The edge of tomorrow: The impact of 5G MEC and location on the automotive industry

here

for location

Executive summary

Automotive and technology providers working on automated and connected driving will benefit greatly as 5G networks and Multi-Access Edge Computing (or MEC, formerly known as Mobile Edge Computing) capabilities are deployed over the next decade. Together, 5G and MEC can deliver the computing and network performance required to serve even the most demanding applications in our emerging automated world. Yet getting the most out of these exciting technologies will require the help of another: location intelligence. The field of location intelligence has developed significantly in recent years. Today, organizations harness highly accurate geospatial data and advanced location technology to address a wide range of business needs. We've assessed the vital role location intelligence plays in a 5G MEC world and how it will have an impact on automated and connected driving.

We discuss how location data and technology are indispensable in:

→ Realizing the full benefits of low-latency and high-throughput applications enabled by 5G MEC, including machines on the move

→ Enabling automotive companies to maximize 5G MEC for safer, automated driving

→ Enabling people to monetize their data and also manage their privacy in a 5G MEC world

Our views are based on two fundamental beliefs: in no generation of mobile technology has location intelligence been more critical or precise than in 5G; and that in no business is it more critical than automotive, one that is inherently mobile.

Want to talk? We do, too. Get in touch here.

Unlocking the full potential of 5G MEC with location intelligence

The continued advancement of 5G, presently still in the early stages of a multi-year build-out, will accelerate the efforts of enterprises to automate, digitize and enhance their capability to operate autonomous services. MEC technology, which brings cloud computing to the edge of the mobile network, is a key component of future networks. When combined with 5G, MEC promises unprecedented levels of computing and network performance, with high-bandwidth data transfers and ultra-low-latency connections – the kind of connectivity that can power the autonomous services of the future.

Estimates suggest that $1.5 trillion of 5G-enabled revenue is up for grabs before 2030. Huge upfront investments will be required to build cloud processing and storage capabilities deployed closer to where consumers and cars are: exactly where they are can be solved by the key technology of location intelligence. Fueled by affordable, low-powered sensors, big data analytics and artificial intelligence, location intelligence is now at the core of the next wave of digital transformation, helping drive better real-world outcomes. Its emergence is also perfectly timed to meet the needs of 5G MEC deployment, which will feature a dense and complex network of small cells, along with optimally placed edge servers. Automated vehicles will benefit from real-time positioning and situational awareness. Immersive Augmented Reality user interfaces will use high-resolution location data to overlay computer-generated imagery on the world and enhance mobile experiences.

Want to talk? We do, too. Get in touch here.

A leap in positioning accuracy and latency

New network technologies make locating people, assets or vehicles possible, using precise mapping to deliver unprecedented levels of positioning accuracy. Positioning technology has been a secondary feature in previous generations of mobile networks, but has been integral to the development of the 5G standard. The result is that, alongside positioning techniques relying on the new 5G air interface (also known as 5G New Radio), the 5G standard integrates a broad spectrum of positioning technologies, including 4G, GNSS, Wi-Fi and Bluetooth LE. 5G NR itself improves positioning, with the ability to provide greater accuracy and availability than 4G. Estimates suggest that building out sufficient coverage of 5G signals could create 4-10 times as many cell sites per square kilometer compared to 4G networks. That kind of density significantly increases a device's visibility to multiple beacons, while wider bandwidths, especially at high frequencies – together with enhanced antenna solutions – should enable more accurate location estimations. Positioning accuracy can be further enhanced by algorithms running in MEC servers. Most location services today are enabled through a combination of on-device processing of positioning data and the transfer of some data for processing by a server in a remote central cloud.

Calculating a position this way tends to involve multiple hops and takes time. While 5G devices can perform calculations to work out their own location, including drawing on terrestrial and satellite signals, doing so can quickly drain a battery. With 5G MEC networks, the computing effort can be offloaded to nearby edge servers. Devices can be continuously positioned in real time by the edge network. Networks doing the processing work means more computationally intensive positioning techniques and algorithms that can also support novel use cases.

