe travel experiences will help increase interest in using these types of services.

Low cost and safety are the main concerns for both types of providers. The RSUs, in particular, imply several costs for road operators, from acquisition and installation to maintenance and end of life discarding. As such, it is important to install the least expensive and with minimum life-cycle costs that comply with the requirements. RSU capabilities, as well as installation procedures, must keep this in mind. Road operators and end users are also concerned with traffic efficiency, i.e., making vehicles travel from origin to destination in as less time and with as less expenditure of energy as possible.

The OBUs installed in the vehicles allow access to a multitude of information and data of each vehicle. This allows monitoring the correct behaviour of the system and the detection of vehicle faults, as well as the measurement of indicators such as driving speed, acceleration noise, number of lane changes, following distance between vehicles... All this information allows an exhaustive analysis of the user's behaviour and the operation of the entire vehicle system.

Providing vehicles with OBUs capable of working at full capacity with the latest technologies, such as 5G, can lead to better overall driving performance at all levels. It should be added that all V2X communications are supported by the OBU, enabling more accurate information to be obtained from and for drivers. In combination with the RSUs integrated in the road infrastructure, a technology is available that will enhance the improvement and efficiency of driving and traffic management.

One of the main challenges is to achieve full acceptance by users and other stakeholders of this equipment and the benefits that OBUs can provide in their daily lives, which is an essential role for the application of new connected vehicle technologies.

Having devices capable of upgrading to the latest technologies and evolving along with "communication technologies like 5G developments is one of the long-term goals. The overall implementation and upgrade costs and the current shortage of hardware elements such as chips is one of the current "brakes" to the implementation of OBUs in vehicles.

To promote the progress of OBUs and implement improvements in line with mobility needs, it is still necessary to coordinate driving simulation systems with field tests in both controlled and real-world environments.

3.5.3. Jobs to be done and challenges

In the interest of safety, both OBUs and RSUs should be able to acquire and transmit data in as close to real time as possible. While 5G, with its associated very low latency, allow 5G enabled devices to communicate at the necessary velocity, this would be for naught if OBU and RSU sensors/associated sensors are incapable of obtaining data at a similar velocity. It is important to take into account the costs associated with the development of the system, so boosting its scalability in production as soon as possible will be key to achieving its success.

It will also be necessary to study the needs in terms of computing resources, so it will be necessary to take into account the power requirements of the chips, as well as the artificial intelligence that will be used, achieving a good exploitation of data and joint decision making.

When defining the user experience, it is critical to take into account user training, as its misuse could trigger serious problems that would delay the adoption of these technologies, such as the distractions they generate in level 3 automated driving scenarios.

It will also be key to include different user experiences for all users, including groups such as the elderly, people with some kind of disability, etc.. CTAG for example has developed its own OBU (HMCU) integrating elements and the latest upgrades for 5G (using for example Qualcomm chips for its modems integrated in the HMCU). These in-house developments within the research field are helping to drive down costs in the future and bring more OBU options to the market.

3.5.4. What we don't know?

Current investment in device integrations and developments for OBUs and OBUs themselves is still a highly variable factor as they are in many aspects, such as 5G adaptations, research, and experimental deployments. It is also still somewhat uncertain which direction will be taken by the elements to be integrated in OBUs such as 5G modems and chips suitable for full use with 5G technologies and the 5G infrastructure.

How much interest will road operators have in installing RSUs? So far, the interest and acceptance of different operators in devices such as RSUs and OBUs is very positive. In the SISCOGA corridor, for example, numerous devices of this type have been deployed and encouraged development in various projects (5G-MOBIX, AUTOPILOT, CROADS, CMOBILE, CRUSOE ...).

Who is liable for incorrect readings from the RSUs sensors? This question cannot be simplified to a short answer even if we can answer it even without standardisation or supporting regulations. There are several actors involved and the failure to receive or transmit an RSU can be due to a multitude of factors (from purely mechanical failure to failure to send messaging by a sender outside the RSU, sensor failure, network failure, GPS failure....).

As the RSUs are wired together, it is possible to detect problems remotely. If the messages have been sent in a correct way, in this case it can be considered that the vendor of the RSUs or OBUs should be responsible for solving problems in reading the messages and providing the necessary support and maintenance of this equipment in case of failure or error.

How many RSUs will be needed per road segment? It depends on what is considered as a road segment reference as we understand it to be the specific representation of a portion of road with uniform characteristics. If there are no obstacles, an RSU can provide coverage of up to 1km. It does not usually provide coverage over the entire motorway, but it is necessary to have a strategy for its placement, for example to place them at all the entrances to the motorway and if there is no entrance in between, every 10km. This way the events are registered when entering the motorway and if an event update arrived it would receive it every 10km. Anyway, it depends on the characteristics of the use-case you assess. Accidents could result in a short distance message by direct communication (C-V2X, DSRC) and a longer distance message to the downstream flow using a cellular solutions, and to the ITS center for traffic management guidance. It is not a one fit solution. Gantries over the road are a means of communication towards non-connected traffic participants. For some of these items a RSU may be necessary.

What will be the interoperability requirements for easy and cost effective deployment of RSUs and OBUs? The basic requirement to be considered is compliance with the defined standards. For this purpose, for example, regular Plug Test sessions are held, which CTAG also attends with its teams and which ensure interoperability. Also, different levels of interoperability could be considered in order to define the requirements to be considered, also taking into account non-technical aspects of interoperability (Source: EC New European Interoperability Framework 2017):

- Legal Interoperability
- Organisational Interoperability
- Semantic Interoperability
- Technical Interoperability

Within the main technical aspects should be considered as main requirements to be fulfilled to ensure Interoperability:

- Data Security
- Data Integrity
- Data Accessibility
- Transport Protocols
- Services & Messages

Understanding between the different interfaces at all levels (physical layer, data link layer, network layer, access layer, application layer, presentation layer, session layer) must be achieved. Interactions between entities such as messaging servers and end-user applications must also be standardised to ensure interoperability and increase market choice for different vendors and purposes.

3.5.5. Existing Solutions

There are already a range of commercially available OBUs and RSUs with 4G LTE, DSRC and C-V2X PC5 capabilities, though prices are still high and real world, everyday use is still low and mostly untested.

In line with the above, it is important to take into account the costs associated with the development of the system, so boosting its scalability in production as soon as possible will be key to achieving its success.

This would be game changing!

OBUs will allow vehicles to send/receive position and sensor readings to/from other vehicles (V2V), infrastructure (V2I), network connected software (V2N) and pedestrians (V2P). RSUs on the other hand, allow the capture and sending of data related to road conditions and traffic operation. Both technologies would be instrumental in increasing road safety and decreasing accidents and mortality, not to mention reducing traffic congestion and all associated problems. Moreover, OBUs can be installed in legacy vehicles, so we can gain these benefits more immediately, without having to wait for further development of other technologies, like self-driving vehicles. OEMs, road operators and end-users would value efficient, cost effective and interoperable OBUs and RSUs that could be easily deployed and interfaced within an existing communication infrastructure, with minimum configuration effort.

3.6 Road Operators Perspective

3.6.1. Who are our customers / users / stakeholders?

Vehicle drivers (private), freight vehicle drivers, bus and coach drivers, Transport and Logistics companies, Emergency Services, Local and national governments (officers and elected officials). Shortly, everyone using the road.

3.6.2. What are their likes and dislikes?

Road Operators want to provide a high-quality service to their customers. They like systems and technologies that reduce congestion and accidents. A particular dislike is the costs of deploying, operating and maintaining technology solutions.

3.6.3. Jobs to be done and challenges

Road Operators are unsure whether to invest in 5G or ITS G-5 based technologies as they are unclear what technology will become dominant and what will be supported by vehicle manufacturers. Road operators are unsure whether third parties such as mobile operators will roll out the necessary infrastructure or whether they need to deploy it. Road Operators are aware of automated vehicles but unclear on when they will become common on their networks.

3.6.4. Existing solutions

There are some roads equipped with road-side units, 5G and ITS-G5 but these are generally limited to test-bed / technology pilot sites. Older technologies such as variable message signs are used to provide information to drivers such as roadworks or congestion and to provide safety messages such as temporary speed limits.

3.6.5. What we don't know

What will be the uptake of connected and automated vehicle services over the short to medium term (next 10 years). This influences investment decisions and choices on which technologies to deploy on road networks.

3.6.6. This would be game changing!

Provision of affordable 5G services through on-board units and infrastructure that has real impacts on driver behaviour and traffic conditions. If accidents and delays can be reduced, this will significantly improve the experience for road operator's customers. For toll-roads this might lead to increased income as more drivers use the road due to the higher quality experience.

Provision of information directly in-vehicle could lead to reduced need for physical infrastructure such as variable message signs and ultimately, reduce operational costs. However, this would mean that the majority or all vehicles capable of receiving in-vehicle information.

3.7 End User Perspective

3.7.1. Who are our customers / users / stakeholders?

End users will comprise drivers of cars, commercial vehicles such as trucks and vans, passenger service vehicles for example buses and taxis, emergency service vehicles including breakdown services, and vehicles with trailers such as caravans. It could be argued that other users might include non-vehicular actors such as pedestrians and cyclists, as well as motorcyclists, who have an interest in the behaviour and safety of motorised traffic. These are the direct end users although some of those described in the immediately preceding sections above. The 'drivers' includes those using fully automated vehicles as well as those that are manually controlled and everything in between.

3.7.2. What are their likes and dislikes?

For those that will continue to use manually operated vehicles for some time, as well as for pedestrians, cyclists/motorcyclists etc., it will be important that automated vehicles behave in a predictable and consistent manner to prevent potentially dangerous evasive action. Maintaining that predictability regardless of the nature of the road (e.g., urban, rural, border corridor etc.) will be important, as those road users should not be expected to modify their behaviour, depending on whether the road has effective connectivity. This will be particularly important during the transition from driven to automated vehicles, where different levels of autonomy will be using the road along with manually driven vehicles. Where safety is improved it benefits the occupants of all vehicles and potentially other road users such as pedestrians.

Drivers of automated vehicles at different levels will benefit from the ability to remain in 'autonomous' mode in as many locations as possible. In SAE level 1 – 3/4 cars there may be a need for the driver to take control of the vehicle under certain circumstances, and one of those might be in areas where there is insufficient connectivity for the vehicle to operate safely in a collaborative or autonomous condition. Provision of ubiquitous connectivity and access to automation infrastructure in as many locations as possible will minimize the probability of driver intervention being needed, and increase driver satisfaction and confidence in the systems. This in turn is likely to increase the adoption of automated vehicles leading to

greater economy of scale leading to reduction in vehicle prices. Where autonomy is intermittent it will be difficult to achieve widespread adoption of vehicles with the technology.

There are possibilities for commercial users. Automated trucks can provide savings in terms of driver cost, but also from potential fuel savings gained by platooning, which has the added benefit of increasing road capacity safely. Buses can gain from the ability to remove the driver, potentially creating space for more passengers. Removal of the driver can only happen if journeys can be completed in their entirety without the need for manual intervention and that will depend on ubiquitous connectivity and access to infrastructure before those benefits can be realised. Platooning still has benefits when a driver is in place however it is mor valuable if it can be achieved in unbroken sections of road.

