5G travel corridors enabling connected and automated mobility

The deployment of 5G connectivity along travel corridors will promote investment in, and take up of, connected and automated mobility (CAM). This technology will transform the automotive and transport sectors, leading to an array of benefits including:

Improved productivity from reduced driving times - the cost of traffic jams may be as high as **1% of EU GDP**

Improved fuel efficiency and reduced emissions - transport is responsible for nearly **30% of the EU's total C0² emissions**

Fewer road accidents – **23,400 people were killed in road accidents in 2018 in the EU**

These net benefits alone are estimated to be **c.€15 bn annually in 2030.**

Beyond these first order impacts, there is considerable scope for broader industrial agglomeration benefits around CAM-enabled transport corridors. These are derived from gains that occur when proximity reduces transport costs – and specifically where the costs of moving goods, people and ideas are reduced.

Enhanced connectivity links, both digital and traditional transport, between EU member states, are key building blocks for the development of successful industrial zones and clusters. Therefore in the short term, the development of 5G travel corridors, and the associated fibre networks, could lead to the development of industrial zones along key network routes as businesses take advantage of the logistical benefits of these locations and strong mobile and fixed connectivity. Agglomeration can lead to wider regional benefits with strong transport networks to extra-EU trading hubs ensuring that more geographically distant regions are not left behind.

CAM overview

CAM refers to autonomous/connected vehicles or self-driving vehicles that can guide themselves without human intervention. There are several levels of autonomy as can be seen in the graphic below, with the role of the driver reducing at each new level.

Drive Assistance	Partial Automation	Conditional Automation	High Automation	Full Automation
Cruise control Automatic breaking	Steering Acceleration	Environmental detection capabilities Most driving tasks but needs human override.	All driving tasks under certain circumstances	All driving tasks under all conditions. No driver attention required
Advanced drive assistance systems		Autonomous		