Visual positioning with Verizon

HERE has been exploring visual positioning as a proof of concept with Verizon. This advanced technique is similar to the way humans locate themselves; we analyze what we see around us, accessing our visual memories of places. Similarly, visual positioning compares imagery of specific locations to a database of 3D geometry objects, created from Lidar-captured 3D pixel-point cloud maps and stored on MEC servers for fast access. The computation is aided by machine learning and the provision of an accurate position is performed in real time. While not native to the 5G positioning standard, visual positioning is complementary to 5G MEC, as it doesn't rely on a remote server and isn't hampered by tall buildings, urban canyons or signal deserts.

Want to talk? We do, too. Get in touch here.

Location-enabled edge use cases

As edge-based clouds begin to process large volumes of location data, they can also be made accessible to third parties. ETSI, the standards body driving MEC, has defined APIs that provide access to the RAN and expose data for positioning. The positioning data alone has limited value, but location intelligence enables developers to create new or modified applications for the new edge computing environment. McKinsey & Company has identified 107 edge use cases, including automated driving. What is striking is how location data is a common theme across all these scenarios – and often the key ingredient, especially where mobility and autonomy are involved. While the latency and throughput needs of edge cases are heterogenous, many are reliant on location precision and context.

There are three broad types of use cases that 5G technology will serve:

- **Enhanced Mobile Broadband (eMBB),** describing use cases requiring high data rates, such as video streaming and VR. Location can play an enabling role for these kinds of use cases – for example, through location-based beamforming and proactive resource management
- **Ultra-Reliable Low-Latency Communication (URLLC),** characterized by delay- and mission-critical use cases, such as intelligent transportation systems and autonomous driving, and
- **Massive Machine Type Communication (mMTC),** characterized by industrial and use cases such as automated last-mile delivery vehicles, where millions of IoT sensors spread over geographically small areas require connectivity for tracking, monitoring and reporting.

Enabling the data infrastructure for the vehicles of tomorrow

A benefit of 5G MEC is how it can contribute towards improving road safety, reducing traffic congestion, cutting pollution and enabling new vehicle-centric experiences. With 5G, vehicles can be continually connected to the internet and each other, as well as to traffic lights and road infrastructure. MEC, meanwhile, ensures large volumes of data from vehicles and infrastructure can be rapidly aggregated, analyzed and redistributed. The greater computing and network performance will accelerate vehicle-to-everything (V2X) communication, enable vehicles to tap into their surroundings for greater situational awareness and, eventually, facilitate the transition to full autonomy on public highways.

Want to talk? We do, too. Get in touch here.

Transforming the in-car media and infotainment experience: from intermittent to continuous data delivery

Standard 4G LTE wireless networks are generally sufficient for today's connected vehicle services. Telematics data can typically be cached and communicated later if there is a drop in coverage. Over-the-air updates for non-safety-critical systems and strategic planning can usually wait for good network coverage and throughput. Similarly, infotainment systems that offer live traffic-aware routing, surface parking availability, or enable payment at a drive-through generally do not need round-trip latencies of a few milliseconds. However, there are plenty of ways 5G MEC can transform the in-car experience. One example is in delivering seamless high-definition 3D views and augmented head-up displays of the driving environment. 3D maps tend to be highly memory-intensive, restricting their storage in the car – and size makes downloading over 4G challenging too. 5G MEC solves this problem, with eMBB enabling rich map tiles and data layers to be cached at the edge and streamed on demand, based on the vehicle's planned route.

