Fifth Generation Cross-Border Control

Deliverable D5.1
Description of 5GCroCo Business Potentials
Version: v1.0
2019-09-10

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http://www.5g-ppp.eu
## Deliverable D5.1
### Description of 5GCroCo Business Potentials

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<th>Description</th>
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<tr>
<td>3GPP</td>
<td>Third Generation Partnership Project</td>
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<td>5GAA</td>
<td>5G Automotive Association</td>
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<td>5G-PPP</td>
<td>5G Private Public Partnership</td>
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<td>ACCA</td>
<td>Anticipated Cooperative Collision Avoidance</td>
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<td>AD</td>
<td>Automated Driving</td>
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<td>ADAS</td>
<td>Advanced Driver Assistance Systems</td>
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<td>AV</td>
<td>Automated Vehicle</td>
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<tr>
<td>BMC</td>
<td>Business Model Canvas</td>
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<tr>
<td>C-V2X</td>
<td>General term for V2X based on cellular technology</td>
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<tr>
<td>CAD</td>
<td>Connected and Automated Driving</td>
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<td>CAPEX</td>
<td>Capital expenses</td>
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<td>CBA</td>
<td>Cost/Benefit Analysis</td>
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<td>CCAM</td>
<td>Cooperative, connected and automated mobility</td>
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<td>CEA</td>
<td>Cost – Effectiveness Analysis</td>
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<td>ETSI</td>
<td>European Telecommunications Standards Institute</td>
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<td>GDPR</td>
<td>General Data Protection Regulation</td>
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<td>ICT</td>
<td>Information and Communications Technology</td>
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<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineer</td>
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<td>IETF</td>
<td>Internet Engineering Task Force</td>
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<td>IoT</td>
<td>Internet of Things</td>
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<td>IR</td>
<td>Internal Report</td>
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<td>ITS</td>
<td>Intelligent Transportation Systems</td>
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<td>KPI</td>
<td>Key Performance Indicator</td>
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<td>LTE</td>
<td>Long Term Evolution</td>
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<td>MAMCA</td>
<td>Multi Actor Multi Criteria Analysis</td>
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<td>MBB</td>
<td>Mobile Broadband</td>
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<td>MEC</td>
<td>Mobile Edge Computing</td>
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<td>MNO</td>
<td>Mobile Network Operator</td>
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<td>MSL</td>
<td>Minimum Service Levels</td>
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<td>MWC</td>
<td>Mobile World Congress</td>
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<td>NHTSA</td>
<td>National Highway Traffic Safety Administration</td>
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<td>OEM</td>
<td>Original Equipment Manufacturers</td>
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<td>OPEX</td>
<td>Operational expenses</td>
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<td>QoS</td>
<td>Quality of Service</td>
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<td>RSU</td>
<td>Road Side Unit</td>
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<td>SaaS</td>
<td>Software as a Service</td>
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<td>SLA</td>
<td>Service Level Agreement</td>
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<td>SME</td>
<td>Small and Medium-sized Enterprises</td>
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<td>TCO</td>
<td>Total Cost of Ownership</td>
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<td>ToD</td>
<td>Tele-operated Driving</td>
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<td>UC</td>
<td>Use Case</td>
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<tr>
<td>V2I</td>
<td>Vehicle-to-Infrastructure (communication)</td>
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<td>V2N</td>
<td>Vehicle-to-Network (communication)</td>
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<tr>
<td>V2V</td>
<td>Vehicle-to-Vehicle (communication)</td>
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<tr>
<td>V2X</td>
<td>Vehicle-to-Anything (communication)</td>
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<td>VCoC</td>
<td>Vehicle Control Center</td>
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<td>WG</td>
<td>Working Group</td>
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<td>WP</td>
<td>Work Package</td>
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1 Introduction

1.1 Objective of the Document

This report identifies new business opportunities that exist in the challenging 5GCroCo Ecosystem based on multi-vendor for telco equipment, multi-vehicle OEM (Original Equipment Manufacturer), multi-MNO (Mobile Network Operator) and multi-data/content providers in a cross-border 5G setup. The investigation is done using Key Performance Indicators (KPIs), and Vehicular-to-Anything (V2X) technologies and standards.

There is specific focus on the adaptation of existing business validation canvases to the new automotive ecosystem, including new KPIs and business model building blocks.

Existing business analyses derived within other relevant 5G consortia and projects (e.g., 5GAA, GSMA, 5G NetMobil, and 5GCAR), serve as starting point.

Innovation will emerge from the following activities:

- Proposed new business opportunities and criteria (i.e. business oriented KPIs, collaboration/role models) to be used in the validation of 5G automotive business opportunities through a new business canvas.
- New value propositions and business opportunities scenarios.
- Identified business opportunities as incentives for enhanced inter-car and car-road side infrastructure cooperation.
- Proposed new automotive value chains based on the 5GCroCo Ecosystem.
- Defined and analyzed novel ITS and other applications enabled and enriched with additional data-sets as for example the information provided from connected vehicles.

Therefore, the following analysis relevant for 5GCroCo is done and presented in this report:

- Identification of drivers in the following areas: technology, economics, environment, society, regulation, politics, etc.
- Description of KPIs to validate business opportunities.
- Markets in terms of: sizes, segments, competition, interrelation.
1.2 Structure of the Document

Section 1 is the introduction to the topic of new business systems for cooperative, connected, and automated mobility (CCAM). Section 2 focuses on new business ecosystems being created by automated driving. This includes a brief overview of the project scope, as well as a discussion on methodologies for business model analysis and generation, some general business concepts for automated driving use cases, and some other relevant activities related to business concepts for CCAM in the context of Europe. Section 3 describes the influences and new opportunities of 5G for the new business in CCAM. Section 4 discusses potential gaps which need to be covered and developed to guarantee the success of any business case for CCAM based on 5G. Section 5 summarizes the report.
2 New Ecosystems for Automated Driving

2.1 5GCroCo Project Overview

5GCroCo will trial and validate 5G technologies for cooperative, connected, and automated mobility (CCAM) in a large-scale cross-border scenario. The aim is to conduct 5G large scale validations in the Metz-Merzig-Luxembourg area (see Figure 2.1). The key outcomes expected from the project are:

- Identification of requirements and KPI’s for CCAM in cross-border scenarios.
- A set of technical innovations towards the validation of 5G technologies considering the particular challenges that cross-border operation implies.
- The deployment and validation of large-scale demonstration of 5G technologies for CCAM to generate recommendations for any cross-border deployment of 5G (reaching beyond the specificities of the selected corridor and selected use cases).
- Contributions to future releases of communication standards (e.g. 3GPP) and automotive-related standards and regulation (e.g. ISO).
- Identification and definition of novel business models that can be built on top of new CCAM services which may be facilitated by 5G technologies exploiting the cross-border operation.

![Figure 2.1 : Corridor for Large Scale Trials in 5GCroCo](image-url)

Figure 2.1 : Corridor for Large Scale Trials in 5GCroCo
The impact of relevant KPIs for selected use cases in combination with business requirements will be described in the remainder of this section. The focus is directed on general questions for new ecosystems for Automated Driving (AD) solutions.

2.2 5GCroCo Use Cases with Relevant KPIs

The 5GCroCo project will implement a set of use cases to validate 5G technical solutions for AD. The specification of use cases and user stories to be trialed are being defined in 5GCroCo, and an initial description can be found in 5GCroCo D2.1.¹

The use cases in 5GCroCo will lead to a big range of different requirements for performance indicators. The concrete values are expected as results of the planned pilot projects and trials. The research will be focused on 5G network parameters like latency, data rates (uplink/downlink) and reliability.

The overall objective of 5GCroCo is to enhance the viability and sustainability of the existing cross-border procedures in the context of the piloted use cases and subsequently facilitate the large-scale uptake of these solutions. It is crucial to move from pilots and innovation ecosystems to business ecosystems, thus identifying necessary steps towards future large-scale deployment and developing strategies for transferring the demonstrations to permanent installations.

AD is seen as one of the key technologies and major technological advancements influencing and shaping the future of mobility. It should be understood as a process taking place in parallel with other evolutions of Intelligent Transportation Systems (ITS) like electrification and shared mobility concepts. Therefore, the impact of 5G must be evaluated not only for private passenger cars, but also for the exploitation of wider shared mobility and ITS concepts.

To fulfil the above-mentioned objective – seamless operation of AD functions in cross-border scenarios - the deliverable will support the following main activities:

- Validate business processes and models with the KPIs in relation to the pilot sites and use cases.
- Identify business opportunities considering the conditions and characteristics of the pilot (e.g. pre-conditions, key enablers, barriers to short-term and long-term developments, technologies and standards, political support, financial and organizational issues).

2.3 Current Industry Research

This section is split in three parts which describe current industry research.

The first part examines the methodology of business modelling that will be used to identify and later evaluate the business opportunities within the 5GCroCo project. As the methodology, it has

¹ http://www.5gcroco.eu/
been decided to use the business model canvas by the economists Osterwalder and Pigneur\textsuperscript{2}. The canvas maps components of organizations, or projects, and helps as a reference point for further analysis, followed by the analysis of the business case. This will be used to support the very descriptive and qualitative canvas with insights on monetary values which we will assess from the pilot site.

The second part gives an overview about the market situation for the selected use cases. In order to develop future business models and identify business opportunities in the context of new technologies, it is important to gain insight of pre-conditions, enablers, and barriers that a certain market might bear.

The third part concludes findings from finished and running projects in the area of 5G for connected and automated cars.

\textbf{2.3.1 Methodology for Business Model/Case Development}

The concept of business modelling has evolved over time and has been influenced by various disciplines dealing with technological, organizational or strategic approaches. This discipline has seen the emergence of various tools to drive business models. For example, the business model canvas (BMC) is today one of the instruments used to discuss and assess innovation and value creation of an organization. The mapping is done through various components, with at least one of them being the main focus. The components of the BMC and the focus are explained below.

Figure 2.2, already developed for cross-border 5G-trials of 5GCroCo.
The BMC contains nine blocks:

- **Block 1: Key Partners**
  
  The network of participants who contribute to the value creation is described in the block “Key Partners”. Partnerships are critical to succeed because they are minimizing risks or unlocking key resources that are not owned by the company.

- **Block 2: Cost Structure**
  
  The block “Cost Structure” describes the total costs incurred within the business model. The costs should be structured according to their type (CAPEX/OPEX) and, if possible, interrelated with the other blocks.

- **Block 3: Key Activities**
  
  “Key Activities” are the success-critical actions of a business. With these activities, the value proposition is created, brokered, and opened up the intended market. Another key activity is to establish and maintain customer relationships.

- **Block 4: Key Resources**
  
  “Key Resources” are the basis for creating the value to be conveyed. A company needs more than just one key resource to succeed. Resources can be anchored physically, financially, intellectually, personally or as partnerships.

- **Block 5: Value Proposition**
  
  It contains all quantitative and qualitative assets, which a business offers to the customer in order to solve problems or to satisfy needs. This variety of services primarily includes products and services as well as the integration of services into customer processes or the project management.