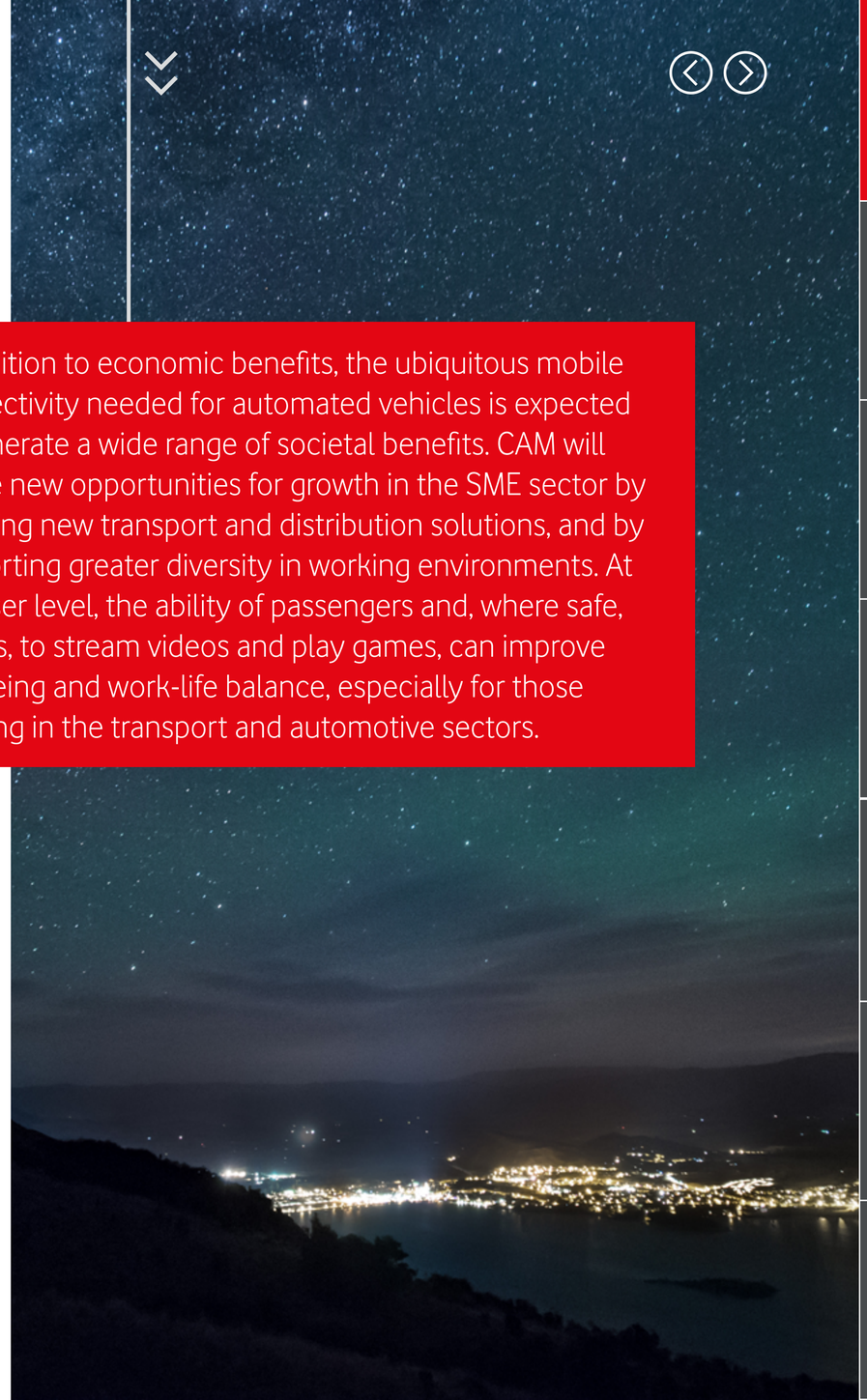
Overland transport is a key sector in the EU, facilitating trade through the movement of goods and people, and accounting for a significant portion of total EU freight and passenger transport. Road freight makes up 75% of all tonne-kilometres transported overland in the EU and transports a similar tonnage to air transport, making it vital for the €256 billion of intra-EU trade. Road and rail are also essential for the transport of goods internationally, accounting for c.20% of EU international trade. CAM can have a big impact on the transport and automotive sectors. For instance, sharing information on loads can reduce inefficiencies from empty or partially full lorries – inefficiencies currently estimated to reach €160 billion. In total, the benefits of 5G for the automotive and transport sectors in the EU could reach €50 billion in 2025.

[1] United Nations Conference on Trade And Development (2019), World Investment Report 2019. Available from: https://unctad.org/system/files/official-document/WIR2019_CH4.pdf

[2] Statistics taken from Eurostat.

[3] European Commission (2017), Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe. Available at: https://op.europa.eu/en/publication-detail/-/publication/2baf523f-edcc-11e6-ad7c-01aa75ed71a1/language-en

In addition to economic benefits, the ubiquitous mobile connectivity needed for automated vehicles is expected to generate a wide range of societal benefits. CAM will create new opportunities for growth in the SME sector by enabling new transport and distribution solutions, and by supporting greater diversity in working environments. At the user level, the ability of passengers and, where safe, drivers, to stream videos and play games, can improve wellbeing and work-life balance, especially for those working in the transport and automotive sectors.



exponential growth in the market for CAM

The market for CAM is starting to grow exponentially allowing for the realisation of these benefits

4%

Autonomous vehicles could exceed **4% of the European market in 2025,** and an exponential acceleration should be seen from this date.

€200

The global connected car market is projected to reach a value of **€200 billion by 2025**

€3.8 billion

The total EU market size for car data services, could already reach **€3.8 billion per year in 2021**

The challenges for investment

Due to the requirements of ultra-reliability and low latency, CAM will require the development of 5G networks with functional redundancy. The development of autonomous cars and the associated benefits rely on prior investment in 5G along major transport routes to ensure that stakeholders across the value chain can have sufficient confidence and interest in the future of the technology. However, without an immediate business case, investment by the private sector in 5G networks is likely to be prioritised in urban areas where the immediate business case is stronger. This means that there is a failure of the market to deliver sufficient investment along these transport routes.

