TRANSFORMA INSIGHTS

Ubiquitous Connectivity:
For a Smarter Automotive Future

cubic³ SoftBank

1. A world of ubiquitous connectivity

In today's fast-evolving world, connectivity has become a fundamental enabler of innovation, efficiency and safety across numerous industries. However, despite the rapid advancements in communications technology, vast parts of the globe still suffer from inadequate or non-existent connectivity, particularly in remote regions. This connectivity gap presents significant challenges, particularly for industries such as automotive, agriculture and transportation, where operational efficiency, safety and data-driven decisions depend on seamless communication.

In May 2025 the world's first automotive-grade SIM to integrate terrestrial and non-terrestrial networks (NTN) was showcased at a 5GAA event in Paris. This ability to switch seamlessly between cellular and satellite is a milestone in the journey towards ubiquitous connectivity and will unlock new possibilities for car automakers, drivers, farmers, distributors and other sectors in underserved areas.

For car makers, the ability to offer always-on connectivity is no longer just a competitive advantage; it's becoming a necessity. Vehicles are evolving into complex, interconnected systems where real-time data exchange is critical for vehicle performance, driver safety and user experience. From over-the-air (OTA) software updates to autonomous driving capabilities, continuous, low-latency communication is a backbone of the software-defined vehicle (SDV). The promise of ubiquitous connectivity, delivered by both satellite and cellular technologies, enables car manufacturers to ensure that every vehicle, regardless of location, remains connected to the network, offering benefits like predictive maintenance, safety features and access to real-time traffic data.

Similarly, industries such as agriculture, will derive immense value from reliable, real-time access to data for irrigation control, crop monitoring and machinery operation.

In this report we highlight the importance of ubiquitous connectivity, the technology capabilities required to deliver it, and some of the challenges. In particular, we focus on the automotive sector, and the growing availability of satellite connectivity. But we should note: ubiquitous connectivity is a journey, not a destination, with constantly evolving and improving capabilities reducing the barriers to a hyperconnected world.

2. Demand for ubiquitous connectivity and the benefits it delivers

The demand for ubiquitous connectivity in the automotive and other sectors is growing at an unprecedented rate, fuelled by a combination of technological advancements, shifting consumer expectations and evolving industry trends. As the landscape for software-defined vehicles and other devices continues to transform, connectivity has become a cornerstone of functionality, safety and user experience.

Automotive

Considering the connected software-defined vehicle first, the growth in the number of cellular-enabled cars, trucks, motorcycles and other vehicles is one of the primary drivers behind the heightened demand for seamless, reliable and global connectivity. According to Transforma Insights, there will be a total of 1.4 billion vehicles with embedded connectivity at the end of 2034, up from 463 million in 2024.

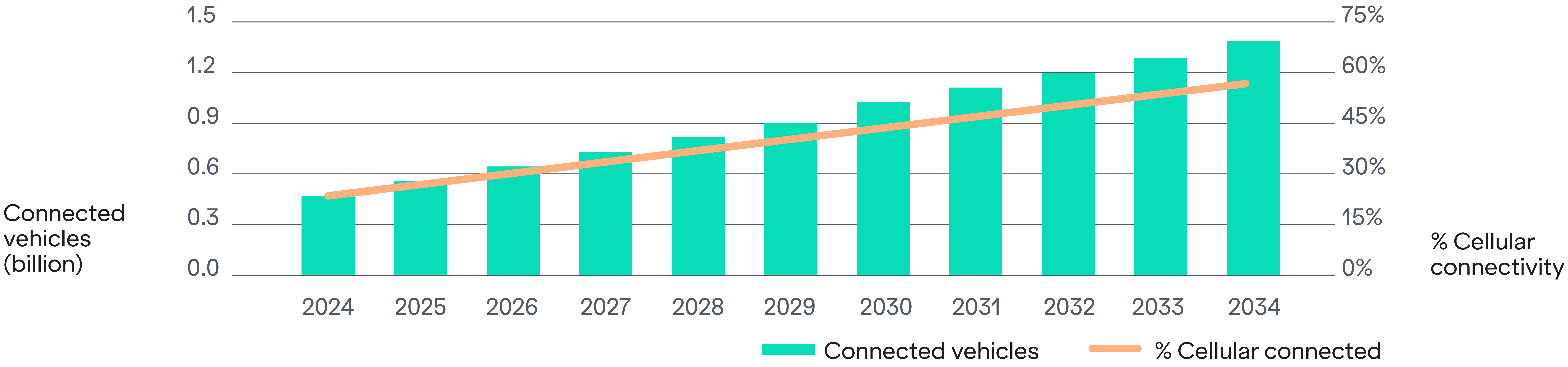

Figure 2: Global vehicles with embedded connectivity [Source: Transforma Insights, 2025].

It is not, however, only the volume of connected vehicles that is increasing, so too is the criticality and complexity of the applications being delivered. Connectivity in vehicles is going from a nice-to-have to being an essential. Today's vehicles rely on connectivity for everything from navigation and infotainment to advanced safety systems like collision avoidance and driver assistance. Connectivity also plays a crucial role in enabling real-time communication between vehicles, infrastructure and cloud-based services, ensuring that cars can share critical data for enhanced performance and safety. With increasing reliance on connected systems, any disruption to connectivity can negatively impact the user experience and the vehicle's ability to operate at full potential.

User demand for connected services

Modern consumers expect their vehicles to provide the same level of connectivity they experience with their smartphones, tablets and other devices. The car has become the 'fourth screen' (after the smartphone, PC and TV). According to a Cubic³ survey of 8,000 consumers and 60 OEM leaders one in four drivers have paid for digital services in their vehicles, rising to 44% of 18-24-year-olds[2]. Connected services such as infotainment, safety assistance packages, navigation, remote locking and remote parking assistance are becoming increasingly ubiquitous on new vehicles. This demand is further amplified by the increasing presence of multiple screens within vehicles, the greater use of services during waits at charging stations and, with the car being increasingly used as a third living space, with the consequent greater demand for connectivity.

Moreover, connectivity has become essential for delivering critical services, such as emergency call systems (eCall) and breakdown assistance, both of which are integral to ensuring safety and compliance with regulatory requirements in many regions.

Opportunity for car makers to expand their service offering

Car makers are witnessing a noteworthy increase in paid subscriber penetration rates which highlights the rising consumer interest in using connected vehicle services. For example, General Motors (GM) had a significant paid customer penetration rate of 26% in 2021; out of 16 million connected vehicle users in North America, 4.2 million were paying for subscription services. GM also expected a more than 1,000% increase in its in-car subscription revenue by the end of 2030, up from USD2 billion in 2021 to USD25 billion in 2030. Stellantis – which owns the Chrysler, Citroen, Fiat, Opel and Peugeot brands, amongst others – had 5 million users of its subscription-based products in 2023, out of a connected car fleet of 13.8 million. The group witnessed software revenue growth of 150% and a monetisable fleet growth of 15% between 2021 and 2024. It expects EUR20 billion (USD22 billion) in software-enabled annual revenues by 2030.