Ensuring that the connectivity and infrastructure is present throughout the road network will benefit the end user in terms of safety and commercial returns, as well as driving the adoption of vehicles with higher levels of autonomy, bringing multiple benefits such as access to efficient cost-effective transport to a greater number of people and enabling the transition from legacy transport modes.

3.7.3. Jobs to be done and challenges

The infrastructure and technical jobs to be done are discussed in other sections of this report. The need to gain long-term user acceptance and 'buy-in' will be needed for adoption of automation. End users must be informed and educated so that they understand why this is taking place and what the benefits will be to each user group. There will be implementation costs and many of those will be borne by users both through the vehicles they use and also via taxation for some of the infrastructure.

The process will need to start before implementation of infrastructure, to encourage acceptance and to prepare users to invest in vehicles with the necessary technology. There will be challenges to persuade users who do not appreciate the proposed benefits, and will wish to continue using manually driven vehicles for longer periods. Interaction between automated and manual vehicles will be important.

3.7.4. What we don't know?

The biggest unknown is how user groups will react to automation and therefore the rate of penetration into the market. The 5G infrastructure must be able to deal with the highest rate of adoption that can be foreseen to maintain confidence in user groups from the outset.

It may be assumed (but needs to be tested) that commercial road users will see the biggest benefits first, and therefore are likely to adopt technology earlier than the general population. Early adopters will be important to demonstrate the benefits to ither use groups.

It is not yet known how incidents will be viewed among user groups and those that will have to fund the technology and infrastructure. Any incident that can be interpreted as being related to automation and 5G, could be reported unfavourably by press and other actors that are external to this endeavour. This could affect confidence and adoption of the technologies.

3.7.5. Existing Solutions

This is a wide-ranging and open question. From a user perspective the technology should be transparent, requiring no prior knowledge or ability to interact. As a newly emerging technology the only alternatives

from this perspective are the current situation of manually controlled vehicles, some with ADAS capability and earlier-stage autonomous capability, and other modes of transport.

3.7.6. What would be game changing?

The main influences here are likely to be cost, confidence and legislation.

The cost equation must work for commercial adopters of automation. For freight forwarders, for example, the benefits must at least match the cost of implementation. Adoption among one set of end users provides confidence to others to consider automated vehicles and use of the infrastructure.

Legislation that encourages implementation would be beneficial. It may relate to road operators' responsibilities, or to determination of liability in the event of an accident, or to a number of other areas that will either drive or hinder this programme. It is important that there is an alignment between states to ensure consistency across border corridors in terms of both cost and legislation.

These are areas that address the needs of potential end users.

4. RECOMMENDATION EVALUATION

In this chapter, recommendations are taken from D6.2 preliminary report of on the business models for cross border 5G deployment enabling CAM. Recommendation rating methodology is taken from "D6.1 plan and preliminary report on the deployment options for 5G technologies for CAM".

Recommendations are categorized with four different group:

- XBR – Cross border corridor recommendations,
- HCR – Human centric recommendations,
- D&I – Deployment and investment recommendations,
- L – Legal recommendations.

The prioritization of the measures is shown next to the recommendations under the following terms:

U:	Utility Score
C:	Lifecycle Cost Score
F:	Final Score = (Utility Score/Lifecycle Cost Score)

High priority
Medium priority
Low priority

The scores listed in subsections were provided by a questionnaire that asked to the 5G-MOBIX stakeholders. Questionnaire is also mentioned in the section 2.2.

4.1 Cross-Border Corridor Recommendations

Table 3 presents the Cross-border recommendations provided by the 5G-MOBIX project partners in relation to 5G technology for CAM applications. According to the responses by the interviewed stakeholders, large-scale validations were consistently rated as the most important recommendation in terms of utility, as well as the most costly one in effort. The variety of studies that target a good understanding of the business ecosystem and the driving forces behind the market were considered especially useful as well, with a much lower cost. Therefore, in the case of the utility-to-cost ratio, they were ranked higher than large-scale validation. The recommendation that offered the best utility-to-cost ratio is the requirement for a cost-benefit analysis in the critical corridors, that is contingent on the definition of critical parameters for policy and business requirements.

Table 3: Cross-border Recommendations

ID	Recommendation	Description	U	C	F
XBR1	**Create a Cost Benefit Analysis for the critical corridors**	In order to execute on the existing plans regarding the 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	3.101	2.04	1.52

		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.			
XBR2	**Perform a VRIO analysis for potential products and offerings**	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.	3.1	2.1	1.48
XBR3	**Perform large-scale validation to increase trust in the research results**	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.	3.799	3.02	1.26
XBR4	**Regional market analysis**	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.	3.1	2.08	1.49

4.2 Human Centric Recommendations

These recommendations are part of what D6.2 identified as 'Cooperation enablers', which are the group of technologies, policies, cooperation strategies, etc. that can be considered to help alleviate the negative impacts of the barriers and act as business catalysts boosting adoption and deployment of 5G and CAM. The purpose of these recommendations would be to increase awareness, research and innovation human capital within the EU. According to the responses by the interviewed stakeholders, recommendation HCR1 'Upgrade of current skills' is clearly considered the most important recommendation in terms of utility, its final score being the lowest of the four recommendations due to its being also the one considered the most costly. It should be noted, that even if the overall utility score of HCR1 is the highest of the group, when looking at the business impact alone, this recommendation is only third of the four, so it seems that there is agreement between the responders that this is a complex recommendation to assess. The highest ratio of the four measures corresponds to the HCR4 'Guaranteeing consumer choice', which also places second in overall utility, and second best in terms of costs, and second best again in business impact on its own, making it an agreed recommendation to focus on.

It should be noted, however, that absolute differences in the final scores of the 4 HCR recommendations are quite small. Utility in all 4 cases was considered between 3 and 3.5, Cost between 2.5 and 3, with overall ratios with even smaller differences. This seems to suggest that none of the recommendations in this category can be considered to be a clear priority over the others. The fact that they were all more or less equally rated as something that can be addressed in the next decade in terms of time criticality also suggests that the way these are described, they could be seen as a sort of a 'set', and somehow related with each other, but without an urgency to push for any of them significantly.

Table 4: Human-centric Recommendations

ID	Recommendation	Description	U	C	F
HCR1	**Upgrade of current skills**	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.	3,433	3,04	1,13

HCR2	**Improve 5G and CAM related education in universities**	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.	3,168	2,72	1,16
HCR3	**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.	3,067	2,56	1,20
HCR4	**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)	3,218	2,68	1,20

4.3 Deployment and Investment Recommendations

Table 5 presents the Deployment and Investment recommendations provided by the 5G-MOBIX project partners in relation to 5G technology for CAM applications. The responses show that the most important recommendation regarding utility was Investment on Software Architectures, SOC and AI Development, though it was also the recommendation rated with the highest cost. On the other hand, the Cooperate for 5G Deployment was, by a significative margin, rated the lowest in cost. Though its utility was rated the lower of the Deployment and Investment recommendations, it was only by a small margin, so it is also the recommendation with the best utility to cost ratio.

Analysing the responses, we also found out that the 5G-MOBIX project partners see the most business value on the Investment on Better Infrastructure and Investment on Software Architectures, SOC and AI Development recommendations, while the Investment on Software Architectures, SOC and AI Development recommendation is seen as the most time critical.

Table 5: Deployment and Investment Recommendations

ID	Recommendation	Description	U	C	F
D&I1	**Investment On Better Infrastructure**	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.	3,67	3,23	1,14
D&I2	**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	3,74	3,34	1,12

		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 position as all the IP and the owner of the value add business for the European economy would be outside of the EU.			
D&I3	**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.	3,59	2,76	1,30

4.4 Legislative Recommendations

Table 6 presents the legislative recommendations regarding the cross-border issues. From the utility perspective the highest average value of the score is attributed to the "Creating a data economy" recommendation, with a very low deviation of both scores (utility and costs) between the partners. Furthermore, the highest ratio of utility over score is marked by the data economy recommendation. From the cost perspective, the recommendation of "Determine the Best Use of Public Funds for 5G Infrastructure" has the lowest score, which makes it the most accessible recommendation from the economic point of view.

Overall, the legislative recommendations are commonly agreed by the partners and the scoring is constant with the lowest deviations in "Creating a Data Economy" and "Having Open Discussions About Machine Ethics".

Another significant finding is that all recommendations are equivalent in value, have low deviations between the partners and low costs of implementations. A crucial aspect of the costs in the legal sections is that it cannot be compared with the required costs in recommendations targeting infrastructure aspects.

Table 6: Legal Recommendations

ID	Recommendation	Description	U	C	F
L1	**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 sanitized data to any interested third-party, in order to minimize risks to citizens' digital rights and ensure GDPR	3.516	2.81	1.25

		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 sanitization services that would facilitate multimodal transportation, providing a complete travel experience for passengers.			
L2	**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. Currently the vehicle owner is responsible for any kind of damage caused by the vehicle. The risk is typically covered by insurances. With automatic driving vehicles this may have to be changed, because the OEM or car operator (in case of remote driving or fleet management) gets a higher responsibility for failures. This will have to be aligned within Europe.	3.334	2.42	1.38
L3	**Determine the Best Use of Public Funds for 5G Infrastructure**	the EU has already signalled 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	3.183	2.21	1.44
L4	**Having Open Discussions About Machine Ethics**	Certain application follows the state of the user, and once a HO is performed the application instance running on the other side of the border needs 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 showed that moral choices when driving are not universal. Although the EU has provided guidelines for Trustworthy and	3.234	2.37	1.36

		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. have the previous user information/data from the instance running in the originating country border.			

5. ANALYSIS OF QUESTIONNAIRE ANSWERS

5.1 Introduction

5G-MOBIX plans to demonstrate the potential of different 5G features to bring automated driving to the next level of vehicle automation, through trials on real European roads, along cross-border and local corridors. 5G core technological innovations are used to qualify the 5G infrastructure, evaluate its benefits in the Connected and Automated Mobility (CAM) context, and create sustainable business models to develop 5G corridors.
The emergence and rise of connected automated vehicle refer 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 manoeuvres. 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 or notify the driver that a manual takeover is necessary. 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.

In this survey, 5G-MOBIX tries to elaborate business perspectives of various stakeholder, how they see value proposition, who are the key partners for them, what are the challenges on business level, what are their key resources to achieve 5G-CAM application, network, equipment etc.
The survey is targeted at 5G or CAM ecosystem stakeholders and differentiates between different categories with a tailored questionnaire for each.

The current questionnaire has been running for more than one month, from May 17th to June 27th 2022. We had huge difficulties to collect enough responses for each stakeholders' groups. Indeed, the final number of responses for each group is:

Table 7: Survey Respondents

Stakeholders' Group	Number Of Respondents
Software / Service Providers	11
Road Operators	4
OBU/RSU Providers	6
Network Equipment Providers	3
Cloud/MEC Providers	1
OEM	3
MNO	8
End Customers	27

We decided to exclude from the analysis the stakeholder group categories with less than 3 respondents in order to have representative results. Since, Cloud/MEC Providers stakeholder group has less than 3 respondents, it has been excluded and marked as red in the Table-7.
Nevertheless, even within the categories with more tant 3 respondents, the number of no answer and/or a big standard deviation between the responses did not allow us to capitalize all the questions.
Therefore, the following results are not as wide as we expected, but all insights possible have been extracted.
The analysis of the results will be presenting following the cases of the Business Model Canvas [7], for all stakeholders but the End-Customers. For these last one, a dedicated paragraph is available at the end of this section.

