5G Strategic Deployment Agenda for Connected and Automated Mobility in Europe

(This is an Initial Proposal for reaching out towards a broader range of potential stakeholders in the area of connected and automated mobility in Europe with the target to develop a blueprint document)

31 October 2019

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1. Introduction and main objectives

This document sets out the **shared view of a wide group of industry stakeholders** supporting the objectives of the **5G Strategic Deployment Agenda** (SDA). The common aim is to support **Connected and Automated Mobility** (CAM) in Europe, based on future-proof 5G infrastructure, technologies and vehicles.

5G-based Connected and Automated Mobility services along roads are a broad range of digital services in and around vehicles including both safety-related and other commercial services provided, enabled, or supported by 5G multi-service networks.

The imminent rollout of the next generation of mobile technologies (5G) is expected to become a "game changer". For the first time, mobile networks will offer a broad range of connectivity performances including gigabit speeds and mission critical reliability. Most importantly, the prospect that 5G will be a unified multi-service platform, serving not only the traditional mobile broadband market but also enabling digital transformation in a number of so-called "vertical industries", is expected to result in the creation of unprecedented opportunities for innovation and economic growth.

Europe must seize such new opportunities arising in vertical industries to remain competitive on the global level and to meet sustainable development goals, in particular in areas of high societal impact such as manufacturing, healthcare, energy, education, public security and transport.

The promoters of this EU 5G SDA for CAM believe that transport and specifically Connected and Automated Mobility is the area where 5G technologies can yield tangible benefits more rapidly, acting as a catalyst to accelerate the way towards other sustainable 5G ecosystems.

Moreover, the European Commission has fully recognised the importance of 5G for future mobility solutions and embraced the deployment of 5G technologies including both network and direct communication in transport as a European public policy priority. To that end a strategic partnership with road and transportation stakeholders is critical to fully achieve the objectives of the European Commission. Therefore, the future deployment agenda will build upon other relevant public policy initiatives that have already been adopted at EU level, namely:

1) The **5G Action Plan for Europe**[1] (5GAP), adopted in 2016, calling for action to ensure that the EU can use advanced 5G connectivity as a strategic advantage to lead in digital transformation, in particular in vertical industries, and in support key societal objectives. While these transformations have already started on the basis of existing networks, they will need 5G if they are to reach their full potential in the coming years. The Plan was endorsed by the EU Member States and European Parliament. It includes the specific EU objective of achieving uninterrupted 5G coverage in all urban areas and along all main transport paths in all Member States by 2025.
2) The **European Strategy on C-ITS**[2]**,** which further elaborates on how 5G works together with existing short-range communication technologies.

[1] http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=17131

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016DC0766&from=EN

3) The **third EU Mobility Package "Europe on the Move"**[3] of May 2018 defining an integrated policy to ensure a smooth transition towards a mobility system which is safe, clean and paves the way to connected and automated mobility.

More recently, the European Commission has also proposed, in the context of the preparation of the next Connecting Europe Facility Digital (CEF Digital), a major public financing support action for accelerating private investments in 5G infrastructure along highways known as **"5G Corridors"**, intended to enable Connected and Automated Mobility solutions. The CEF Digital programme has been agreed politically between the EU co-legislators in March 2019, and will soon be the subject of the next budget negotiation phase with Member States. It is expected that public funding for the 5G corridors will amount to a significant part of the €3 billion requested by the Commission for CEF Digital. In addition, the overall coherence and coordination with other CEF funding instruments should be reinforced, in order to achieve the set objective of "mutualisation" of costs between various services and sectors.

This supportive public policy context creates a favourable environment to encourage private investments in large scale deployment of 5G infrastructures, supporting the way to future autonomous mobility. In the next five years, the promoters estimate that more than 70% of new vehicles and other mobility devices will be exchanging data with external sources, bringing new services and business models to automotive and transportation markets.

The 5G-PPP board, co-led by the European Commission and the industry, has tasked the 5G-PPP Automotive Working Group to develop a common SDA for CAM.

In a first open stakeholder workshop[4] in February 2019 the stakeholder community decided to develop, in addition to the overall societal vision, three main elements as part of the SDA: (i) Deployment Objectives; (ii) Cooperation Models; (iii) Regulatory Innovation. The SDA initiative follows high-level discussions[5] at the Mobile World Congress 2019, where Mariya Gabriel, Commissioner for Digital Economy and Society, and Günther H. Oettinger, Commissioner for Budget and Human Resources, encouraged key representatives of the mobile industry to boost investment in 5G technologies with a particular focus on vertical industries.

The initiative builds on the high-level process facilitated by the Commission, which led to the creation of the European Automotive Telecom Alliance (EATA). A network of 5G cross-border corridors has already been identified by EU Member States and will serve for large-scale experimentation and early deployment of 5G for CAM.

It is planned to serve as the basis for a public-private partnership on Smart Networks and Services. In general, this partnership should develop the next wave of technologies beyond 5G, and in parallel, contribute to the digital transformation of vertical sectors through deployment of connectivity infrastructure. In this context, its particular role will be to coordinate a pipeline of projects for the optimum use of public funding for 5G corridors, as proposed in the renewed CEF Digital programme for 2021-2027.