With better margins in software services than in traditional car sales and sustainability initiatives set to lead to a reduction in new cars being bought in the coming years, OEMs are moving away from hardware as a main line of business, towards aftermarket services.

Data analytics drives more efficient practices and better products

In addition to the above-mentioned direct monetisation models, car makers also use vehicle data to improve their business efficiency. Analysing data from millions of vehicles can allow them to provide better understanding of faults or problems to be corrected immediately or in future models, understand how use of each model differs to allow for enhancements to future features and functionality, allow for greater customisation of products and to understand how connected services are being used by drivers to further enhance those.

The growth of EVs

As the automotive industry increasingly embraces electric vehicles (EVs), the need for connectivity grows even further. Range limitations still affect many electric cars and charging stations are still not always easily accessible. Connectivity in electric vehicles allows drivers to easily adapt journeys to their vehicles' needs through the use of navigation services that can direct them to the nearest available charging station or schedule of charging. In addition, it can remind users to charge their stationary vehicle and allow remote activation of air conditioning while the vehicle is plugged in, thereby reducing load on the vehicle's battery.

Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I)

Looking toward the future, the need for ubiquitous connectivity will continue to evolve in line with emerging technologies like vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. These technologies will enable cars to communicate with each other and with road infrastructure, creating a more coordinated and efficient driving environment. This connectivity will also be crucial for autonomous driving, as self-driving cars will need to exchange data with other vehicles, traffic systems and cloud-based platforms in real time to ensure safe navigation. The ability to connect vehicles to each other and their surroundings is a key part of the smart city, and will be essential for reducing accidents, improving traffic flow and enhancing the overall driving experience.

Other sectors

The demand for ubiquitous connectivity is rapidly increasing across industries beyond automotive, driven by the need for seamless communication, data exchange and real-time insights. Sectors such as agriculture, logistics, energy and mining are increasingly relying on both cellular and satellite connectivity to enhance operations, improve efficiency and ensure safety in remote or underserved areas.

In agriculture, for instance, the growing adoption of precision farming techniques demands constant connectivity to control and collect data from various machines, sensors and drones. Farmers require reliable communication networks to monitor soil conditions, track crop health, optimise irrigation and manage fleets of autonomous equipment. Cellular and satellite networks are vital for providing coverage in rural and remote locations where traditional infrastructure is lacking, ensuring that these services remain effective across vast expanses of farmland. The agriculture sector has, out of necessity due to poor cellular coverage, been forced to find alternative approaches to meeting its connectivity needs, involving the deployment of private networks and the use of satellite. Other sectors, such as automotive and transportation, can learn lessons here in terms of making use of alternatives to terrestrial cellular networks.

Similarly, other sectors such as transportation, the need for real-time tracking of shipments, monitoring of vehicle fleets and drivers, and coordination of remote teams has led to a surge in connectivity demand. Satellite connectivity, alongside cellular networks, can help bridge coverage gaps in remote locations such as oceans, deserts, and mountainous regions, facilitating global supply chains, improving efficiency, reducing downtime, and enhancing safety.

3. How is ubiquitous connectivity being delivered

The ability to deliver ubiquitous connectivity for IoT devices is constantly improving as the range of technologies and associated business models evolve. In this section we explore the most important technologies, some of which are already quite mature, others relatively nascent, but almost all continue to be revised and enhanced.

The below illustrations present the plethora of technologies that have arrived recently to help build the path to ubiquitous connectivity (Figure 3-1) and their current status, prognosis and the impact we expect they will have (Figure 3-2).

Figure 3-1: On the road to ubiquitous connectivity [Source: Transforma Insights, 2025]

The technology building blocks delivering ubiquitous connectivity [Source: Transforma Insights, 2025]

Technology	Current status	Future capability	Impact
Cellular networks (4G/5G)	Cellular network coverage of populations is excellent, but coverage of remote areas is often poor. 4G is giving way to 5G. 5G NSA is widely deployed delivering high bandwidth services. Limited deployment of 5G SA.	Mass deployment of 5G SA will happen over the next 2-3 years. This will enable richer functionality, most notably network slicing. At the same time, we will see the development of associated ecosystems (e.g. for common slicing approaches between MNOs) and commercial models. Further enhancements are inevitable with 6G.	Strong potential for delivering a very rich set of functionality that will be able to deliver dramatic enhancements to IoT offerings.
Satellite connectivity	Relatively mature early phase for connecting high value assets is giving way to the early stages of a more significant uptake. Direct-to-device services for handset messaging are increasingly well proven. NTN-IoT is available but relatively immature today.	NTN-IoT is only 1-2 years off full maturity, making for more cost-effective and simplified deployments. NTN-NR is probably 3 years from becoming truly available. The deployments continue of LEO constellations. Commercial models are becoming increasingly mature.	Satellite connectivity for IoT devices will grow rapidly, particularly in 'hybrid' use cases involving both cellular and satellite, as envisaged in ubiquitous connectivity.

Technology	Current status	Future capability	Impact
eSIM and remote SIM provisioning	The first variants of RSP (SGP.02 and SGP.22) are somewhat mature, offering a limited additional option alongside traditional roaming and multi-IMSI SIMs.	The most capable RSP standard, (SGP.32) will be commercially available around the end of 2025. This will trigger new business models for connectivity providers focusing on managing eSIM profiles.	SGP.32 particularly promises to simplify the process of managing connectivity localisation.
Edge computing	Edge computing will be necessary for high function IoT deployments, particularly those involving AI. But to date deployments have only scratched the surface of those requirements.	Dramatic increase in the amount of processing located on (or close to) the edge device. Need for orchestration of edge and cloud resources and model management.	Significant impact as a support function for AI, particularly for the use of AI in remote assets, such as cars.

Technology	Current status	Future capability	Impact
AI	We're now moving beyond the early stages of exploration and POCs with increasingly proven AI capability available in areas such as video analytics, autonomous driving and agentic-powered decisioning and process automation.	The sky is the limit in terms of the evolution of the functionality which is likely only constrained by the availability of processing and inertia in adoption.	Potentially highly transformational through the facilitation of a broad array of intelligent automation functions. Greater use of AI in IoT e.g. connected vehicles and smart network management, necessitates much more edge computing.
Software stack	Relatively mature set of platform functionality that has dramatically reduced the cost and complexity of deploying IoT.	Continued refinement of features and functionality aimed at streamlining multi-carrier, multi-country and eSIM-based connectivity, plus greater integration for simplification of troubleshooting.	Most of the impact has already been felt, but with continued refinements.

Figure 3-2: The technology building blocks delivering ubiquitous connectivity [Source: Transforma Insights, 2025]

5G

Mobile networks have evolved significantly in recent years. 5G arrived in 2019 and has been subsequently enhanced with capabilities for supporting IoT applications. 6G will arrive some time in the early 2030s.