5.2 Value Proposition

This section aims to highlight the value propositions underlining the 5G services.
In the first question, we asked the stakeholders what the most valuable border crossing 5G-CAM service for their organization is.

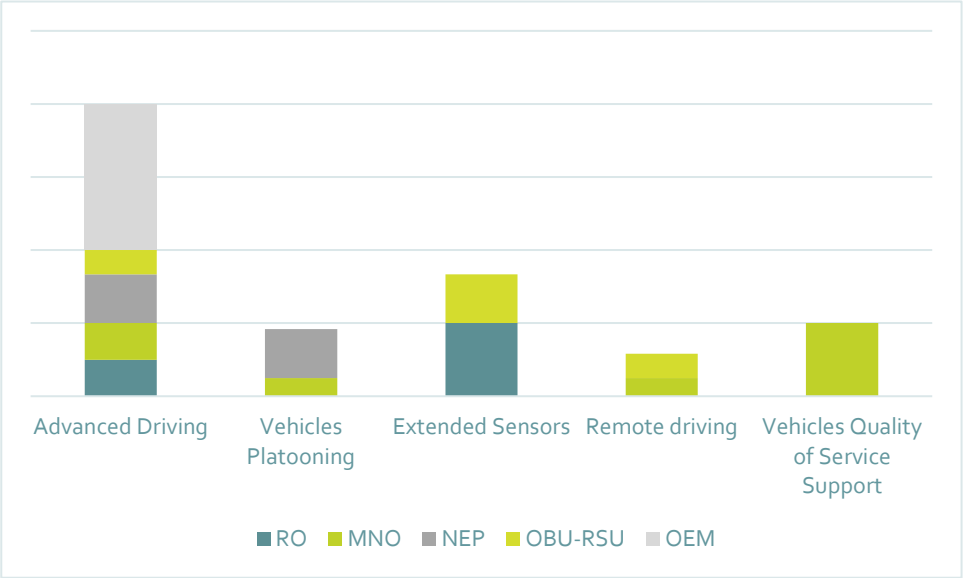

Figure 3: Value of border crossing 5G-CAM Services

For road operators, extended sensors (50% - commenting with the reduction of accidents) then advanced driving (25%) are the most valuable services.
For MNO, the most valuable services are vehicles quality of service 50%, advanced driving 25%, vehicle platooning 12,5%, but they highlighted that MNO do not choose the use cases and that the technology is not mature enough to really determine the value of the services.
From network equipment provider perspective, there is no value difference, but selecting the firsts in time, they have chosen advanced driving (33.3%) and vehicle platooning (33.3%).
OBU/RSU have chosen extended sensors (33.3%) to further develop traffic data sensing and management, but also advanced driving (16.67%) and remote driving (16.67%).
Advanced driving is the most valuable border crossing 5G-CAM service for OEM (100%) even if they comment that extended sensors and remote driving are also valuable.

The second question aimed at rating the value propositions for each 5G-CAM service category regarding their relevance for their organisation.
Road operators, MNO have very divided opinions, with no consensus on the value proposition, and they split their preferences between all responses, without allowing us to reveal clear trends.
Road operators emphasized for Extended sensors on improved maintenance and cost reduction and they added Improve Highway safety in this new environment, New business models based on network services and edge computing services to reduce CAPEX and OPEX costs of Road Operators and Automation of Road Operator' services related to traffic management as possible value propositions.
For MNO, the value proposition "Reduce Investment costs" is important for Advanced driving, Vehicle Platooning and Vehicles QoS. They also consider that Vehicle Platooning will improve quality of customer experience and that Vehicle QoS will create New Data based services and New customers.
Network Equipment Providers gave us a more united point of view. They consider the value propositions: Improved market share, improved quality of service, new customers, energy efficiency, innovative image and security adequate for Advanced Driving, Vehicle Platooning, Remote Driving and Vehicle QoS.
More than half of the on bord unit providers' respondents did not answer the question, but they suggested the value proposition "Emissions reduction".

Concerning OEM, they consider that the value of Advanced Driving is: Increased market share, improved safety of vehicles and new revenue opportunities, for Extended Sensors it is Improved safety of Vehicle, Innovative Image and New Revenue Opportunities, for Remote Driving : Innovative Image, Closer customer relationships and New Revenue Opportunities and for Vehicle QoS: Improved Safety of vehicles. They also commented that Increase customer happiness and decrease their cost of ownership to vehicle is their number one priority and added Higher multi-Gbps peak data speeds, Production improvements and new invest, More reliability and Massive network capacity that increased availability and consequent more vehicles capacity on the road and a more uniform user experience to more users as Value proposition.
Software Service Providers also gave very heterogenous responses that do not allow us to make conclusion. Most of them did answer the questions but no real trend is determined.

Then, we asked the stakeholders on the impact of the 5G-CAM services on the goals of city and transport planners.
This question was targeting only Road operators. The following table represents their responses concerning the consequences they foreseen.

Table 8: Impact on the goals of city and transport planners

Support and Improvement	Neutral
Reduction of (individual) motorized traffic.	Promotion and supplement of public transport.
Reduction of vehicle ownership.	Enhancing cross-border labour mobility
Promotion of active modes of transport (walking, cycling).	Promoting cross-border trade
Improvement of traffic flow and infrastructure capacity.	Less conflicts between different road users.
Improvement of traffic flow and infrastructure capacity while border crossing.	Increase of equity/ improving mobility of mobility constrained users.
Improvement of traffic safety.	Improvement of land use/ less space required for road transport (parking space, cross-border site etc.)
Lowering emissions caused by road traffic (air pollution and greenhouse gas emissions).	
Integration of land use and mobility needs.	
Less noise emissions.	
Efficient/ less investment in (road) infrastructure.	

5.3 Key Resources

This section is dedicated to key resources and aims to fine tune the focus of the stakeholder's portfolios.

The following table represent the responses:

Table 9: Stakeholders' portfolio focus

Stakeholders Group	Focus
Road Operators	Traffic management and safety Tolling payment. Efficiency of the road infrastructure. Users Security, Traffic reduction
MNO	Connectivity New services, including connectivity Mobile network, Data network, Application platforms, Service management Communication
NEP	Radio and Core HW and SW MEC Network Management solutions (inc. network orchestrations and slicing) 5G RAN and core provider
OBU/SRU	Software developer Artificial intelligence Design and development of multi-sensor perception systems for the automotive industry. Backoffice tools (video big data). Tools for integrated mobility management Simulation and planning of new mobility strategies. RSU manufacture Roadside extended sensors to support automated vehicles comprehensive solutions for traffic management Focused on the infrastructure side
Service Providers	Autonomous Driving software Remote operation and highly automated driving Privacy and data protection, ethics-by-design, security, social acceptance of technology Big Data MLOps Integration Software Development Data ingestion from the car AI/ML based post processing ad intelligence generation at the cloud/edge

	feedback to the car / autonomous driving commands to improve efficiency and safety ITS Solutions for Infrastructure Operators Testing and certification, and test tool development

Then, we asked OEM about their 5G key resource factors that are mandatory to enable 5G-CAM. They considered the following key resource factors:

- Mobile Network Operator (MNO), 5G devices and properly infrastructure
- Labour. It is very tough to find qualified person on the job market which fit with your demands.
- Vehicles. They will have extra equipment to enable 5G-CAM and it will cost a lot.
- Labour, hard to find well trained employee. Network prices are unknown, and it will affect also.

The following question considered the difficulty to integrate 5G for the CAM services in each stakeholders' operations, especially while border crossing.
Advanced Driving seems to be difficult to be integrated in the operations for all stakeholders but Road Operators.

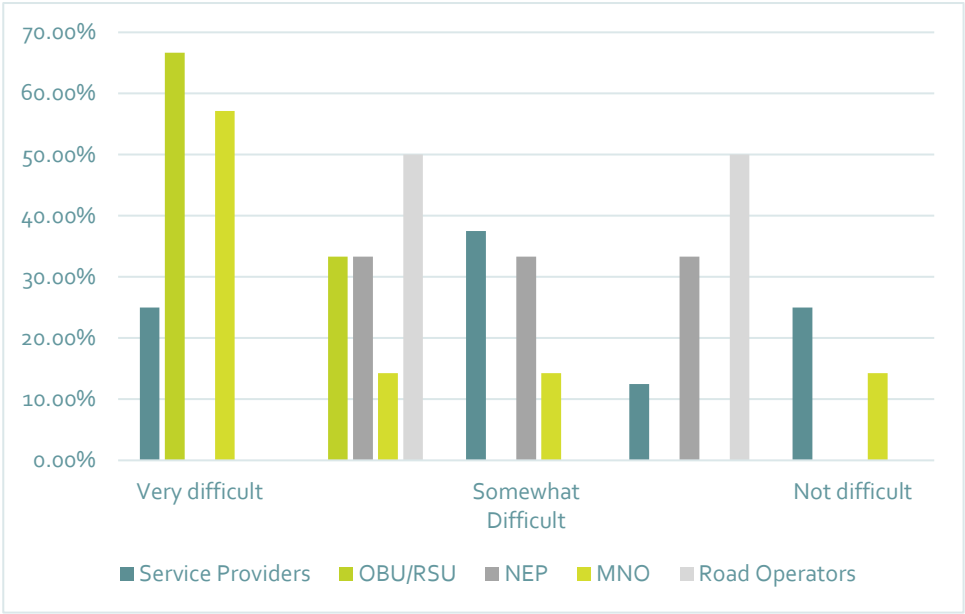

Figure 4: Difficulty for Advanced Driving

For Vehicle Platooning, the integration in the stakeholder's operation is less difficult, even OBU/RSU and MNO have some doubt.

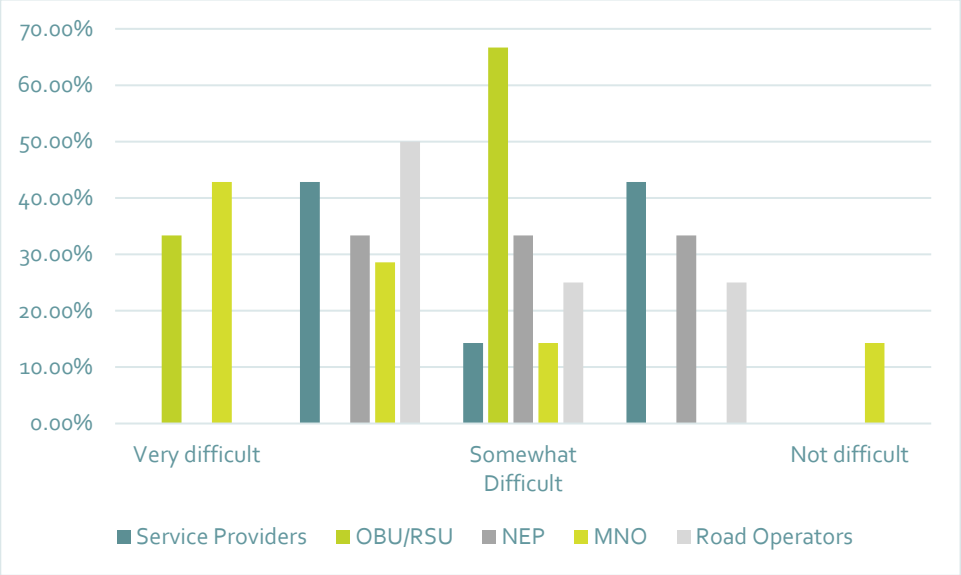

Figure 5: Difficulty for Vehicles Platooning

Concerning Extended Sensors, there is no clear trend concerning the implementation in the operations.