[3] https://ec.europa.eu/transport/modes/road/news/2018-05-17-europe-on-the-move-3_en

[4] https://ec.europa.eu/digital-single-market/en/news/5g-strategic-deployment-agenda-sda-connected-and-automated-mobility-cam-stakeholder-workshop

[5] https://ec.europa.eu/digital-single-market/en/news/europe-advancing-5g-new-wave-projects-launched-accelerate-5g-take-vertical-industries

Against this background, the present document takes into account the important work by the 5G-PPP Working Group and concentrates on identifying the key elements to progress along the strategic priorities mentioned. The initial goal is to stimulate investments into a network of pan-European 5G[6] Corridors for Connected and Automated Mobility as a first strategic step towards large scale deployment of 5G for CAM[7] and other high value services related to connected vehicles, road operation and overall smart transportation. In contrast with more traditional bottom-up innovation, Connected Mobility will not happen without a concerted and proactive action by Industry, public authorities and governments to first build the required infrastructure along transport routes.

[6] 5G has to be understood as a **family of mobile technology standards** including 4G LTE since 5G will seamlessly interoperate with 4G legacy systems.

[7] In this document, CAM infrastructure includes all components of V2N, i.e. V2V, V2P, V2I and V2N.

2. A shared Vision based on common principles

The world is on the verge of a new technological era in which 5G is more than just a generational step. It represents a fundamental transformation of the role that mobile technology and real time data play in society. As demand for boundless connectivity grows, 5G is an opportunity to create an agile, purpose-built network and set of technologies, tailored to the different needs of citizens and the economy.

Next-generation communication technologies are set to unlock future innovation and economic growth and deliver benefits for consumers, enterprises and society at large. 5G is developing in parallel with rapid advances in Artificial Intelligence (AI), smart platforms for new services such as mission-critical communications and the Internet of Things (IoT). This powerful combination will enable the digital transformation of industry verticals, providing the networks and platforms required to drive the digitisation and automation of industrial practices and processes.

The inclusion of communication technologies into vehicles and along the roads has already been extremely successful in delivering benefits to the drivers, the automakers and other stakeholders in the transportation and emergency service ecosystems.

These connections are used for a wide variety of services which first and foremost consist of non-commercial safety services including automatic crash notification (ACN) such as eCall, the recognition of slow or stationary vehicle(s) and informational alerts for events like traffic jams, road works, weather warnings and other hazardous conditions. In regions where the information is available to the public, advanced services such as “time to green light” and “emergency vehicle approaching” are regularly conveyed via the mobile network. Furthermore, commercial services such as, telematics, diagnostics, theft prevention, connected infotainment, real time navigation and traffic optimisation can be enabled by cellular networks.

In addition to network-based communications, direct short-range communication will offer a complementary yet integrated set of critical safety services in between vehicles and road infrastructure e.g. intersection movement assist, emergency brake warning, lane change warning or road-works ahead.

In the future, CAM will provide even greater benefits. Fully automated driving promises to contribute to vision, by significantly reducing the risk of road accidents. It also promises to optimise vehicle flows and complex logistics and hence energy consumption on a large scale. Finally, the driver becoming a mere “passenger” will be able to devote his time to other activities, opening new economic possibilities such as transforming the vehicle into a mobile office space.

In that context, the global connected car market is projected to reach a value of €200 billion by 2025, growing at a compound annual growth rate (CAGR) of 14.8% from 2018 to 2025. It is also forecast that more than 125 million passenger cars produced in the next four years will be equipped with embedded connectivity, out of a total of 1.2 billion motor vehicles in use worldwide. In addition, car data related services are already reaching €225 per car per year and the total EU market size for card data services, unleashed by advanced connectivity, could already reach €3.8 billion per year in 2021[8].

[8] https://www.marketsandmarkets.com/PressReleases/connected-cars.asp

It is therefore expected that the economic and societal impact of Connected mobility will be very significant, and that mobile communication systems such as 5G will play a central role in the future transport ecosystem. Indeed, a fully automated mobility will require a totally reliable and safe guidance infrastructure, which will have to combine all available technologies: sensors (in vehicles and on the ground), high accuracy location, precise positioning, high definition mapping, converged AI on devices, at the edge and in the cloud, and, in particular high quality direct and network communications between all moving and fixed elements (vehicles, bikes, pedestrians, and road infrastructure). Functional redundancy and complementarity in the architecture will be necessary to be able to meet the demanding KPIs of such full automation.

The parties participating in the development of this SDA believe that there are synergies between the societal (public) goals and the commercial (private) objectives when building the basic infrastructure for CAM. Commercial opportunities are essential to attract the substantial investments to fund the infrastructure while public support will be key to ensure that the proper framework conditions are in place as well as to foster a high degree of acceptance by the general population.