A key element of the technology upgrade path for 5G, is the move from 5G Non-Standalone (5G NSA) to 5G Standalone (5G SA). The former makes use of existing legacy 4G core networks, while the latter involves an upgrade to a 5G core, allowing the provision of improvements to underlying capabilities as well as new features. As of the end of March 2025, 349 mobile network operators around the world (i.e. most global operators) had deployed commercial 5G services. At that date, however, just 72 had deployed 5G SA, although we expect quite rapid growth in that figure in the coming three years. The 5G functionality available in most countries today is only a limited version of what will be available in just a few years.

The line-up of capabilities enabled by 5G include:

- Enhanced Mobile Broadband (eMBB) – 5G provides significantly higher data speeds, reaching 1-2 Gbit/s for 5G NSA and up to 20Gbit/s with 5G SA. Capabilities such as this are valuable for downloading large amounts of data, e.g. for firmware updates, or for internet services.
- Ultra-Reliable Low-Latency Communications (URLLC) – Delivers high reliability and minimal latency, as might be used in 'real-time' use cases such as augmented reality and autonomous vehicles.
- Massive Machine Type Communications (mMTC) – Supporting battery-powered and low-cost devices, through technologies LTE-M, NB-IoT and 5G enhanced RedCap (eRedCap).

- Non-Public Networks – Private mobile networks are being deployed for dedicated use at specific sites, such as manufacturing plants or warehouses, offering increased control and security.
- Non-terrestrial networks (NTN) – The inclusion of support for satellite connectivity to 5G devices, as discussed in detail in the next section.
- Network Slicing – Network slicing enables delivery of dedicated capacity for specific functions, industries or user groups, allowing features such as 'Quality-on-Demand'.
- Network Exposure Function (NEF) and APIs – NEF introduces a programmable interface that exposes network capabilities through secure APIs, allowing enterprises to build their own use cases on the back of the functionality delivered by 5G SA.
- Cellular Vehicle-to-Everything (V2X) – Allows vehicles to communicate directly with other vehicles or infrastructure, allowing them to be much more responsive to their environment and supporting autonomous driving.

This combination of these technology functions provides a very rich set of additional features that could be delivered to end users. However, we should note that there is a time lag associated with most of them. While eMBB is relatively mature, 5G SA deployments today are patchy, and furthermore companies are really only just exploring what the network slicing and NEF capabilities can provide. The potential of such technologies to add a further layer to the ubiquitous connectivity functionality is significant.

Satellite connectivity

Cellular networks face limitations when used to connect devices globally. Coverage is largely restricted to populated areas, leaving remote and rural regions underserved. Furthermore, infrastructure requirements, such as cell towers and maintenance, make expansion costly and slow.

In contrast, satellite connectivity offers global coverage (albeit with limitations on indoor coverage) with more consistency of deployment. Satellite has been used to connect remote assets for decades, but historically with very high costs. In recent years those costs have come down quite significantly. The arrival of NTN also promises to further reduce the cost and complexity of using satellite.

The satellite connectivity landscape is discussed in more detail in Section 4.

eSIM and remote SIM provisioning

The mechanisms for delivering cellular connectivity across multiple countries have become much more sophisticated in recent years. Historically it was achieved via roaming. Some providers additionally adopted a multi-IMSI approach, with multiple SIM profiles on a single SIM card. Most recently these approaches are giving way to the use of eSIM and Remote SIM Provisioning (RSP). The combination of eSIM/RSP involves changing the SIM profiles over-the-air to localise onto an appropriate national network (or satellite NTN network), effectively re-homing the connection to a local network. To support RSP, the GSM Association (GSMA) has established a series of standards, the latest of which, SGP.32, will become commercially available late in 2025 and promises to dramatically simplify the process of localising a SIM to a domestic network. The big advantages of this approach are that it ensures compliance with national rules about SIM registration, reduces the latency of connectivity and generally reduces cost and complexity.

Edge computing

In recent years there has been a pronounced trend towards edge computing, which makes processing and storage resources available in close proximity to edge devices or sensors, complementing centralised cloud resources. This results in a number of benefits that can be very relevant in an enterprise context, including near real-time responsiveness, improved reliability, better security, regulatory compliance and reduced operating costs.

Edge computing is crucial for connected cars because it enables real-time data processing closer to the vehicle, reducing latency and enhancing performance of applications like autonomous driving, safety features and navigation. It also alleviates network congestion by reducing the volume of data sent to the cloud, optimising bandwidth usage. Additionally, edge computing supports mission-critical applications, such as real-time traffic updates and vehicle diagnostics, ensuring reliable and efficient operation even in remote areas with limited connectivity. This enhances the overall driving experience and safety.

AI

The main driver for edge computing is the ability to run AI inferencing closer to the source of the data. With edge computing processing data locally, AI can quickly analyse vehicle sensor data, such as camera feeds, radar and LiDAR, to support applications like autonomous driving, collision avoidance and driver assistance. AI can also optimise vehicle performance by analysing data related to driving behaviour, engine health and road conditions in the moment.

The integration of AI into various technology environments is attracting considerable attention, with a notable focus on its application within Internet of Things (IoT) devices. Embedding AI directly into IoT hardware can enhance device functionality and support the development of value-added services. As a result, many organisations are incorporating AI capabilities into their device portfolios. This trend is expected to accelerate, influencing product development, system architecture and market dynamics, and driving the requirement for ubiquitous connectivity.

As AI becomes more embedded in IoT systems, the orchestration of computing workloads and data storage across device, edge and cloud environments becomes increasingly important. Effective orchestration ensures optimal use of distributed compute resources and supports dynamic data management, especially for latency-sensitive applications. Coordinating the flow and processing of data across these layers is essential for achieving efficient and scalable AI deployment.

There is also a further expectation that AI will increasingly be integrated into the network itself to support a more seamless experience for ubiquitous connectivity, with AI powered traffic routing and workload distribution helping to optimise end user experience. This is likely to be one of the key functions within 6G.

A more capable software stack

A major component of the IoT ecosystem has been the development of middleware platforms, which streamline key functions such as device management, connectivity management and application enablement. The adoption of these software tools is standard practice due to their ability to simplify the deployment and operation of IoT solutions.

The increasing capabilities of these platforms, particularly in terms of managing connections across multiple operators, significantly reduces the complexity of managing a global fleet of vehicles enabled by ubiquitous connectivity.

4. Satellite connectivity developments and market landscape

Terrestrial cellular networks are insufficient for providing the universal coverage needed to realise ubiquitous connectivity, due to their reliance on land-based infrastructure, which is limited to populated areas.

Today, cellular networks only cover approximately 20% of the earth's surface in total, and around one-third of land. While this addresses the needs of 95% of the world's population for mobile services, many connected IoT devices are permanently remote, for instance in agriculture or forestry, or temporarily so, such as vehicles. This is not to say that satellite offers anything like a ready-made alternative to cellular networks, but it does offer a strong complement. In the context of ubiquitous connectivity, a combination of satellite and cellular will be required.