- **Block 6: Customer Relationship**
  
  The way a company wants to get in touch with the customer segments is described in the block “Customer Relationships”. Customer relationships have a significant impact on the customer experience and should, therefore, be tailored to the type of customer segment. In addition, it should be based on the nature of the value offered and its complexity, where less complexity (e.g. consumer goods) implies less interaction.

- **Block 7: Channels**
  
  The block “Channels” acts as an interface between the value propositions and the customer segments. The block describes the different communication, distribution and sales channels, through which the offered value is communicated.

- **Block 8: Revenue/Refinancing Streams**
  
  The block “Revenue/Refinancing Streams” describes the way in which the monetary values of the business are generated and used. Therefore, the biggest drivers of revenue
streams are the customer segments and value propositions as these are generating the revenue. One or more revenue streams can be established for each customer segment. Revenue streams are usually described through one-time or continuous (contract) payments.

- **Block 9: Customer Segment**
  
  The customer is the first and most important element of economic activities. In this block, customers are grouped into clusters according to homogeneous needs, behaviors and characteristics. The targeted division allows to focus on which segment should be served and how.

The BMC can be completed, for example, in brainstorming sessions or workshops with contributors who have insight in the daily routine of the organization/project. The canvas is a guideline and assists in discussing the already running activities and further opportunities.

Out of this business model development, based on qualitative approaches combined with more experts’ inputs, business cases can be developed. A business case examines a particular scenario which can derive from the business modelling canvas process in terms of its profitability and the given investment opportunity. Developing a business case helps for strategic decisions or can also be used to align strategies.

Therefore, the business case can be described by the following five components:

1) **Definition of the scenario.**
2) **Cost elements of the scenario.**
3) **Monetary benefits of the scenario (e.g. cost-reduction, revenues).**
4) **Non-monetary aspects of the scenario (e.g. risks and other benefits).**
5) **Evaluation of the scenario.**

The business case analysis is usually considered over a time frame of three to five years.

Besides the analysis of monetary and non-monetary values in the project, it is also important to analyze the overall market in which the project will evolve.

### 2.3.2 General Business Concepts for Automated Driving Use Cases

Use cases are some of the main drivers for the development of business models, business cases, value chains, and strategic decisions. Therefore, they should also drive the exploitation plans of research and innovation projects to ensure that project results can eventually become new technologies and have impact on markets. Consequently, the current market situation has to be analyzed, also looking further into the changes that this market will then face. AD will comprise many stakeholders and use cases. Beside the already existing players in this market, such as car OEMs, tier 1 suppliers or telco operators, among others, many new actors are expected to arise in this new ecosystem of CCAM. The future relations are quite complex and challenging for existing partners. A non-exhaustive and illustrative overview of the complex and new emerging ecosystem is given in Figure 2.3.
The definition of the AD market can be structured in the following sub-topics:

- Market size (current and future).
- Market trends.
- Market growth rate.
- Market profitability.
- Industry cost structure.
- Distribution channels.
- Key success factors.
- Key success details.

Market analysis strives to determine the attractiveness of AD products and their market share, currently and in the future. Organizations active in the field of AD should be able to evaluate such future attractiveness of the AD market by understanding evolving opportunities, and threats linked to the organization’s own strengths and weaknesses.

For 5GCroCo, the implications for business models will be studied along the pilot site stakeholder eco-system and its use cases focusing on:

- Predictions for system uptake.
- User expectations for service quality and availability.
- Cost / benefit analysis for the AD ecosystem.

This is foreseen in later stage of the project and reflected in D 5.2.

Analyzing the stakeholder environment includes the processes required to identify the people, groups or organizations that could impact or be impacted by the project, to analyze stakeholder expectations and their impact on the project and to develop appropriate management strategies.
for effectively engaging stakeholders in project decisions and execution. The methodology will be used to assess the attitudes of the stakeholders regarding the potential changes along the time-to-market phase.

In AD ecosystems many new players and relations will be present. The following text analyzes the most important building blocks for such new business opportunities.

2.3.2.1 New Market & SWOT

New markets in AD environments mostly arise from the overlap of several industries. These are mainly automotive (OEM) and suppliers, IT (information technology) and telecommunication industry including ITS - combined with the very dynamic mobility service industry. For all these industries, the strengths, weaknesses, opportunities and threats (SWOT) of the specific industry must be identified. Only with the help of a profound SWOT analysis, adequate business strategies for the industry and service lines mentioned can be derived leading to profitable and sustainable business activity.

2.3.2.2 New Customers

New customer products for AD will be focused on mobility services. Mobility as a service will extend existing OEM – consumer relations. Among these customers, some are existing customers, e.g. tourists for car sharing services, whereas some might be totally new customer groups, e.g. logistics service providers using AD car sharing and platooning services for urban logistics and delivery in congested shopping malls, etc.

2.3.2.3 Benefits (safety, security, mobility, environment, etc.)

The benefits that the AD would imply to different areas (like safety, security, mobility, environment, etc.) are crucial parameters to the business assessment. They should be closely monitored and evaluated, to be used as primary axis for the products’ deployment, exploitation, advertising, etc.

2.3.2.4 New Value Chains

In a cross-border environment, new relations between market players will be established. Therefore, at least the following aspects must be considered:

- New services definition and how connectivity can affect them by enhancing or enabling them for deployment.
- Practicalities, where some of the main risks for the connectivity business model definition are shown.
- Business model examples, where the evolution from a linear value chain to a multi-linear relationship model might be expected.
- New neutral operators for dedicated AD and network functions (e.g. MEC service, RAN sharing, ToD) will erase.
• Adaptation of accounting and payment models in an inter-operator environment for mixed markets and different use cases.

2.3.3 Related Activities in EU Context

Other EU-funded projects and European initiatives have already covered different aspects for business modelling in the intersection of both automotive and ICT fields. The purpose of this section is to summarize the main activities which are relevant for 5GCroCo.

2.3.3.1 5GCAR

5GCAR\(^3\) (June 2017 to July 2019) was one of the 5G PPP Phase 2 projects\(^4\). 5GCAR was devoted to conduct research in the area of V2X communications for and the automotive vertical sector towards the adoption of 5G technologies. In the project consortium, telecom vendors were well represented (Ericsson, Huawei and Nokia) as well as the automotive sector (Bosch, PSA Group and Volvo Cars), while there is one single MNO (Orange) and no road operator involved. Academia (Kings College London, Chalmers University, CTAG and CTTC) and SMEs (Viscosa, Sequans, Marben) are also well represented. Some of the 5GCAR business-related output is its two 5GCAR project deliverables D2.2\(^5\) and D2.3\(^6\).

In 5GCAR D2.2, the service definition and how connectivity can affect new services by enhancing or enabling them for deployment are discussed, as well as practicalities where some of the main risks for the connectivity business model definition are shown. Further, the business model examples, where the evolution from a linear value chain to a multi-linear relationship model is explained focusing on two examples: over-the-air (OTA) updates and autonomous driving. Figure 2.4 illustrates the 5GCAR value chain and possible ecosystems which gives an understanding of the perspective from different sectors.

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\(^3\) 5GCAR Project website: [https://5gcar.eu/](https://5gcar.eu/)

\(^4\) 5G-PPP Phase 2 Projects: [https://5g-ppp.eu/5g-ppp-phase-2-projects/](https://5g-ppp.eu/5g-ppp-phase-2-projects/)

\(^5\) 5GCAR [https://5gcar.eu/wp-content/uploads/2019/03/5GCAR_D2.2_v2.0.pdf](https://5gcar.eu/wp-content/uploads/2019/03/5GCAR_D2.2_v2.0.pdf) 5GCAR D2.2

"Intermediate Report on V2X Business models and Spectrum", February 2019

Figure 2.4: 5GCAR Value Chain and Possible Ecosystems

In 5GCAR D2.3\(^8\), an automotive use case roadmap in the 2020-2030 time horizon is outlined together with current 4G situation, challenges and 5G advantages as well as reflections on both 5G performance KPIs and societal KPIs. Further, business model analysis of 5GCAR technical components as well as business market opportunities for V2X are presented.

2.3.3.2 5G-PPP Automotive Working Group (WG)

The 5G-PPP Automotive WG\(^9\) released two white papers at the Mobile World Congress 2018 and 2019, respectively. They are presented as different versions (Version 1\(^{10}\) and Version 2\(^{11}\)) with the same purpose: provide a first approach on a business case for 5G V2X deployment using a highway as an example. Both papers are providing figures about the costs and possible incomes related to Connected Automated Driving (CAD) services and connectivity needs. The second version goes deeper into different deployment scenarios exploring different network sharing options and revenue share between several MNOs which will affect the CAD business case.

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\(^9\) 5G-PPP Working Groups [https://5g-ppp.eu/5g-ppp-work-groups/](https://5g-ppp.eu/5g-ppp-work-groups/)


2.3.3.3 5G Automotive Association (5GAA)

The 5GAA was created on September 2016 and is a global cross-industry organization that promotes the development of end-to-end specifications for future transportation and mobility services. So far, more than 110 companies have joined 5GAA12.

The 5GAA White Paper “C-ITS Vehicle to Infrastructure Services: How C-V2X technology completely changes the cost equations for road operators”13, published January 2019, shows how the business model and business case definition methodologies described earlier in this report are used to evaluate the business impact of new solutions. The different cost-aspects of C-V2X technologies are evaluated based on capital expenses (CAPEX) and operational expenses (OPEX) and stated in different delivery models which road authorities can use to reduce the implementation and operating costs of the technologies.

Key aspects that are mentioned in the white paper are:

- If ITS services have to be delivered uniformly over all roads, the cost of delivering ITS services with existing cellular networks is significantly lower compared to widespread Roadside Unit (RSU) rollout: in the most extreme cases, it could be greater than a hundred times lower than with only dedicated RSUs;
- The cost gap between RSU and cellular is larger for rural and minor urban areas and lower (but still very significant) for motorways and major urban roads.
- The cumulative connectivity cost is not offset even within ten years, by which time 5G will be the common cellular standard and a new standard might already be in deployment phase.
- It is not a common business assumption to consider that road authorities should pay for cellular subscriptions in vehicles. In the case that the OEM or vehicle owner pays connectivity, and not the road operator, it is feasible to assume that the portion of data transmitted in relation to the services considered for this study would represent a small fraction, compared to infotainment and other V2N services.

With the above-mentioned assumptions, it can be seen that the white paper focuses on costs and delivery models of RSU technology, and less about connectivity or the impact of 5G itself. Indeed, the paper shows that 5G could be better positioned than any other technologies to provide CCAM services with connectivity.

2.3.3.4 AUTOPILOT

Another project in the context of connected and autonomous driving is AUTOPILOT. The overall objective of AUTOPILOT14 is to bring together relevant knowledge and technology from the automotive and the Internet of Things (IoT) value chains in order to develop IoT-architectures and platforms which will bring AD towards a new dimension. This IoT-architecture is said to enhance the security and comfort of the autonomous driving services. AUTOPILOT project focus is on the

12 http://5gaa.org/about-5gaa/about-us/
13 https://5gaa.org/5gaa-in-motion/news/
14 http://autopilot-project.eu/
following use cases: automated valet parking, highway pilot, platooning, urban driving and car sharing.