Therefore, we share the following principles that underpin our common vision for the 5G SDA for CAM:

1) The deployment of the 5G infrastructure for CAM should follow **an evolutionary path in order to cope with future market developments and technological progress**. 5G is not a prerequisite to the deployment of automated driving functionalities: most services improving traffic efficiency and safety can already be implemented using existing direct and network communication technologies, while others may remain sensor based. 5G networks will initially co-exist, and where necessary be interoperable, with 4G (LTE) and other communication technologies to deliver a boundless, high-speed, reliable and secure broadband experiences for all.

2) The infrastructure should aim at providing boundless connectivity with **continuity of service across borders, across Mobile Network Operators, across vendors/OEMs, as well as across traffic managers, road operators and across service providers**. CAM services will be “mission critical”. This commands for uninterrupted 5G/4G service coverage in complement with V2X direct communications, including along road sections spanning across borders. Vehicles and road equipment are fully part of this overall service ecosystem for CAM.

3) The CAM infrastructure, including vehicles and road equipment, needs to have a very high level of **cybersecurity**. The concerned stakeholders will discuss requirements and performance criteria for cybersecurity compatible with the requirements of a CAM infrastructure.

4) The 5G infrastructure for CAM will need to be a **multi-service/multi-application platform** using standardised specifications and/or data interfaces. One of the main benefits of 5G is the “mutualisation” of costs between various services and sectors based on slicing with differentiated capabilities and QoS, using the same underlying network infrastructure and thus improving the overall economic case.

5) The deployment of 5G infrastructure for CAM in Europe should **be coordinated with public and private actors in charge of delivering V2X services in an extensive manner, starting along main pan-European cross-border corridors and expanding to cover all**

roads. The initial focus on highways is required for feasibility reasons, as well as to prove the benefits of 5G for CAM. However, a more comprehensive coverage, including secondary roads and urban areas, should be considered as part of the longer-term goals.

6) **Public administrations in charge of roads and mobile networks should collaborate to create synergies for connectivity deployment along CAM corridors**. The involved parties share the objective of using 4G and 5G in complement to other technologies for saving lives by reducing accidents and improving emergency services, optimising traffic management, saving energy and reducing CO2 emissions. There should be sufficient capacity to accommodate these services as well as a broad range of other services on the platform. The signatories call on public authorities to collaborate to identify the best way to combine services and create synergies in the infrastructure deployment strategy.

7) **Need for flexibility within a cooperative planning model**. There is a necessity to deliver **future networks innovatively and with optimal economics**: All stakeholders will strive to **deliver improved networks in a cost-effective manner**, relying on a combination of mainstream and alternative technologies, using both unlicensed and licensed spectrum for direct and network-based communications and innovative cooperation models.

8) Accelerate the **digital transformation of industry verticals**: The mobile industry will provide the networks and platforms to drive the digitisation and automation of industrial practices and processes.

3. Developing a 5G CAM ecosystem in Europe

Achieving this vision, and the associated economic and social case for smart mobility using a combination of 5G and other technologies, will require Europe to shape a complex connected vehicle ecosystem involving many different stakeholder communities and technologies.

The promoters of the 5G SDA for CAM call for a regular and structured dialogue between the concerned stakeholders in order to establish the appropriate ecosystems that are needed for CAM deployment as well as the related synergies with other high value services, leveraging existing sectorial dialogue platforms in Europe.

It is expected that there will not be a single “monolithic” ecosystem but rather a number of sub-systems which will collectively address the key areas. However, it is also clear to the stakeholders that CAM needs a holistic approach on EU level in order to achieve adoption in vehicles, which should at least specify data interworking between vehicles, infrastructure and the supporting ecosystem.

The following ecosystem categories have already been identified:

1) **Driving safety and automation sub-system**: This category represents the community of stakeholders that will have to cooperate to ensure the progressive automation of driving functions, from today’s level up to higher levels of vehicle automation beyond level 3 on the longer term. It will consist of automobile manufacturers, mobile network operators, road operators, relevant regulatory authorities and government agencies, information technology (IT) companies and system integrators, connected car hardware manufacturers and academia and research institutes. The stakeholders will have to agree on standards and spectrum to ensure safety with interoperable communications,

ensuring that there will be uninterrupted and reliable CAM service coverage and adopting the most appropriate business approach (e.g. CAM roaming functionality, seamless hand-over of CAM service between operators, capacity management between CAM and other (commercial) services, etc).

2) **Mobile broadband emergency services**: When CAM becomes progressively available on a large scale, it would be natural and cost effective to ensure that the same infrastructure can also be used to improve the effectiveness of emergency services such as urgent medical assistance, disaster recovery, safety and police services. This could require a new type of collaboration between safety authorities and organisations and mobile operators and possibly other categories of stakeholders such as vehicle manufacturers, road authorities and road infrastructure operators. This cooperation may need to be coordinated at EU level due to the increasing cross-border nature of the delivered services and the potential economies of scale. This challenge is likely to arise at a time when many safety and police authorities will be in a process of looking for a successor to their existing mission-critical TETRA systems, with 5G offering new opportunities. It is therefore important to establish a stream on this topic in the overall CAM ecosystem.