> "At SoftBank, our fundamental concept is to combine terrestrial cellular networks, HAPS and satellites to provide communication anytime, anywhere. We refer to this vision as a 'ubiquitous network.' Instead of choosing between LEO or GEO, we believe in a combination. With customer needs varying depending on region, performance and cost, our flexible model always supports them.
>
> **Takenori Kobayashi**
> Vice President and Head of Product Technology Division, SoftBank Corp.

The use of satellites to connect IoT devices has been established for some time, primarily supporting the tracking of high-value assets in remote locations, without terrestrial cellular coverage. However recent developments, particularly through the deployment of constellations of LEO satellites and the availability of 3GPP-based non-terrestrial networks, are expanding the potential role of satellite connectivity across a broader range of IoT use cases.

In this section we explore the technology and capabilities of satellite technology for connecting cars and other IoT devices.

The satellite connectivity landscape

Satellite connectivity is delivered using a range of different types of satellites, frequency bands and connectivity protocols, all of which have different characteristics making them optimised for different use cases.

GEOs, LEOs and MEOs

There are three types of communication satellites: GEO (Geostationary Orbit), LEO (Low Earth Orbit) and MEO (Medium Earth Orbit), of which GEOs and LEOs are the most commonly used for connectivity.

GEOs orbit at 35,786km and remain fixed over the equator. They provide excellent coverage and the user equipment is generally simpler as it is always pointing at a fixed point in the sky. The downsides are that their distance leads to high latency (100-300ms) and consequently less optimal performance for real-time communication. They are also less ideal for devices at higher latitudes.

LEOs operate between 160km and 2,000km, offering lower latency (~20ms) and high data rates. They require hundreds of small satellites to provide continuous coverage, or with smaller constellations the device will need to wait for a satellite to pass overhead in order to send or receive data, with an associated increase in latency. LEO constellations are more complex to manage, requiring more ground stations and more advanced user equipment due to their movement through the sky.

LEOs are more cost-effective to deploy and more suitable for broadband services (for instance from companies such as Eutelsat OneWeb and SpaceX), while GEO and MEO satellites support simpler tracking and less complex user equipment. Many satellite companies use a combination of LEO and GEO to optimise coverage. For customers, requirements will vary depending on the use case but generally speaking a combination of all of them are required for ubiquitous connectivity.

Frequency bands

Satellite communications use several frequency bands, some allocated globally for satellite (so-called mobile satellite service, or MSS, spectrum), others ‘borrowed’ from mobile network operators, and in a few cases the spectrum is license-exempt. MSS spectrum holds an advantage that it is consistently available, is licensed and therefore only to be used by the spectrum owner and is not subject to reliance on a third party.

Low frequency L-band (1-2GHz) is commonly used for narrowband IoT applications like asset tracking and telemetry, offering reliable connectivity with relatively lower data rates. This is used by narrowband IoT-focused satellite providers such as Globalstar and Iridium. Ku-band (12-18GHz) and Ka-band (27-40GHz) are used for higher-bandwidth applications and is used by satellite providers focused on providing broadband services, such as SpaceX and Eutelsat OneWeb (which is now owned by Eutelsat). Some support both, such as Viasat. NTN makes use predominantly of frequency in the L-band and S-band in early releases, with Ku and Ka bands subsequently added.

Connectivity protocols

Satellite communications use a range of different communications protocols. Many constellations, including Globalstar, Iridium, Myriota and Starlink, rely on proprietary technologies. However, there has been an increased and pronounced shift in recent years towards making use of standards-based cellular technologies, most prominently 3GPP non-terrestrial network technology, for instance by OQ Technology, Sateliot, Skylo and Viasat. Proprietary technologies tend to be more spectrally efficient, making the connectivity cheaper and also less power hungry. The downside is that they are tied to a specific provider, and often they will lack the scale of the standards, with notably fewer hardware makers and other vendors supporting. The strength of the standards-based approach is the interoperability and interchangeability between different vendors' hardware and networks. Specifically in the case of NTN there is also the advantage that the integration with terrestrial networks is significantly better – most notably benefiting devices requiring both terrestrial and satellite connectivity – and the cost to add satellite to the relevant cellular technologies (NB-IoT or 5G NR) is much reduced.

Satellite protocols are typically optimised for either connecting higher data rate services ('IP-based'), such as the broadband connections addressed by Starlink or connecting vehicles, or low bandwidth, non-real-time communication ('messaging'). The optimum, of course, depends on what services need to be delivered, but with the added development that the 3GPP technologies now introduce, in terms of potentially delivering both narrowband and broadband services to existing cellular terminal equipment, for instance to support high data rate services for connected car via a 5G NR connection.

The arrival of 3GPP NTN and implications for connected car services

In 2017 3GPP, the standards body for mobile communications, started to examine the potential for integrating satellites into 5G. Non-terrestrial network functionality was introduced first in Release 17 of the cellular standards, in 2022. There are two versions: IoT over NTN (NTN-IoT), which is effectively extending NB-IoT narrowband connectivity, and 5G NR over NTN (NTN-NR), which does the same for 5G New Radio (i.e. broadband 5G over satellite). With this functionality, the existing baseband connectivity chipset for terrestrial cellular will also be able to send and receive via satellites, albeit with some diminution in functionality, poor in-building coverage and an increase in connectivity cost, relative to the terrestrial counterpart technology. Subsequent 3GPP releases will include significant enhancements to NTN.

With the ongoing developments, NTN supports all orbit types (LEO, MEO and GEO) as well as high altitude platform stations (HAPS), which involve aircraft flying in the stratosphere.

The first NB-IoT service was launched over satellite in June 2021 by Skylo in collaboration with Inmarsat. Several others have followed, including OQ Technology and Sateliot. The broadband equivalent, NTN-NR, is perhaps a further three years from commercial availability, meaning that a need for broadband connectivity will need to be met through one of the other alternatives for the time being. There has been a notable shift from many satellite providers towards focusing attention away from proprietary technologies and towards 3GPP.

The later iterations of the 3GPP standard, including the forthcoming Release 19, introduce several developments in satellite communications that carry significant implications for car manufacturers aiming to enhance vehicle connectivity and operational resilience. The inclusion of regenerative payload support allows satellites to process data onboard, reducing latency and dependence on ground stations. This benefits applications such as real-time vehicle diagnostics, dynamic traffic updates and critical safety communications in remote areas.

Support for GNSS-independent location services is also crucial, as it enables more reliable positioning in environments where traditional satellite navigation signals may be weak or blocked, such as urban canyons, tunnels or mountainous terrain. This enhances continuity for location-based services, including emergency response and route optimisation.

Improvements in uplink performance and broader service coverage in higher frequency bands expand the range of use cases vehicles can support, such as high-throughput over-the-air software and map updates, or vehicle-to-cloud data exchange. Enhanced multicast and broadcast capabilities facilitate efficient delivery of common content across many vehicles, reducing network load and improving update distribution.

