# Cooperation Models enabling deployment and use of 5G infrastructures for Connected and Automated Mobility (CAM) in Europe

5GAA Automotive Association

White Paper

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# Contents

# Cooperation Models enabling deployment and use of 5G infrastructures for Connected and Automated Mobility (CAM) in Europe

This White Paper outlines five non-mutually exclusive options for ecosystem cooperation models relevant to 5G CAM infrastructure deployment and use. 5GAA believes these options may bring even more benefits when combined.

Building upon this first assessment, 5GAA considers that in the context of the large-scale introduction of advanced safety and automated driving use cases supported by C-V2X, a more integrated model involving all parties (vehicle manufacturers, road operators, communication service providers i.e. mobile network operators and neutral host infrastructure providers) should be considered as well as other services providers who will play an increasing role in the ecosystem e.g., location-based data marketplace, Mobility as a Service (MaaS), etc.

# 1. Introduction

It is widely agreed that the «fifth generation» of telecommunication systems, or 5G, will be one of the most critical factors to strengthen our digital economy and society in the next decade. Automotive is one of the fields 5G will help to transform: it has the potential to have the most revolutionary impact by saving millions of lives. In addition to safety (reducing road accidents), it will produce more efficient journeys, minimise travel times, traffic jams and improve environmental footprints. Whenever a use case impacts safety, it also has a positive impact on congestion, emissions and, therefore, public expenditure, but also public satisfaction and acceptance, as there are fewer accidents and traffic flow is more fluid.

It is important to note that many automotive services such as C-ITS Day 1, infotainment, insurance, telematics & diagnostic services, can be supported by the current global cellular standard LTE-4G, which is seen as an essential foundation to further progress towards Connected and Automated Mobility. As a complement, 5G offers further (and improved) options for C-V2X communication and is seen to be more 'future proof' in the shift towards fully autonomous driving in future.

For example, although the C-V2X technology is available at present, the 5G Automobile Association (5GAA) acknowledges that "to support the [automated] vehicles of tomorrow, the technology must evolve to meet more demanding safety requirements. 5G will facilitate this evolution. It's extreme throughput, low latency, and enhanced reliability will allow vehicles to share rich, real-time data, supporting fully [automated] driving experiences."

5G-V2X is therefore considered for advanced driving and LTE-V2X is considered for basic safety use cases, each encompassing both network and direct communications. Mobile network operators worldwide have started to deploy 5G, building on current 4G networks. In the meantime, the planned releases of the 3GPP standards include new features for direct communications, such as low power consumption in handheld devices, enabling additional use cases.

The deployment of such applications requires a well-developed digital infrastructure. As the lifetime and user-requirements of the digital infrastructure differs widely from the physical infrastructure and the development of the infrastructures are not congruent, specific (but integrated) strategies for the various levels of transport infrastructure are required. This asks for a closer coordination between different stakeholders (and possibly even other organisation models), as the various infrastructure levels are managed by different parties, with shared responsibilities.

1. Visionary Roadmap for Advanced Driving Use Cases, Connectivity Technologies, and Radio Spectrum Needs, September 2020
2. The impact of emerging technologies on the transport system, Study conducted for the European Parliament TRAN Committee by TNO and CE DELFT (pp 14)

## 1.1 Ecosystem cooperation

Ensuring rapid and efficient deployment of 4G/5G along road networks is critically important to the future of mobility and will result in numerous safety benefits, especially reducing road fatalities for European citizens.

Three major industries within the connected automotive environment must work closely to bring about change in good time: vehicle manufacturers (OEMs), road operators (ROs) and communication service providers (CSP), which include mobile network operators (MNOs) and neutral host infrastructure providers (NHPs). Other Services Providers (SPs) will play an increasing role in the ecosystem e.g., location-based data marketplace, Mobility as a Service (MaaS), etc.

Each party (OEMs, CSPs and ROs) has its own set of high-level service-level requirements, as per their respective business models, that must be met to trigger deployment. All stakeholders would benefit from a clear understanding of the others' requirements, influences and longer-term objectives as they must be reconciled to achieve a truly connected mobility ecosystem.

OEMs' deployment strategies are driven by consumer service requirements, but also influenced by the regulatory framework (or lack thereof). OEMs will only deploy connected and automated mobility services if a sustainable business model, relying on profitable and added-value services to the end-customers, supports it. The sustainability of such business model will be assessed against the cost of the required communication enablers, as well as, for certain services, the pre-existence of the C-V2X infrastructure needed to support them (e.g., I2V). Regulatory stability and predictability are also required to trigger investment decisions.

Although there are many different types of road operator (motorway, city, rural, tolling etc.), they share common objectives of "safe, reliable, efficient and environmentally friendly mobility in the face of traffic growth, ageing infrastructure and limited public financing."[3] Road operators acknowledge the need to simultaneously develop a digital road infrastructure and improve their backend systems, services, and underlying processes. This is to enhance the effectiveness of their operations but also "safeguards their interests and avoid having to adapt to or comply with what will be delivered by industry (at the risk of putting things on the road that adversely affect road safety, traffic flow and the environment)"[4]. However, these significant investments can no longer be "isolated and under total control of the road operator" as they will only deliver upon the promised benefits if they also match other ecosystem stakeholders' deployment.