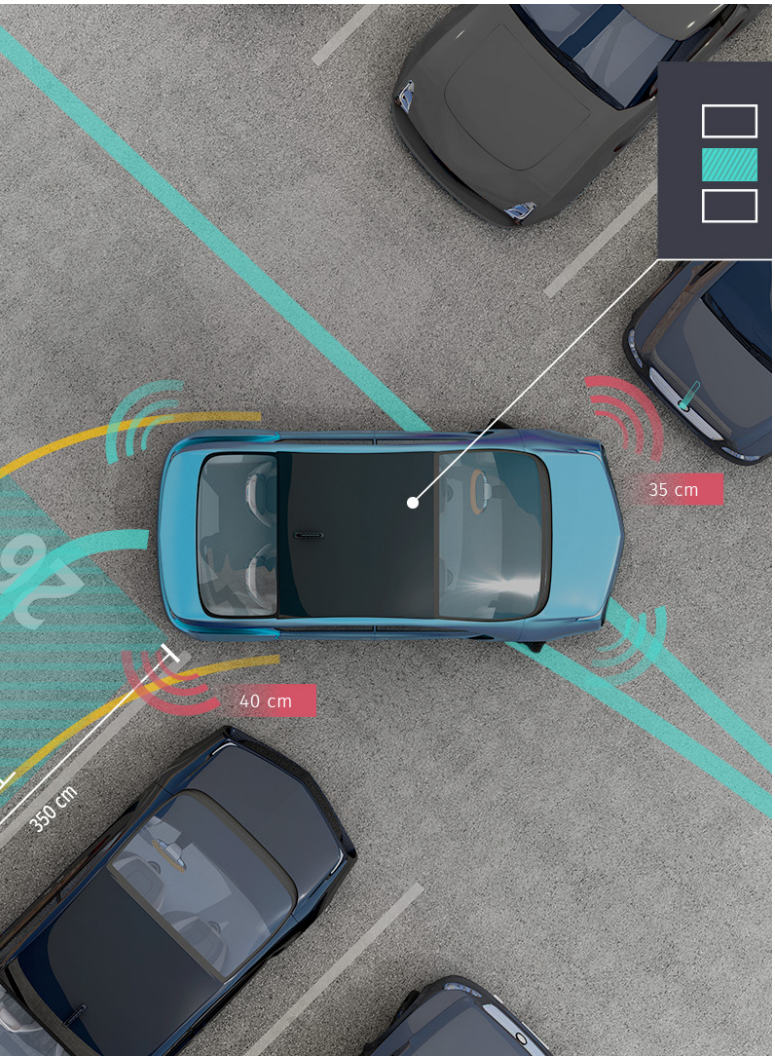
Rich maps as context and insight into vehicle behavior

As vehicles become more automated, rich maps keep passengers informed about their decisions – for example, changing lanes to avoid an obstacle on the road ahead, or pulling over to allow an approaching emergency vehicle to pass. The car's access to a live representation of its environment is enhanced by 5G MEC technology, enabling passengers to be given timely insight into the vehicle's behavior.

Parking and indoor venue experiences

HERE recently teamed up with leading parking provider APCOA. The aim is to develop and commercialize digital parking services and HD indoor maps of parking facilities in Europe. To achieve this, they plan to combine complementary capabilities in parking and mapping to pursue business opportunities in the automotive and urban mobility sectors. APCOA and HERE are also looking to create HD 3D indoor maps of parking garages in Europe, to enable the development of new services such as autonomous valet parking and the pre-booking of parking spaces for seamless end-to-end routing, as well as augmented reality-related experiences for end users. Enabling 5G and MEC can bring precision to vehicles, objects and consumers within parking structures and, eventually, to the venues they serve.

Want to talk? We do, too. Get in touch here.



Connectivity maps for reliable always-on mobility

Just as with today's networks, connectivity in the era of 5G MEC will not be uniformly robust. Levels of service will vary, thanks to variations in the availability of frequency bands, signal attenuation, and the changing number of end-users and their data traffic load. Some vehicles will require a continual connection to low-latency information and edge computing capabilities. For them, anticipating the level of connectivity will become imperative. Cars, trucks and machinery might even re-route to ensure a continued connection to the resources they need. Such connectivity maps also enable MNOs to anticipate the needs of moving subscribers to better manage their service, drive network efficiencies and create, where necessary, context-aware handovers.

Connectivity to support vehicle safety and automation

The biggest impact that 5G MEC and location intelligence will have on road transportation is in vehicle safety and automation. As the automotive industry embraces ZERO vision, including reducing accidents and deaths on the road (to zero, hence the name), it must optimize investment in new technologies that build trust in automated systems. Location data, 5G and MEC infrastructure engender trust in such systems because they work to enable a real-time data infrastructure that helps vehicles see and understand their surroundings, know where they are going and make safe, efficient and legal driving decisions. The successful introduction of autonomous transportation on our roads will depend on the vehicles driving in a way that is acceptable to their occupants. Today, ADAS functions mostly rely on input from on-board sensors with a limited sensing range. As the industry shifts to greater levels of autonomy, the extended awareness and visibility that location data provides becomes a more critical element of vehicle path and strategy planning. For that, high-data volumes must be transmitted fast. A vehicle needs awareness of the road environment, in the form of lane configurations, the rules of the road, traffic flows, road construction, hazards and weather conditions. These data inputs enrich the AI-based systems that support decision-making by vehicles. In such a dynamic environment, the speed and accuracy of these inputs is vital.