3) **Uptake of high-value commercial 5G services along transport paths**: This is the area where the main economic value will be created. It relies on the multi-service and multi-application nature of the 5G infrastructure, which should unleash potentially unlimited creativity. At the moment, it is already clear that 4G and 5G connectivity is attractive for vehicle manufacturers and vehicle fleet operators to optimise maintenance, traffic, as well as the overall management of vehicles. Mobile network operators will also play a central role and be in the lead to deliver new high quality broadband and infotainment services on the shared infrastructure. It is essential however for road operators and vehicle manufacturers to be closely associated to the definition of future business models, building upon their specific missions e.g. road traffic safety, traffic management and operations. The key will be to install a proper governance and mechanism to be able to balance out dynamically the shared used of infrastructure, taking into account critical priorities (like CAM) as well as the fair share of the use taking into account individual investments and various roles. It will require novel investment approaches including the use of co-financing by public authorities, the sharing of infrastructure and co-investment in some cases. Public authorities should facilitate these novel approaches through for example financial and regulatory initiatives, in respect of competition rules.

   This strong expectation has been the basis for the CEF Digital proposal, which includes an indicative list of 5G Corridors envisaged for funding. The SDA promotors recognise that this pan-European network of priority 5G Corridors (see Annex 1) constitutes an essential backbone for early European-scale CAM services. It is well accepted by Member States and stakeholders, as it follows broadly the TEN-T network of European highways. In the future however, further coordination is expected e.g. with CEF transport to foster synergies and efficient use of public investment required to support “digital roads”. Stakeholders will continue further work to complement it with additional highway segments, where stakeholders see early business opportunities for CAM services from a cross-border perspective, but also from a national and regional perspective.

4. Key Drivers for accelerating infrastructure rollout

Need for appropriate cooperation models to enable the initial deployment of 5G highways corridors

Highly assisted driving and early automated driving services are expected to be first rolled out along highways as it is recognised to be the most appropriate environment in terms of technical complexity and prospects for investment profitability. Highways are not where the largest amount of fatal accidents occur in Europe but economies of scale for the technology will most likely to be achieved in this context before being extended to the more challenging areas of secondary roads and eventually dense urban districts. One will also benefit from a well-established infrastructure management structure, usually led by national or regional road authorities in cooperation with private or public road operators. The latter will be central actors as they entertain direct relationships with car safety authorities, infrastructure providers and telecommunications operators.

Based on various estimates from different sources (including 5G-PPP, Commission study, EIB, various industry players), the estimated upfront investment required to achieve the goal of uninterrupted 5G coverage (CAM-grade) along highway ranges between €5 billion and up to €18 billion[9], only for the first 26,000 kilometres of highways in Europe. These first indications need to be further refined and detailed, as the cost of deploying 5G infrastructure depends on several varying factors, such as the site grids of existing cellular networks which can be leveraged, the spectrum available for deploying 5G, the mode of 5G deployment (initially 5G NSA, i.e. non-standalone as a 5GNR supplement to 4G networks) and the network capacity required to serve the road transport traffic including ITS over cellular evolving over time. These factors differ across the corridors, countries and regions. The first challenge to unleash such investment is to develop the appropriate cooperation models, in close cooperation with road operators, and stimulate the related business ecosystems in order to establish initial economies of scale. This level of investment is unlikely to come only from the private sector, at least within the 2020-2025 target timeframe.

The need to bridge this investment gap, and to lower the overall business risk level, is the basis of the Commission's proposal for allocating a part of the proposed Connecting Europe Facility Digital programme to co-finance 5G corridors. The Commission proposal already includes an indicative list of the priority 5G Corridors envisaged for EU public funding support (see figure in Annex 1). This list of corridors has already been welcomed by Member States and by many private stakeholders as it follows broadly the well-known TEN-T network of European highways. It should therefore constitute a valid first step in the overall strategy to build the essential backbone infrastructure for European-scale CAM services.

The promoters of this SDA strongly agree with the objective of starting with the deployment of the identified set of 5G corridors, taking advantage of the wider dynamic created by the planned public financing, in particular CEF and other sources of EU and national funding. The need for EU support should reach at least €1 to €1.5 billion in view of the objective to

[9] Interim results of a Commission study preparing for the implementation of CEF Digital, see Annex 2, and EIB estimates most substantial differences in investment estimates depend mainly on assumptions regarding needed KPIs, efficiency of the future technology, and the extent to which active digital platforms are needed (e.g. Mobile Edge Cloud).

mobilise sufficient private investments for a perspective of a deployment over the full network of 5G corridors identified in the CEF Digital legislative proposal.

It is well understood that the targeted 5G corridors is only a concrete step towards the longer objectives underpinning the long-term societal vision. On this basis, the stakeholders participating in the development of this SDA agree to further develop a more detailed 5G corridor deployment roadmap, setting priority areas, service requirements, and connectivity targets, with the view to guide the implementation of CEF Digital funding planned for the period 2021-2027.

Stabilising the technology roadmap

Standards

Standardisation remains an essential pillar of CAM. V2X communications technology is expected to play an ever-growing role in ensuring the safe and efficient operation of autonomous driving systems. While initial interests were concentrated on V2V and V2I services, cellular connected vehicle deployments have recently gained considerable momentum spearheaded by cellular industry in 3GPP with support from the automotive industry.