There are economic opportunities for mobile operators associated with autonomous vehicles, including the provision of SIMs, services and data. However, there is uncertainty as to whether CAM will generate sufficient return to incentivise the significant investment involved in deploying 5G networks along transport routes, particularly given the long lead times on other key CAM-enabling technology.

In order to accelerate investment in 5G travel corridors, it is expected that €1-1.5 billion public funding for 5G CAM rollout will be made available as part of the 'Connecting Europe Facility' (CEF) Digital. Up to 50% of the costs of a cross-border route would be publicly funded, with up to 30% of costs being covered for national routes.

Given the requirements for uninterrupted 5G coverage, it is estimated that it will cost between **€5 and €18 billion to provide connectivity for the 26,000km of highways** in Europe covered by the CEF Digital program. To realise the full benefits of 5G corridors and enable further private investment, the EU and Member States can complement the support provided by CEF digital.

Some countries, such as Germany, have introduced coverage and minimum service levels, such as required speed and latency, for 5G networks along the road network. These obligations have to take into account the economics of the sector and, if deemed to be justified, policymakers should provide the necessary support to deliver them such as allowing for increased infrastructure sharing (as discussed on the next page), lowering spectrum fees and providing state funding. National coverage obligations also make it more challenging for providers to develop a compelling pan-EU proposition under CEF.

Transforming the rail industry

The benefits of investments in connectivity along travel corridors are not limited to Europe's roads. The adoption of the Future Rail Mobile Communication Systems (FRMCS), of which 5G is a key enabler, will allow for the automation of several aspects of the rail value chain, and will provide passengers and rail operators with real time information with several benefits including:

- More efficient use of both **trains and track** improving utilisation rates
- Real time data on **train load rates and train availability** to help distribute passengers
- **Monitor wear** on railway infrastructure
- Information on freight trains such as **location and load monitoring**
- Access to reliable connections for passengers allowing them to **access mobile applications**

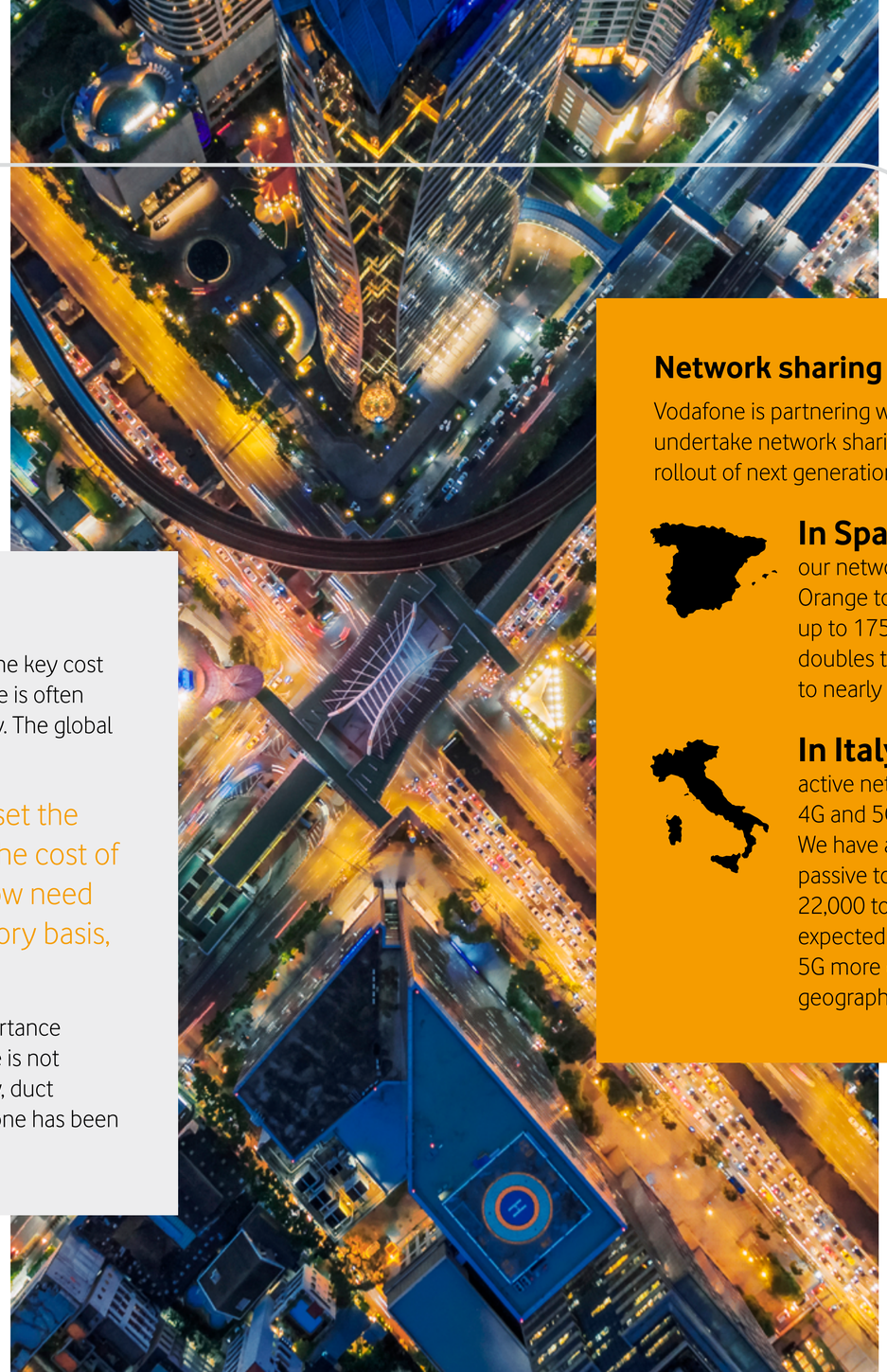
Case studies:
Network slicing in Germany