Want to talk? We do, too. Get in touch here.

Towards collaborative safety with C-V2X

Vehicle-to-everything (V2X) powered by cellular networks, known as C-V2X, has emerged as a compelling alternative to Wi-Fi-based Dedicated Short-Range Communication (DSRC or 802.11p) technology. In the medium term, it has the potential to gain further favorability amid the growth of 5G and MEC. Several major automakers have signaled their support for C-V2X, while the expanding membership of the 5G Automotive Association (5GAA) also suggests the industry is inclined to support 5G cellular connectivity.

Regulatory factors also influence rollouts, but C-V2X is gaining momentum as a preferred way for vehicles to communicate with one another and their surroundings. The European Union had diverged from the trend towards cellular-based V2X connectivity, but it is now adopting a technology-neutral stance that allows for C-V2X deployment. The US is also technology neutral, while China is a strong promoter of both C-V2X and 5G. Sidelink is another important element of C-V2X: within a 5G network, it enables direct communication between 5G-equipped vehicles and devices within range. After decades of development, the expectation now is that V2X, in C-V2X form, can finally start fulfilling its key promises: safer roads, greater traffic efficiency, intelligent transport and energy savings.

Three waves of C-V2X developments – **Now, Next** and **Long** – reflect our core assumption about the increasing impact on automotive safety and vehicle automation of improved connectivity and location intelligence over the next decade. Vehicles will become more proactive in their driving strategies, harnessing information shared across the road network, to develop a clear and uninterrupted understanding of the environment in which they are traveling. As 5G MEC networks roll out, we anticipate a significant increase in collaborative safety, ultimately laying the ground for coordinated autonomous driving before 2030.

The Now

phase is characterized by the use and exchange of low-throughput data to enhance driver awareness. Such services are already being deployed today, providing safety benefits, though none are mission critical, nor are 5G or MEC technologies required for services to operate as intended. The primary role of location intelligence in this phase is to provide situation awareness and context for drivers and vehicles, to plan and react in near real time to live road conditions.

The Next

phase introduces real-time, low-latency V2X communication to support ADAS and highly automated driving use cases in the medium term. Vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-cloud or vehicle- to-network (V2N) and vehicle- to-pedestrian (V2P) are more influential, with 5G and MEC also featuring in many use cases. Location intelligence becomes a more significant input into the driving experience, supporting vehicles with hyper-precise positioning and path planning for automated driving.

Collision avoidance with Verizon

HERE and Verizon collaborated to demonstrate some of the possibilities of combining the power of 5G MEC with location intelligence. One application that was developed – a prototype collision avoidance application, aimed at increasing pedestrian and driver safety – is a good example of what will emerge in the Next phase. The application leverages HERE HD Live Map and HERE's proprietary Live Sense computer vision technology, to create a V2N communication system that identifies vehicles, pedestrians, bicycles and barriers from a vehicle-mounted smartphone. The data is then sent to Verizon's 5G MEC network, where the Collision Avoidance AI predicts likely travel paths and warns vehicles of potential collisions.

Vodafone/Porsche
A collaboration between Vodafone, Porsche and HERE is using 5G's ultra-reliable data speeds to share real-time information. The aim of the proof of concept is to improve the safety of all road users by informing drivers of potentially hazardous situations around them. The collaboration uses Vodafone's 5G MEC network in tandem with HERE products, including HD GNSS Positioning for precise positioning, trajectory and location relevance analytics, and HERE Live Sense SDK vision technology, which detects pedestrians. The visual data from HERE Live Sense SDK also turns vehicles fitted with cameras into highly intelligent sensors. Pedestrian detection data from vehicles is sent to Vodafone's 5G MEC network for analysis. If a pedestrian is set to cross the trajectory of vehicles nearby, the relevant vehicles are notified in milliseconds, of their presence and movements. That is true even if the alerted vehicles cannot 'see' the pedestrian themselves.