AUTOPILOT actively contributes to standardization activities, as well as facilitating consensus building in the areas of the IoT and communication technologies for vehicle communications (5G, 5G-PPP, ETSI TC ITS and 3GPP, IETF). In particular AUTOPILOT will use the two following V2X connectivity technologies: the standardized ETSI TC-ITS V2X protocols based on the ITS-G5 access, and LTE V2X being under development at 3GPP and being also part of the 5G standardization process. 3GPP is on the way towards standardization of 5G mobile communication networks and aims to deliver these standards around 2020 after which commercialization will take another 1-2 years. Concrete realization and roll-out planning will be different in the dedicated markets – e.g. Asia, US, Europe. Within the context of AUTOPILOT, pre-5G networks will be tested at the Brainport Pilot Site in the Netherlands. The 5G development now taking place in the scope of AUTOPILOT will introduce changes to be able to comply with severe latency requirements and high frequency transport of small messages (M2M). Brainport is one of six AUTOPILOT test sites. As AUTOPILOT is still running until end of 2019, no test results are publicly available regarding the 5G standardization contribution or test results. AUTOPILOT also examines the business opportunities, specifically the business impact and exploitation are under research.

The impact assessment uses the FESTA methodology\textsuperscript{15} and KPIs for evaluation of IoT services, architectures and platforms for autonomous driving. The task applies the Multi-Actor Multi-Criteria Analysis (MAMCA) methodology, which will collect and prioritize stakeholder input using a set of criteria and weights and facilitates the Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA). A market study involving the relevant industry segments is examined within the project. The market study shows relevant revenue and value streams, as well as time-to-market aspects.

The business exploitation activities are aimed at the sustainability of the pilot sites and exploit the business opportunities at the specific pilot site to upscale the results on national or international level. In conclusion, the AUTOPILOT projects results will be of interest regarding the business opportunities and autonomous driving assumptions while taking into consideration that 5G is not the key focus of this project.

2.3.3.5 CONCORDA

The Connecting Europe Facilities (CEF)-funded Connected Corridor for Driving Automation (CONCORDA) project evaluates connected services and facilities. Use cases considered are high-density truck platooning and highway chauffeur automated driving on motorways. It evaluates ITS-G5 and C-V2X (short-range and long-range) communication technologies aiming at overcoming fragmentation and assuring backward interoperability between Cooperative ITS (C-ITS) services and technologies providing them.

\textsuperscript{15} https://fot-net.eu/context/the-festa-methodology/
Trials are conducted in Netherlands, Belgium, France, Germany, and Spain. Interoperability for system architecture and communication technologies, services, and actual implementation is evaluated between the sites.

Besides communication aspects, CONCORDA also evaluates enabler such as precise positioning and the non-technical aspects of cost-efficient realization of services. Especially the later will allow findings from CONCORDA regarding ecosystem and business aspects to be considered for 5GCroCo once the respective CONCORDA deliverables become public.

2.3.3.6 Other ICT-18 PROJECTS (5G-CARMEN and 5G-MOBIX)

5G-CARMEN

5G-CARMEN is similar to 5GCroCo, but with other partners and running trials in a different cross-border corridor.

The goal of 5G-CARMEN is to create new and realistic opportunities for generating competitive advantages for the European ICT, as well as the automotive, and road equipment manufacturing sectors. The vision of connected vehicle will transform the automotive industry that will benefit from the same level of agility as what is available today in the IT world: Time to market for new innovative services will be significantly improved, and overall Total Cost of Ownership (TCO) will be reduced. In the commercial field, 5G-CARMEN will help to open the market to new actors and will provide more compelling competitions over service availability and proper handover/roaming between worldwide operators.

The main objectives are:

- Setting up a process to elaborate the cooperation models and cooperative future business models for connected mobility in 5G-CARMEN, between all stakeholders (i.e., vehicle manufacturers, telecom operators and public authorities, road operators, service providers, etc.).
- Defining and validating these cooperation models during the piloting phase of 5G-CARMEN, based on the defined use cases and the direct involvement of main partners and their data sharing in the demonstration phase.
- Building business models for connected mobility, including the multiple contributions from partners, which scale up from corridors and tested areas to widely distributed services for mobile end users and connected travelers in Europe.

There are two tasks in 5G-CARMEN dealing with business modelling:

**T6.2: Market analysis and business modelling**

Task 6.2 will perform a market analysis of cooperative, connected and automated mobility for the three main stakeholder groups (vehicle manufacturers, MNO-Mobile Network Operators and road infrastructure authorities) and additional service providers needed to cooperate in order to address the preferences of future mobile users on their selected personal platforms. This process
is planned to conduct the following steps: Stakeholder analysis and contributions to CCAM, definition of cooperation models for demonstrations on the Bologna-Munich corridor in 5G-CARMEN, generate general business models for upscaling and service extensions. Hereby, a revision of business aspects of participants from all areas of the value chain in 5G-CARMEN will contribute to a strong business case and a robust environment of partners supporting each other. The single aspects will be addressed based on the selected CCAM use cases and extended towards larger market segments and stakeholder groups.

**T6.3: Exploitation and commercialization**

This task will address the exploitation of results from the demonstration phase for vehicle manufacturers, road operators and telecom network operators and their suppliers. Extension of demonstration results to multichannel service distributions and different mobile platforms.

For the MNOs, an assessment of the advantages and financial viability of "neutral hosting approach" for specific parts of the infrastructure will be carried out to evaluate a more cost-effective cooperation model" for the future of CCAM. Additionally, for specific elements of the mobile network (e.g., MEC or multiple parallel data streams from vehicles) the demonstrated results will be used to generate an economically favorable outlook of the mobile communication network, and to define the first commercial elements for the support of CCAM roll-out on different road infrastructure networks and connectivity environments.

**5G-MOBIX**

The 5G-MOBIX project is also organized in the frame of Horizon 2020 co-financed by the European Commission.

5G-MOBIX will develop and test automated vehicle functionalities using 5G core technological innovations along multiple cross-border corridors and urban trial sites, under conditions of vehicular traffic, network coverage, service demand, as well as considering the inherently distinct legal, business and social local aspects.

The project will evaluate benefits in the CCAM context as well as define deployment scenarios and identify and respond to standardization and spectrum gaps.

The expected benefit of 5G will be tested during trials on 5G corridors in different EU countries as well as in China and Korea.

Several automated mobility use cases are potential candidates to benefit from 5G such as cooperative overtake, highway lane merging, truck platooning, valet parking, urban environment driving, road user detection, vehicle remote control, see through, HD map update, media & entertainment.

5G-MOBIX will explore and assess new business opportunities for CCAM with 5G like 5GCroCo and 5G-CARMEN.

The adoption of new business models for CCAM will help to identify appropriate financing schemes for 5G-enabled transportation solutions, revenue allocation and procurement models.
The main activities will be to explore financing schemes such as Public-Private Partnerships, subsidization, crowdfunding, in-kind contribution, venture capital, etc. along with the associated products as well as revenue allocation models considering concepts concerning e.g., OEMs, as well as transport operators.

As a result of the evaluations and international consultations with the public and industry stakeholders, 5G-MOBIX\textsuperscript{16} will identify new business opportunities for the 5G enabled CCAM and propose recommendations and options for its deployment.

In the Report D6.3 (5G enabled business models for automated mobility) the main findings for new business models will be presented - expected in Q1 – 2020.

2.4 5GCroCo Use Cases as Enablers of Automated and Safer Driving

5GCroCo has selected three use cases to develop and demonstrate cross border trials for CCAM. In Report D2.1\textsuperscript{17} (Test Case Definition and Test Site Description Part 1) the full use cases and user stories are described in detail and are referred to in the following subsections where the current market situation is depicted and the 5G technology drivers for business development is analyzed.

2.4.1 UC1: Tele-Operated Driving

2.4.1.1 Use Case Description

Tele-operated Driving (ToD) is defined as remote control of automated vehicles by a human over mobile radio networks, within one country or across borders. It is meant to complement AD by bringing the tele-operator, located in a so-called vehicle control center (VCoC), into the control loop in situations an automated vehicle (AV) cannot or should not handle. Therefore, this concept utilizes the strength of human beings to handle complex scenarios. The overall architecture of the ToD use case is shown in Figure 2.5. The vehicle, provided with automated and Tele-operated Driving functions, is sending to and receiving data from the vehicle control center, transmitted via the mobile 5G network. In the following, the current market situation of ToD will be given, together with a brief outlook on 5G technologies as drivers for potential business opportunities.

\textsuperscript{16} https://www.5g-mobix.com/  
2.4.1.2 Current Market Situation

Tele-operation has been a field of active research in past years. It has been applied successfully in hazardous or inaccessible environments, e.g. by the military\textsuperscript{18} or in space operations\textsuperscript{19}. With the 4G/LTE mobile network standard, it became conceivable that tele-operation of road vehicles could be a feasible undertaking. Startups, e.g. Phantom Auto\textsuperscript{20}, evolved. Also, larger companies, such as Ericsson in cooperation with Scania\textsuperscript{21}, or Huawei in cooperation with SAIC Motors\textsuperscript{22}, are working on tele-operation.

2.4.1.3 5G Technology Drivers for Potential Business Opportunities

Until today, there do not yet exist business models for Tele-operated Driving. It demands a high reliability of the network that may not be achieved with the current 4G/LTE mobile network standard. However, with the mobile network standard 5G promising to drastically reduce network latency and reliability, this is subject to change. Furthermore, seamless service along the route, where the vehicle is tele-operated, can be enabled with the 5GCroCo solution predictive Quality of Service.

2.4.2 UC2: High Definition Map Generation and Distribution for Autonomous Driving

2.4.2.1 Use Case Description

High definition maps for autonomous driving (HD Mapping) are defined as real-time, intelligent high definition maps that provide highly accurate position and traffic information of dynamic and


static objects for optimal route and lane selection by an autonomously or semi-autonomously driving vehicle.

For each user story, potential business cases will vary and depend on relevant stakeholders and the demonstrated benefit for deploying 5G in each story against various 4G technologies including 4G, 4G including roaming, 5G, 5G including roaming, 5G including Mobile Edge Computing (MEC).

2.4.2.2 Current Market Situation

Broadly, HD map data is used to identify the position of vehicles and traffic events. This is achieved using the updates provided by mapping companies and also the localized information provided by vehicles. It is important that accurate HD Maps are maintained, especially with respect to frequently changing data. As a result, these updates can be large and with some map information having very high demands on bandwidth. AD cars, in particular, have very high requirements for coverage and availability of high-quality accurate map data, without which will have the effect of limiting their functionality.

HD maps require numerous sources of information for road routing/layout as well as traffic signs including speed, warnings, and general road information. The mapping system receives and stores the information from the vehicles available.