The winning combination of NTN satellite with cellular

Together, these developments position satellite-based NTN as a complementary connectivity option to terrestrial 5G, enabling car makers to design vehicles with more robust, globally available communication features that support advanced automation, predictive maintenance and improved customer experience, regardless of location.

Integrating 3GPP non-terrestrial networks with terrestrial 5G, as envisaged in a world of ubiquitous connectivity, enhances vehicle connectivity by enabling seamless coverage, especially in remote or rural areas. This extended reach supports more reliable over-the-air software updates, real-time telematics and continuous vehicle tracking. Enhanced service continuity ensures navigation and emergency systems remain operational outside urban environments. The satellite element also improves resilience and redundancy in data transmission, contributing to safer autonomous driving and better predictive maintenance.

As a result, car makers can deliver a broader range of connected services with greater reliability, ultimately improving user experience, operational efficiency and safety across varied geographies.

Cubic³ and its partners' approach to delivering ubiquitous connectivity

Leveraging 3GPP standards-based solutions, as described in the prior sections, Cubic³ is focused on seamlessly aggregating NTNs and cellular connectivity to provide ubiquitous coverage all managed through one platform.

The 5GAA has an aggressive roadmap for adding new and innovative capabilities aimed at addressing key connected car services such as safety and infotainment, vertical requirements such as in intelligent transportation systems or Fleet Management, as well as critical underlying systems such as V2V and V2I, or cybersecurity. NTN is a key part of that roadmap.

For automakers, these partnerships will accelerate connected vehicle innovation while also enhancing safety, efficiency and user experience across the industry.

A series of announcements in May from Cubic³, under the auspices of the 5GAA, emphasise the significant strides being made. In a major industry milestone, Skylo and Cubic³ introduced the world's first unified automotive-grade eSIM that supports both terrestrial and satellite connectivity. This 3GPP Rel-17 compliant solution will eliminate the need to support multiple networks or hardware upgrades.

Meanwhile, Intelsat and Cubic³ successfully demonstrated the integration between Intelsat's FlexMove fleet product and Cubic³ Cloud, showcasing how terrestrial and non-terrestrial networks can seamlessly link to deliver always-on connectivity regardless of location. This builds on an extensive collaboration agreement signed in 2024 between Intelsat and SoftBank Corp.

Key partners of Cubic³ include the leading satellite operators Intelsat, Skylo and Viasat, which collectively address the range of satellite connectivity required to realise the ubiquitous connectivity vision.

5GAA NTN use case roadmap proposal for mass deployment GEO/LEO (Source: 5GAA)

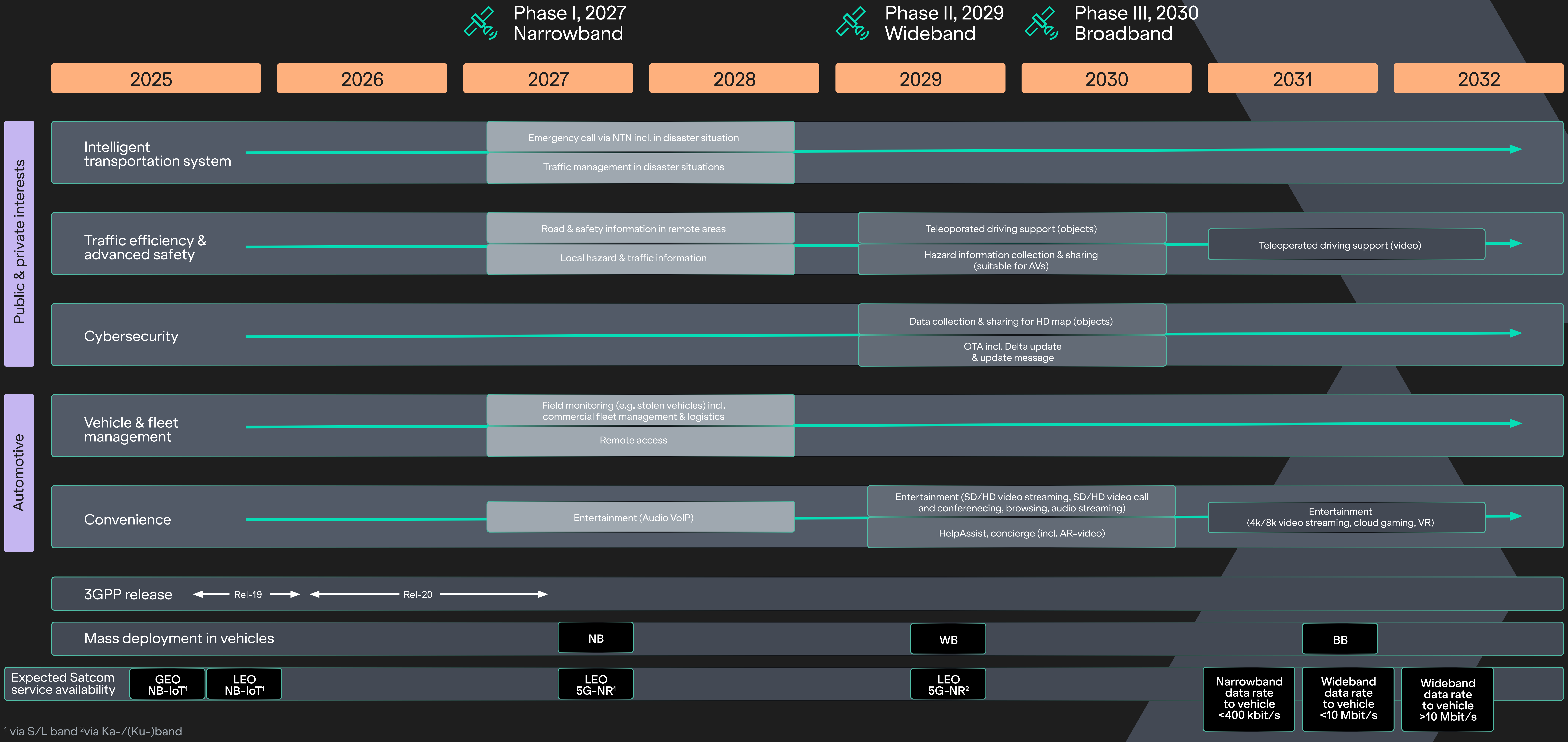

Figure 4: 5GAA NTN use case roadmap proposal for mass deployment GEO/LEO (Source: 5GAA)

INTELSAT

Next-gen automotive experiences including high-definition streaming and autonomous driving

Intelsat's use of the Ku-band spectrum, which is already used to support broadband use cases globally, provides many advantages. It is defined across all regions so devices operating on this band can rely on consistent access to the same spectrum anywhere in the world and Ku operates across more than 3GHz of spectrum so in addition to global coverage, broadband throughput and applications are easily supported and services are not limited to text and voice.