Finally, CSPs are the indispensable enablers of digital road, as the intermediates between OEMs and road operators. They must deliver upon both OEMs and road

3. CEDR NRA CAD Strategy discussion paper, 2018
4. Idem

operators' service and communications requirements while being subject to specific regulatory requirements as service operators. As private entities, they also have their own financial and operating requirements to maintain business profitability on invested capital e.g., in terms of infrastructure rollout, service take up and cooperation models.

Cooperation among all stakeholders involved, both private and public, is pivotal for road operators and public authorities across Europe to meet their policy objectives. By leveraging synergies with CSPs existing infrastructure alongside roads, public and road operators can minimise their investments through shared economics to better target where there is need for new public investment. A positive mindset on the role that CSPs can play as a bridge between customers and road operators is needed as pre-requisite for cooperation.

In the 5G Strategic Deployment Agenda for Connected and Automated Mobility in Europe[5], the authors note that to accelerate the infrastructure rollout, identifying appropriate cooperation models is a game changer. To that end, 5GAA industry representatives have compiled this paper that is geared:

- To identify several alternatives or complementary cooperation models, which identify the roles and responsibilities of each stakeholder, including the relationship between the different categories of actors.
- To contribute to a predictable and sustainable environment enabling the enhancement of the attractiveness of investments in 5G corridors, new use cases and possible business models they will enable.
- To provide input to upcoming Work Programmes and Calls of the CEF2 Digital Programme for 5G Corridors for CAM.

In preliminary research, the Commission has set out what appear to be five non-mutually exclusive options for cooperation models relevant to 5G CAM infrastructure deployment and use (in particular regarding CEF2 Digital), namely:

1) Investment by single Neutral Host infrastructure Provider ("NHP") in passive infrastructure to enable mutual open access models
2) Investment by road/rail operator in passive infrastructure
3) Co-investment by a consortium of interested companies in passive infrastructure
4) Investment by MNO in a fully active 5G network
5) A mutual open access model not necessarily wholesale only. This can involve CSP incumbents and municipal networks and regulatory intervention can be envisaged if no market solutions exist (see Arthur D. Little study)

There are also other possible model(s) e.g., CSPs deploying different segments across Europe mutually providing access to passive or active infrastructure.

5. https://5g-ppp.eu/wp-content/uploads/2020/10/20201002_5G_SDA_for_CAM_Final.pdf

## 1.2 Background research already undertaken in this area

When drafting this paper, one of the considerations was whether specific cooperation models or certain elements should be included in CEF Work Programmes/ Calls. In summary, it will not be feasible or appropriate to 'define the right model' in the context of the CEF2 Funding Round.

This view can be supported by two recent studies which have recently been undertaken in this area.

### CERRE report on Implementing co-investment and network sharing[6]

In relation to the country case studies examined, this report concluded the following:

- The drawbacks of infrastructure sharing discussed [in the report] are possible concerns and have been addressed in various cases.
- Very different forms and intensities of infrastructure sharing have taken place, and they are mostly considered successful; and
- There is no one best form, but it is important to address the concerns that we discussed [in the report] when the agreements are designed.

### GSMA report on Mobile Infrastructure sharing[7]

This report examines in detail different considerations relevant to infrastructure sharing, focused on:

- The types of network infrastructure sharing models which are available to operator (Site sharing, mast sharing, RAN sharing, MEC colocation, core network sharing and network roaming)
- The strategic rationale behind network sharing (drivers of infrastructure sharing and the business case for infrastructure sharing)
- Regulatory considerations and driver (efficiency improvements: coverage, quality and pricing, impact on competition, regulatory approval for infrastructure sharing, controls on charges and regulatory safeguards), and
- Technical and environmental issues (technical limitations to infrastructure sharing and environmental impact).

The GSMA's work in this area has also shown that infrastructure sharing agreements can take many different forms. This means that the benefits and disadvantages of infrastructure sharing can vary and general implications and/or predictions may not be precise.

6. See https://cerre.eu/publications/telecom-co-investment-network-sharing-study
7. See https://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf

Additionally, it is worth noting that in 5GAA's White Paper on CSP Network Expansion Mechanisms to Fulfil Connected Vehicle Requirements[8] identified some cost drivers for mobile network infrastructure setup.

These costs are mainly based on:

1. **Optimising location of antennas:** Network operators often need to revert to sub-optimal antenna placement. This, in turn, may lead to the need to install additional antennas.
2. **Finding new sites and erecting masts:** the processing time and cost of getting building permission are the biggest cost driver. Reduced costs for the mast could be a result of the shared use of (public) infrastructure, e.g., lamp poles, traffic lights, noise barriers, advertising screens, public transport information screens, etc.
3. **Access to power:** The connection to already existing electric grids, the shared use of ducts, etc. could significantly reduce the costs.
4. **Access to fibre connection or similar:** The connection to already existing (public) fibre networks, shared use of ducts, etc. could significantly reduce the costs.

Capital expenditure (CAPEX) on the radio access part in a 5G mobile network is strongly related to the frequency band used. In city areas, where 3.5 GHz and 26 GHz will be used, base station densities are considerably higher than in rural areas, where 700 MHz is more likely to be used. Therefore, the availability of sufficient spectrum in the right bands is also an important cost driver.

Examples of operating expenditure (OPEX) cost drivers are maintenance, licence costs and site operational costs.