The quality of HD mapping data increases with the number of sensing vehicles and, therefore, additional vehicles will place increasing demands on cellular networks that will likely be beyond the dimensioned capacity of today’s 4G networks. Also, in order for the service to be ubiquitous, map updates require seamless access across multiple networks and national borders something which is not currently widely deployed for localized mapping data services.

This HD Map information is localized and made available to vehicles by regular downloads for non-urgent information, or pushed to vehicles for highly urgent or emergency information for a road accident or similar. Hence HD map distribution may take advantage of MEC deployments, hosting HD Map components relevant for the local area to reduce the demand for downloading large volumes of map information and to provide a fast, reliable and efficient access to relevant local map data. The technical summary identifies how map data will be distributed and maintained in case localized map data is available for each vehicle, and how it may be optimized through the deployment of 5G technologies.

2.4.2.3 5G Technology Drivers for Potential Business Opportunities

The 5G technology drivers that will enable new business opportunities with relevant KPI Minimum Service Levels (MSL) include latency, bandwidth, coverage, and availability. The requirements for these KPIs will be delivered through MEC, high speed data transmission, support for higher bandwidth, and network slicing.

MEC will deliver improved performance where localized mapping data may be stored at the edge of the network providing this high volume and map data to local vehicles. MEC will offer added
advantages including reduced network load and reduced latency of map data delivery to the vehicle.

The extent of these technology benefits will be investigated in the 5GCroCo use case trials which will also identify where potential business opportunities will appear. It is likely that these technologies and applications will support emerging business opportunities for HD maps services for HD map data and traffic alerts sold to OEM’s through a subscription-based model in addition to the possibility for OEM to sell vehicle sensor data to HD Mapping services. There may also be opportunities for separate services for incremental updates of road alert information or changing traffic conditions such as speed warnings provided on a transactional basis.

Additionally, opportunities may emerge for OEM’s and ITS providers in providing the up-to-date sensor data used to increase accuracy of HD mapping data as a SaaS-type service. These emerging business opportunities are described in further details in Section 3 Evolution of Defined Use Cases with New 5G Functions.

Network slicing, and the virtual network that can be defined, may offer an optimized solution for downloading of mapping data, particularly for highly urgent information such as road accident updates.

2.4.3 UC3: Anticipated Cooperative Collision Avoidance

2.4.3.1 Use Case Description

5GCroCo will allow to anticipate the detection and localization of dangerous events, and exchange them among vehicles in real-time, to facilitate smoother and more homogeneous vehicle reaction. This is called the Anticipated Cooperative Collision Avoidance (ACCA). ACCA is part of the Advanced Driver Assistance Systems (ADAS).

ACCA application relates to the possibility to anticipate certain events in order to reduce the probability of collisions in situations when typical sensors will have only partial, no visibility, or a short detection range (a few hundreds of meters). In certain situations, typical stand-alone sensing systems (e.g., radar, camera, lidar) will not have sufficient and safe performances to detect and localize dangerous events on the road and with sufficient level of anticipation. In such situations, too late detection of a dangerous event will trigger hard braking or dangerous maneuver potentially leading to a collision.

2.4.3.2 Current Market Situation

Since 2018, new vehicles are connected in order to provide eCall as a mandatory service in Europe. The eCall services use 2G or 3G standards and permits to improve the safety of the car passengers. However, this service only provides information after an accident occurred.
In addition, some automotive OEMs have already deployed proprietary services, such as ‘Slippery Road Alerts’\(^{23}\), to distribute information collected by their vehicles over 3G/4G network and backend servers to other vehicles of the same manufacturer. So far, this information is only used to inform or warn the driver. Work is ongoing between different OEMs to use one shared backend server to allow information dissemination across brands.

In the context of automated driving, which increases the responsibilities of the car manufacturers, a service which could increase the safety of passengers by giving information on road risk events would be seen as a huge improvement.

The cooperative features of 5G and the capability to process data in the low layers of the network will increase the performance for delivery of such information in terms of latency and reliability.

2.4.3.3 5G Technology Drivers for Potential Business Opportunities

As mentioned above, ACCA is already possible with existing (network) communication technology. However, 5G technology will enable new business opportunities with relevant KPI MSLs including latency, bandwidth requirements, coverage, and availability in general but also in a cross-border respectively cross-network roaming context. Also, the new features in the network itself, like network slicing and MEC, will improve the performance of ACCA. 5G will also improve the roaming convergence which improves ACCA especially in cross boarder situations, where vehicles are connected to networks in different countries and need to share information.

ACCA (beyond the collision avoidance benefit) opens the door to offload some processing in the MECs and build a consolidated and real-time collective awareness of the road events under the MEC coverage. It also allows to mutualize the computational effort which is common to many vehicles, instead of having each vehicle running the same calculations. In addition, the services which are offloaded in the MEC can apply complex data fusion algorithms, combining detected events from multiple vehicles or from cameras installed along the roads. The delivered output of such offboard service of a collective road perception may be highly complementary with the outcome of what an onboard road perception service can detect using V2V communications. This is due to two main reasons:

1) The location of an event can be much more accurate by combining inputs from multiple vehicles. For AD/ADAS systems, it is key to map a hazard with lane-level accuracy.

2) The confidence of an event is higher and, therefore, more trustable by the AD/ADAS system if the information about an event is confirmed by multiple sources.

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The ACCA service has to be seen as a clear social benefit due to its potential to reduce accidents. Studies show that, thanks to the information shared between vehicles, in 2025 5G will lead to a 5% reduction in road accidents\(^{24}\).

The benefits of 5G for transport and smart cities are forecasted beyond 16 billion in the same year, considering strategic, operational, congestion reduction, social and environmental aspects.

This service has a high value if many vehicles contribute to building this collective perception of the road and if the shared information is very accurate and trustable. Therefore, the vehicles providing information should be rewarded: the vehicles may receive incentives for their cooperative road perception. And those which deliver very accurate information (e.g. can localize an event very accurately) should have a higher incentive.

The road operators, managing public infrastructures, shall get economic incentives from the administrations, linked to road safety indicators. This has already been proofed as a good approach in the past, even when connectivity was not applied. Based on this, the road operators can lead the deployment of the needed connectivity infrastructures to enable this use cases\(^{25}\).

Another success criterion to enable such off-board services is that MECs of multiple MNO’s within the same country or beyond the border can cooperate; otherwise, the road perception which is collectively built in the MEC would stop at the border or would stop at the MEC coverage of the given MNO.

If MEC is not used for ACCA, 5G will also significantly improve the cross border and cross MNO handover, avoiding service interruption where no communication is possible. With 4G, the time to switch between MNO is around 30 seconds. 5G aims to bring this time down below 1 second.

5G network slicing is another crucial technology driver for this use case. First, it can improve the security of the ACCA service as it “bundles” similar traffic allowing easier detection of security threats like network intrusion. In addition, this feature enables different infrastructure sharing opportunities than can lead to CAPEX savings from 16% up to 45% depending on the type of sharing strategy analyzed\(^{26}\).

To sum up, it has been shown that thanks to 5G there are elements to work on a business case for ACCA service combining the potential revenue sources and cost reductions possibilities described in this section.


\(^{25}\) [http://oa.upm.es/21361/1/AAP-D-12-00796-paper.pdf](http://oa.upm.es/21361/1/AAP-D-12-00796-paper.pdf)

3 Evolution of Defined Use Cases with New 5G Functions

The automobile industry is at the start of a transformation that will take 15 to 20 years to realize. Billions of euros are being invested in advanced vehicle technologies that will enable the introduction of new safety and efficiency systems and, ultimately, driverless cars. This future generation of automobiles will require the exploitation of sophisticated wireless telecom capabilities in order to communicate with one another, with road side equipment, with local traffic control systems, with manufacturers and with third-party service providers. According to NAVIGANT RESEARCH’s\textsuperscript{27} forecast, the number of automated vehicles will reach 95.4 million by 2035. All new cars will be connected by 2025 according to Accenture\textsuperscript{28}. Following these forecasts, we can expect an evolution of the use cases developed within the 5GCroCo project, reaching different industry and administration players, and creating a socio-industrial ecosystem influencing in part the global economy. In this section, we will tackle the evolution of the use cases with a prime vision on how the upcoming and new 5G functionalities can sustain novel opportunities. New roles and business opportunities will be identified or at least directions drawn.

In general, the cost of deployment of the 5G technology to be used in any of these use cases shall be divided in three fractions:

1) Cost of 5G network deployment (CAPEX).
2) Cost of HW and SW for the embedded telco system in the cars (CAPEX).
3) System operation (OPEX).

In order to have a good profitability, these costs shall be balanced and compensated by, for example, the subscription of the customers, or by inclusion in the price of the vehicle. Other alternatives may exist, and this will be explored during the 5GCroCo execution.

For example, eCall today has no subscription fees. This is justified because it is a very rarely occurring service. However, it is not judicious for assistance in automatized driving which occurs more often.

Also, based on OEM experience, it is difficult to sell a telecommunication subscription to the private car owner. The alternative to adding a separate mobile subscription would be to use the SIM access profile of the embedded telematics equipment (more efficient and more stable in terms of mobile radio device and network performance) in order to remove recurring costs for the customer.

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\textsuperscript{27} Navigants Research Forecast. https://www.navigantresearch.com/reports/navigant-research-leaderboard-automated-driving-vehicles
The following section will present the main relations between components in the new AD ecosystem, the key drivers for this business, and according business opportunities.

### 3.1 Building Blocks of 5G-Enabled Solutions

Taking a general perspective, the building blocks of the next generation of 5G-enabled solutions integrate multiple telecommunication and computing technologies as presented in Figure 3.1.

![Figure 3.1: Technical Building Blocks](image)

From a business point of view, these elements are developed and/or managed by different stakeholders that will participate in the value chain. Beyond the structural parts, there are stakeholders that will take advantage of the infrastructure, on a first stage extending well-established businesses, and in the second stage developing added value services on top of them.

In this section, we will focus on the identification of early business opportunities that can be derived from the evolving infrastructure and also services sustained by it. We will briefly summarize those technical aspects and identify, from a business perspective, what are the selling arguments and key advantages that the technical elements enable.

#### 3.1.1 Key Technical Drivers

Figure 3.2 provides the high-level application architecture for the project. The 4G and/or 5G network is connecting applications in vehicles with their counterparts in the backend. The network is expected to fulfil the requirements of the use case specific applications.

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Therefore, the following technical components are evaluated in the project. Each component can also have implications for value chains and business modelling:

**Mobile Edge Computing (MEC):** Today many providers offer public and semi-public clouds. They are accessed through the public Internet and MNOs have no or only limited control over QoS in the public Internet substantially hindering Service Level Agreements (SLAs) considering the end-to-end path. MEC enables MNOs to host backend applications within their network domain enabling end-to-end QoS and respective SLAs.