One key application is teleoperated driving, where high-bandwidth, low-latency video transmission is crucial for remote vehicle control. This will allow for safer deployment of autonomous and semi-autonomous vehicles, especially in environments where full autonomy is not yet feasible and human intervention is required.

Cubic³'s partnership with Intelsat to provide broadband NTN will also enable advanced in-vehicle entertainment systems, Car passengers will be able to enjoy ultra-high-definition (4K/8K) video streaming, immersive cloud gaming and virtual reality (VR) experiences, even in remote or rural areas where terrestrial networks are weak or unavailable. For OEMs this will enable them to transform cars into connected digital spaces and ensure they meet consumer expectations for seamless, high-quality digital experiences on the move.

> The Intelsat-Cubic³ collaboration addresses a critical gap in today's increasingly connected world. Despite advances in autonomous mobility for automobiles, ships, drones and other vehicles, many areas remain without ground-based mobile network coverage, requiring separate devices and accounts to connect to satellite networks.
>
> The Intelsat-Cubic³-SoftBank partnership aims to eliminate this fragmentation by blending Intelsat's global multi-orbit 5G NTN solutions with Cubic³'s portfolio of connectivity solutions.
>
> **Bruno Fromont**
> Chief Technology Officer, Intelsat

skylo

Supporting advancing automotive industry safety and efficiency

Cubic³'s partnership with Skylo brings together our advanced connectivity solutions and geographical footprint with Skylo's satellite network, to enable greater vehicle safety, efficiency and user experience.

A key application is emergency services. Narrowband NTN makes bidirectional emergency messaging possible. Vehicles will be able to send emergency alerts, vehicle status messages and real-time updates over the Skylo network when out of cellular coverage. Skylo's collaboration with 5GAA member Fraunhofer outlines exciting areas of future development using advanced voice codecs to enable voice calls and messages from consumer devices and vehicles over the Skylo network.

This partnership also delivers more resilient traffic management, especially when terrestrial networks may be damaged or overloaded while the ability to deliver local hazard and traffic information to the vehicle means drivers can make better decisions in difficult circumstances.

> Skylo's partnership with Cubic³ is a key enabler for OEMs to seamlessly bridge satellite and cellular networks for remote vehicle monitoring and control, emergency messaging and roadside assistance in a cost-efficient way, with service that's live and available today.
>
> **Parthsarathi Trivedi**
> Co-Founder and CEO, Skylo

Viasat

Enhancing user experiences and vehicle functionality

Working with Viasat, Cubic³ is focused on how NTN connectivity can deliver increased information gathering and sharing for OEMs. This capability will initially allow vehicles to notify recovery services in the event of a breakdown or accident, manage hazards by communicating real-time safety alerts, allow for remote access in the event of lost keys and will even allow voice calls.

As wideband satellite connectivity develops overtime, high-definition (HD) map data collection and sharing is expected to emerge. This ability to provide vehicles with the most accurate and current information, will ensure autonomous driving and advanced driver-assistance systems (ADAS) are future-proofed regardless of where the vehicle is in the world.

The in-car experience will also be enhanced. Being able to streamline over-the-air updates through satellite networks will mean fewer dealership visits as software improvements and new features can be delivered to cars globally, regardless of location. Entertainment services like audio and standard-definition video streaming will be enhanced while assistive services like augmented reality (AR) video can deliver personalised support and navigation, elevating convenience and safety.

> 3GPP Release 17+ enabled NTN services are set to shape a new world of experiences for the driver in the coming years. Beginning with the ability to access emergency notifications, traffic management and remote vehicle access, anywhere, narrowband connectivity will eventually enable voice calls through the car's TCU. There are even more significant changes to come with entertainment, over the air updates and data collection and sharing for HD map, earmarked for development over wideband services.
>
> **Tim Daly**
> Vice-President Business Enablement, Viasat

5. The benefits of ubiquitous connectivity

The evolution of vehicle connectivity has moved in clear stages, from unconnected, standalone machines to connected platforms, and now toward a future of ubiquitous connectivity. Each step has expanded the scope of what vehicles can do, transforming them from isolated systems into intelligent, data-driven platforms that improve performance, enhance user experiences and support entirely new business models.

The introduction of basic cellular connectivity enabled a host of core services such as over-the-air software updates, remote diagnostics, real-time navigation and infotainment enhancements. These connected features allowed manufacturers to improve vehicles post-sale, reduce service visits and extend product lifespans. At the same time, they gave car makers access to real-world performance data, enabling predictive maintenance, design refinement and better understanding of driver behaviour.

However, as connectivity becomes essential to nearly every aspect of vehicle operation, the limitations of terrestrial networks become more apparent, especially in rural, remote, or cross-border contexts. The next major step is the shift to ubiquitous connectivity, enabled by the combination of terrestrial cellular and satellite networks. This integrated model ensures that vehicles maintain a reliable, high-quality connection regardless of location.

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> Customers expect not only the device and SIM, but also the overall experience — including billing and traffic management — to meet their expectations. In that sense, we believe Cubic³'s platform, Cubic³ Cloud, plays a central role. Combining our cellular technology, NTN expertise and Cubic³'s platform, we aim to deliver a unified, high-quality experience to our customers.
>
> **Takenori Kobayashi**
> Vice President and Head of Product Technology Division, SoftBank Corp.

With this advancement, new services become viable. OTA updates can now be delivered without interruption, even in regions with limited cellular coverage. Telemetry data becomes truly continuous, improving the accuracy of predictive maintenance and fleet management. Safety features such as eCall become more universally available. Real-time services such as live traffic-aware navigation, voice communications, usage-based insurance and vehicle tracking are no longer constrained by network availability.

For commercial fleets, the benefits are even more pronounced. Enhanced connectivity allows for better route optimisation, remote diagnostics, driver performance monitoring and fuel or energy management, all of which reduce operational costs and increase uptime. For electric vehicles, ubiquitous connectivity supports smart charging, battery health monitoring and integration with energy infrastructure.

In a ubiquitous connectivity environment, personalisation and user engagement also reach new levels. Vehicles can deliver tailored services and content based on user preferences and location, remembered across journeys and geographies. Voice interfaces, dynamic media and real-time commerce can be consistently supported.

Organisations adjacent to car makers can also benefit. Insurers can offer more accurate, behaviour-based policies. Cities can use aggregated vehicle data for traffic and infrastructure planning. Advertisers and content providers can target in-vehicle audiences with location-aware offerings. And beyond the car market, many other sectors gain value from this evolution, including agriculture, transportation and energy.

Ultimately, ubiquitous connectivity is more than an extension of existing services. It is a foundational enabler of the next phase of automotive innovation. It underpins the shift to software-defined vehicles, supports evolving business models and ensures that as the industry advances toward electrification, automation and shared mobility, the digital connection between vehicle, driver and ecosystem remains uninterrupted.

6. Challenges of ubiquitous connectivity for automakers

In previous sections we identified the value of ubiquitous connectivity in building an enhanced user experience, new revenue opportunities, increased safety and other features. In this section we explore some of the challenges.