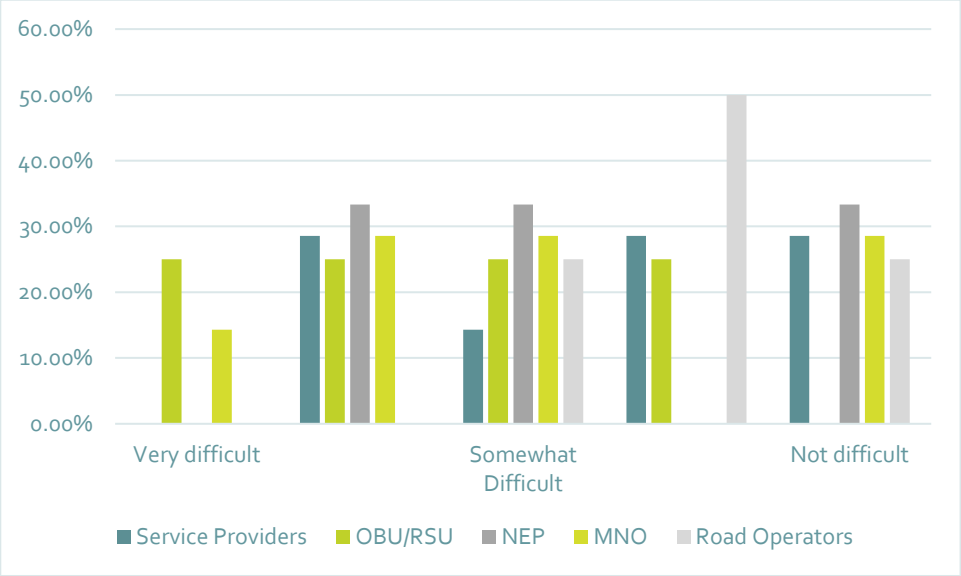

Figure 6: Difficulty for Extended Sensors

Remote Driving, like Advanced Driving, will be difficult to integrate for all stakeholders.

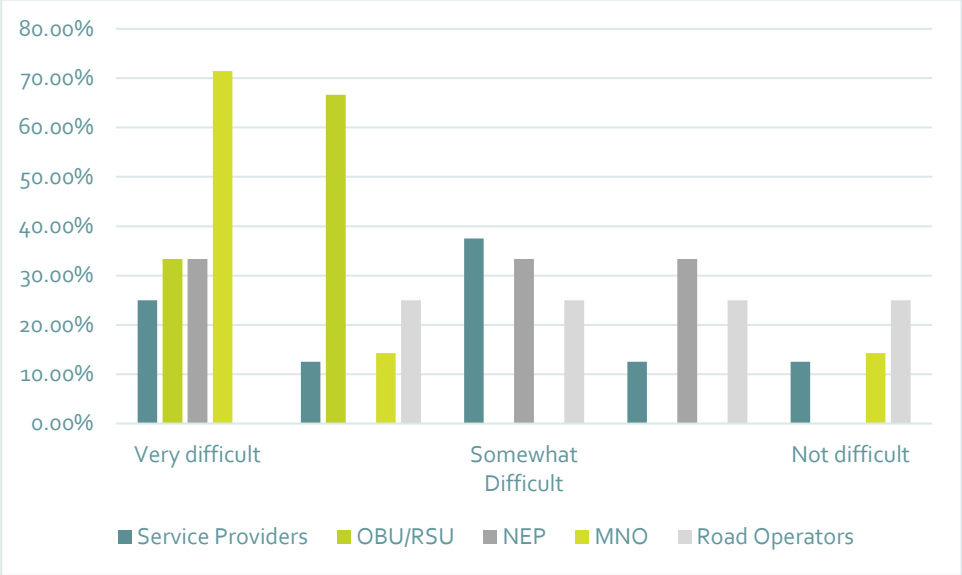

Figure 7: Difficulty for Remote Driving

And finally, for Vehicles quality of service support, no clear trend can be extracted.

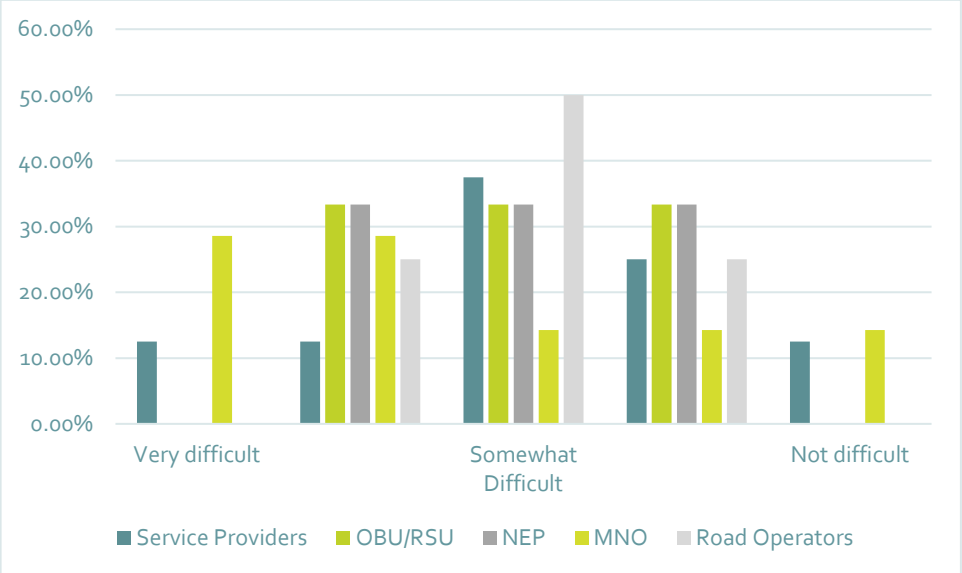

Figure 8: Difficulty for Vehicles QoS Support

Then, we asked the OEM whether their organization is currently developing or offering the following 5G-CAM services for their customers, and how, in context of border crossing, they would put effort in regard to the implementation of 5G for the following CAM services in their production.
They declared having extended Sensors and Remote Driving services in development, but they did not respond or give clear trends for the other services.

Moreover, they considered that Advanced Driving and remote Driving will demand very high efforts, Extended Sensors high efforts, Vehicles Platooning low efforts, while no clear trend for Vehicle QoS Support.

The next question explored in what areas is further expertise and/or substantial progress necessary to enable deployment of the 5G-CAM services.
In general, all stakeholders did not respond to this question.
One participant as MNO declared needing digital road information and regulation and one Service Provider highlighted Certification Processes.

Considering the importance of the enablement of border crossing 5G-CAM services most of the participants responded between somewhat important and very important.

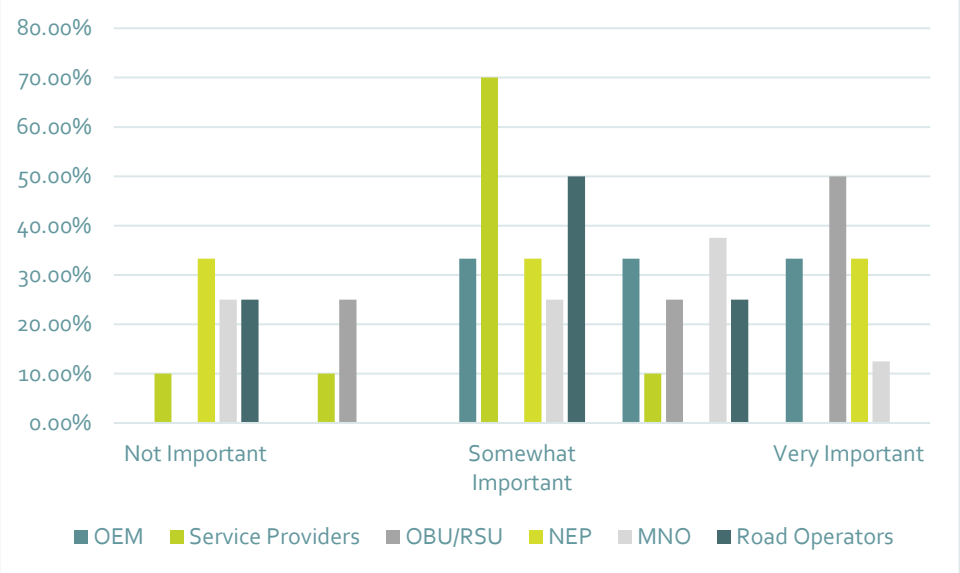

Figure 9: Importance of the enablement of border crossing 5G-CAM Services

To finalize this section, the last two questions were pointing out the expectations of OEM about seeing "5G" connected autonomous vehicles on the EU public roads, and the estimated percentage of the vehicles produced by them with "5G" connectivity in 2030.
One third expect 5G connected Autonomous vehicles on the roads between 2026 and 2029, and the other two thirds between 2030 and 2035, and two thirds expect to have more than 20% of their production equipped with 5G connectivity in 2030.

5.4 Customer Relationship

In this section, we asked the stakeholders which 5G-CAM services will bring changes to their relationship with their customers.
MNOs indicate that all services will change their relationship with their customers.

OEMs consider that Advanced Driving, extended Sensors and Remote Driving services will change their relationship with customer, but Vehicles platooning and Vehicles quality of Service Support will not.
Network Equipment providers consider that none of the proposed service will strongly change their relationship with customers.
OBU/RSU indicate that only Extended Sensors Service will change their relationship with customers.
For Road Operators, Remote Driving and Vehicles Quality of Service Support will have an impact on their relationship with customers.
Software Service provider mostly did not respond to this question.

5.5 Key Partners

In this section, we asked the participants what partnerships are essential for them to support deployment of border crossing 5G-CAM services.