**Predictive QoS:** Many use cases can tolerate limited times and/or areas where the requested QoS cannot be delivered. This requires less complex networks for the benefit of the customer who would have to pay less for their services. Rather than guaranteeing close to 100% availability, the network will inform the user in advance if the requested QoS cannot be provided or might be degraded. For many automotive use cases, this needs to happen predictively since the vehicle needs time to enter a state where it can cope with the upcoming degraded network performance.

Besides safety critical applications, prediction can also support non-safety related ones. Non-critical information, e.g. HD map updates, can be transferred at times and/or places where the network has spare capacity. As a reward, the customer pays less due to the willingness to delay the transmission.

**Mobile Radio Network Supported Precise Localization:** Only relying on satellite-based localization (GNSS) creates a dependency that is not acceptable for many use cases. Furthermore, the accuracy is often insufficient. By supporting precise localization by one of the many available mobile radio network related solutions, MNOs can enable or enhance use cases which are not
possible today such as Vulnerable Road User Protection and generate further revenue by charging for that service.

**E2E QoS with Network Slicing:** The demand for end-to-end QoS was already discussed above in context of MEC. Furthermore, network slicing enables reuse of network infrastructure for safety critical and non-critical services. This ensures increased utilization, especially compared to today’s existing silos like GSM-Rail and public safety Long Term Evolution (LTE) or Terrestrial Trunked Radio (TETRA) networks. Furthermore, network slicing enables roaming and improved security beyond today’s best effort situation when leaving the home network. Related technical and business aspects are being evaluated by GSMA in its Network Slicing Task Force (NEST)\(^\text{30}\).

### 3.1.2 Key Business Drivers

**Enhanced safety:** brought by the combination of 5G communications, embedded real time sensors, and information awareness is expected to reduce traffic accident rates. It is estimated that if 90% of vehicles were automated, the number of traffic accidents would decrease by nearly 80% and the number of fatalities by about 60%\(^\text{31}\). The US National Highway Traffic Safety Administration (NHTSA) predicts that light and medium-sized vehicles with vehicle-to-vehicle communications (V2V) can avoid 80% of accidents, and large vehicles with V2V can avoid 71% of the accidents. With a rapidly aging population and many accidents involving senior citizens, the automatic driving function will become a standard safety feature for future vehicles. In 2017, the European Union member states promoted the development for Vehicle-to-Everything (V2X) infrastructures installed alongside roads to implement information exchange between vehicles and infrastructure. Korea and Singapore deployed V2X roadside units in 2017 and 2018\(^\text{32}\). V2X technology is maturing and being deployed in multiple countries. Emergency Call (eCall) and V2X are becoming standard features for vehicles and will reach a penetration of 30% in 2021\(^\text{33}\).

**Improved efficiency:** the connected vehicle and automated driving can reduce traffic congestion by 60% and improve traffic capacity by two or three times\(^\text{34}\). Vehicle stop time and running time can be reduced by 30% and 13–45%, respectively, cutting fuel consumption by around 15%\(^\text{35}\). Manpower released from traffic congestion will increase economic production and give people more free time. The consulting firm McKinsey believes that commuters around the world will save up to one billion hours per year in total when driverless vehicles become mainstream\(^\text{36}\). Driverless


\(^{34}\) https://www.ssti.us/wp/wp-content/uploads/2012/05/CMU-PennResearch_final_4-23-12.pdf


vehicles also free people's hands and eyes, allowing them to handle important business or entertain themselves while driving. However, existing networks cannot meet the requirements of future demand to support smart driving applications. 5G networks are expected to enable safe and efficient passenger experience through smart driving. 5G technology has aroused people's interest with its promise of flexible networking, high real-time performance, and extremely fast data rates. In the telecommunication and automobile industries, integrating sensing and awareness information, automated driving technologies and 5G has become an important research direction to improve traffic safety and develop business applications.

**Real time awareness:** connected vehicles will be aware of potentially infinite information in the geographic area they are located in real time. This will favor novel service models where information will be delivered on-demand to the vehicles. Local services, parking availability and reservation capabilities will be integrated as vehicle services. Cities and infrastructure operators will be able to deliver modal transport information enabling the optimization of traffic and inhabitant's movement. A third-party ecosystem will develop leveraging connectivity, vehicular information and Internet services.

**Privacy/security services and models:** the emergence of delay-sensitive applications such as automated driving is requiring low-delay and highly-secure network services. In these scenarios, the 5G network is designed to support high reliability while providing QoS guarantees and constrained delays so as to prevent accidents such as vehicle collisions. Security technologies have been redesigned in 5G networks in order to support efficient, lightweight, and compatible mobility management mechanisms to meet the more stringent delay requirements. Enhanced security is, therefore, an enabler of critical broadband applications such as those required by vehicular applications.

**Infotainment services:** a significant component of the automotive infotainment systems is mobile device connectivity. The new mobile network standard 5G will enable completely new functions in the vehicle and beyond. In addition to pave the way for future mobility and automated driving, will also provide enhanced multimedia and infotainment features in the vehicle. With 5G over-the-air updates of applications and software in the vehicle are possible almost in real time and even more 5G connectivity will allow for seamless and delay-free video and music streaming for example, as well as for the integration of weather forecasts, or information on the current traffic situation. These features need to be also provided in cross-border scenarios dealing with roaming delays in an efficient manner.

### 3.2 Interactions and Opportunities

Having understood the use cases from a business perspective and having identified the business enablers for the technologies developed in the 5GCroCo project, this section discusses the possible interactions and opportunities that have to occur in order to build up an innovative ecosystem.
### 3.2.1 Stakeholder Overview

Interactions will be enabled by potential business opportunities. 5GCroCo has identified the key stakeholders that need to define and drive the development of the market. First and immediately, through generating value from the potential applications defined in the proposed use cases. On a second iteration, by applying the technologies developed and evaluated within the project in other existing but relevant applications. Finally, by empowering new applications based on the experience and outcomes gained.

![Stakeholder Categories Diagram](image)

**Figure 3.3: Main Stakeholders Categories**

In the envisioned 5GCroCo ecosystem, the following stakeholders will take a structural role:

**The Automotive industry players, including vehicle manufacturers and Tier 1/OEM providers** will be in charge – with other partners in the ecosystem - of embedding both intelligence and communication components in vehicles and in dedicated infrastructures (e.g. Mobile Edge Cloud). Vehicles that are smoothly collaborating with other vehicles or devices, will enhance awareness and problem-solving functions for safety, automation and traffic efficiency under very strict time/space performance requirements. In the early days they will be the drivers of novel 5G empowered applications, especially related to the safety of the vehicles. The existence and growth of the 5G infrastructure (through eMBB for example) will motivate development in the application market and favor the development of additional services.

**5G Industry: telecom infrastructure providers and manufacturers** will develop the infrastructure to meet the 5G requirements, as defined by the regulation bodies. Telecom industries including operators, vendors and telecom manufacturers will need to collaborate and align their developments to the automotive industry and other sector demands. In this context,
the manufacturers need to have an influence on early harmonization and system specifications, in order to create the corresponding markets and address them with competitive products at the appropriate time. This is achieved today thanks to their presence in regulation bodies.

**Industrial and Telco equipment vendors** recognize the need to disassemble vertically integrated technologies and to support success stories to validate the KPIs that stand their technological assumptions. The generation and ownership of intellectual property is essential to ensure profitability of the manufacturer’s business, and at the same time, to provide incentives for competition through open platforms or cross-license agreements on fair and reasonable terms.

**Mobile network operators** recognize the potential that the automotive sector offers to expand their total service offering, thereby increasing their market size and growth rate. The need to enhance existing infrastructure or functions has also been identified in order to achieve V2X Services’ QoS metrics. Yet, the risk of a single infrastructure technology will polarize the stakeholder’s opinion, enabling alternative ecosystems to further develop (e.g., IEEE802.11p vs C-V2X).

**Small to medium sized enterprises (SME) in the sector** will create strong R&D links with both academia and leading industrial entities, which helps them within the value chain. The SMEs, at the same time provide, an innovative character with necessary edge competence, services and products. In the figure 3.3. MNO is included in 5G industry.

**Road infrastructure operators:** Road Traffic Authorities (RTA) are mainly responsible for operating road infrastructure; they can be public or private entities and usually manage a large infrastructure for long periods of time. RTA’s take into consideration the necessary requirements to address the most challenging scenarios such as the cross-border corridor. RTA need to be convinced by Telecom industries to adopt 5G technologies. The automotive industry will also play a fundamental role. Without a clear alignment in the ecosystem Regulator-RTA-Vehicle Manufacturer-Telecom industry, the expected growth of the vehicular connectivity will not develop.

**Standardization bodies:** V2X standards are being developed at different bodies; e.g. the ETSI, 3GPP, IEEE, and others are developing core specifications to regulate the communication of vehicles at different layers and sometimes proposing competing technologies. The role of standardization bodies is crucial to ensure that the investment of large companies is taking the right directions and also allows for interoperability among different vendors. Standardization bodies must, therefore, define clear pictures of the technologies and align, when possible, to avoid non-coexisting, non-compatible, and fragmented markets.

**Academia and research** are interested in building on and further developing existing software skills and research strength in V2X systems. The gained expertise will permeate into the daily university life and will be disseminated within academic education as preparation of future European ITS and 5G experts.

**Insurance companies:** among other sectorial institutions related to risk assessment and management, updates in the vehicular/transport infrastructure and the early focus of 5G
technologies to provide extended security services in vehicles are of utmost relevance to their business models. To this end, we expect 5G enabling extended services and tailored audits to improve risk assessment in such companies.

**User**: are the consumer of dedicated services, in different relation B2C, B2B or B2B2C. This includes “mobility service providers and logistics” (MSP) fleet operators, freight transport services etc.

### 3.2.2 Synergies per Use Case

Table 3.1 identifies categories and subcategories of stakeholders playing a role in 5GCroCo use cases. This approach has been used to illustrate the possible synergies of the relevant players in the market. Through their interactions, the potentials of the technology and use cases have to be evaluated, driving to future success stories and reaching other sector stakeholders and markets.