Availability of 5G networks and roaming

The most obvious challenge is establishing and maintaining reliable network infrastructure to support global connectivity. While many regions have robust 4G and 5G networks, rural, remote and mountainous areas still suffer from limited or no coverage, especially in developing countries. Furthermore, network coverage may vary by country or even by city, making it difficult to ensure continuous connectivity for vehicles traveling across borders or through areas with sparse infrastructure. Today, around one-half of the world's population is covered with 5G, while over 90% have access to 4G/LTE. As noted in Section 3, only a relatively small proportion of MNOs have launched 5G SA, which limits their capacity to deliver the most advanced services.

Beyond the availability of networks, there is also a requirement to establish roaming for the more advanced 5G SA capabilities described in Section 3, which is very limited today. Each mobile network will support 5G SA in a slightly different way, necessitating a mechanism for ensuring consistency, for instance for a common network slice supported globally.

Availability of satellite constellations/ technology

Much of the satellite functionality described in this report relates to NTN deployments, and in the context of ubiquitous connectivity there is a definite benefit to using a technology that is common across both the terrestrial and non-terrestrial elements. However, we do not yet have a mature set of satellite networks deployed to support. Currently NTN-IoT is available in a limited way, and predominantly via GEO satellites. A full deployment of NTN-NR is approximately three years away.

Seamlessness

Another challenge is ensuring interoperability between different telecommunications providers, network types, platforms and standards across various regions. The requirement to support global deployments necessitates the use of multiple cellular networks and probably more than one satellite network, each with their own platforms and operated by different companies. Cars that require connectivity must be able to seamlessly switch between cellular networks (both 4G and 5G) or other forms of communication (e.g. Wi-Fi or satellite) without disrupting services. This requires a robust roaming agreement infrastructure, as well as eSIM management, which can be complex and costly to implement globally. With such a complex landscape it will be challenging to ensure a seamless user experience.

Cost

As a side-function of the relative complexity of deployments spanning multiple operators and technologies, there are also potentially additional costs associated with supporting ubiquitous connectivity. Satellite connectivity is inherently more expensive, so any proposition will need to allow for that. Furthermore, managing connectivity across multiple providers requires an agile approach to managing partner networks.

Reliability

Ubiquitous connectivity must ensure a consistent, high-quality user experience for both drivers and passengers, particularly for critical functions like navigation, safety features and remote diagnostics. Connectivity disruptions, such as slow speeds, dropped connections or insufficient bandwidth, can negatively affect the vehicle's performance and the overall user experience. Achieving this level of reliability across diverse environments—urban areas, rural regions, highways and remote locations—poses a significant technical challenge.

Adaptability

Supporting the same applications over satellite and cellular networks for vehicles presents several challenges due to differences in network performance, reliability and cost. Cellular networks typically offer lower latency and higher bandwidth, making them ideal for real-time applications like navigation and telematics, whereas satellite networks, especially GEOs, have higher latency and lower bandwidth, which can affect performance for data-heavy tasks. Additionally, satellite connections are more susceptible to disruptions, such as weather interference, while cellular networks excel in urban areas but may be lacking in remote regions.

Adapting applications to perform seamlessly across both network types requires handling data buffering, adaptive quality (e.g. for video streaming) and smooth failover between networks. Security protocols must be robust across both, with attention to encryption and threat detection. Power consumption is another concern, as satellite communication typically demands more energy than cellular, impacting vehicle battery life, particularly in electric vehicles.

Ultimately, the challenge lies in creating intelligent applications that can be optimised to reflect the deployment parameters such as connectivity, power consumption, security and costs, all while providing consistent and reliable service regardless of the network type.

Compliance

Regulatory compliance has long been a component of IoT, particularly in relation to device certification and product safety. However, as IoT is increasingly deployed in critical infrastructure and sensitive environments, and governments focus more attention on the issue, the scope and complexity of regulatory requirements are growing. This shift underscores the importance of making compliance a core element of any IoT strategy, rather than treating it as a secondary consideration.

Different countries have distinct regulatory requirements for telecommunications, data protection, safety and vehicle standards.

For example, there are many different rules related to permanent roaming or eSIM localisation for cellular connectivity, with many countries, such as Brazil and Turkey, having rules explicitly prohibiting it. Similarly, know-your-customer (KYC) rules for registration of SIM cards are variously required for connected car deployments in different markets. There are also many different vertical-specific regulations, for instance, European regulations such as the EU's eCall system for emergency response, which might require specific hardware or software integrations that differ from standards in the U.S. or Asia.

Recent years have brought significant regulatory developments with additional regulation such as the EU's Data Act and Cyber Resilience Act, the UK's Product Security and Telecommunications Infrastructure (PSTI) Act and various US initiatives.

Privacy and security

Security remains one of the primary challenges in deploying IoT systems. The more connected a vehicle is, the greater the risk of cyberattacks and data breaches. A globally connected vehicle that is continuously transmitting data poses significant cybersecurity risks, such as unauthorised access to sensitive vehicle systems, tracking of user locations or theft of personal information. Securing communication channels and ensuring the integrity of the data being transmitted is a substantial technical challenge. Additionally, regulations surrounding data privacy, such as the European Union's General Data Protection Regulation (GDPR), impose strict rules on data storage and usage, creating the need for robust encryption, data anonymisation and compliance mechanisms that are consistent worldwide. To address these risks, a Secure-by-Design approach is recommended. This involves considering security at every stage of development and deployment, ensuring that protections are integrated into the entire IoT ecosystem.

7. Conclusions

Based on the topics discussed in this report, we can derive the following conclusions:

- The world's demand for connectivity continues to grow and is particularly being driven by newer use cases such as the connected car. This is reflected both in the growing number of connections and the increasing criticality of the associated connected applications. Not only are there hundreds of millions of connected vehicles expected to be connected in the coming decade, accounting for almost 55% of vehicles in 2034, but the services are becoming more and more intrinsic to the driving experience and automotive OEM business models.
- The growing demand translates into additional requirements for highly available and ultra-resilient networks to support an increasingly diverse and demanding set of applications. This places greater requirements on the providers of telecommunications networks to ensure 'ubiquitous connectivity'.
- 5G is delivering qualitatively better services for IoT, beyond what have been seen before. The capabilities of network slicing, ultra-low latency, quality-on-demand and other functionality provide rich capabilities that have great potential for supporting many IoT use cases, particularly for software-defined vehicles.
- Satellite is key to delivering ubiquitous connectivity. While it's not new to use satellites to monitor remote assets, it is increasingly a requirement to fill in the substantial gaps in coverage of terrestrial networks for the growing requirement for constant connectivity to support critical applications.
- The ability to transition seamlessly between terrestrial and non-terrestrial networks will form the bedrock of ubiquitous connectivity. This becomes a reality with the arrival of NTN, in combination with 5G.
- The arrival of 3GPP non-terrestrial networks, both NB-IoT and New Radio, offers a new paradigm for ensuring connectivity of cellular devices even outside of coverage of traditional terrestrial networks. Collectively these technologies are able to address both low and high bandwidth connectivity use cases, being particularly adept at integrating both satellite and terrestrial coverage.
- The benefit of ubiquitous connectivity for automotive and transportation is substantial. In the automotive sector alone, it enables additional safety features, continuous product improvement, enhanced user experience and new service-based revenue models by supporting real-time updates, remote diagnostics, personalised features and data-driven product development for car makers. It also drives operational efficiency and broader ecosystem value through fleet optimisation, predictive maintenance, energy integration for EVs and data monetisation by stakeholders such as insurers, municipalities and content providers.

