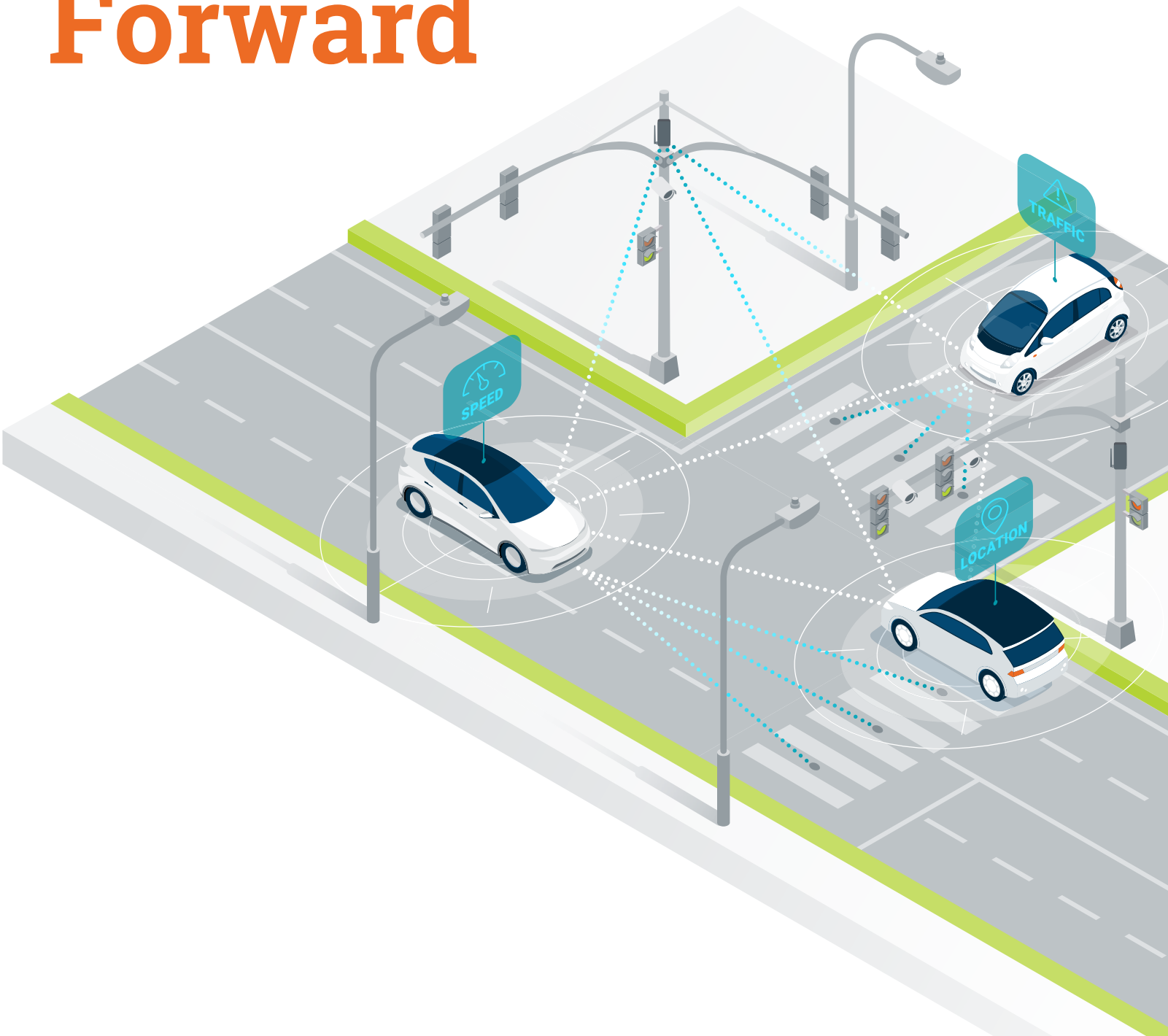
ALLIANCE FOR AUTOMOTIVE INNOVATION | ctia™

How 5G Is Driving the Auto Industry Forward



The automotive industry continuously advances new innovation to better serve drivers, from enhanced safety features to electric batteries to information-sharing with other vehicles and infrastructure.

Today, wireless networks are an integral part of this innovation, guiding how drivers gain awareness of what's around them, how they entertain passengers, and how vehicles are manufactured.