<table>
<thead>
<tr>
<th>Stakeholder category</th>
<th>Subtype</th>
<th>Description</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users</td>
<td>Drivers</td>
<td>Person managing the vehicle.</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>Passengers</td>
<td>E.g., passengers of public transportation or taxis.</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>Vehicle Owners</td>
<td>E.g., Rental Car SME (Small and Medium Enterprise).</td>
<td>VO</td>
</tr>
<tr>
<td>Mobility Service Provider</td>
<td>Logistic &amp; Mobility Service Provider</td>
<td></td>
<td>MSP</td>
</tr>
<tr>
<td>Automotive Industry</td>
<td>Car OEMs</td>
<td>Car manufacturers.</td>
<td>OEM</td>
</tr>
<tr>
<td></td>
<td>Tier 1 Supplier</td>
<td>On-Board Unit (OBU) manufacturer.</td>
<td>1TS</td>
</tr>
<tr>
<td></td>
<td>HD Map provider</td>
<td>Provides HD maps in streaming.</td>
<td>MP</td>
</tr>
<tr>
<td></td>
<td>Map provider</td>
<td>Provides updated maps in real time; e.g., Open Street maps.</td>
<td>MP</td>
</tr>
<tr>
<td>Stakeholder category</td>
<td>Subtype</td>
<td>Description</td>
<td>Symbol</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>5G Industry</td>
<td>Tele-operated service providers</td>
<td>Enables automated vehicles to be tele-operated in critical situations.</td>
<td>TO</td>
</tr>
<tr>
<td></td>
<td>Vehicle Control Center</td>
<td>New business opportunity. For safety and security purposes, in private or rental fleets. For example, it could be an SME providing this service.</td>
<td>VCoC</td>
</tr>
<tr>
<td>5G Industry</td>
<td>MEC providers</td>
<td>Provide the virtualization of edge computing facilities close to the Telecom operator infrastructure.</td>
<td>MEC</td>
</tr>
<tr>
<td></td>
<td>Mobile Network Operators &amp; Infrastructure Provider</td>
<td>The provider of the ICT infrastructure or network services. Can be cellular but also other technologies can be considered. There can be neutral operators leasing the infrastructure.</td>
<td>MNO</td>
</tr>
<tr>
<td></td>
<td>Cloud provider, backend system host</td>
<td>Provide computing infrastructure. Coordination with MNOs will be required in order to guarantee QoS.</td>
<td>CL</td>
</tr>
<tr>
<td>Regulators &amp; Law-makers</td>
<td>Transport and road authorities</td>
<td>Authorities should regulate the use of 5G in the vehicular space.</td>
<td>TRA</td>
</tr>
<tr>
<td></td>
<td>Telecom and spectrum regulators</td>
<td>Need to drive the technology growth by providing the needed regulations to support the requirements of the technology.</td>
<td>TSR</td>
</tr>
<tr>
<td>Road Infrastructure Operators</td>
<td>Road operators</td>
<td>Owners/managers of the infrastructure. Play a critical role as they must deploy and operate the technology in the infrastructure.</td>
<td>RIO</td>
</tr>
<tr>
<td>Standard Developing Organizations</td>
<td>-</td>
<td>Should drive the technology to be more secure, more efficient and enable market defragmentation.</td>
<td>SDO</td>
</tr>
</tbody>
</table>
### Stakeholder category

<table>
<thead>
<tr>
<th>Stakeholder category</th>
<th>Subtype</th>
<th>Description</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academia and Research</td>
<td>-</td>
<td>Should research novel approaches and techniques to improve the technology. Should also be the tool to disseminate and train new professionals in the sector. Can also act as neutral players when decisions must be taken based on technical and societal criteria, and not only commercial interest.</td>
<td>AR</td>
</tr>
<tr>
<td>Insurance companies</td>
<td>-</td>
<td>Should be in touch with regulation authorities and the manufacturing sectors. Should be vigilant to the regulations and technical possibilities.</td>
<td>IC</td>
</tr>
</tbody>
</table>

The synergies identified are focused on the inter-relationships that are required and that 5G provides for each of the identified UC’s. Platform and system standardization activities, though essential for further developing and maintain the 5G features referred to in this study, are specifically not included in the following subsections.

### 3.2.2.1 Potential Stakeholders Synergies for Tele-Operated Driving

The development of a fully automated vehicle has proved to be a challenging task; it can be observed by the fact that the number of self-driving car services that have been deployed and are offered for use by the public is still limited. Until today, safety drivers are still present. They can still take over control of the vehicle in case the automated system requires it. However, as we get closer to fully automated units (Automation Level 5, according to the latest visual chart within SAE J3016™ 37), vehicles will become more and more independent and safety drivers will no longer be required. Based on this situation, it is necessary to consider that for a period of time a mix of non-automated and fully automated vehicles will coexist. ToD emerges to prepare for this transition and other related use cases. It is seen as a fallback procedure for automated vehicles as well as a concept for overcoming the “last mile” to the destination. This new functionality serves as an aid for automated systems, when they have problems to perform a complex task or as personal convenience alike. In addition, ToD can become a possibility to solve traffic situations that would require a very high complexity and effort to be solved.

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Figure 3.4 shows the main relations and synergies for different players in the ToD ecosystem. In it, an overview of potential stakeholders for ToD is shown. In the first place, there are the customers and users of the technology. These include passengers (P) and owners of vehicles (VO), either privately owned or by service providing companies. For the deployment of the ToD technology, the three identified main players are: 1) the original equipment manufacturers (OEM), 2) the mobile network operator (MNO), and 3) the operator of the vehicle control center (VCoC), where the tele-operator (TO) is located. The identified infrastructure-establishing, monitoring and regulating bodies of the ToD ecosystem are the road infrastructure operators (RIO), the transport and road authorities (TRA) and the telecom and spectrum regulators (TSR). Similar to the automation of driving functions, ToD is expected to open new business opportunities for insurance companies (IC). At last, map (MP) and MEC providers (MEC) may also establish themselves as players within the technology.

**Figure 3.4: Synergies between Stakeholders of Tele-Operated Driving**

### 3.2.2.2 Potential Stakeholders Synergies for HD Mapping

The development of the HD mapping has the potential to further improve road safety. Additionally, with the implementation of cross-border support for HD mapping there is a potential for stronger investment support from key stakeholders. Figure 3.5 identifies the potential relations and synergies for the different stakeholders in the HD mapping ecosystem.
These key stakeholders include transport and road authorities (TRA) and road infrastructure operators (RIO) who collect and provide changing traffic information including, road conditions, adverse weather, road works and accident information among others. This dynamic information compliments the map data car original equipment manufacturers (OEM) will contract from map providers (MP) who provide the dynamic HD map content for navigation, support of connectivity and other value added services.

MNO’s provide the additional connectivity services for use by vehicles and their drivers and passengers including transmitting location based map information. There can be expected significant benefit from the implementation of technologies including network slicing and MEC in order to further provide seamless cross-border implementation. This will be of significant value-add in maintaining localized and changing traffic information continuously provided and dynamically updated to vehicles as they cross though national borders and pass through MNO coverage regions.

With insurance, the risk reduction provided by HD mapping through implementation of AD improves the customer insurance benefit for the Vehicle Owner (VO) or Passengers (P). In the case the OEM has the insurance liability, safety improvements will provide opportunities for similar strong benefits for OEM’s, and indirectly Vehicle Owners (VO), with insurance companies (IC).

Figure 3.5: Synergies between Stakeholders of HD Mapping

The common roadmap will be established between transport and road authorities (TRA) and telecom and spectrum regulation (TSR) ensuring support for V2X services across OEM, telecom vendors and MNOs’.
HP map data is based on different layers of road and traffic data including base road and dynamic traffic information which is pushed to vehicles as necessary. There are, therefore, business opportunities for cloud providers & back-end system hosts (CL) to host HD map content, complimented with MEC (MEC) hosted map data, where very localized and frequently updated content is not required.

3.2.2.3 Potential Stakeholders Synergies for ACCA

Connectivity can help increase security and comfort for both human driven cars and for autonomous driving. In the first case, by providing visual and/or acoustic warning information, for example. In the AD case, the event provided by the connectivity will be used, together with information from onboard sensors, in the decision-making process leading to a potential automated collision avoidance mechanism.

In these two scenarios, the relationship between the insurance companies (IC) and the road users (D, VO, MSP) will be different. In the first case, the risk reduction thanks to the ACCA use case benefits the driver (D) as the customer of the insurer. In the second case, in high AD levels, the liability may lie on the OEM instead and, therefore, the safety improvement will modulate the relationship between the insurance company (IC) and the (OEM) or mobility provider (MSP).

This service could be provided by different stakeholders and at different levels. For example, the (MNO) could integrate the ACCA service inside the connectivity offer, it could be provided by a specific MEC provider (MEC), or it could be one of the features delivered by the road operator (RIO). The OEM could also have their own ACCA application off board and the service demanded to other stakeholders would only be the service hosting (CL, MEC).

With the arrival of the connected vehicle, all OEMs have deployed the extended vehicle paradigm where the car will have a portion of the vehicle information in the cloud. In the market, OEMs have partnered with cloud providers (CL) for this service. This cloud could interact with the connectivity context, especially in cross border situations where the MNO, MEC, and road operator will probably change. Even if the interoperability between those stakeholders will be developed, the OEM cloud will be aware of this transition and inform the vehicle.

Several options are possible for the ownership of the data which will be sent off-board by vehicles. Depending on regulations and type of data, local constraints and road infrastructure, several owners could be possible such as local authorities, car manufacturers, road operators, MNOs or the vehicle driver.

There are different ways to do the road perception. Also means to communicate it between vehicles on the road need to be defined. These design decisions will have an impact on the revenue streams which would be generated. In the current architecture proposal, the information is delivered only to those who register and subscribe to a given information type.

Finally, in terms of legal framework, a continuous interaction and common roadmap should be defined between the transport and road authorities and telecom and spectrum regulation in order
to achieve common goals for V2X services related to cross vendor interoperability, communications requirements, etc.

Figure 3.6 shows the main relations and synergies for the different players in the ACCA ecosystem.

Figure 3.6: Synergies between Stakeholders ACCA
4 Gap Identification from Business Case Perspective

To fulfill the expected new business opportunities enabled by CCAM, new horizontal working topics are relevant. Without a proper development and formalization of these topics, a successful 5G-enabled CCAM business case will not be possible. In this section we identify these topics and the gaps in the interrelation of stakeholders from a business and legal perspective pointing out those elements that are needed to make the business cases realizable.

We will first address the regulation and liability issues, then the gap in terms of stakeholder involvement is addressed - namely what is missing today in the ecosystem in terms of business-then some points regarding technology (including data) standardization and deployment are developed and at end the problematic of security and privacy is addressed.

4.1 Homologation, Liability and Regulation

This section deals with all the aspects concerning the gaps relating to regulation, certification, and liability. Indeed, automotive is a domain where security has a strong importance that implies many constraints in terms of process which could have an impact over technical architecture and business.

4.1.1 Certification/Homologation

Certification (Homologation) of the autonomous vehicle for safety and security will require the full technical chain homologation: vehicle, network, cloud, application (software). Today, homologation of standalone autonomous vehicles is already a real problem especially in the case of vehicles controlled by artificial intelligence. In addition, future 5G connected vehicles with 5G connectivity software will need to be certified including the V2X infrastructure. A certain level of standardization will be required to guarantee interoperability between MNOs and telecom vendors for V2X functions, especially when considering the cross-border/frontier operation of the vehicles.