Clear synergies with road operator deployments are found that enable business case improvements for network expansion for mobile network operators:

- **Simplified site permits:** planning authorities can ensure that mobile network operators get quick and easy approvals for planning permission and construction permits, and easy access to rooftops and in-building cabling. This particular topic must be addressed in the review of the Broadband Cost Reduction Directive.
- **Provide access to passive infrastructure:** road operators can provide easy and predictable access to passive infrastructure such as ducts and poles, dark fibre, and power to allow cost-effective construction of mobile networks.
- **Shared use of roadside infrastructure** road operators can provide easy, secure, and predictable access to public assets such as lamp poles, traffic signs, etc. to allow cost-effective construction of mobile networks.

8. See https://5gaa.org/wp-content/uploads/2020/06/5GAA_B-200044_WI-NetExp-White-Paper.pdf

## 1.3 General recommendations

In summary, **the different options that have been identified are not mutually exclusive and none should be ruled out as being viable options to be explored as part of CEF Digital 2.**

In practice, at least some of these options may be combined (e.g., investment by MNO in active 5G network combined with road operator or neutral host provider (NHP) investment in passive infrastructure).

The road operators, public and private, should play an important role in enabling and easing access to required facilities to set up mobile networks. For instance, the Commission's 3rd party research has identified, availability of and access to road operator fibre as a key consideration to fulfil the objectives of CEF2. It is estimated that "20 to 50% motorways benefit from an existing fibre backhaul infrastructure suitable to support 5G deployment". In addition, a significant number of road operators will need to install new or upgrade their fibre and power. Fit for purpose duct access is also a key consideration in this respect.

There are also several important regulatory dependencies, primarily related to the Broadband Cost Reduction Directive and European Electronic Communications Code (see dedicated section on BCRD policy recommendations).

Private companies putting in their own funds into CEF2 projects should have the appropriate incentives to invest (e.g., need to ensure those that are taking risks by putting their own money in this have the right incentives to do so). Any rules should be such that any private investment that was made earns back at least its risk adjusted Weighted Average Cost of Capital (WACC).

# 2. Possible cooperation models

## 2.1 Investment by MNO in full active 5G network (along the roads)

The most plausible deployment model is MNOs' investment in a fully active 5G network. In this scenario, MNOs may use their own network to deliver a broad range of CAM services including safety related services, as the communication bridge between the vehicles and the connected road infrastructure.

Today, non-safety critical Day 1 or Day 1.5 C-ITS services can be delivered via a back-end data exchange mechanism which does not really require contractual a relationship between RO and MNOs since the data would transition with cloud/data integrators like HERE, TomTom, etc.

While OEMs would have a contractual relationship with MNOs to provide vehicle connectivity and the cloud/data integrator, ROs would have a similar relationship with the cloud/data integrator e.g., to provide road signage updates, etc. This is likely to require roaming agreements to allow seamless transition from one MNO network to another.

For such services to be delivered optimally, continuous mobile network coverage alongside roads would be required. Road operators can contribute to achieving such coverage by facilitating access to passive infrastructure (see point 2.2). In some countries, road coverage obligations towards MNOs have been requested by regulators e.g., as part of 5G auctions. 5GAA underlines, however, that these should always be considered as part of a series of linked policy measures.

Several market failures, especially in cross-border regions, have also been identified in the 5G Strategic Deployment Agenda. Specific investments should be earmarked to address these issues, considering that they are not necessarily tied to an infrastructure gap but also radio spill-over, cross-border frequency coordination and related capacity limits. A dedicated study investigating the issues at stake would be required.[9]

Addressing white spots might require the definition of a targeted cooperation model depending on the specific local conditions (e.g., geographical situation, road operator(s) involved and availability of other types of physical infrastructure, available spectrum, available tower company(ies), etc).

At this juncture, there are limited numbers of real-life examples of use cases that would require direct cooperation between CSPs and ROs. A likely scenario is a simple customer relationship between MNO-RO (e.g., to connect RO traffic surveillance cameras to 5G). The cooperation with road operators would however benefit from similar mechanisms as described under point 2.2.

9. See also 5GPP White Paper based on inputs from 5G MOBIX, CROCO, CARMEN

It is very unlikely that MNOs would refuse to deliver safety services. 5GAA considers, in any case, that a 'public safety network' dedicated to CAM would go against the principle of the business model of multi-service networks that can enable synergies with other services besides CAM. In addition, this would be state centric as it focuses on national service and cross-border roaming opportunities are extremely limited. It is, also, worth noting that this is a very specific set-up and is not likely to be relevant for Europe, as it is unlikely to have one "road safety slice" dedicated in Europe.

As regards mobile edge to support V2X services over the network, we assume that this option would pave the way for more complex CAM services. Although a first assessment has been undertaken by 5GAA[10], it requires further investigation, especially as regards the underlying business models, the use of existing infrastructure and cooperation opportunities with ROs or the access to edge computing centres for application processing.