Automakers are first movers in understanding how new generations of networks, like 5G, help unlock new capabilities, including:

+ Increasing the amount of data that can be carried and the speed at which this data arrives to a navigation app, onboard infotainment system, or internal system for predictive and planning functions

+ Ultra-low latency that eliminates lags and delays when split seconds matter

+ The potential to support 100x more devices for connecting everyone and everything on the road, from sensors to smartphones to public safety and traffic management systems

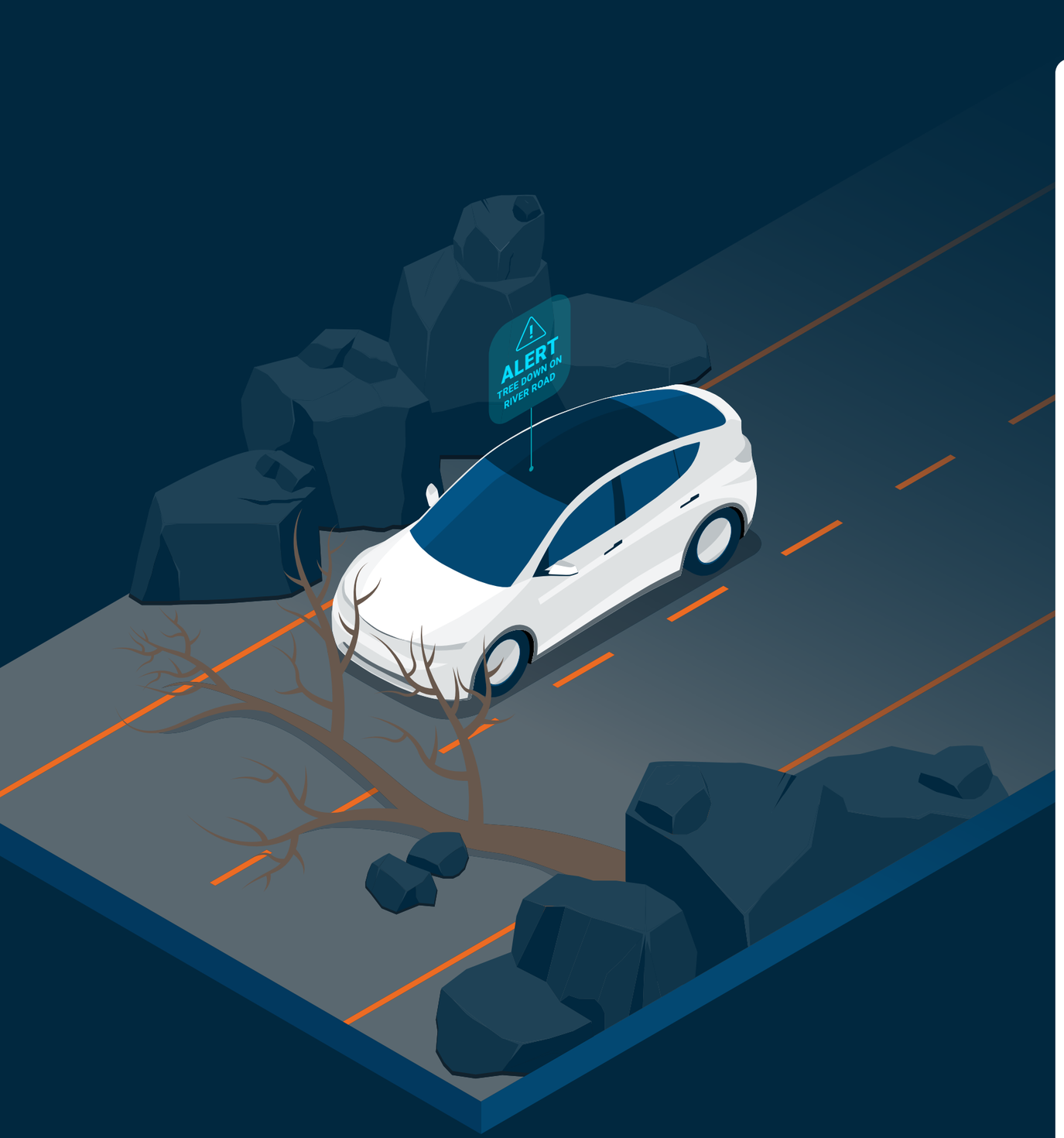
To drive these innovations, U.S. policy needs to continue to provide access to full-power licensed spectrum for the deployment of wide-area networks that reach America's drivers in urban, suburban, and rural areas.

The industries represented by CTIA—The Wireless Association and the Alliance for Automotive Innovation (Auto Innovators) work at the confluence of wireless capability and automative innovation to power, drive, and build the vehicles of the future—and the policies needed to support these efforts.