In Erzgebirge, Thales Transportation has started the trial of a driverless train by remote control using Vodafone's 5G network. Vodafone uses 5G network slicing, which helps different virtual networks share a physical network structure but provides a separate 5G network for railway trials. This means that remote-controlled mobile radio capacities are always available to control the train remotely, even if numerous users in the immediate vicinity also generate significant demands on mobile networks from their personal devices. In addition, the data is processed directly on-site in a small data centre in the immediate vicinity of the mobile base station via a Mobile Edge Cloud (MEC), allowing data to be processed without delay. The 5G technology enables **bandwidths greater than 500MB/second on the test track and reduces the latency to less than 10 milliseconds.**

Connecting trains and passengers to mobile networks is notoriously challenging for several reasons, including the high speed of travel. By leveraging our existing 5G networks, rail operators can lower their costs by developing connectivity-based applications across their rail networks.

Other policy opportunities

Given the high costs of rolling out 5G networks, there are several other policies that governments can promote in order to address the market's failure to invest sufficiently in 5G networks along travel corridors. This includes policies set out by the EU in the Broadband Cost Reduction Directive such as providing access to exiting physical infrastructure and more efficient permit granting.



Improved access to fibre infrastructure

Connecting fibre to new mobile sites alongside major routes is expected to be one of the key cost drivers for 5G corridors.[iv] While fibre has been deployed along many highways, this fibre is often not accessible to telecommunication operators due to configuration or lack of capacity. The global estimation of available fibre along 5G corridors is estimated at **c.50%**.

The latest European Electronic Communications Code (EECC) has set the right framework to provide access to pre-existing ducts to reduce the cost of rolling out fibre along 5G corridors. National administrations will now need to ensure that duct access is readily available on a non-discriminatory basis, combined with effective dispute resolution procedures.

A **study** previously carried out for the European Commission has highlighted the importance of fit for purpose fibre infrastructure along public highways. However, the infrastructure is not necessarily accessible to the telecom network service providers due to lack of capacity, duct access, or for reasons of security or price. An exception to this is in Spain, where Vodafone has been able to install fibre inside the ducts.