For Day 1 services, in Australia, Ericsson and Telstra conducted a series of trials with a "Virtual RSU" architecture, where V2X Cloud was acting as a "RSU anywhere" providing traffic light timing, MAP information, speed limits, pedestrian status, etc. without deploying any physical RSUs. Although tests were successfully conducted using existing LTE network (E2E latencies of less than 50ms were observed in 95 percent of trials), partners concurred that the solution can be further enhanced as 5G and edge compute technology are rolled out.[11]

5GAA's upcoming Technical Reports on MEC for Automotive in Multi-Operator Scenarios will discuss the architecture and deployment aspects when Edge Computing is used for V2X use cases. Exploring different scenarios, they describe how interoperability and service continuity can be solved, in particular by providing guidance on how to realise and manage the interoperability of automotive services in a multi-MNO, multi-vehicle OEM and multi-MEC vendor environments. Based on OEMs' feedback, four use cases were prioritised in the context of these two reports: VRU protection, Smart Intersection, See-through and Platooning (road operators' specific use cases e.g., delivery of "lane merge assist" using roadside sensors have not been assessed yet).

For these four use cases, MEC is expected to play an important role due to the low latency required due to both the overall multiple hops the message needs to cover, but also with all the procedures and services needed when more than one MNO is involved. The MEC platform in those cases will not only instantiate the application but also some of the entities in the V2X service architecture. The reports provide some examples of Edge Computing architectures, realising the multi-MNO communication in different ways, as well as some application layer deployments for the considered use cases. Finally, some MEC security guidance is provided to allow secure multi-MNO interoperability on the MEC. In particular, security boundaries are determined for the main multi-MNO scenarios.

10. Business Aspects and Requirements of 5G Network slicing (BARNS) Report, November 2020
11. Ericsson "Towards Zero: creating safer roads with cellular-V2X in Australia", 2020

## 2.2 Investment by road/rail operator in passive infrastructure

Road infrastructure upgrades are required to deploy most Vehicle-to-Infrastructure (V2I) or Vehicle-to-Network-to-Infrastructure (V2N2I), regardless of if cellular networks or RSUs are ultimately used. In some cases, there is fibre and power available, but cabinets must be installed. Moreover, road infrastructure and/or roadside units (RSUs) need to be connected to the backend system, and such backend system needs to be able to monitor events according to requirements. Even if in some cases the service delivery might work with minimal integration with the infrastructure, some level of integration is always required with central systems for security certificate distribution. Some regions and cities already have upgraded infrastructure, thus significantly reducing the costs for providing V2I (or V2N2I) service. However, it is not a pre-existing condition in many cities where different (and sometimes multiple) traffic control systems coexist. Being mindful of existing constraints related to public investments, 5GAA believes the focus should be on establishing a supporting and investment-friendly environment.

### Brokering of road operator fibre and utilities (e.g., electricity)

The introduction of 5G new radio equipment in the RAN is expected to require more dense radio sites. For roadside deployment, this will require the installation of additional cell towers and edge data centres meaning significant CAPEX investments. As explained in the 5GAA Entex White Paper[12], the roll-out of this additional infrastructure will be beneficial regardless of the spectrum bands used to deploy 5G.[13] CSP deployment can be greatly facilitated if road operators grant CSPs access to key passive infrastructure (fibre, electricity). MNO service and maintenance operations are highly secure, access to shared infrastructure will need to be organised in cooperation with road operators to ensure service continuity but is not expected to cause any disruption or traffic disturbance.

Providing optical fibre connectivity to the new sites is expected to be one of the key cost drivers. Therefore, the idea of allowing mobile network operators to make use of road operators' under-used optical fibres capacities to lower the CAPEX costs for roadside 5G coverage has become a popular one in the 5G community.

However, although simple in its concept, it is unknown today what complexities may need to be overcome when deploying 5G new radio equipment using this paradigm. More research is needed to establish whether this is a feasible approach, how it should be organised, and what the main challenges are when doing this in practice. For example, the fibre may not belong to the road operators but to the state and is sometimes reserved for state services like defence, national intelligence, or the police.

12. MNO Network Expansion Mechanisms to Fulfil Connected Vehicle Requirements, June 2020
13. Although 3.5 GHz band is frequently mentioned among the 5G pioneer bands, studies have shown Day 1 or Day 2 services do not necessarily require using that specific band i.e., in city areas, 3.5 GHz and 26 GHz will most likely be used since base station densities are considerably higher than in rural areas, where 700 MHz is more appropriate.

An approach currently under investigation by the Dutch government is to take a broker role between the road authorities and the mobile network operators. This way, access to the road operator's infrastructure can be given under the same conditions to all mobile network operators, while minimising the burden on the road operator. This also makes it easier to explore the reverse approach: can the road operator use MNO's fibre-optic infrastructure in locations where the road operator has insufficient low capacity today.

This research is being organised in a stepped approach: first, identify if there is overcapacity that could be shared by the road operator and explore if it is actually suitable or appropriate for usage by a mobile network operator, then investigate how this could be organised technically and define how the broker role could facilitate the execution of that technical integration process, and only then execute it in real life on a specific test location.

During these steps, the deployment requirements of all involved parties (road operator, broker, NHP, MNO) will be considered, and the corresponding set of agreed processes and monitoring methodology will be described.

In parallel, other elements such as legal implications, financial models, the future scalability of the model, etc. must be investigated, and corresponding recommendations will be delivered.

Note that insights will be gathered and delivered within these activities, but no decision about the eventual 'adoption model' is expected during the course of this research. This action hence defines how the adoption of this paradigm could be organised if valuable and feasible, but not if and when it will be adopted.