The key now is to ensure public policy promotes future innovation in the United States. This includes reauthorizing the FCC to hold needed spectrum auctions and allocating more spectrum that's targeted to meet consumer demand and drives future industry advancement and investment.

Auto Innovators and CTIA support thoughtful spectrum policy that allows industries to invest long-term in future solutions and technologies, as well as policy that reflects the importance of international harmonization to support global economies of scale for equipment and related technologies.

Read on for a peek at how the wireless and automotive industries are working together to offer 5G-powered innovations, with a focus on roadway safety, commute improvements, smart manufacturing, connected transit and entertainment, and emissions reduction.



5G Innovation for Automotive Safety

The auto industry has made safety a guiding priority for years, and 5G is enabling further advancements in this space.

5G will help a vehicle automatically share crash information with first responders. Drivers and cars will use 5G to respond to real-time routing and weather information. These features and others allow parents to maintain their peace-of-mind as 5G-enabled safety features work to protect young drivers.

5G-powered infrastructure will speak with the traffic management systems around it to provide valuable information about a vehicle's surroundings.

For these and other auto safety scenarios, information is everything. 5G networks help send data faster, decrease reaction times, and support more devices that talk to each other in real time.

Empowered by this next generation of connectivity, manufacturers, end users, city planners, and more are exploring ways 5G-enabled vehicle solutions can make our roads, vehicles, and communities safer.

Honda and Verizon:

Pushing Onboard Innovation to the Edge

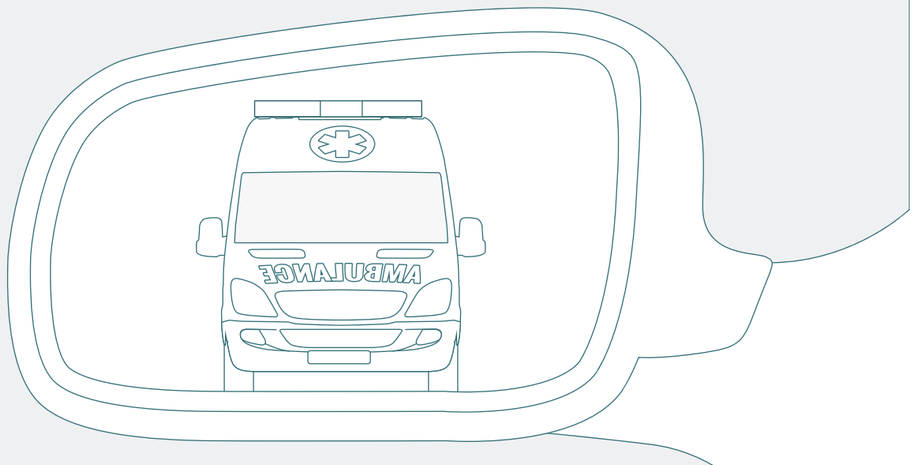
Across the University of Michigan's 32-acre Mcity, smart cameras scan the intersections, Honda vehicles equipped with multi-access edge computing (MEC) capabilities travel the roads, and a 5G Verizon network connects it all, testing out the next generation of automotive safety.

With MEC, vehicles can take advantage of advanced IoT solutions without needing complex computing capabilities on board. For automakers, this simplifies manufacturing while enabling them to offer their customers innovative new technology. Meanwhile, drivers benefit from state-of-the-art—and potentially life-saving—safety tools and warning systems.

Here's one example. A driver approaches a building-filled downtown intersection and doesn't see a pedestrian about to cross the street. Data about the pedestrian's exact location travels at lightning speed from a smart camera to the car, assisted by Verizon's Hyper Precise Location Services. The driver stops just in time.

In another scenario, a driver's music drowns out the siren of an ambulance speeding up from behind. A MEC-enabled warning device picks up the noise and automatically mutes the vehicle's sound system.

MEC can also help support advanced technologies like AI, to bring further innovation safely to America's roads.