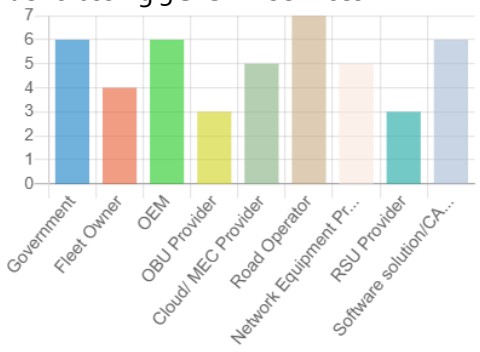

Figure 10: MNO partnerships

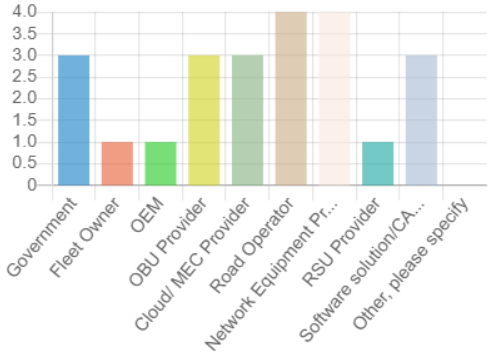

Figure 12: OBU/RSU partnerships

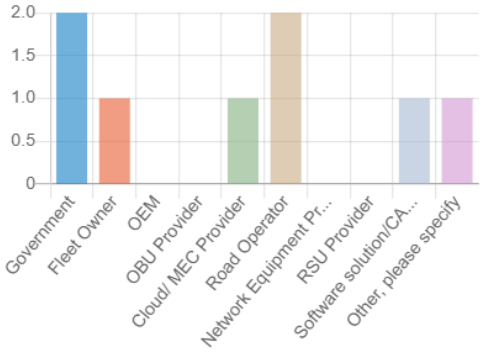

Figure 11: NEP partnerships

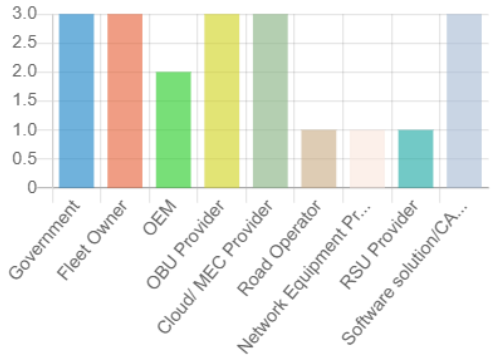

Figure 13: OEM partnerships

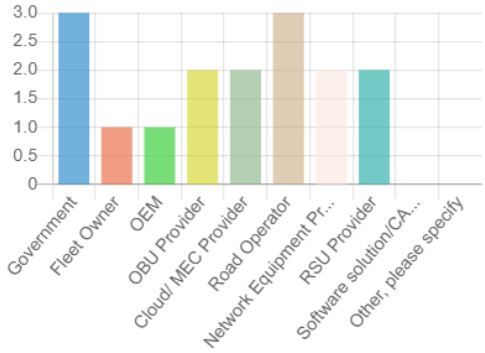

Figure 14: Road Operators partnerships

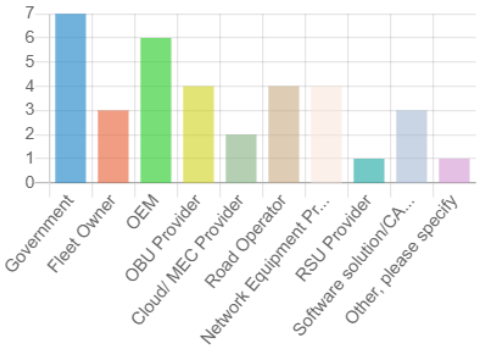

Figure 15: Service Providers partnerships

Government is always a key partnership for almost all stakeholders' groups and Road Operators also play a huge role. They mainly cited that standardized services are needed, and government is driving a lot of the standards, and road operators are required to take ownership and work together to digitize the roads.
MNO and OEM are describing the largest ecosystems. Indeed, OEMs are driving the technology and future demand, and connectivity is required because there will be no utilisation of 5G without working and reliable networks.

The survey tried to understand what steps are needed to form the cooperation between the above-mentioned partners, but participants did not respond to this question.

5.6 Obstacles and Changes

In this section, the first question is investigating the concerns of some of the stakeholders on dedicated subjects.
66.7% of OEMs have concerns related to accepting maneuvers coordination messages from a road infrastructure, mostly in regard to safety and responsibilities. They consider that liabilities must be defined strictly.
75% of Road operators considers having concerns related to accepting data from vehicles, from a data protection / GDPR point of view, but also considering the quality of data (real data, with no errors or delays) whereas 66% of OBU/RSU have no concerns on this issue.
The second question addresses the most topical challenges for each stakeholder in its operation. The following tables illustrate the stakeholders' responses. To summarize, we can say that:
For MNO, the main challenges are Roaming handover, Cross-border operations, Standardization and low-coverage areas for 5G-CAM applications.
For OEM, the main challenges are Standardization, Accuracy of geo-positioning and low-coverage areas for 5G-CAM applications.
For NEP, the main challenge is MNO handover, but RAN optimisation and cross-border operations are also challenging.
Considering OBU/RSU, the main challenges are MNO handover, connection loss while cross border operation, latency and Data and application-level protocol interoperability, but 6 more categories are also challenging.
Road operators have totally different concerns, and their main challenge is Cybersecurity, and Service providers consider that packet loss caused by congestion is their main challenge.
These tables give the detailed results:

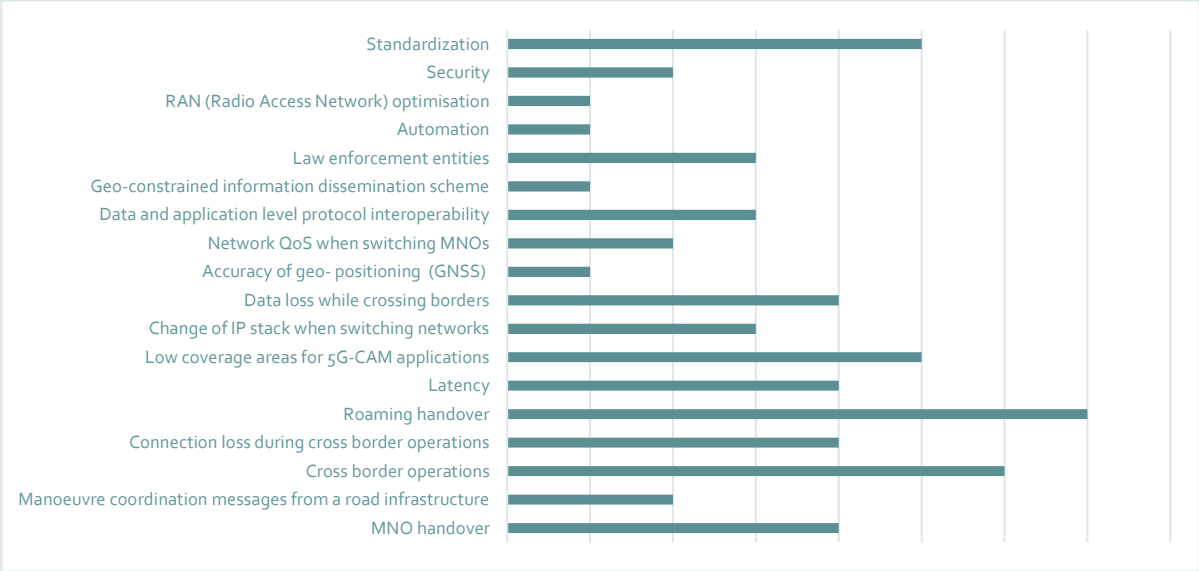

Figure 16: MNOs challenges

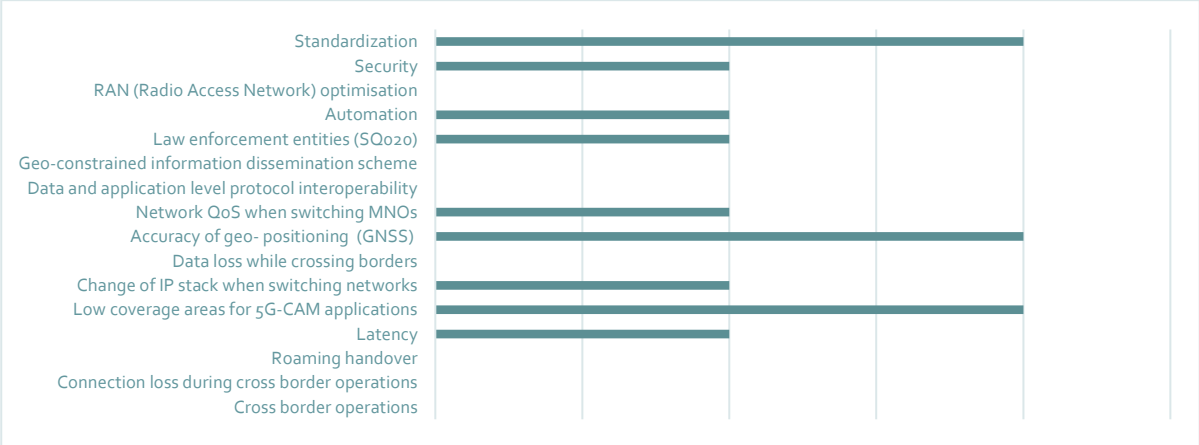

Figure 17: OEM challenges

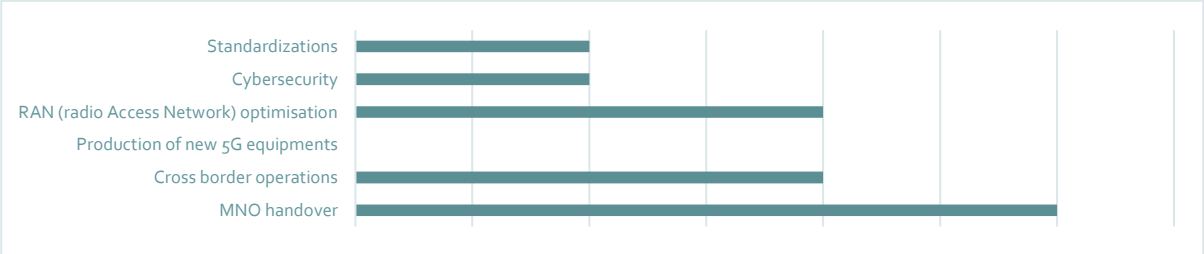

Figure 18: NEP challenges

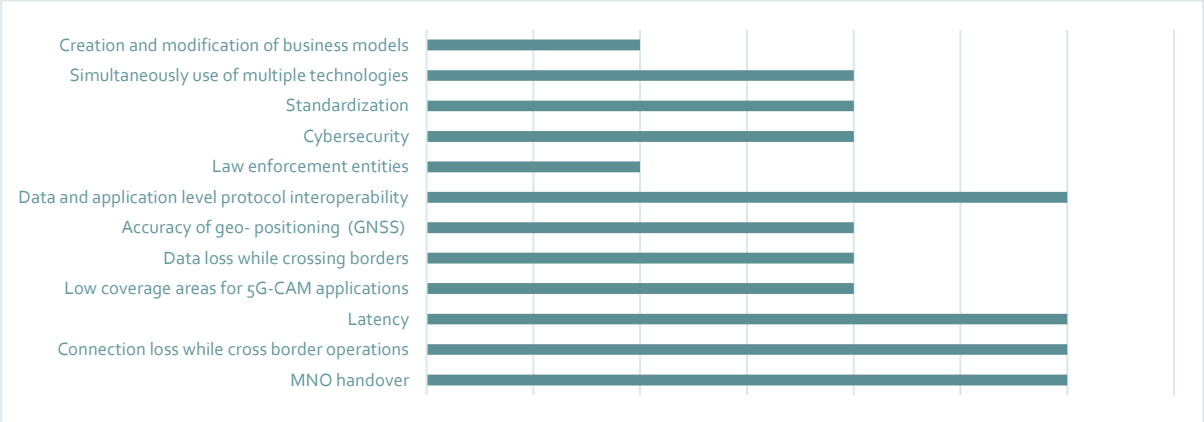

Figure 19: OBU/RSU Challenges

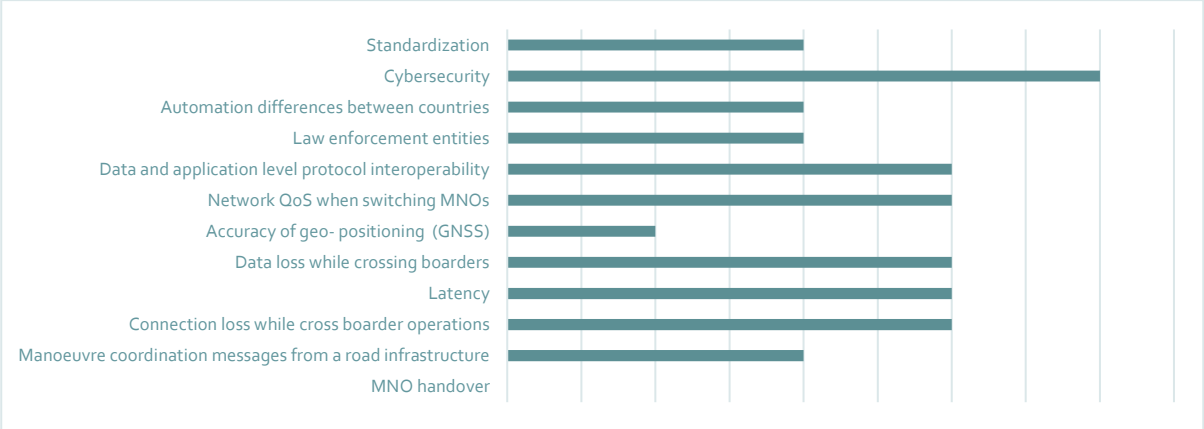

Figure 20: Road Operators challenges

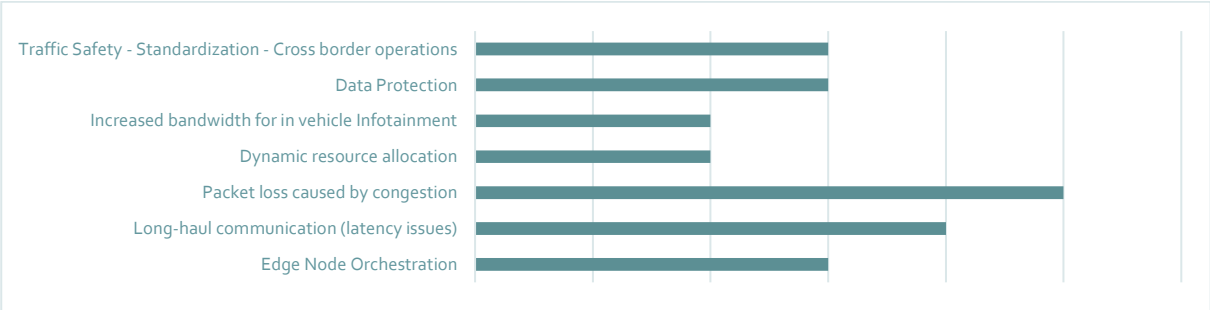

Figure 21: Service Providers challenges

In the next question, the focus was made on challenges related to the implementation of 5G-MOBIX border-crossing services.

OEMs, which expect to have around 10% of their vehicles production equipped with a sim card from the factory to enable advanced driving functions in 2024, think that the main challenges related to the implementation of the 5G-MOBIX services are the lack of standardization, the fact that the technology, as well as the equipment is not ready, and expensive. Concerning the liability challenges of 5G-CAM services in case of safety-critical issue occurred, they consider that liability must be defined strictly in regulations,

and that strict agreements between MNOs to understand liabilities are mandatory. They also consider as moderate the level of costs required for data protection. They highlight the fact that regulations must be completed in order to see 5G-CAM enabled vehicles on the road before 2026, and that standardization of 5G-CAM application is needed, as well as minimum required KPI's definition.
On their side, MNO consider that there is no clear demand for border crossing 5G-CAM services, and thus no priority. Nevertheless, they cited standardized network slice instances, interoperability and contracts as challenges. They also consider that a network service provider can never take responsibility for safety-critical issues regarding mobility. From a legal point of view, they highlight some issues currently known, like data breakout at other country will conflict with current data interception legislation and data exchange during handover that might cause issues with privacy legislation, as well as new challenges around responsibilities, governance, sanction regime, agreements for TDD interference avoidance, RAN optimization to achieve coverage and avoid ping pongs, and resources sharing.
While considering regular congestion and traffic safety as the most topical challenges on their road networks, Road operators did not give a clear answer to the question related to the implementation of 5G-MOBIX border-crossing services. Nevertheless, they highlight the challenge of a common traffic regulation between road operators in European corridors, as well as the need of high performance to automatize traffic management services and continuous control of traffic management services when switching from one MNO to another. In order to enable 5G-CAM services, they added the need of a common traffic policies between different countries and common regularization and standardization of CAM road infrastructure technologies.
For NEP, the main challenges related to the implementation of border-crossing 5G-CAM services are Radio optimization and KPIs generation for service monitoring, cross-border MNO seamless handovers; networks synchronization; solution scalability, and the coordination of large group partners, arranging permissions at border area and working conditions at border area. They consider that a connectivity and roaming framework for CAM services is needed to enable 5G-CAM services.
For OBU/RSU, the main challenges are achieving homogeneity of processes and legislations, obtaining network values that are truly adequate for the implementation of the proposed CAM services, minimizing costs, as well as the connection between MNO and legal aspects, together with procurement processes that are considered as the key blockers for any actual deployment. Moreover, the harmonization of data privacy related aspects (namely in the scope of video technology), together with responsibility related aspects on automated/remote driving need to be address by legislation.
Then, service providers consider that the main challenges from their perspective are the absolute certainty in handover from network to others, data protection and data sharing issues among third parties through ethical data proxies/trusted intermediaries, as discussed in the upcoming EU Data Governance Act, as well as regulation, interoperability, issues related with bad network coverage and long interruption times and MNOs agreements. For the challenges related to liability for the safety-related issues, they consider that liability borders are not well-defined, and it could complicate insurance claims and corporate liability policies, and that a clear framework is needed. Moreover, in their opinion, applications must handle latency and data loss related issues, and a clear regulation should decide who is responsible and to what extent.

5.7 Cost Structure

The following questions of this section aim to obtain financial information. Nevertheless, and due to the sensitive nature of the questions, the questions were not answered by the participants, and we fully understand. However, some of them provided some indicative figures that are summarized in this paragraph and tables.

For the expected increase in some cost categories for supporting the deployment of 5G-CAM services for the next 10 years, we can find some insights for Service Providers, MNO and OEM.

Table 10: Expected impacts on costs

	Service Providers	MNO	OEM
Staff costs	Negligible to Minor	Minor to Moderate	Moderate
Equipment and materials, including maintenance costs	Moderate to Significant	Significant	No data
Consulting / External services	Minor to Moderate	Moderate	Minor to Moderate
Network / Cloud / Hosting	Moderate	Significant to Major	Moderate to Significant
Patent / Sublicense	Moderate	Moderate to Significant	Moderate

5.8 Willingness to Pay

In this section, we wanted to estimate how likely the stakeholders' groups are to invest in supporting 5G-CAM services during the next 10 years, considering the different 5G-MOBIX services.
In some case, the responses were too eclectic to be usable, but some trends can be analyzed.
To start, all stakeholders' group are somewhat or totally likely to invest in Extended Sensors.
NEP are also likely ready to invest in all the described services.
Vehicle Platooning and Vehicle Quality of Service Support seem to be a good investment idea for Service Providers and NEP, but not for Road Operators, and Remote Driving do not really interest Service providers and Road Operators.

5.9 Revenue Streams

The final paragraph is dedicated to revenue stream.
Considering the mode of payment, OEM prefer Onetime Payment for Equipment and materials, they also consider Onetime payment or Pay per vehicle as a possibility for Consulting / External Services. For Network / Cloud / Hosting, they prefer Payment per use or Monthly / Quarterly / Yearly fees, and for patent they expect a Pay per use. They consider that customer could have discounts if the drivers provide road data.
In the last question, stakeholders had to evaluate the expected impact in revenue for their organisation as a result of deployment of 5G for the CAM services for the next 10 years.

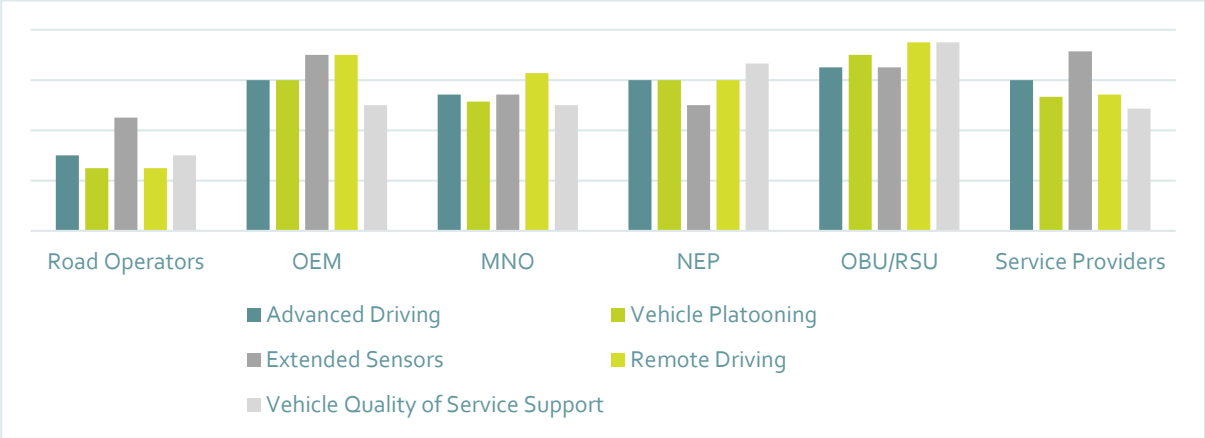

Figure 22: Expected Impact on revenue per stakeholders' group

Road operators are the most pessimists considering possible incomes. They quoted "they have nothing that come to generate extra incomes".

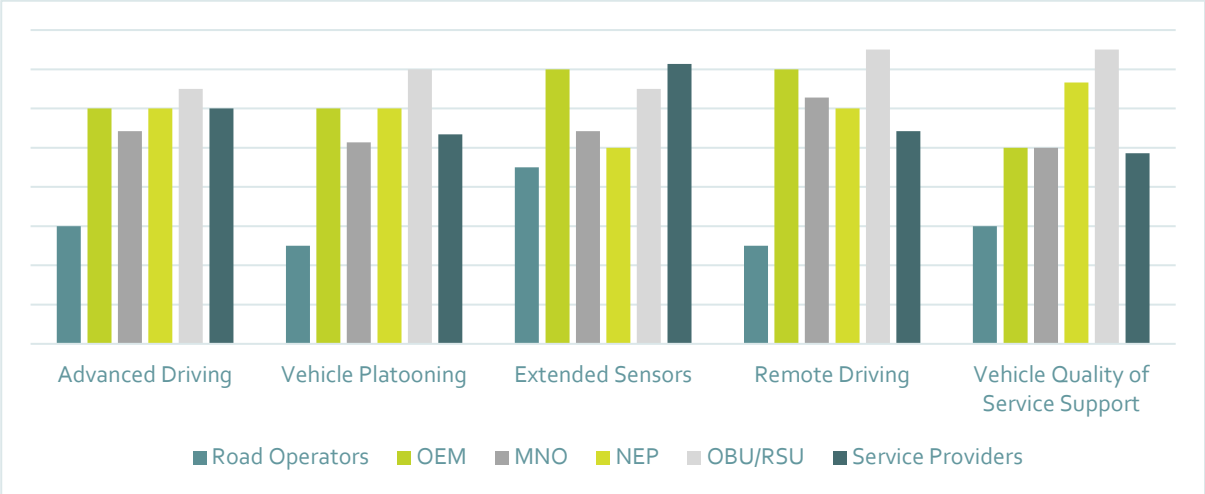

Figure 23: Expected Impact on revenue per service

Considering the services, they are quite balanced in terms of revenue generation, even if Vehicle Quality of Service Support is less prolific.