### Site sharing for base stations

Two types of site sharing can be distinguished: usage of public infrastructure by private mobile network operators or NHPs and the sharing of (privately owned) mast sites between MNOs. Sharing of infrastructure owned by private companies (e.g., private road operators) is also an option, however that is done on commercial terms between the involved parties and addressed.

#### a) Public

The first aspect concerns the sharing of public infrastructure. For this, the new European Electronic Communications Code[14] is very relevant. According to article 57-4, MNOs should have the right to make use of public buildings and other infrastructure for the deployment of small cells:

> *"Member States shall, by applying, where relevant, the procedures adopted in accordance with Directive 2014/61/EU, ensure that operators have the right to access any physical infrastructure controlled by national, regional or local public authorities, which is technically suitable to host small-area wireless access points or which is*

14. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1547633333762&uri=CELEX:32018L1972

*necessary to connect such access points to a backbone network, including street furniture, such as light poles, street signs, traffic lights, billboards, bus and tramway stops and metro stations. Public authorities shall meet all reasonable requests for access on fair, reasonable, transparent and non-discriminatory terms and conditions, which shall be made public at a single information point."*

5GAA recommends that such mandates should not be limited to small cells only, but also comprise wide-area cells.

Use of local public assets like location, fibre/backhaul and power by parties such as CSPs (NHPs and MNOs) depends on bilateral agreements between the parties. Experience in Spain showed that there needs to be clearly communicated benefits to society (e.g., improved emergency services, road safety, traffic efficiency, environment) to create acceptance for use of public infrastructure by private companies.

In June 2020, the German BMVI (Federal Ministry of Transport and Digital Infrastructure) and stakeholders developed some recommendations for the shared use of public infrastructure in the context of the 5G roll-out. The report investigates aspects such as the identification of potential carrier infrastructure (lamp posts, traffic signs or traffic lights), the upgrade of existing macro-network sites and identification of new possible locations, as well as the deployment of small cells.[15]

### b) Private

The second aspect of site sharing is the **sharing of (privately owned) network elements and associated facilities between MNOs**. This was required by the European Directive 2002/21/EC and has already been implemented by several countries in Europe. For instance, Dutch national law has required for some time that providers of electronic communication services and mast sites must comply with reasonable requests for shared use of their sites, antenna systems or antennas.

In conclusion, close cooperation among road operators, MNOs and NHP tower companies will be mutually beneficial, allowing economies of scale for all involved stakeholders. This will also prevent unfortunate situations where public money is eventually misspent due a misalignment with the real-life needs or ways of working of the private sector. For instance, one road operator's initial proposition combining investment in passive infrastructure and a neutral host model failed to attract MNO 'residents', despite initial interest, due to the calibration of the broker's role.

There are other positive examples that Europe could seek inspiration from.

Launched in 2018, Paris2Connect is a public-private consortium gathering 8 companies (ATC France, Audiospot, Aximum, Exem, Nokia, Parking Map, RATP, Signify) to build a shared and open digital infrastructure supporting smart city and mobility services in the City of Paris. The project aims to leverage public infrastructure (traffic lights, lamp

15. Mitnutzungspotentiale kommunaler Trägerinfrastrukturen für den Ausbau der nächsten Mobilfunkgeneration 5G, BMVI, June 2020

posts) to deploy 5G telecommunications network serving new mobility use cases (e.g., autonomous shuttle).[16]

In Japan where the government allowed MNOs in 2019 to set up 5G base stations on the roughly 200,000 traffic signals administered by local governments[17]. Sumitomo and NEC announced since then that they had agreed with the Tokyo Metropolitan Government to start installing and testing 5G Antenna-equipped Smart Poles with the aim of bringing these systems into full-scale use by March 2021[18]. In 2020, Sumitomo Corporation also launched the first proof-of-concept for 5G base station sharing by multiple cell phone carriers in a railway tunnel with Osaka Metro.[19]

More recently, Hong Kong operator SmarTone announced the implementation of Hong Kong's first 5G SmarTransport Safety Monitoring System at Tai Lam Tunnel crossed by 140,000 vehicles per day. The system leverages edge computing among others and does not require fixed network placement within the tunnel area[20].

### Broadband Cost Reduction Directive (BCRD)

There is much that still needs to be done at EU and national level to ensure a fit-for-purpose approach in this area. Permit costs and procedures vary across member states and local municipalities. The bureaucratic variability in costs and processes involved with obtaining relevant permits in different Member States (and on a more granular, local (regional and municipal) level) creates a lot of inefficiency, cost, and delay in the deployment of new networks. A pan-European process should be developed for network deployment that will harmonise current local and municipal rules and help achieve European digital aspirations. The current rules in the BCRD need to be strengthened and further streamlined to ensure its goals are achieved.

A simplified rights of way mechanism allowing deemed consents where essential infrastructure is deployed without major disruptions to private or public land should also be the norm. A universal regime where consents are "deemed" to be given unless there is objection from relevant interested parties is an efficient and tested model for cost-effective and timely delivery of new broadband networks. The EU could seek to replicate US FCC's concept of "shot clocks" to simplify and speed up the process by local decision-makers. It effectively removes the need for complex and lengthy waiting periods and variable permit procedures, while requiring a notice period within which objections may be submitted.