While the preference of individual stakeholders for the deployment of a certain radio technology standard must be respected, a cooperative solution to the interoperability issue between technologies and across borders must be defined.

Finally, there is a need to advance standardisation of C-ITS solutions in general. Whereas 5G systems for CAM will go well beyond the scope of C-ITS, progress made in the context of 5G corridors may be important elements for advancing C-ITS standardisation and implementation towards more elaborated functionalities such as overall traffic situation awareness and anticipation beyond line-of-sight/line-of sensors.

Network Slicing

Network Slicing will make possible to operate multiple virtual, sometimes called “logical”, networks with defined functionality, reliability and quality of service on top of a common physical network infrastructure. It should therefore be essential to facilitate the future establishment of innovative ecosystems and business models at the core of connected mobility.

A party willing to cover the cost for a Network Slice will want to have a Service Level Agreement (SLA) with one or more network operators. Network Slice Templates (NESTs) currently specified by GSMA [Ref N.116 NEST] currently provide 34 attributes to support description of what a customer expects from the Network Slice. Many attributes are optional allowing a wide range of service descriptions from best effort services with certain minimal geographical coverage to mission critical services requiring high reliability including guaranteed low latency bounds and packet loss ratios. NESTs assure a common format and understanding across network operators on how to define and interpret SLAs.

Cybersecurity

End-to-end cybersecurity aspects are essential to ensure secure C-ITS services. They need to go beyond the currently defined security specifications for short-range V2X to encompass the full cellular network context, respectively 5G-based communications as well as

distributed edge cloud and backend cloud systems. From that regard, it will be required to develop a holistic three-tier cybersecurity model encompassing the vehicular/roadside systems, the short-range and long-range 5G cellular domain including backbone communications, the cloud and edge cloud-based distributed and centralised computing domains. Along with cybersecurity, privacy and GDPR aspects will need to be addressed appropriately, across the same three tiers.

Regulatory Innovation

The regulatory environment will play an important role to enable innovative business approaches and incentivise investments in mobile network expansion for CAM. This concerns in particular:

- The different network sharing options.
- The co-investment approaches and wholesale-only model.
- The spectrum needs some harmonization assignment and roll-out obligation.
- Regulatory provision for seamless connectivity.

It will also be important to both exploit all possible regulatory options and maintain regulatory flexibility to enable innovative automotive propositions. In this context, it is anticipated that the CEF programme will offer concrete opportunities to test, in a "green-field" scenario environment, new regulatory approaches supported by the modernised telecom rules.

A particular aspect of the regulatory environment is compliance with competition rules when CEF funding will be used. While CEF funding is not subject *strictly sense* to state-aid rules, the different models and supporting arrangements need to be consistent with competition principles and avoid devaluing or crowding-out private investments.

When the particular use of CEF funding is being considered, cooperation arrangements involving at least two or more undertakings from the same or different sectors may have to be set-up according to specific models regarding the sharing of passive and active infrastructure network elements, in so far as they may have implications on the level of investments required to deploy. Moreover, the project may involve different funding mechanisms and financial instruments, including resources from the Member States.

For that purpose, the participating organisations in this SDA see the need to identify criteria to ensure consistency with EU competition law principles applied to CEF-funded projects, in particular with respect to antitrust and state-aid rules.

The stakeholders are ready to cooperate to identify a common approach to evaluate the investment gap (a hypothetical and illustrative example is given in Annex 3).

There are also other areas which will have to be tackled in due time such as the regulatory handling of Net Neutrality in the context of 5G services for CAM, the liability treatment in case of accidents and the free movement of CAM products and services in the single market. The promoters of the SDA for CAM will pursue further work on the most important issues and suggest if and when further public policy action would be welcome.

Data Access and Data Sharing

Modern vehicles are digitally connected IoT and AI devices. They are equipped with sensors that continuously collect data on the mechanical functioning and location of the vehicle. These data can be communicated in real time from the car to a variety of stakeholders from public sector to service providers and open possibilities to improve the efficiency of existing services and to offer new services. For instance, the Extended Vehicle Concept as

standardised in the context of ISO is being deployed by vehicle manufacturers to ensure data exchange in a safe and secure manner.

The promoters of the SDA take note of the fact that the Commission formulated principles to access and reuse of non-personal data generated by IoT objects in the Communication "Towards a Common European Data Space" in April 2018. These principles should be taken into account in contractual negotiations in Business-to-Business contexts with the aim to develop a competitive and fair data market in the automotive sector.

It is also welcome that the Commission is conducting consultations with various groups of stakeholders on the possible creation of sectoral European data spaces, including in the transport and mobility sector. Such data spaces would facilitate the sharing and use of data (including car data) and could benefit from the support from the Digital Europe Programme towards appropriate technologies, standards and policy frameworks.

The promoters of the SDA call for a new impetus to the inter-sector dialogue on data access and data sharing. The support of the Commission as facilitator would be welcome. A particular interest of Industry is to progress on agreed principles for a data governance in relation to the following situations:

- Promote data sharing necessary for public interest (safety reasons, e.g. ITS services).
- Principles for ensuring non-discriminatory access and innovation in relation to services relying on access to data in the respect of investment in data management.
- Promote data sharing necessary for other public interest purposes (e.g. environmental purposes).