4.1.2 Liability Support

In case of an accident, it will be necessary to identify the responsibilities of each stakeholder involved in the safety V2X system. Today, sharing of responsibility has to be clearly defined in a distributed application environment. Responsibility in case of accident could be more difficult to define for connected vehicles relying on an external infrastructure (5G), than for completely autonomous vehicles without any help of connectivity. When using 5G infrastructure, MNO responsibility could be involved. How the responsibility will be shared between MNO and car OEM

is a main issue. Even pure V2V services could raise some problems of responsibility sharing between car OEM’s. Some cases of liability problems could be seen as indicated in the Uber accident in USA, with the dramatic death of a pedestrian crossing the road\textsuperscript{39}. In the case of this accident, the first accident involving an autonomous driving car and a pedestrian and causing death, the responsibility of pedestrian as well as driver has been questioned as well as the responsibility of the car control system. Indeed, in the case of this accident, it has been shown that radar has detected the pedestrian before the driver could detect her but breaking has not been triggered. Thus, we can anticipate that defining responsibility will be more and more complicated in the future with the high level autonomous car, and the remote driving. To support the development of the business, clear laws need to regulate the distribution of responsibilities as well as require the proper mechanisms to assess the validity of the claims.

4.1.3 Cross-Border Regulation

Today it is common that vehicles cross not only countries but large geographies and continents. The V2X infrastructure needs to support vehicles roaming independently while ensuring coexistence of V2X technologies and interoperability. Authorities and civil infrastructure operators need to ensure that the nation-wide infrastructures support the roaming of vehicles without influencing its operation. Regulations will be required to ensure that infrastructures are being updated and compatibility maintained.

4.1.4 Regulations/Incentives in the Technological Domain

Different regions exhibit different trends. Concerning Europe, the Delegated Act of the commission recommended ITS-G5 rather than C-V2X for ITS services. However, this recommendation appears open for discussion once again inside European institution (parliament, council, commission)\textsuperscript{40}. The USA seems more open to C-V2X but still nothing is announced. In China, the choice has been made for 5G V2X.

It should be considered that the harmonization for the choice for technology will be solved at international level in order to harmonize the choice (ITU, World Road association). World Road association\textsuperscript{41} is gathering 122 members representing different states, and other participants belonging globally to 140 countries. Harmonization could be performed at this level.

4.2 Stakeholder of ITS Involvement

This section deals with the need of involvement of some existing stakeholder or new ones of the ITS ecosystem in order that 5G-enabled CCAM services could take off in the future.

\textsuperscript{39} https://driverless-futures.com/2019/03/18/who-killed-elaine-herzberg-one-year-on-from-the-uber-crash/
\textsuperscript{40} https://www.reuters.com/article/us-eu-autos-tech/eu-opens-road-to-5g-connected-cars-in-boost-to-bmw-qualcomm-idUSKCN1TZ11F
\textsuperscript{41} https://www.piarc.org/fr
4.2.1 ITS Application Operation: the Role of Vehicular “Traffic” Controller

The role of vehicular traffic controller will have a paramount importance. This role could be also called ITS application operator because he will have an operational role in the ITS area. His mission will be controlling/managing/informing the vehicles (i.e. trajectory, speed, etc.) thanks to messages exchanged between vehicles (V2V mode), between vehicles and road infrastructure (V2I), between vehicles and dedicated servers (virtual or physical) (V2N) in order to allow autonomous driving features, remote driving, and exploit accurate data from vehicles to impose higher safety measures.

He will have to handle the data involved, generated by the vehicle “traffic” control. These data will be generated by vehicles or elements of physical infrastructure such as RSU along the road. He will have also to deploy the applications on the physical architecture, to maintain it, debug it, etc. These applications relying on pieces of software will run completely or partially inside the 5G architecture and will be one of the bricks involved in the vehicular control system. As depicted on the 5GCAR architecture studies\(^\text{42}\), the system will be deployed on the basis of IT resources at access part using for instance MEC server to reduce latency for some of its critical operation. This doesn’t mean that MNO, or the entity owning the MEC will play the role of vehicular “traffic” controller. MNO could for instance rent the IT infrastructure one the basis of Infrastructure-as-a-Service has depicted in the 5GCAR deliverables dealing with architecture\(^\text{43}\).

We have to notice that, the role of vehicular traffic controller could use internal resources for the development of application, or externalized ones to a software company for instance. The same remark could be done concerning the managing/handling/processing of data. But it remains that the vehicular traffic controller will be responsible of the behavior of the system at last resort.

This role can be derived to road/infrastructure operators or can be centrally controlled by the government authorities. This is completely open today. The main question, however, is who will be the responsible to drive this vehicular control system (one component of the global ITS). In the following, we discuss several options:

**State-controlled ITS:** A nationwide ITS seems a reasonable option as it is not dependent on any commercial interests. Countries use well defined contracts with public or private companies to run a single infrastructure managing the V2X application. States sign contracts with MNOs and define the regulations (at European level) with car manufacturers.

**Road/infrastructure operator consortium with joint ITS:** As of today, different roads are managed by different infrastructure operation companies. Some of them are private entities that have a long-term contract with the state for the maintenance and operation of the infrastructure, and others are public. A viable option is that different road operators operating in a country come

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\(^{43}\) 5GCAR Project, Deliverable D4.1 Initial design of 5G V2X system level architecture and security framework.
into an agreement to interconnect/exchange some of the information in their databases related to V2X operation. Such consortium will need to include nationwide agreements with MNOs and vehicle manufacturers.

**MNO as a V2X application operator:** MNOs point themselves as possible candidates to host and run such application and be responsible of application. While this seems possible from a technical perspective, politically may raise certain concerns about the fact that MNO will endorse a lot of responsibility (own skill and additional skill from ITS domain) Furthermore this could lead to possible monopolies for the MNO which will become exclusive V2X application provider in the ITS domain because it could be difficult to open widely the market for technical reasons (for instance interconnection between to different V2X application from two different V2X provider).

**Third party companies:** Opening this market may result in competing companies to provide ITS systems to coordinate the operation of autonomous vehicles. Third party companies may partner with MNO and Road operators and deliver high quality applications pushed by free market competence.

**Cross-border aspects:** In all cases depicted previously, it will be mandatory that different vehicular traffic controller could be interconnected and interact with each other to manage border crossing for instance, or manage harmonization vehicle control in each country as it has been done for road signs in the past.

### 4.2.2 Vehicle Control Center

Vehicle control center could be integrated in the activity of vehicular traffic controller as it seems logical, but could be independent as well. In the automotive stakeholder category that was defined, the Vehicle Control Center subtype might be considered as a gap, as VCoC’s are not existing today in the operational setup defined by the 5GCroCo project for the Tele-operated Driving use Case (Allowing to remotely control a vehicle). Today, only few structures and organisations, all mandated or operated by road authorities, are permitted and able to collect official road status information, sharing about traffic status (including warning of critical traffic situations) and influencing/steering traffic (e.g. via variable message signs). These structures and organizations have to evolve or have to be extended / complemented in order to perform VCC functions, including the evolution of required platforms, digital road infrastructures (such as sensors and camera with automated incident recognition\(^\text{44}\)) and respective extension of the scope of mandate.

### 4.2.3 Tele-Operator

The role of a tele-operator does not exist today and therefore might present a potential gap. This presents an opportunity to new, specialized SMEs, but also to traditional taxi or chauffeur service companies, to car rental companies or other transportation service providers, including fleet

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service operators and vehicle manufacturers. This role has to be developed and there are already startup companies emerging, for instance Phantom45. We have to notice that tele-operated driver could be an independent player performing remote teleworking and not from of a vehicle control center.

4.2.4 MEC Provider

Within the 5G Industry stakeholder setting, the subtype MEC provider could be considered as a gap until edge computing capabilities as an ITS enabler become available per MNO network or across networks. Who will be in charge of providing MEC capabilities and MEC-based applications: MNOs, cloud computing providers, road operators or other players? Positioning of ITS ecosystem regarding MEC is not clear today.

4.2.5 Trucks Companies

It is important to also consider truck companies in the ecosystem, especially for safety reasons and for many use cases related to transportation of goods. Note that European corridors have been defined as an essential tool to allow mobility of people and goods along main transportation corridors in Europe. As the trucking business becomes more and more limited by the availability of skilled drivers4647, high level of automation in both stand-alone and platooning mode become a prerequisite for overcoming this scarcity and thus tele-operated driving in exceptional situations (like after an emergency or safe stop) or for parking maneuvers like for loading/unloading freight presents a gap required filling for unleashing this opportunity for a safer and more efficient road freight transport.

4.3 Deployment, Technology and Data

This section describes some aspects relating to technical fields: deployment, technology and data. These aspects will have an impact over the 5G ecosystem for ITS. Standardization aspects in connection with technology are also addressed.

4.3.1 Towards an Ecosystem of Data

Data ownership, as well as data protection is one of the most challenging aspects to address. The different stakeholders in the V2X ecosystem are responsible of part of the data and the vehicle owner/driver privacy is of utmost importance. Some practical issues appear for instance when video sensor capture private data. Data repositories will be used to store the real time data generated by different actors and sub-systems, e.g., by the vehicular control application running at MEC server or RSU, and also the operational logs of the infrastructure (e.g. telecom operator) which may be used to determine load in the road infrastructure among other derived applications.

45 Phantom Auto: https://phantom.auto,
Other stakeholders may be interested in the stored data, such as insurance companies or security authorities as well as third party companies that aim to exploit mobility patterns to derive other businesses (e.g. smart parking). Considering the criticality of the infrastructure and the generated data, regulators should clearly define protective laws and enforce that the storage of this data must be subject to respecting the General Data Privacy Regulation (GDPR).

**Data ownership**

As discussed, data ownership needs to be regulated and protected. Agreements between vehicle owners and manufacturers should be signed when vehicles are acquired so their data can be used to improve the safety of the vehicle. Laws should enforce that users have the rights of this data being able to remove it at all times. The data that leaves the vehicle and is stored by the road or telecom operator should preserve the highest level of privacy as defined by the GDPR. Authorities should regulate its use enforcing privacy at all times.

**Data sharing agreements**

Stakeholders in the value chain, including car manufacturers, telco operators, road/city/highway infrastructure operators, navigation and map providers and protection authorities should define data sharing agreements so the entire infrastructure can be monitored, evaluated or tested. It is, however, not clear today which are the authorities that should take responsibility for orchestrating nationwide infrastructures.

**Cross-border data exchange**

Nationwide data should be exchanged to nearby countries, first to cover cross-border scenarios but also to enable international support to V2X technologies. Once the regulation authorities of a country are defined, those will need to define the agreement policies for transnational information exchange.

**4.3.2 Standardization and Technology Status**

The deployment of the complete V2X infrastructure is very complex and requires the involvement of numerous stakeholders as described in previous sections. There are open issues in terms of current technology status, standardization directions, market fragmentation and regulations so business opportunities can arise. The 5GCAR deliverables (D2.3: Automotive use cases and connectivity challenges, business models and spectrum related aspects) addresses the subject of adaptation of ITS standards to 5G context in the part dealing with automotive standardization miss. It is indicated that an adaptation of existing application protocols as well as new application protocol should be required.

C-V2X and IEEE802.11p are alternative technologies that can be used by vehicle manufacturers to enable inter-vehicle communication. As regulations are not enforcing one of the technologies it will be possible that different vendors use different technologies. This will create coexistence problems and hence uncertainty about the market. The commercial interests may bias the

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48 Project 5G CAR, Deliverable D2.3, Automotive use cases and connectivity, challenges, business models and Spectrum related aspects
decision rather than focusing on purely technical aspects. At the ITS level, V2X data formats need to be defined so different ITS providers can exchange data and provide cross-border integrated systems.