The BCRD should also provide for a single information point at national level that would allow access to minimum information concerning the existing physical infrastructure, including road operator infrastructure, to any network operator (e.g., location and route, type, and current use of the infrastructure). Once this is in place, we believe this should result in accurate and easily available databases for fibre (and other infrastructure) that allow prospective new investors to quickly plan and execute deployment.

16. See Paris2Connect initial press release (2018) and YouTube video (Sept 2020)
17. Japan to greenlight 5G base stations on 200,000 traffic signals (Nikkei, June 2019)
18. Agreement with Tokyo Metropolitan Government on trial installation of 5G antenna-equipped smart poles, May 2020
19. Japan's first proof of concept of 5G base station sharing in a railway tunnel to begin, March 2020
20. Hong Kong's First 5G SmarTransport Safety Monitoring System for Tai Lam Tunnel, January 2021

Clear synergies with road operator deployments can be better leveraged already on aspects such as access passive infrastructure power), simplified site permits and shared use of roadside infrastructure (lamp poles, traffic signs, etc.). In particular, permit costs and procedures vary across member states and local municipalities. The bureaucratic variability in costs and processes involved with obtaining relevant permits in different Member States (and on a more granular, local (regional and municipal) level) creates a lot of inefficiency, cost, and delay in the deployment of new networks. A pan-European process should be developed for network deployment that will override current local and municipal rules and help achieve European digital aspirations.

## 2.3 Investment by single Neutral Host infrastructure Provider ("NHP") in passive infrastructure

A neutral host infrastructure comprises a single, shared network infrastructure for certain key subsystems. These assets can be provided on an open access basis to all MNOs seeking space, power, and connectivity. Assets are usually deployed, maintained, and operated by an independent, third-party provider like a 'tower company' such as American Tower or Cellnex (a former division of Abertis toll road group).

A good example of such a model can be derived from the initial deployment in Virginia, United States, where the Virginia Department of Transportation, Audi, Qualcomm, and American Tower have joined forces to deploy expanding roadside and vehicle safety use cases[21]. American Tower Corporation is providing a neutral host model to drive value to multiple public and private stakeholders, helping to deliver safety and mobility services with C-V2X. All interested mobile network operators get access to sites, owned by the third party, to host their base stations.

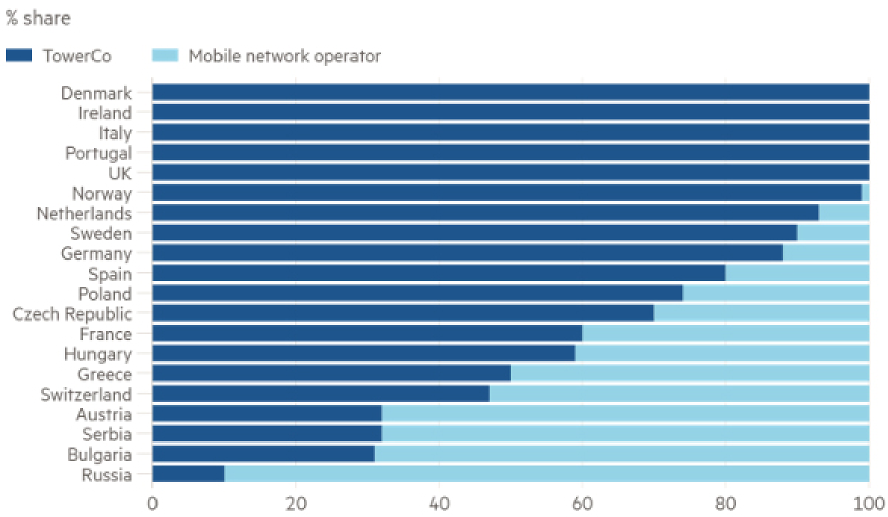
In Europe, Cellnex is coordinating the 5GMED consortium, which gathers 21 partners from seven countries to demonstrate advanced Cooperative Connected and Automated Mobility (CCAM) and Future Railway Mobile Communications System services (FRMCS) along the "Figueres – Perpignan" cross-border corridor between Spain and France (Mediterranean Cross-Border Corridor). The project will run from September 2020 until November 2023[22]. Among the foreseen services to be tested: remote driving use case, advanced traffic management, applications and business service continuity in railway, and follow-me infotainment both in highway and railway scenarios. As another example of a neutral host alongside the road network, in Italy, Cellnex claims to cover over 220 km of tunnels, managing multi-operator and multi-service coverage facilities.[23]

21. C-V2X Communication Technology Now Deployed on Virginia Roadways, September 2020
22. 5GMED: The future of mobility in the Mediterranean cross-border corridor, June 2020
23. Cellnex Indoor coverage and special projects

Unlike vertically integrated networks that could accommodate one technology solution, neutral host infrastructure is a shared platform, potentially capable of supporting ITS services in addition to all MNOs and IoT smart city technologies, giving their customers what they are looking for – sensors, seamless coverage, and high capacity. This approach allows operators to focus on service delivery and infrastructure companies to focus on real-estate development and capital investment. By shifting investment from an upfront, CAPEX-heavy model where MNOs shoulder all deployment costs to a neutral host model where NHP shared infrastructure helps to spread costs across multiple parties and converts a CAPEX burden to an easier to manage more efficient OPEX.