Spectrum

5G will reach its full potential only if sufficient harmonised spectrum is made available to deliver the service in a timely way and with long term license duration. It will also be important to ensure that spectrum is assigned under fair and reasonable economic terms so as to not hinder the spectrum holder's capability to invest in network infrastructure.

At the moment, it is expected that CAM services can be supported by V2N communications using existing cellular mobile frequency bands (e.g. 800, 900, 1800, 2100and 2600, MHz), new cellular mobile frequency bands (e.g. 700 and 3400-3800 MHz), as well as using the globally harmonised 5.9 GHz band (5 855 – 5 925 MHz), which is expected to remain an important resource for short range ad hoc ITS safety communications (V2V, V2I, V2P). With respect to the 5.9 GHz ITS spectrum, sharing the band with other non-ITS applications (e.g. RLAN) would limit the potential of rolling out advanced safety and automated driving.

Further ITS spectrum for V2X needs attention. Early discussions are ongoing for the potential use of new bands, for advanced V2X applications LOS (Line-of-Sight) and high data rate V2X[10] applications e.g. sensor data sharing.

A thorough inter-sector dialogue needs to be conclusive regarding the above spectrum issues in order to create stability in the spectrum roadmap and facilitate technology development and lower infrastructure investment risks.

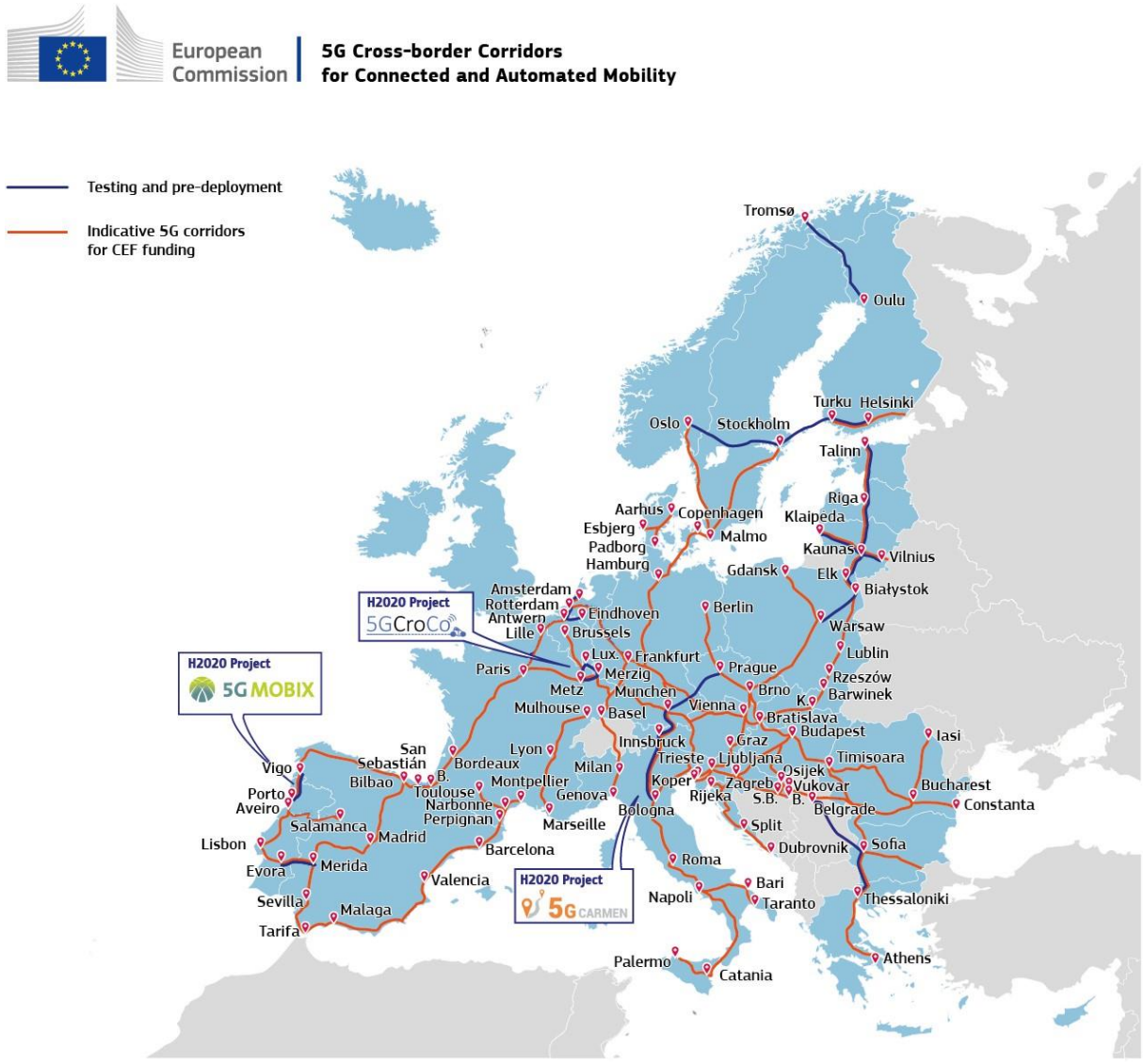
[10] V2X includes V2V, V2P, V2I, and V2N.