Intelligent EV charging
HERE EV Charge Points is a cloud service that helps electric vehicle drivers find the right public EV chargers for their vehicle when they need it. It helps drivers pinpoint suitable chargers for every journey, based on the required connector type, accessibility, payment method and other rich information criteria. Among the information on EV charging stations available to service users is rich static content (name, location, hours of operation, charger types, number of connectors, etc), dynamic content on real-time usage of the charging station and the different methods of payment available.

V2I intelligent parking
HERE Indoor Routing helps to route users through an indoor space using detailed information from HERE Indoor Maps, including indoor parking levels. Together, Indoor Routing and Indoor Maps provide precise, end-to-end routing for customers. The service enables parking garage operators to leverage hyperlocal information about indoor spaces to improve the customer experience.

Other use cases are possible during Next.

- → **Reactive and proactive vehicle decision-making (V2V or V2N2V).** A car instantly communicating its condition and intent to nearby vehicles provides them with insights undetectable by their onboard sensors, creating a faster response time. This makes for safer reactive, tactical and strategic maneuvering decisions. For example, after an accident at a busy junction, approaching vehicles can be alerted to its existence and precise location.

- → **Intelligent traffic systems (V2I or V2N2I).** Fast two-way communication between vehicles and roadside infrastructure brings safety, efficiency and environmental benefits. Connected traffic signal systems can adapt to traffic conditions in real time, to maximize flow and create 'green waves', alert vehicles approaching a red light too fast, and enable emergency responders to override signaling. 5G MEC also enhances other use cases, where real-time V2I information flows are useful, such as intelligent parking, and real-time alerts on hazards and nearby construction.

- → **Platooning for transport fleets (V2V and V2N).** V2V technology also offers new opportunities for transportation and logistics (T&L) companies to deploy safer vehicles. The use of automated vehicles and robotics is already widespread in controlled environments. The Next phase will also see the virtual coupling of trucks on highways, enabling them to drive closer together, reducing wind resistance, saving fuel and cutting emissions. V2N communication is used to form a platoon, with V2V (and V2N as a backup channel) used for control during travel.

- → **Safety for vulnerable road users (V2P or V2N2P).** The primary goal of V2P communication is to improve the safety of vulnerable road users (VRUs) by providing alerts to the driver of the vehicle and/or the VRU. Significantly less investment has been made in this area of V2X, but the importance of making cities safe for micromobility and pedestrians suggests this will change.

- → **Self-healing maps and swarm intelligence (V2N).** Data is gathered from vehicles in the cloud, with location intelligence helping validate and stitch together the transmitted information. This builds a real-time picture of the road network from each car's experience, before redistributing relevant information to other vehicles that need it. As cars scan and analyze their surroundings, 5G MEC networks enable the rapid collation and re-use of information, an approach that also forms the basis of some of today's self-healing, high-definition maps.

The Long

phase envisions extensive sharing of data on 5G MEC networks, enabling autonomous vehicles to coordinate driving strategies in real time. In this phase, location intelligence becomes indispensable to generating a real-time representation of cities and road networks in motion. It also unites disparate data streams and harnesses machine learning and advanced platform analytics to orchestrate the delivery of the right information to the right people, devices and vehicles at the right time.

Want to talk? We do, too. Get in touch here.