- Of course, the benefits are not without challenges. While the technologies might exist to deliver ubiquitous connectivity, they often await widespread deployment, as with non-terrestrial networks and 5G Standalone. There also remain challenges of bringing all the various elements together to provide a seamless, reliable experience in a cost-effective and compliant way.

As automotive, agriculture and transportation OEMs contend with the rise of 5G, the emergence of non-terrestrial networks, and increasing demands around compliance, cost control and user experience, the need for a more flexible, future-ready approach has never been greater.

How Cubic³ is enabling ubiquitous connectivity

Our SIM

In May 2025, Cubic³ showcased the world's first automotive-grade SIM to unite terrestrial and non-terrestrial networks. This enables vehicles to seamlessly switch between cellular and satellite, ensuring uninterrupted service anywhere.

Our partnerships

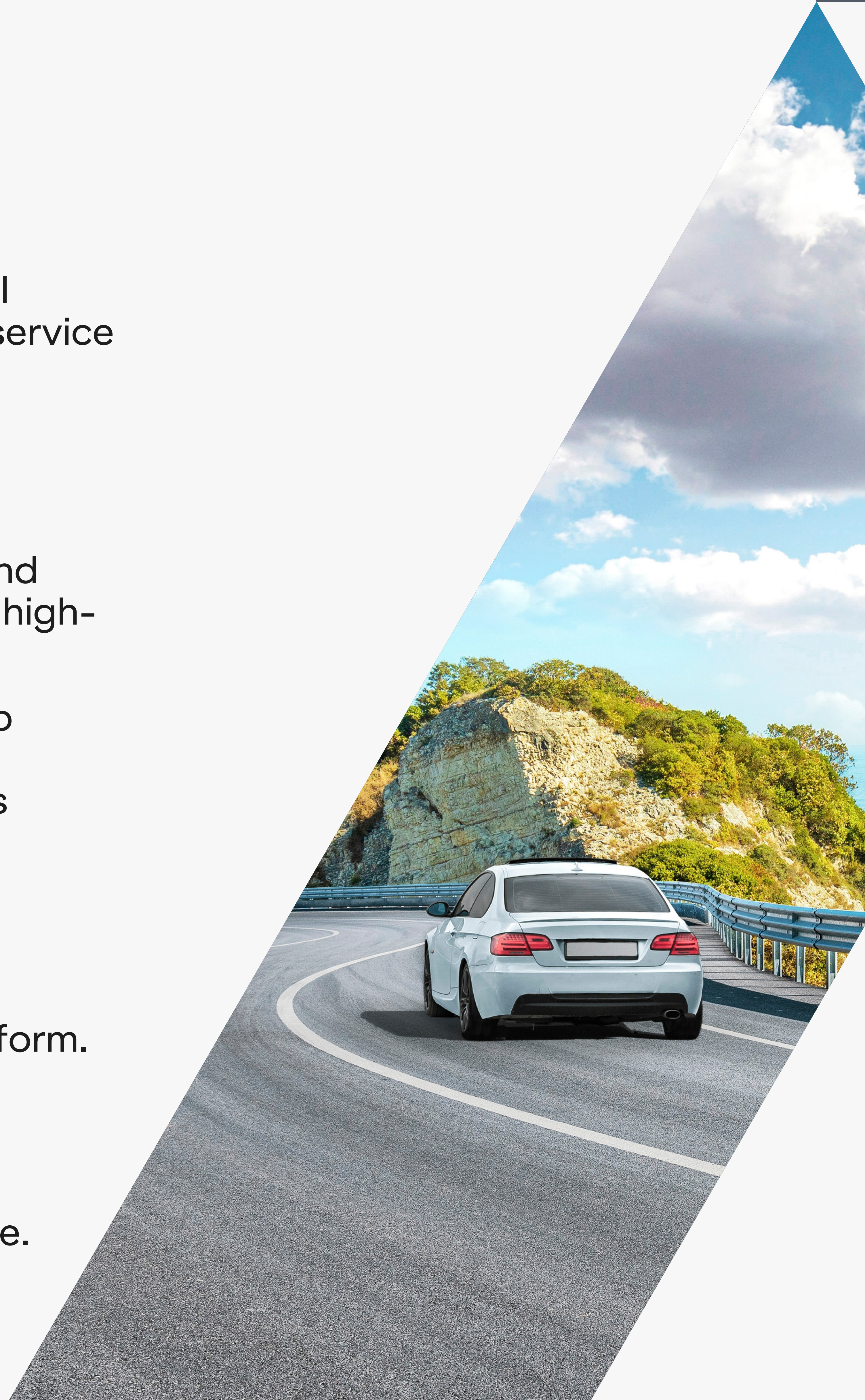
We partner with leading satellite providers — including Intelsat, Skylo and Viasat — to integrate terrestrial and non-terrestrial connectivity into a unified experience. Our partnerships help extend global reach and enable high-quality service even in traditionally underserved locations.

Cubic³ and Tokyo-based telecommunications and IT operator SoftBank Corp. formed a strategic partnership in 2024, and we are now collaborating to advance the seamless integration of satellite-based non-terrestrial networks (NTN) with terrestrial networks (TN) to create a 'Ubiquitous Network' for software-defined vehicles (SDVs) and other high-value mobile assets.

Our platform:

Seamless, secure and scalable, Cubic³ Cloud unifies cellular and satellite connectivity in one centralised platform.

- We provide always on coverage across urban, rural and remote areas, without the network complexity.
- We optimise connected services like navigation, diagnostics and infotainment in real-time.
- Our one, central point of control helps OEMS to boost performance, efficiency and user experience at scale.



TRANSFORMA INSIGHTS

Transforma Insights is a research firm focused on the world of IoT, AI and Digital Transformation (DX). Led by seasoned technology industry analysts we provide advice, recommendations and decision support tools for organisations seeking to understand how new technologies will change the markets in which they operate.

Decision tools include the extensive TAM Forecasts of the DX market opportunity, covering IoT and other technologies across hundreds of use cases, Insight Reports providing qualitative guides to the critical technologies and market developments, the Regulatory Database analysing laws and regulations around the world, and Analyst Enquiry giving direct access to our analysts.

Ubiquitous Connectivity: For a Smarter Automotive Future

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