Coordination of Deployment

One of the specific aspects which have not been satisfactorily addressed yet is the issue of coordination between the deployment of the 5G infrastructure for CAM, and more generally the cellular coverage extensions, and a roadmap for ramping up vehicles equipped with 5G-enabled (as well as other technologies) onboard units supporting CAM. This aspect should be the subject of a specific inter-sector dialogue, which must bear initial fruits before large commitments in 5G CAM network infrastructures.

Annexes

ANNEX 1: 5G cross-border corridors for CAM as identified in the draft CEF regulation



ANNEX 2: Extract of the Commission Study on CEF – Cost of deployment of 5G corridors

Disclaimer: This annex is solely illustrative since there is no consensus among stakeholders on this approach, nor on the services, scenarios, or overall cost levels.

According to the interim finding of a study conducted by a team of independent consultants for the Commission in view to support the implementation of CEF Digital[11], and which were presented in a public workshop on 1st October 2019, four scenarios can be devised:

- **Minimum scenario**: a scenario based on the critical data that should be transmitted in any traffic conditions. The reference is the minimum bitrates observed on the current tests. Use cases that require additional services, such as the video visualization to improve driver comfort and to reassure him, are not considered as critical services during the busy hour (busy hour : the worst traffic conditions meaning almost 200 vehicles per km on highway). However, they will be available in more flexible traffic conditions. Under this scenario (equipment every 4km), the total investment required to cover the 26,000km CEF2 corridors will be €800m with a price of €12,000/km for fibre, a price of €1700/km for V2I and a price of €17,000/km for V2N. This would represent a total of €31,000/km.

- **Classic scenario**: a scenario based on the critical data that should be transmitted in any traffic conditions. The reference is the average bitrates observed on the current tests with the possibility to have main use cases at the same time (the majority are not always-on). Under this scenario (equipment every 3km), the total investment required will be €988m with a price of €12,000/km for fibre, a price of €1700/km for V2I and a price of €24,000/km for V2N. This would represent a total of €38,000/km.

- **Breaking scenario**: a scenario based on all 5G CAM use cases, including those that are more specifically designed for the driver (and not for the unmanned algorithm) or those that are designed for the V2V communication, V2N2V as a fallback. It also takes into account future services that will require higher bitrates and have not been tested yet. With this scenario (equipment every 1 km, bitrate of 30 Mbps), the total investment required will be €2,578m with a price of €19,000/km for fibre, a price of €10,000/km for V2I and a price of €70,000/km for V2N. This would represent a total of €99,000/km.

- **Future Proof scenario**: in this scenario, the network will support any conceivable future service, (equipment every 0.4 km, bitrate of 100 Mbps), the total investment required will be €5,460m with a price of €19,000/km for fibre, a price of €10,000/km for V2I and a price of €181,000/km for V2N. This would represent a total of €210,000/km.

[11] Supporting the implementation of CEF2- SMART 2017/0018, Ecorys, figures based on interim results to be released in Nov. 2019 [EMBARGO until then].