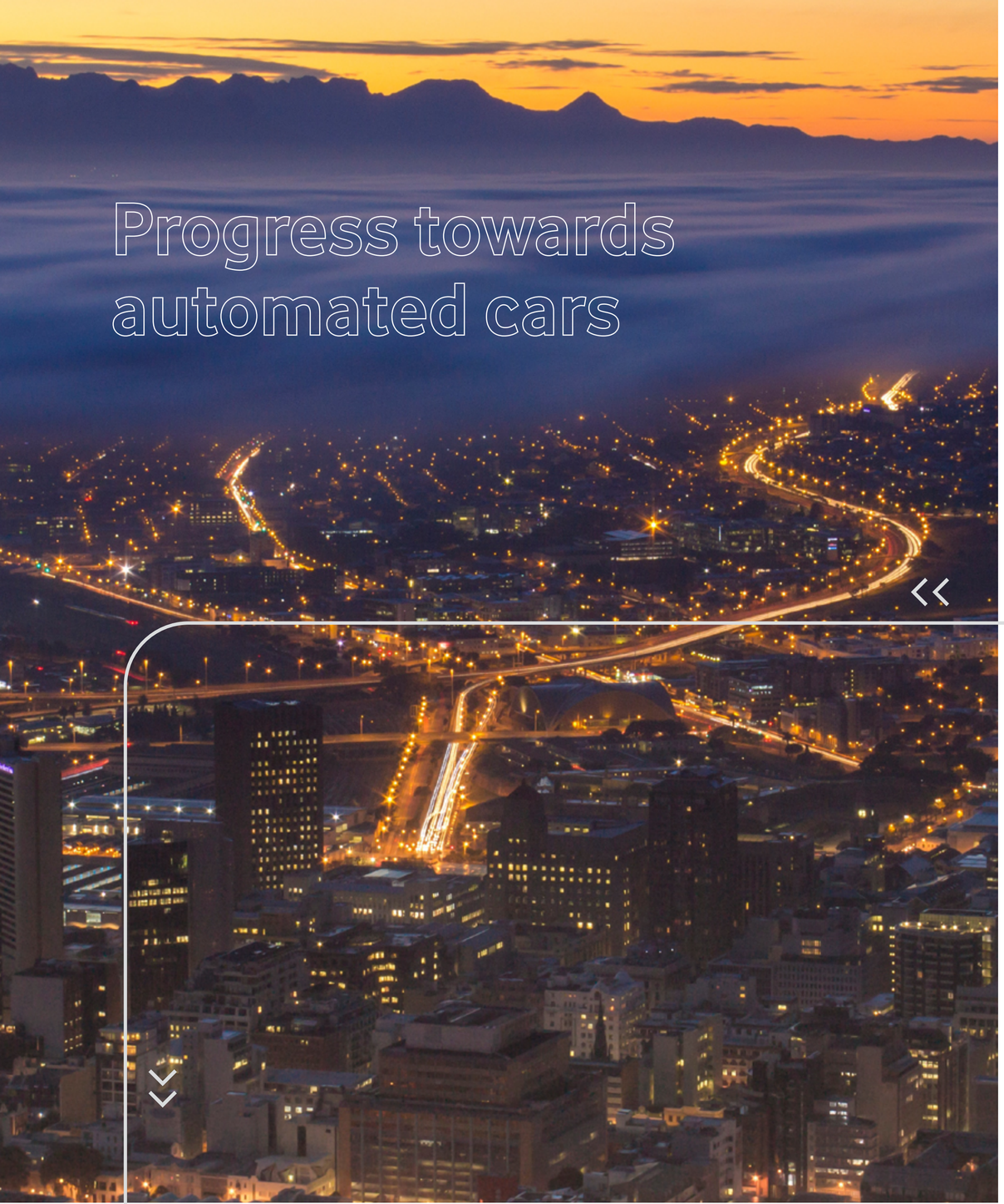
Network sharing partnerships

Vodafone is partnering with other operators to undertake network sharing deals to enable faster rollout of next generation networks.

In Spain, Vodafone has expanded our network sharing agreement with Orange to cover all towns and cities up to 175,000 people. This more than doubles the number of towers shared to nearly 15,000.