The OEM monetization challenge

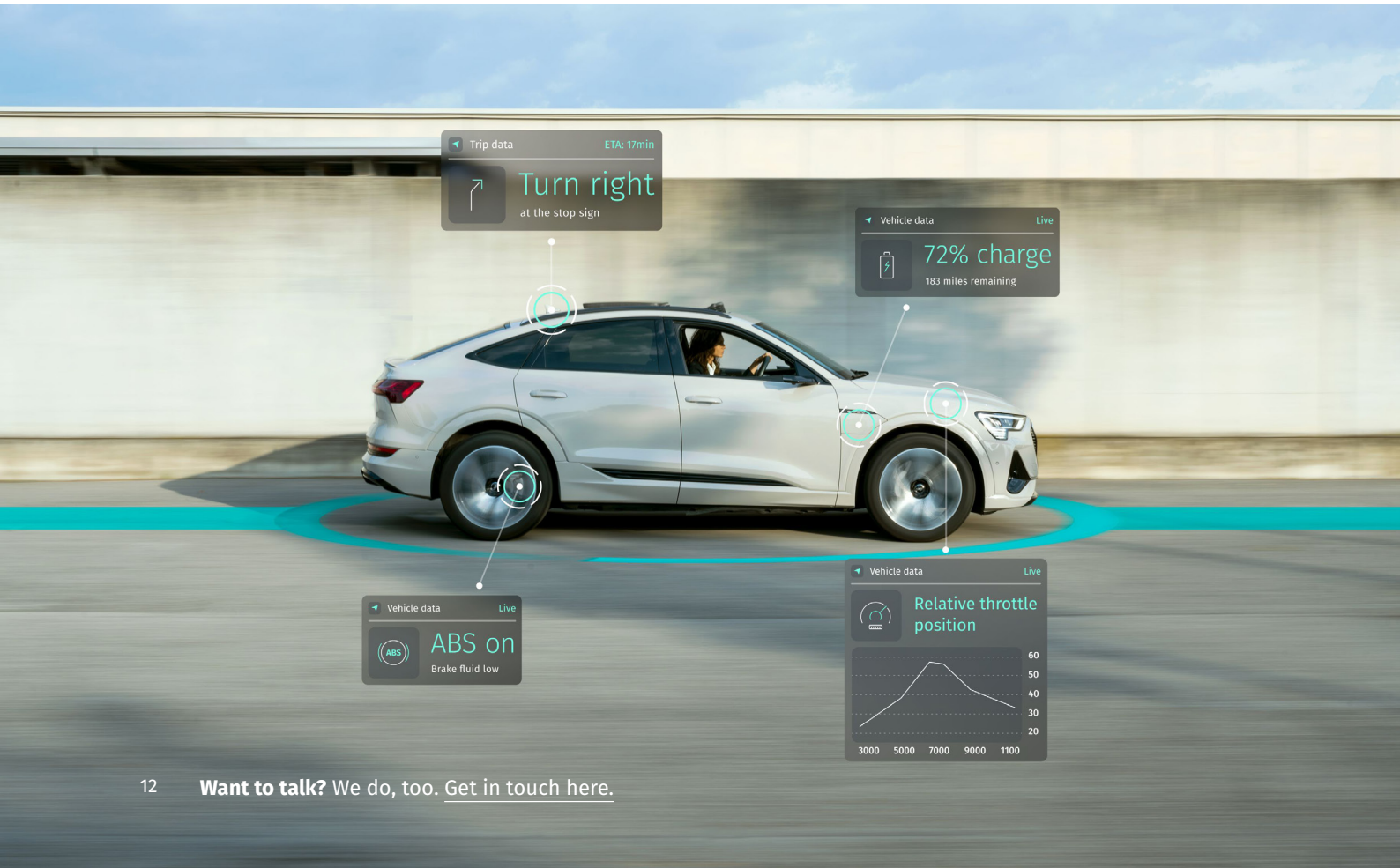
Advances in vehicle automation, connectivity and digitalization will create new monetization opportunities in the automotive industry. ABI Research predicts that the revenue for 5G-enabled sector services could be $5.6bn by 2025.

Automakers will seek to monetize their customers' need for mobility, including through services that boost safety, security and convenience. But taking advantage of 5G MEC raises the average cost of vehicles. Automakers will look at regulations, tax breaks and other government stimuli to help create the market – anticipating that costs will be more than offset by savings from a safer and more efficient transportation infrastructure.

Most automakers have already started to evaluate and demonstrate 5G MEC opportunities. Location intelligence must be part of the equation for any automaker looking to turn innovation into a commercial reality. Only with real-time and geo-referenced data and precise positioning will it be possible for the industry to deliver safer, more enjoyable and more efficient user-centric driving experiences.

Location data privacy in the age of 5G MEC

More than two-thirds of people share their location data with application providers, according to research by McKinsey. We don't just blend into a crowd, though, especially when our location data is part of the equation, because our mobility habits are unique. Our route to work, from door to door, is different from anyone else's and our traces identifiable with only a few location data points. Technologies such as anonymization can protect users' privacy while retaining enough data to be of use to service providers.



Want to talk? We do, too. Get in touch here.

But organizations must get smarter about how they handle data.

Using location context to manage privacy

If people are to enjoy new services in a 5G MEC world, a new approach to managing privacy is needed, and location intelligence has a role to play. Privacy is always about context – and location is an important element in determining this context (alongside parameters such as time of day, day of the week and type of activity). Location drives context in many different scenarios, and contextual thinking can be important in consumers controlling how and when their data is shared and used.