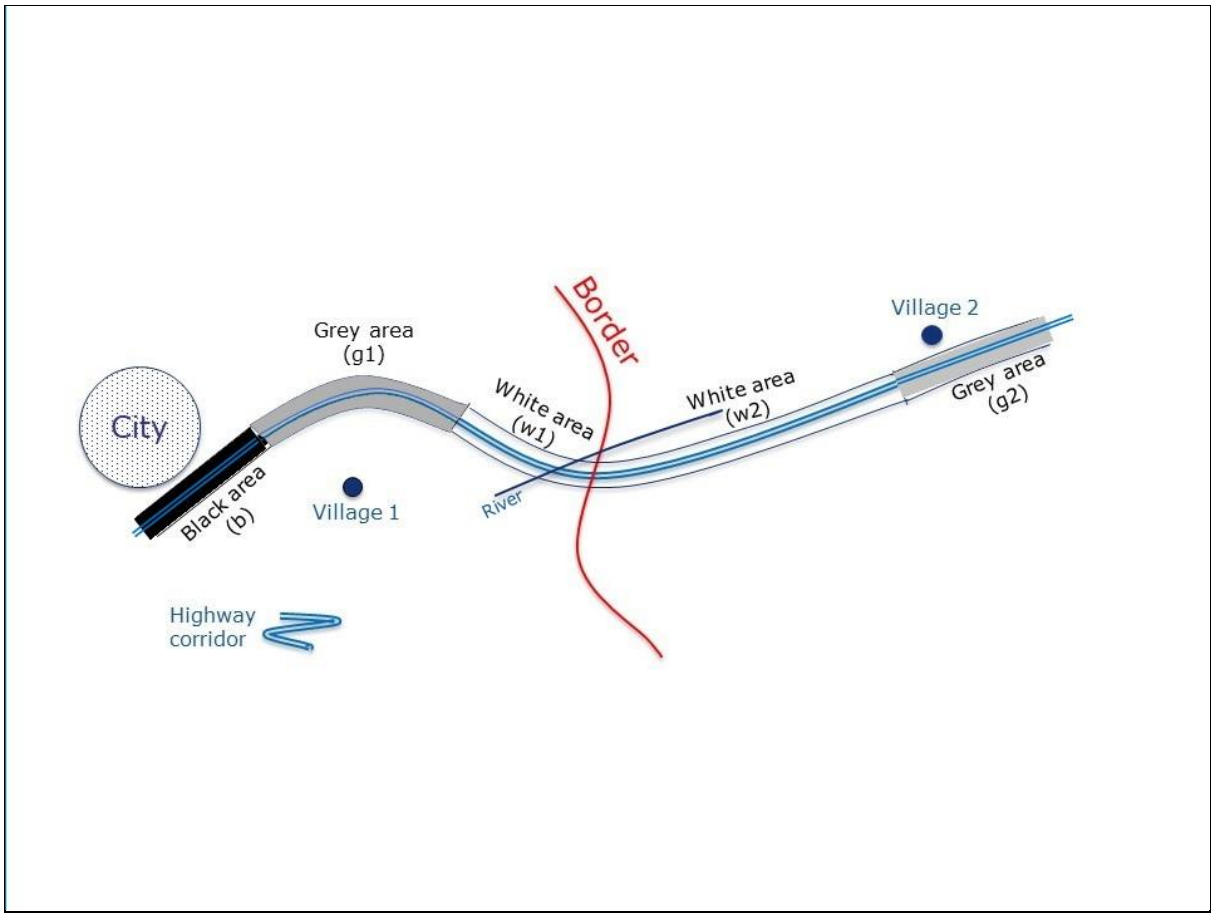
On this basis, different deployment costs have been estimated as follows:

		MINIMUM 5G Scenario	CLASSIC 5G Scenario	BREAKING 5G Scenario	FUTURE PROOF 5G Scenario
BACKHAUL NETWORK	Existing Backhaul along 5G corridors	**50%** available		**20%** available	
	k€/km	12	12	19	19
	m€	314	314	500	500
5G CELLULAR NETWORK	CAM use case	**1 Mbps Guaranteed** bitrate *in highly trafic period*	**2 Mbps Guaranteed** bitrate *in highly trafic period*	**30 Mbps Average** bitrate *normal conditions*	**100 Mbps Average** bitrate *normal conditions*
	Available Frequencies	700Mhz & 3500Mhz, 260Mhz nationwide BW			
	Business Model	**Multi-operators & Active Ran Sharing**		**Standalone & Passive Ran Sharing**	
	Inter-site distance evaluated	**≈4 km**	**≈3 km**	**≈1 km**	**≈0,4 km**
	Site cost (& installation)	90k€			
	5G corridor dist.	26 000 km			
	Existing radio sites	1 every 10 km			
	5G site upgrade	40 k€			
	k€/km	17	24	70	181
	m€	443	631	1 818	4 700
TOTAL 5G V2N COSTS		757	945	2 318	5 200
V2I INFRA	RoadSide Unit cost (& installation)	5 k€		20 k€	
	Distance between two RSU	3 km		2 km	
	5G corridor dist.	26 000 km			
	k€/km	1,7	1,7	10	10
	m€	43	43	260	260
TOTAL V2I & V2N COSTS		800	988	2 578	5 460

However, the figures in the table above only represent a first and generalised indication which will vary across member states and regions (e.g. cost for civil works) and significantly depend on the specific topography and the availability/reusability of legacy mobile network infrastructure, i.e. existing 2G/3G/3G/4G sites of mobile network operators and the various network grid structures deployed so far. A refined model has to reflect that the requirements for ITS and CAM services have to take into account that the corridors and each corridors sections have different numbers of vehicles on average and during rush hours, which could be grouped into traffic demand scenarios. This will lead to a more differentiated model for addressing the traffic demand (physical and digital) by 5G network deployments without significant overprovisioning and associated costs.

ANNEX 3: illustrative distribution of black-grey and white areas over a CEF 5G corridor

One significant feature of CEF implementation is the trigger for market failure. While we are not strictly bound to competition rules for CEF, we must adhere to the main principles. Below an example showing sections of black, grey and white sections of highways.



Note: Please note that there is no requirement to include a cross-border section to identify a situation of "market failure". The above example is for comprehensiveness purpose and in view of the possible focus of CEF projects on cross-border sections.

White, black and grey area should broadly be understood in the usual meaning of market competition terminology (i.e. levels of intensity of competition).

In the specific context of CEF Digital for 5G CAM corridors, a possible approach would be to consider a market failure holistically on a sufficiently large section of highway by applying a standard formula. Such formula could be considered as best practice "ex-ante" between the Industry and the Commission services as guidance for CEF project proposals and their evaluation by independent experts. Example: (0.5 X km of grey areas + 1X km of white areas) / (total length of highway section covered by CEF project) > 30% = market failure.

The Commission will however always reserve its right to decide on individual project basis, as appropriate.