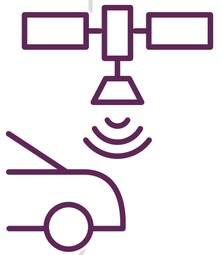
In Italy, Vodafone has created an active network sharing partnership for 4G and 5G with Telecom Italia Group. We have also agreed to merge our passive tower infrastructure, comprising 22,000 towers. This partnership is expected to enable Vodafone to deploy 5G more quickly, and over a wider geographic area.

[iv] 5GAA (2020); MNO Network Expansion Mechanisms to Fulfil Connected Vehicle Requirements



Progress towards automated cars

As a leading pan-European operator, Vodafone has been at the forefront in developing CAM, leading in cellular vehicle to everything (C-V2X) technology.



C-V2X modes

C-V2X technology uses LTE and 5G based communications on high frequency 5.9Ghz spectrum for short ranged vehicle to vehicle (V2V), infrastructure (V2I) and pedestrian (V2P) communication. In addition, it allows for wide area communication via mobile infrastructure for vehicle to network communication (V2N).

C-V2X in Germany

Vodafone is trialling V2V and V2I communication for cars along the A9 highway in Germany over long distances. Messages include signals around automatic braking, lane-tracking, blind-spot warning and information from nearby traffic lights. Whilst the solution is currently being trialled on an advanced version of 4G, the introduction of lower latency 5G networks will enable real-time communication with the cars (i.e. instant warnings), whilst the higher bandwidth will enable richer information, such as audio-visual entertainment, to be communicated. This has the potential to lead to several benefits including less congestion from more efficient traffic flows, increased safety, and new driving experiences.

The impact in Europe

While the investment needed to develop 5G travel corridors is large, the benefits can be expected to significantly outweigh these costs.

For example, there are clear economic benefits to enabling regional industrial clusters. Current regional clusters in the EU account for 50% of employment in exporting sectors and firms participating in clusters generate productivity and wage gains of 25% above average. Developing high-performing clusters, which require high-speed connectivity as well good transport links, has been shown to deliver productivity gains of up to 40%. 5G corridors can facilitate the creation of these clusters in Europe.[v]

CAM technologies enabled by 5G corridors deliver significant benefits:[vi]

300 million

By 2035 there could be over **300 million cars with V2X services**, either using C-V2X or IEEE8.02.11 in the EU.

The net benefits to the EU are estimated to be up to **€43 billion in terms of road safety, fuel consumption, CO^2 emissions and time spent on the road,** accounting for costs of infrastructure upgrade and in-vehicle systems integration incurred by automotive producers.

190,000 - 220,000 jobs will be directly and indirectly created. These jobs are supported by the investments in deployment of CAM technologies in the automotive industry and the increase in industry output.

[v] European Commission (2020). European Panorama of Clusters and Industrial Change. Available from: https://ec.europa.eu/growth/content/clusters-drivers-european-economy-results-2020-european-panorama-report_en

[vi] Analysys Mason (2017); Socio-economic benefits of cellular V2X. Available at: https://5gaa.org/wp-content/uploads/2017/12/Final-report-for-5GAA-on-cellular-V2X-socio-economic-benefits-051217_FINAL.pdf

[vii] European Commission (2019). ERTMS business case on the 9 core network corridors. Available from: https://op.europa.eu/en/publication-detail/-/publication/a5c88a67-994f-11e9-9d01-01aa75ed71a1

In addition, there are significant benefits in developing rail connectivity across Europe's main corridors, such as increasing capacity whilst avoiding the need for new rail routes costing billions of Euros. For example, on the **460 km high-speed line between Paris and Lyon**, better connectivity along the line is expected to improve capacity by up to 25%. With investment of €600 million, the increase in capacity avoids up to €12.9 billion of spending on a new line that would otherwise be required to provide this capacity. While benefits of this scale would be limited to capacity-constrained lines, the 50,000 km of core rail corridors in Europe illustrates the scale of potential savings.[vii]

A coordinated approach to promoting 5G corridors by European governments can help the EU become a global leader, promoting cross-border connections, more sustainable growth and social cohesion within the EU.