### 4.3.3 Deployment: multi MNO Context

Coordination between MNOs will be required to ensure high level reliability, as well as advanced mechanisms allowing real time handover between MNO(s) and this could change the business status compared to today’s Mobile Broadband (MBB) deployments for mass market. Network sharing, as well as slicing has been identified as possible solution\(^ {49}\). But this raises many challenges in term of responsibility sharing between MNOs in order to achieve high availability of the overall system end-to-end. Indeed, if one MNO is renting a piece of infrastructure from another MNO, the latter could be held responsible if an accident occurs due to infrastructure breakdown at the time when cars are connected via MNO infrastructures. This could change commercial relationship between MNOs and the risk will likely be integrated in the pricing. This will apply especially in the case of Tele-operated Driving.

Fallback procedures should be defined at the car side, but it could be not sufficient in some cases (no possibility to park the car autonomously along the road). Furthermore, the revenues will have to be shared considering the level of investment of each MNO, as well as the quality of infrastructure which will have to be measured in real time. This will include complex mechanisms involving several MNOs. The same principles apply to MEC platforms in the respective MNO networks for enabling ITS applications, as these applications require interworking cross-MNO in both domestic and cross-border constellations.

### 4.4 Security and Privacy

Due to its growing ecosystem complexity, CCAM raise deep security, safety, and data protection concerns. An increasing number of attacks have for instance already been reported\(^ {50}\). Strong protection is therefore mandatory. We provide a short overview of some key security and privacy challenges, overall, and for each tier of the V2X ecosystem, highlighting also some security service opportunities.

#### 4.4.1 Security and Privacy Challenges Overview

The V2X ecosystem appears at first sight as a complex ecosystem, making it difficult to grasp future business security opportunities. Nevertheless, behind this complexity:

The V2X ecosystem is based on a simple 3-tier structure, described in Deliverable D2.1. The **vehicle tier** includes cars that communicate with one another. The **network** or **edge** tier contains

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\(^ {49}\) 5G PPP Automotive Working Group, Business Feasibility Study for 5G V2X Deployment V2 Feb 2019

cellular networks and ITS infrastructures. Finally, the **cloud** tier includes clouds (or federation of clouds) forming back-end systems.

**The ecosystem is driven by two megatrends**, as vehicles are endowed, with first, rising levels of **connectivity**; and, second, with growing degrees of **automation**.

Such megatrends pose acute **security**, **safety**, and **data protection** challenges. Indeed, vehicles have become juicy **targets for hackers**, as witnessed by recent attacks which numbers are expanding. Safety issues are captured by the **safety-security gap**: the connected vehicle is a cyber-physical system leading to interaction vulnerabilities between safety and security, while threats (malicious) and failures (accidental) have been so far handled separately. Finally, vehicles are at the heart of a **data-shaped ecosystem**: vehicle and passenger-data are collected, analyzed, and shared with all ecosystem stakeholders through multiple channels. Difficult trade-offs must then be found, at rest and in transit, between integrity of information, critical for the safety of vehicles, and privacy of drivers and passengers\(^{51}\).

To meet such challenges, a holistic vision of protection of the V2X ecosystem is needed. To address the multiple security and privacy requirements, protection mechanisms are needed in: vehicle, network, and cloud tiers of the ecosystem; at the software and the hardware levels; and also covering the full data life-cycle. A simplified high-level view of the problem is presented in Figure 4.1, showing where security services may be placed in the V2X ecosystem.

![Figure 4.1: Holistic Vision of Security](image)

Some of the key business questions include: for each stakeholder, in what tier specifically should be deployed the security services. Should an end-to-end approach to security be adopted, using cross-cutting security management planes, or should tier-by-tier solutions be favored? More broadly, are vehicular security challenges automotive-specific, or are they common with other verticals (e.g., Secure FOTA with IoT)? Some of those security challenges will be explored in the transverse 5G-Croco security task force in WP3, for instance in report IR3.3.

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Figure 4.2: Root Causes

Some root causes for security challenges are shown in Figure 4.2, and may be the source of some key business opportunities. Such challenges are explored in more details in Sections 4.4.2 to 4.4.5.

- **Vehicle security**: ECU’s should be isolated for trusted execution of computations. In-vehicle violations of isolation should also be detected, with early remediation. Secure OTA updates of software and firmware should be guaranteed as well.

- **Network security**: Network connections should be strongly isolated end-to-end. Anomalies regarding network isolation should also be detected and mitigated.

- **Orchestration and ecosystem security**: Cyber-resilience is needed to guarantee safety of a distributed decision-making layer highly vulnerable to attacks. Vehicle and passenger data must also be protected end-to-end in terms of confidentiality, integrity, authenticity and privacy, while being compliant with regulations. High mobility imposes security mechanisms to be compatible with low-latency constraints, to manage handover efficiently, and to consider roaming challenges. Interoperability is also tightly linked with the ecosystem dimension, as several stakeholders share the same infrastructures with different non-standardized technological domains, requiring multi-level access control. Finally, responsibilities of stakeholders should be identified, e.g., for accidents, by guaranteeing integrity of relevant data.

### 4.4.2 Vehicle Security Challenges

In the vehicle, weak spots are the complexity (proliferation of ECUs) and vulnerability of current embedded architectures. This requires the vehicle to be considered as a security perimeter, with a defense in-depth approach. A major disruption is virtualization reaching into the vehicle that becomes a “data-center on wheels”. This poses both system isolation and monitoring...
challenges and opportunities to detect and react to in-vehicle anomalies. Services are also needed for OTA updates of software and firmware. However, this last roadblock is common to IoT security to guarantee end-to-end security of device management.

4.4.3 Network Security Challenges

In the network tier, connectivity should be strongly protected, using proper encryption and authentication to defeat attacks such as Denial of service, man in the middle, information spoofing, etc. The key challenge remains isolation of network connections and detecting and mitigating anomalies regarding violations. Slicing is a key enabler to flexibly isolate network connections. Software-Defined Networking approaches to security management may help to define a control plane to ensure centralized decision-making points, dynamic availability, optimal resource use, and context-aware security support.

4.4.4 Cloud Security Challenges

In the cloud, well-known security challenges from virtualization and from network security will need to be reconciled with the vehicular dimension, to guarantee end-to-end isolation from vehicle to cloud.

A first challenge is safety to bridge the safety-security gap and avoid propagation of failures and attacks. Cyber-resilience business opportunities will guarantee safety of a distributed decision-making layer highly vulnerable to attacks. Certification and regulation are key enablers towards those objectives. Security–by-design should be enforced end-to-end on the V2X infrastructure by vehicle manufacturers, MNO and ITS controllers, and properly certified. Regulations should also define the security levels and certification processes to be enforced for safe and secure operation of the system.

Another end-to-end challenge is protection of information, notably for personal data to tackle privacy-by-design and regulatory compliance. For the EU, GDPR compliance should be strictly applied to data related to V2X mission-critical services. For instance, a driver may be allowed to disable V2X road safety and road efficiency services (see 5GCAR Project Deliverable D4.2, Section 5.3). To guarantee that personal data cannot be linked with specific users, data has to be anonymized. It is not clear yet how third-party companies (e.g., insurance companies), or official authorities (e.g., Accident Investigation Office) will need to access to non-anonymized data. These models need to be defined and properly regulated. In any case, the user will have to give consent on what information is shared, with which stakeholder, and for what purpose.

4.4.5 Ecosystem Challenges Impacting Security

Ecosystem roadblocks that impact security are mobility that imposes security mechanisms to be compatible with low-latency constraints, to manage handover efficiently, and to consider roaming challenges; and interoperability as multiple stakeholders share the same infrastructures with different non-standardized technological domains, requiring multi-level access control. The notion of responsibility will also be redefined, e.g., in case of accidents. Stakeholder’s liabilities should
be settled indisputably. Unfortunately, an overall liability model is still lacking today. Such liability issues are notably discussed in Section 4.1.

4.4.6 Edge Opportunities for Security Services

While the end-to-end approach to security is desirable, but hard to achieve, the edge tier offers several interesting opportunities for security services. Indeed, edge computing has benefits such as being agnostic to connectivity, meeting low-latency and heterogeneous QoS requirements, supporting flexible security management, and enabling context-awareness for security. Thus, edge-based vehicular services may be developed such as attack detection from the network, data protection, resilience to authenticate data exchanged between vehicles, or security audit.
5 Summary

This document constitutes a first step in 5GCroCo to identify business opportunities in the new emerging and forming 5G ecosystems for cross-border CCAM.

The document contributes to identify suitable tools to conduct cost/benefit analysis, business modeling and business case generation. In addition, the stakeholders for the different use cases which are considered in 5GCroCo have been introduced and discussed. The approach in 5GCroCo will be, firstly to identify business opportunities for the use cases trialed in the project, and then to widen the scope of the contributions to any 5G-enabled cross-border CCAM service.

Automated Driving (AD) is seen as one of the key technologies and major technological advancements influencing and shaping the future of mobility. Therefore, the impact of 5G must be evaluated for private passenger cars and for the exploitation of wider shared mobility and ITS concepts.

This document provides valuable discussions and insights to all identified key stakeholders which can benefit from new possibilities facilitated by 5G-enabled CCAM:

- Telco and Automotive industries.
- Standardization and regulation bodies.
- Local administrations (cities, countries).
- Road operators and road traffic authorities.
- Governments and policy-makers.
- Start-ups and Small and Medium Enterprises (SMEs).
- Academia and scientific community.

The evolution of dedicated use cases is described with a prime vision on how the upcoming and new 5G functionalities can sustain novel business. New roles, relations and business opportunities are identified or according directions drawn.

The deliverable provides a gap analysis from business case perspective to steer economical examinations in an efficient way to support new AD ecosystems.

To ensure that the contributions of 5GCroCo are aligned with other ongoing activities also studying business opportunities and cost/benefit analyses for 5G and CCAM, the output from other EU projects (e.g. 5G-CARMEN, 5G-MOBIX) and other bodies like 5GAA, GSMA, or 3GPP have been included as input for the ongoing work in 5GCroCo.

In a cross-border environment, new relations between existing and new players will be established in different use cases for AD. In addition, these use cases will force KPI requirements and new functions for MNO’s 5G networks. 5G technologies (e.g. safety, efficiency, real time solution, privacy/security etc.) are main drivers for potential business opportunities.
This document presents the general business concepts for AD use cases under consideration of new value chains (e.g. new customers, additional benefits, new markets and weakness and threats for existing players). The important AD stakeholders and their internal relations have been identified and analyzed in the context of a new CCAM business landscape and ecosystem. This includes a gap analysis considering current technical, economic and regulatory road blocks to the evolution of a true cross-border CCAM ecosystem.

The evaluation in this deliverable for AD – with the focus on the given use cases - has shown the importance of data driven eco systems. The data ownership spread over different actors and subsystems is a key factor for a successful business.