The consolidation of Europe's mast market is on-going with American Tower's recent acquisition of Telxius Telecom and their 31,000 tower sites in Europe and Latin America with a commitment to build 3,300 new sites in Germany and Brazil by 2025[24]. Its rival Cellnex recently completed the acquisition of CK Hutchinson's European portfolio, bringing it close to controlling 100,000 telecom towers (almost a fifth of the EU's total market).[25] Most recently, Vodafone carved out its masts business into Vantage, a separate tower company, owning 82,000 masts in ten European markets.[26] Similar trends in terms of infrastructure sharing can be observed at global level.

*Figure 1: Mobile Tower Ownership in Europe (source: TowerXchange and FT)*




24. American Tower Enters Europe in $9.4 Billion Telefonica Deal" by Bloomberg, January 2021
25. "'M&A machine' Cellnex reviews next move after tower deal-making bonanza" by FT, January 2021
26. Vantage hopes to take advantage of tower deal making boom, by FT, February 2021

## 2.4 Co-investment by consortium of interested parties (NHPs, MNOs, road/rail operators) in active combined mobile network and RSU infrastructure

According to recent Ricardo study conducted for 5GAA[27], one proposition that has sparked real interest from MNOs and road operators is the joint deployment of cellular small cells possibly combined with RSUs on the 5.9 GHz band on targeted areas. ROs can also collaborate with NHPs as part of the ecosystem to deploy RSUs.

This opportunity requires further analysis and empirical studies to identify the magnitude of possible synergies and operational implications (e.g., security) of joint RSU & small cells/ gnome deployment. A first preliminary assessment undertaken by Deutsche Telekom in a city environment found that less than 20% of the investigated locations could be suitable for such joint deployment.

This is mainly relevant in the urban domain where deployment of small cells can support the densification of the cellular network, which will be important for the MNOs to support the increased capacity needed to deliver the full benefits of 5G (especially mmWave) and accommodate a growing number of users and services relaying on data connectivity over the cellular network. On long highways, the cooperation should be on full coverage of V2N cellular service and deploy RSUs on 5.9 GHz only at hotspots.

Deploying connected hardware can be a significant undertaking in terms of planning, access to utilities (power, backhaul) and maintenance. In rural areas, there can be specific challenges around the availability of power and backhaul, while deployments in urban and suburban areas are also challenging due to zoning and licensing restrictions. The planned increase in small cell sites, particularly in urban areas, means there is increased interest from MNOs to identify opportunities for collaboration that can save on costs and support the business case for installing new cellular sites, such as small cells. When looking at the deployment of RSUs and small cells, five types of synergy could be exploited:

- Access and licence to deploy on suitable street furniture
- Access to power for unit operation
- Access to backhaul for connectivity with central systems (RSU) or core network (SC)
- Sharing of module or connectivity and software components for applications
- Sharing of installation and maintenance efforts

27. Ricardo Study on Cost Analysis of V2I Deployment, August 2020

These synergies can result in upfront cost savings for both the RSU (i.e., RO) and small cell owners (i.e., MNO). Where there is a need to incur costs related to power or backhaul, costs can be shared by a NHP, and where there are not costs to share, the road operator can leverage access to the site and utilities in return for financial reimbursement or access to connectivity. Furthermore, service agreements can be made to allow joint maintenance that shares the operational costs. Leveraging expertise from the telecoms industry has so far not been something that many road operators or cities have done, and it is particularly relevant when considering joint deployment activities. Some MNOs have been investigating the maintenance of ITS infrastructure (including RSUs) since they have decades of experience in maintaining national networks of connected infrastructure.

Operational synergies may also exist whereby the infrastructure can be used to perform other useful sensor or IoT functions for the RO. Beyond synergies that exist between the stakeholders directly involved in V2I services, there may also be complementarity and potential for business models with other actors such as the power sector (e.g., Japanese example with TEPCO, KDDI, SoftBank and Rakuten[28]). Distribution network operators are also investing in cellular communications as they start to actively control their networks. For example, network monitoring will be needed to manage the integration of electric vehicles into low voltage networks with as little reinforcement as possible. These activities consider many of the same functionality and cost aspects as in V2I deployments, communication technology, network cost, signal coverage and latency.

28. TEPCO PG, KDDI, SoftBank and Rakuten Mobile Network to collaborate on trials of base station equipment sharing utilizing electric power infrastructure, March 2019

# 2.5 Commercial Agreements

Another viable cooperation model are commercial agreements between industry and public authorities to deliver mobile network coverage (in addition to those listed under point 2.2). A successful example of commercial agreement is the development of the GSM-R standard for railway communications. However due to the specificities of telecom regulations and applicable competition law, further assessment on the feasibility of such commercial agreements would be required. One possible option would be for a road operator to enter into an agreement with MNOs to provide mobile network coverage in specific areas e.g., tunnels.

### Network slicing

Mobile networks are multi-service by nature, meaning capacities are shared between different services to be provided to the end-customers. If a road operator wishes to offer specific service(s) with dedicated service-level requirements, MNOs will welcome the opportunity to enter a commercial agreement and to offer a dedicate slice to provide such services as per intended requirements.

### Active Network Sharing

Network sharing is another option in the toolbox that can prove beneficial in specific markets or geographical areas. It is important to note, however, that market realities need to be taken into consideration when examining the impact of each cooperation model to conclude on the most suitable model for each market.