5.10 End Customers Questionnaire

This category of stakeholders had a dedicated questionnaire, very different from the other stakeholders and then not comparable.
In a nutshell:

- 27 respondents
- 50% in age group 36-47 years
- 81% living in urban area
- Current work status: 89% Paid work
- 90% of them have a car available for their use (all the time or quite often)

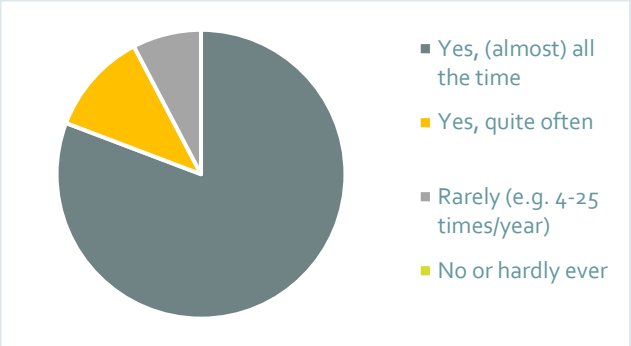

Figure 24: Car availability

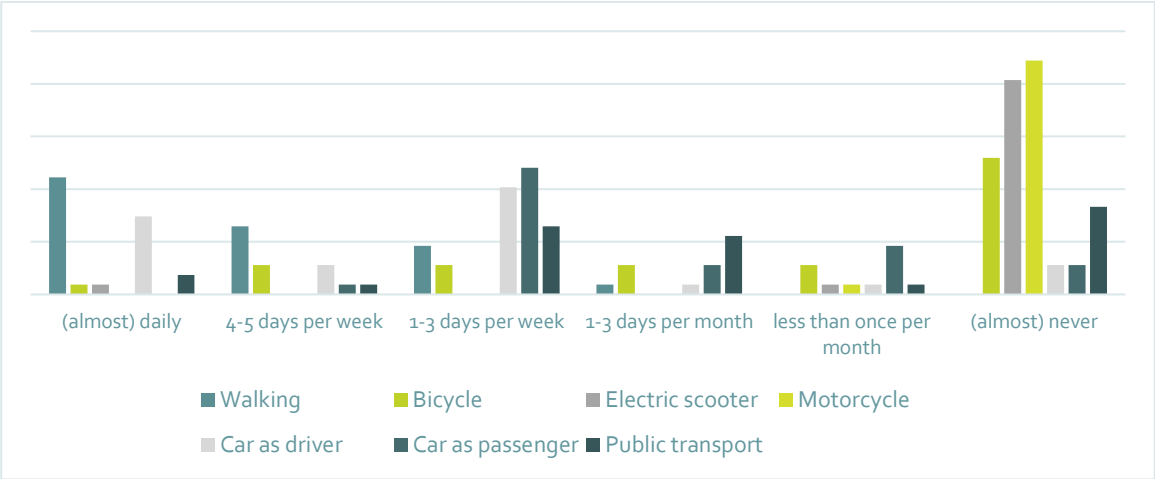

Figure 26: Means of transportation

Concerning their mobility's habits, they use almost daily their car as driver, and they walk. They add bicycle, public transport, and car as passenger in their weekly routine.
Only a very small part of them is used to cross border in their normal life.

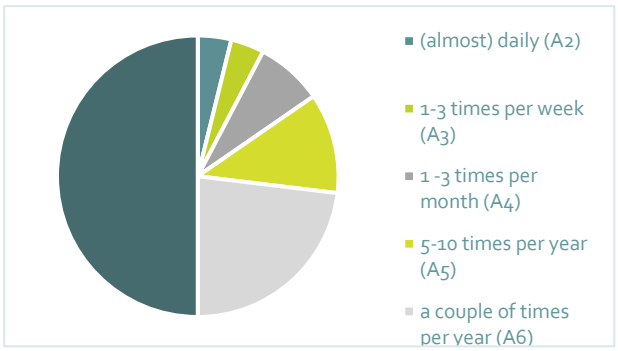

Figure 25: Border-crossing habits

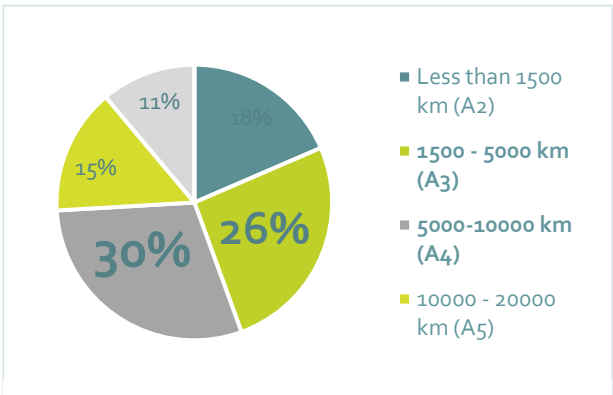

Figure 27: Driving distance habits

56% of the respondents did drive between 1500 and 10000 km during the last 12 months as a driver, and none of them drive more than 50000 km.

More than 50% on our audience declared purchasing or changing their car once in more than 10 years, and when ¼ of them wants to pay less than 15000€, half of them is willing to spend between 15000€ and 35000€. Only one respondent plans not to purchase a car anymore.

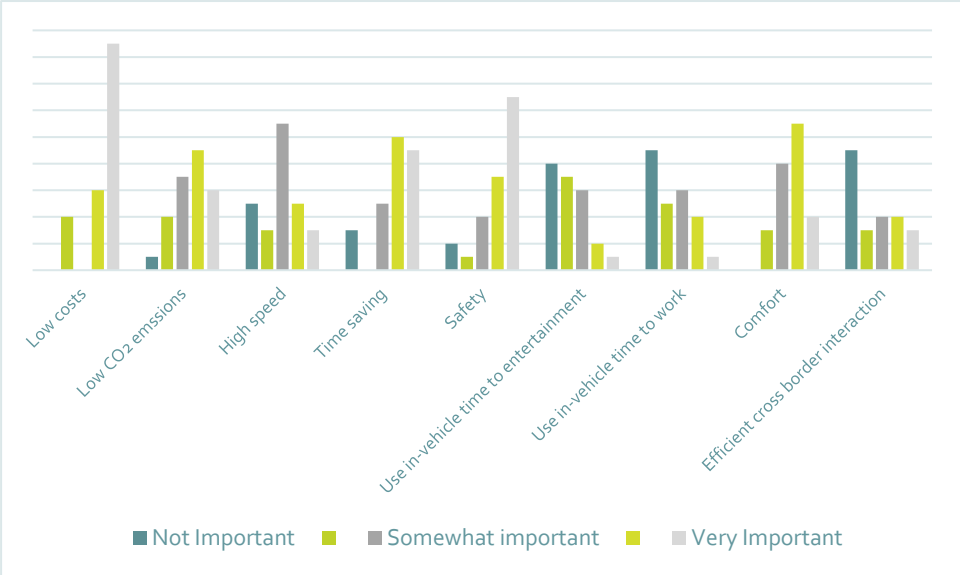

Figure 28: Important factors in mobility choices

The previous figures give us the priority factors of end users for the choice of mobility alternatives.
The cost is definitively the main factors, but safety comes just after, and then comfort, time saving and low CO_2 emissions. Efficient cross border interactions, possibilities to use in-vehicle time to entertainment and to work are the less important factors.
Participants added some other factors, namely:

- Convenience when travelling with kids, pets, goods…
- Freedom / Flexibility (for instance while picking up a child to daycare on the way to work or back home)
- Health related issues (like Covid).

Moreover, they experience the following issues regarding their mobility, number one being unpredictability of travel time, then lack of time.

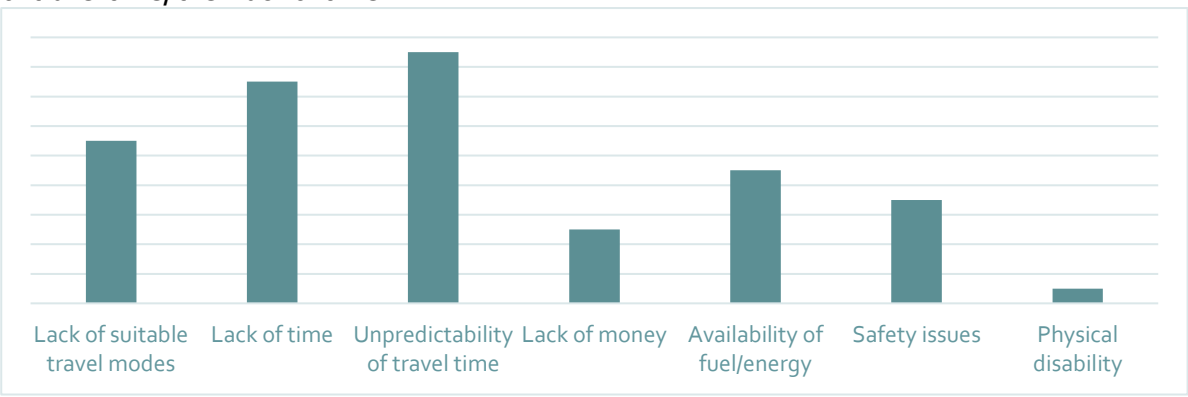

Figure 29: Mobility issues

The next part is assessing cross-border mobility habits of end users.
The favorite means of transportation when crossing borders are first aviation and passenger cars. These choices totally cross-check the previous answers. Indeed, plane is the fastest way to travel, with a level of freedom during the trip and safety that are very high. Then, passenger cars are the mobility choice that allows the most flexibility and freedom, as well as spontaneity.
Considering cross-border travel, it may be important to distinguish EU-wide and World-wide. Indeed, intra-Europe cross-border processes are mainly considered as not complicated and fast for 88% of the respondents, while 67% consider worldwide processes very complicated and time-consuming.

The last section of the survey assesses the 5G-MOBIX services, their value and their advantages for the end users.
Considering the possible use of 5G-MOBIX Services, if available in their cars, respondents in general agree to regularly use them, even if Remote Driving is less accepted than the majority.