Consider a car journey during the Next or the Long phase. Roadside beacons collect information about the vehicle to monitor traffic data, while an edge-hosted application identifies you as a passenger. The vehicle connects to your digital task list in the cloud, planning a route that is the most efficient path to complete all the errands. Parking garages and tolling systems identify the vehicle and charge your account appropriately. Data is exchanged with other vehicles about road hazards and relevant local street conditions. A single trip like this involves multiple instances of seamless communication with other road users and the infrastructure.

Towards a system of preference management In a world of ultra-fast networks and edge computing, privacy goes beyond consent and is more about preference-based privacy management. We envision empowering a vehicle or a digital personal agent to act on an individual's behalf, drawing on a set of desired privacy settings as well as spatial, temporal and other information (habits, preferred driving routes, parking garages, payment methods, etc). Machine learning will know our consent preferences in different scenarios and places, relieving people of the burden of deciding what data to share.

Want to talk? We do, too. Get in touch here.

The HERE platform: supporting businesses on their 5G MEC journey

Acquiring and working with location data used to be complex and arduous, but the proliferation of location-based sensors are massively increases data collection, while automated processing of this data and new platform technologies are making it more accessible to businesses. HERE has a legacy of acquiring and processing location-based data and extensive industry experience in the development of a cloud-agnostic location data and technology platform. The platform provides a wealth of location data to developers, who can also use the HERE platform to create, build and run their own business applications on 5G MEC infrastructure. The platform is formed of several blocks fully tailored to location intelligence applications.

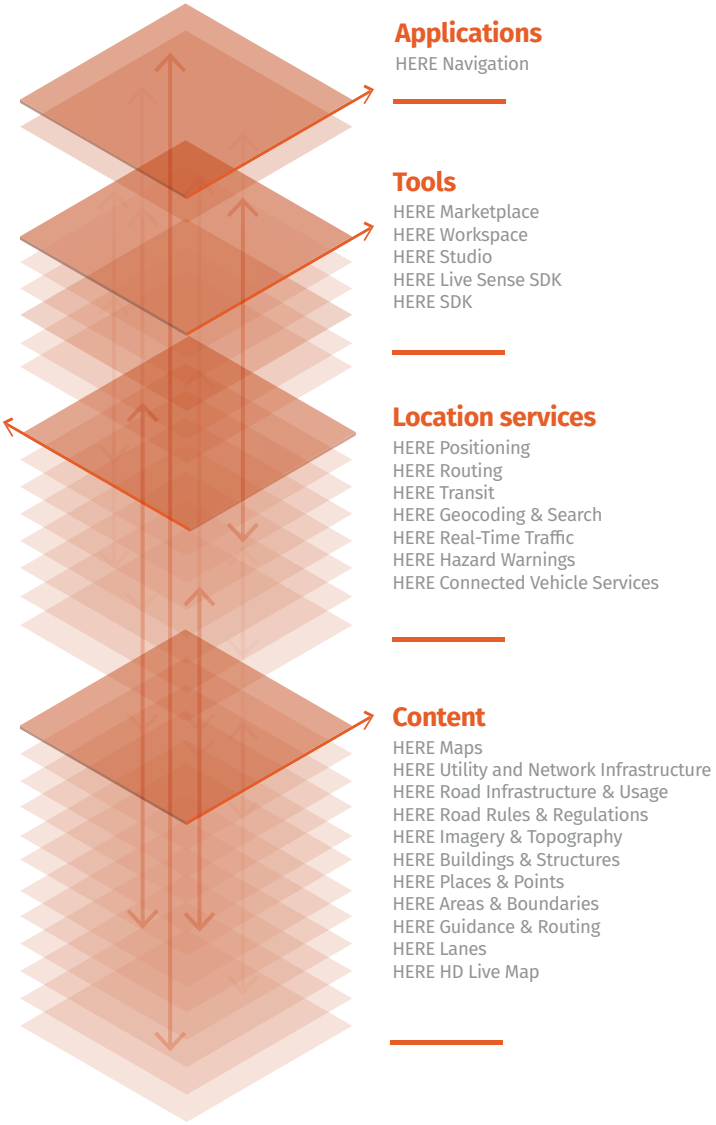
These include:

- → **A development environment** (HERE Workspace)
- → **A data exchange and marketplace** (HERE Marketplace)
- → **Map creation and visualization capabilities** (HERE Studio)
- → **The industry's leading set of location services** (HERE Location Services)
- → **The world's leading global map, with hundreds of attributes** (Content)

These capabilities leverage a Platform Foundation that powers any applications built on top with high availability, security and cloud-agnostic deployment. The HERE platform introduces many essential technological and architectural concepts that are required for services to be run in different computing environments, such as multi-cloud, microservices, containers, security and billing and accounting. Accordingly, the platform will provide the versatility for full, hybrid and on-premises edge deployments.

Data and services available through the platform also enable businesses to exploit the 5G MEC infrastructure in the development and operation of location-enabled use cases (see Figure 10). These include data and services such as HERE Lanes and HERE HD Live Map, designed to support automotive companies building safer and increasingly automated vehicles.

The HERE data universe for 5G MEC planning and location-centric innovation



Want to talk? We do, too. Get in touch here.

HERE is also developing a suite of location privacy services with several components: a set of anonymization solutions that service providers can use to protect their users' privacy while retaining enough data to serve some utility; a privacy diagnostic tool that organizations can use to test how well their anonymized datasets stand up to a reconstruction attack; and blockchain-based consent management technology.

HERE roadmap brings full positioning support for 5G MEC

HERE Positioning (see Figure 11 and 12) presently supports a range of satellite, cellular, non-cellular radio and sensor positioning technologies. We will also incorporate a range of 5G positioning technologies essential for indoor and outdoor use cases. To meet cost, coverage and performance needs, business applications will leverage 5G New Radio, HD GNSS, A-GNSS, Wi-Fi, Bluetooth LE and sensor positioning, as well as visual positioning for additional localization support in certain scenarios and places, such as urban canyons. Our positioning services can be made to run on MEC infrastructure, thereby ensuring that the latency of positioning is optimal for advanced use cases like real-time positioning of IoT devices and vehicles.

The introduction of MEC will also change the way maps of the radio environment – used to help position devices – are maintained. We expect MEC APIs to provide the radio data required for 5G positioning, ending the need for battery-intensive crowdsourcing of such data from devices themselves.

Positioning and localization are also enriched by the HERE Live Sense SDK, a software development kit (SDK) made up of a collection of AI-based perception models that use a forward-facing camera on smartphones, dashcams, personal navigation devices and vehicles to provide drivers with a greater real-time awareness of their environment. By using vision technology, the Live Sense SDK detects different types of objects in the driver's environment.

Besides powering new location-centric use cases, modern network technologies provide another major benefit: they enhance HERE's ability to fully automate the creation, storage and management of geospatial content. 5G and MEC infrastructures are a key part of that effort, supporting rapid feedback loops where changes detected at the edge can be quickly processed and made available for customers and their business applications. The goal is to enable consistent, interoperable map data and location products that meet the most demanding requirements for scale and freshness, setting the stage for further waves of value creation through the platform.

Consumers, enterprises and governments stand to benefit enormously as 5G and MEC capabilities deploy over the next decade. But fully exploiting the transformative potential of these technologies calls for location intelligence.

We have sought to provide insights into how location intelligence supports 5G MEC rollouts, as well as how it directly impacts the automotive industry over the long term. Better smartphone connectivity is just the beginning: 5G MEC networks bring into view a wide array of exciting edge use cases where location data and technology will be an essential ingredient.

To find out how HERE can help your business plan for and thrive in a 5G MEC world, get in touch with us. HERE is a pioneer in location technology. Organizations use our platform to build custom location-based services, create live maps and securely exchange location data. From autonomous transportation and smart logistics to new consumer experiences, we help our customers innovate while safeguarding personal data and privacy.

Find out how spatial intelligence is moving the world forward at here.com.

About HERE Technologies

HERE, a location data and technology platform, moves people, businesses and cities forward by harnessing the power of location. By leveraging our open platform, we empower our customers to achieve better outcomes – from helping a city manage its infrastructure or a business optimize its assets to guiding drivers to their destination safely. To learn more about HERE, including our new generation of cloud-based location platform services, visit **http://360.here.com** and **www.here.com**.