A pro-network sharing approach can offer benefits where it preserves national network-based competition (between the sharing parties, and between the sharing parties and other network operators). Network competition is driven principally by capacity in areas of high traffic (urban and suburban areas) and coverage in areas of low traffic (rural areas).

Among the recent examples of network sharing deals:

- O2 and Vodafone deal[29] in the UK to share 5G active equipment, such as radio antennas, on joint network sites across the UK, in non-commercially attractive areas (23 of the largest cities have been excluded from the deal)
- Deutsche Telekom, Vodafone, and Telefonica agreement to improve LTE coverage in rural Germany around 6,000 white spots and 4,000 grey spots (the latter involving only DT and Vodafone)[30].
- Proximus and Orange joint-venture for a shared mobile network for the Belgium market[31]

29. O2 and Vodafone double down on network sharing deal for 5G, July 2019
30. Deutsche Telekom and Vodafone agree active 4G rural sharing, February 2020
31. Proximus and Orange Belgium signed agreement to set up a shared mobile access network, November 2019

In general network sharing should be supported. We are reminded about this by the latest EC recommendation on best practices for network roll out. Such agreement allows greener, quicker, and less costly roll out. The legal regime applied to them should be clarified to grant enhanced legal certainty to private entities entering such schemes. In this regard, it is worth bearing in mind that network sharing agreements (NSAs), between Mobile Network Operators (MNOs), with a view to accelerating the roll-out of 5G across the EU are often deemed anticompetitive by DG COMP and National Competition Authorities (NCAs) and, hence, prohibited. This lack of consistency with the connectivity objectives pursued by the EU adversely impacts technology's dissemination and high-quality connectivity across the EU, creates legal uncertainty and raises costs for deploying 5G.

MNOs should have more freedom to engage into active network sharing, provided that a certain number of criteria are met in terms of competition.

Such criteria should be clearly defined to improve legal certainty e.g.:

- Guarantees in terms of capacity for commercial differentiation.
- Spectrum sharing not in the scope and each operator has its own backhaul network (while this can be based on backhaul/fibre sharing)
- Safeguards for exchange of competitively sensitive information
- Reasonable geographical perimeter in dense areas, all network operators already have extensive network coverage (with their own network or based on commercial agreements)
- The operators not party to the cooperation have sufficient coverage over the territory concerned by the sharing agreement.

5GAA believes that, instead of pursuing individual cases (which relate mainly to legacy and current technologies) the Commission should focus on **issuing guidelines or other forms of guidance** to MNOs explaining when (5G) network sharing may be problematic and setting out the conditions under which NSAs would be compatible with Article 101 TFEU.

Passive access and co-investment are complementary – multiple options are required for challengers to compete in the market – e.g., markets like Spain and Portugal that have had early adoption of passive access have the right maturity and market competitiveness at network level now for cooperative network sharing and co-investment.

# 3. Conclusion

The various options for cooperation models described in this document should all be eligible under CEF Digital 2 as they are not mutually exclusive and may bring more ecosystem benefits when combined.

Nonetheless, a more integrated model involving ROs, MNOs, NHPs and OEMs should be considered, as we expect from 2024 onwards, the large-scale introduction of advanced safety and automated driving use cases supported by C-V2X. However, these advanced services, enabled by the evolution of communication technologies, will only deliver expected societal benefits if they are matched with significant investment in digital twins for road infrastructure and traffic management, including operational data interfaces and MEC IoT.

5GAA roadmap[32] "Traffic Efficiency" track lists the entry use cases to be discussed with road operators to progress towards a true Digital Roads vision. As an initial step, digital infrastructure will bring dynamic traffic information, hazard warnings, and HD maps to the driver (up to 2024). In a second step, cooperative manoeuvres and HD sensor sharing provided by road operators will support automated driving above Level 2 through "cooperative perception" (2026). Finally, dynamic cooperative driving enabled with the support of road operators at selected hotspots (e.g., intersections) will follow (2029)."

The future cooperation models should reflect upon OEMs' needs and requirements, as infrastructure deployment cannot be detached from the operational considerations to enable future advanced use cases. Other road user groups should also be taken into consideration e.g., Vulnerable Road Users (VRUs), including cyclists, motorcyclists, pedestrians, to develop a holistic model that provides improved safety for all road users. These road users are very often smartphone-equipped – developing solutions to address their specific needs should reflect upon that as their integration will lead to a virtuous circle and market acceleration of C-V2X smartphones.

Previous generational transitions in connectivity technologies have demonstrated that once a new infrastructure is deployed at scale, the ecosystem unlocks a huge wave of innovation in new applications and services, the majority of which were not anticipated at the beginning of the cycle.

We believe that the roll-out of 5G networks, together with the digitalisation of vehicles, roads and other transport infrastructures will enable the emergence of a new economic sector around 'Connected and Automated Mobility', with a much bigger long-term impact than what we can foresee today based on our initial range of use cases.

32. Visionary Roadmap for Advanced Driving Use Cases, Connectivity Technologies, and Radio Spectrum Needs, September 2020

5GAA bridges the automotive and telecommunication industries to address society's connected mobility and road safety needs with applications such as automated driving, ubiquitous access to services and integration into intelligent transportation and traffic management. For more information such as a complete mission statement and a list of members please see https://5gaa.org

5GAA Automotive Association