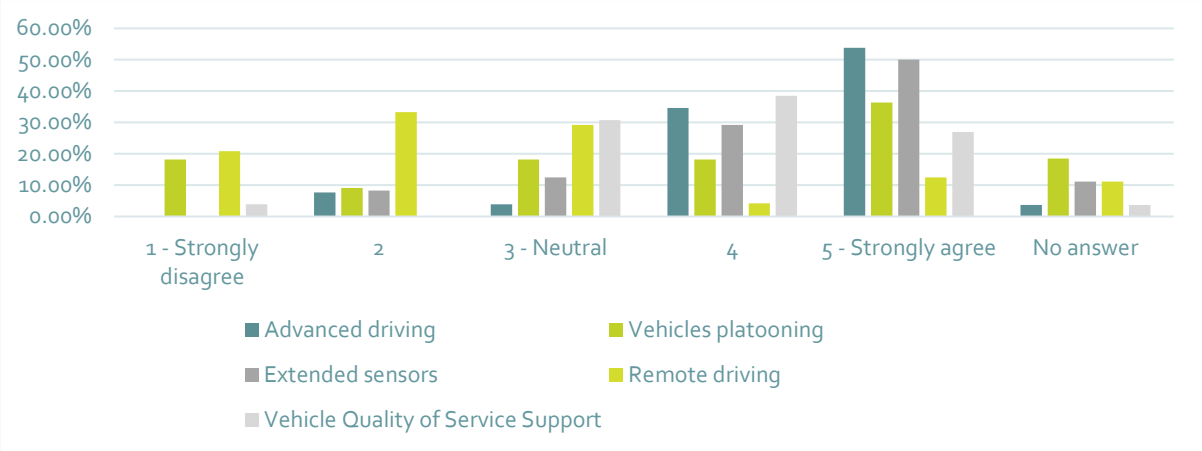

Figure 30: Willingness to use the services

Then, participants were asked about the changes 5G-MOBIX services will imply compared to their usual travels. Their responses are summarized in the following tables:

Table 11: Changes implied by 5G-MOBIX Services

Advanced Driving would affect…	Increase (%)	Same (%)	Decrease (%)	No answer (%)
…. the number of trips I make	18,52	**77,78**	0,00	3,70
… the length of trips I make	25,93	**59,26**	11,11	3,70
… my passenger car use	22,22	**66,67**	3,70	7,41
… my passenger car use during peak hours	18,52	**74,07**	3,70	3,70

… my feeling of safety in traffic	**74,07**	11,11	11,11	3,70
… my travel comfort	**81,48**	14,81	0,00	3,70
… my stress while driving	22,22	14,81	**59,26**	3,70
Vehicles platooning would affect…	**Increase (%)**	**Same (%)**	**Decrease (%)**	**No answer (%)**
…. the number of trips I make	7,41	**62,96**	3,70	**25,93**
… the length of trips I make	14,81	**55,56**	3,70	**25,93**
… my passenger car use	25,93	**44,44**	3,70	**25,93**
… my passenger car use during peak hours	18,52	**55,56**	0,00	**25,93**
… my feeling of safety in traffic	**59,26**	7,41	11,11	**22,22**
… my travel comfort	**59,26**	14,81	0,00	**25,93**
… my stress while driving	18,52	7,41	**51,85**	**22,22**
Extended sensors would affect…	**Increase (%)**	**Same (%)**	**Decrease (%)**	**No answer (%)**
…. the number of trips I make	7,41	**77,78**	0,00	14,81
… the length of trips I make	7,41	**74,07**	3,70	14,81
… my passenger car use	18,52	**66,67**	0,00	14,81
… my passenger car use during peak hours	14,81	**70,37**	0,00	14,81
… my feeling of safety in traffic	**70,37**	11,11	3,70	14,81
… my travel comfort	**66,67**	18,52	0,00	14,81
… my stress while driving	11,11	7,41	**66,67**	14,81

Remote Driving would affect…	Increase (%)	Same (%)	Decrease (%)	No answer (%)
…. the number of trips I make	7,41	**55,56**	3,70	**33,33**
… the length of trips I make	7,41	**59,26**	0,00	**33,33**
… my passenger car use	11,11	**59,26**	0,00	**29,63**
… my passenger car use during peak hours	11,11	**55,56**	0,00	**33,33**
… my feeling of safety in traffic	**25,93**	22,22	18,52	**33,33**
… my travel comfort	**40,74**	18,52	7,41	**33,33**
… my stress while driving	25,93	**29,63**	14,81	**29,63**
Vehicle Quality of Service Supoort would affect…	**Increase (%)**	**Same (%)**	**Decrease (%)**	**No answer (%)**
…. the number of trips I make	3,70	**81,48**	0,00	14,81
… the length of trips I make	3,70	**77,78**	3,70	14,81
… my passenger car use	14,81	**70,37**	0,00	14,81
… my passenger car use during peak hours	11,11	**70,37**	3,70	14,81
… my feeling of safety in traffic	**51,85**	33,33	0,00	14,81
… my travel comfort	**48,15**	37,04	0,00	14,81
… my stress while driving	3,70	37,04	**44,44**	14,81

To summarize, the use of 5G-MOBIX service will mostly increase their feeling of safety in traffic and their travel comfort, as well as decrease their stress while driving.
But when we ask them if the 5G-CAM services would affect their choice of travel mode, they all respond that they will use public transport, passenger car, walk or bicycle and taxi services as often as today, so the availability of 5G-MOBIX service will not affect their choice of travel mode.

The figure below shows us that end-customers are very concerned by data security and privacy, as well as safety for themselves and other road users. They are also somewhat concern by the price of 5G-CAM services, as well as technical aspects (reliable function of the services, insufficient coverage and liability in case of an accident or malfunction). On the opposite, they are not afraid of their need to learn new skills or change their routine.

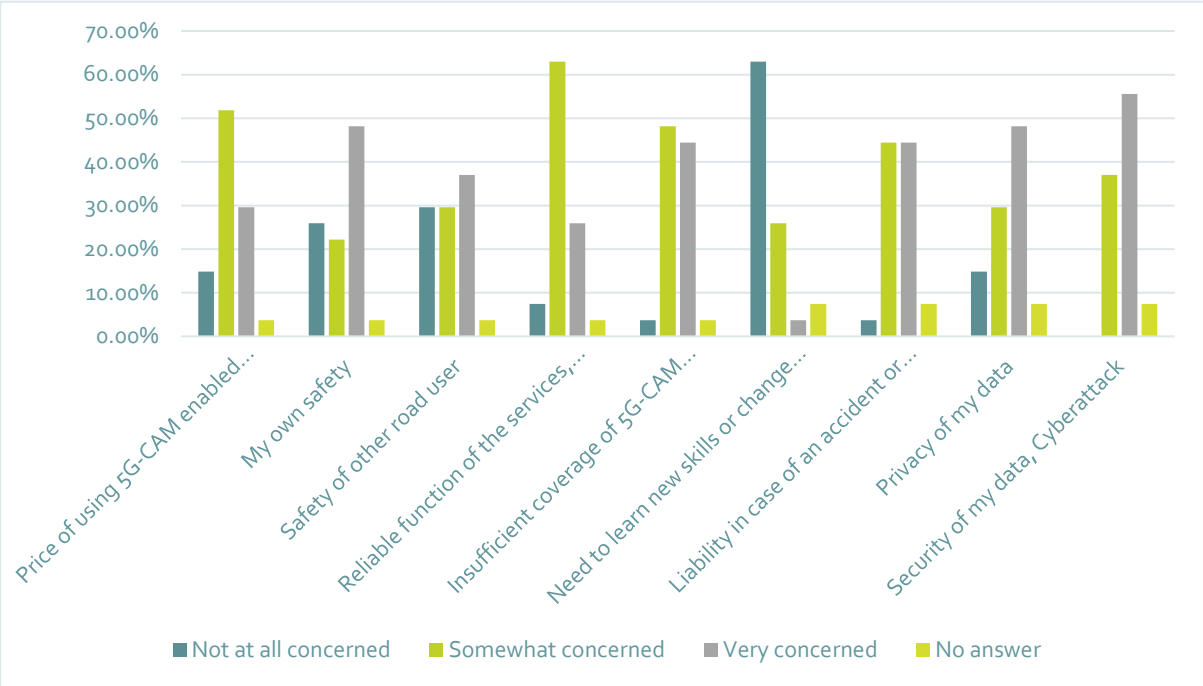

Figure 31: Concerns regarding the future use of 5G-CAM services

The two first services they are willing to pay are Advanced Driving and Extended Sensors, while the one they are the less are Vehicles of Service Support and Remote Driving.
For Advanced Driving, they consider paying one-time fee when buying a new car, for Extended Sensors the same or a yearly subscription. Moreover, they have no clear expectations about savings through using 5G-CAM services (more than 33,3 % of no answer for each category).

6. CONCLUSION

This document describes in detail customer focused approach of 5G-CAM services with customer exploration map tool. This tool helps stakeholders to focus on the most important insights about their customer and additionally to explore existing solutions for existing problems. Moreover, thinking about aspects stakeholders do not know yet about their customer challenges the identified problems and jobs to be done. Expert 5G-MOBIX partners that operate in different stakeholder category provided their insights according to asked questions in the tool. It is shown that each stakeholder has various customers, and these customers have different likes and dislikes. What needs to be done and challenges are also identified per stakeholder. Experts also answered what they do not know yet to have 5G for CAM services on the road and what are the existing solutions on the field. Additionally, they described what would be game changing with commonly seen 5G-CAM services on the public roads. Common unknown is which 5G-CAM services will be the first industry standard to deploy on the public roads.

After customer exploration map study, we exploit recommendation rating methodology that "D6.1 – Plan and preliminary report on the deployment options for 5G technologies for CAM" deliverable used to show utilization cost impact and lifecycle cost impact per recommendation that is described previously in "D6.2 - Plan and Preliminary Report on the business models for cross border 5G deployment enabling CAM" deliverable. Recommendations classified in four different categories and each category evaluated by cost and utility perspective. We showed which recommendation more costly, and which one has more utilization impact. According to answers, in cross border deployment related recommendations, large-scale validations were consistently rated as the most important recommendation in terms of utility, as well as the most costly one in effort. In the human-centred recommendations section, the recommendation "upgrading current skills" is clearly seen as the most important recommendation. In the section of recommendations related to deployment and investment, the responses show that the most important recommendation about utility was Investment on Software Architectures, SOC and AI Development, though it was also the recommendation rated with the highest cost. Based on the responses to the legislative recommendations, from the utility point of view, the highest average score is attributed to the "Creating a Data Economy" recommendation.

According to prepared questionnaires in D6.2, we gathered answers from various stakeholders in and out of our consortia. After that, we analysed these answers per stakeholder category and per business model canvas tool elements that are also explained in detail per user story in our initial study in D6.2. It is shown that, advanced driving use case category is the most valuable 5G-CAM service, but it also seems to be difficult to be integrated in the operations for all stakeholders, except road operators. Government is the main key partner for all stakeholders, since standardization is the main request according to respondents.

Additionally, we plan to organize various workshops with other ICT-18 and 53 projects to increase common understanding about our findings, new possible business model opportunities and how to foster them. These workshops could be enlarged with public attendance to increase awareness more.

Furthermore, a 5G CAM deployment study report that assessing CAM and the 5G infrastructure investment delta in European border corridors will be published by 5G-MOBIX project, before its ending. This report also will show what are the market implications, investment plans, qualitative insights from stakeholders etc. It can be also read by intended audience to have more knowledge about 5G-CAM business models.

7. REFERENCES

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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

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 825496.

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 5G-MOBIX 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!