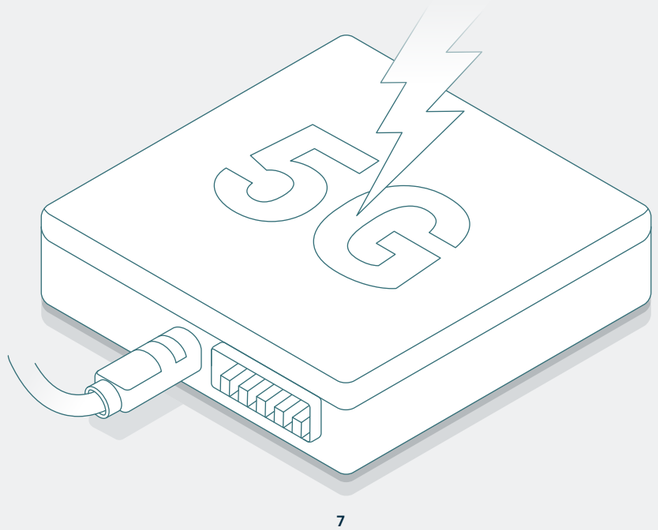
Hyundai:

Bringing All the Pieces Together

To communicate with the infrastructure, traffic, and systems around it, a connected vehicle needs to harness a wide range of devices, capabilities, and technologies, including communication chips, RF circuits, and navigation systems. Bringing all these technologies together into one telematic system expands the possibilities for using data to improve vehicle safety.

Telematics modules are part of an overall drive by Hyundai Motor Group (HMG) and its partners and affiliates to develop mobility applications that merge integrated 5G V2X technology with the autonomous sensors and in-vehicle-entertainment capabilities already in our cars. This will help facilitate more connected car features and autonomous driving.

Hyundai Mobis, part of parent company HMG, developed a 5G telematics module that will share data from sensors between vehicles. This will enable capabilities such as automatic deceleration in school zones and enhanced emergency vehicle controls.



Bosch and T-Mobile:

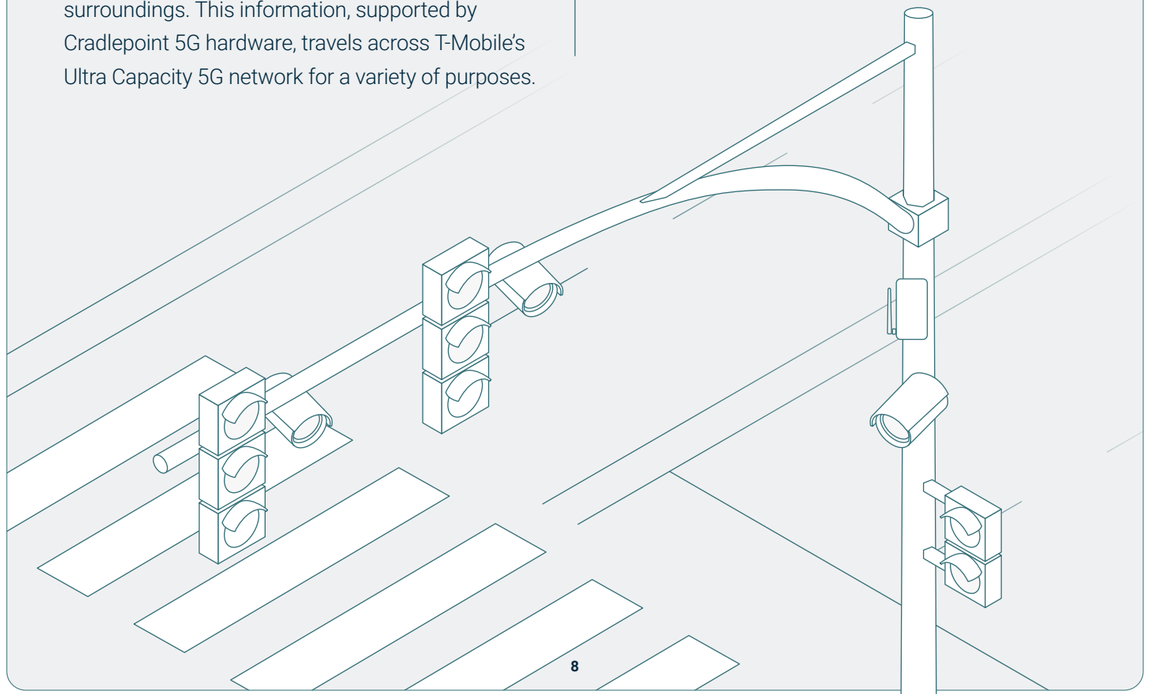
Sharpening the View for Cities and Drivers

Innovation-powered safety means many things in a busy downtown. For drivers, it can involve real-time data directing them swiftly and seamlessly to available charging stations and parking spaces, minimizing congestion, frustration, and potential collisions.

At Curiosity Lab in Peachtree Corners, Georgia, manufacturer Bosch and T-Mobile are testing 5G's capacity to support these scenarios and more.

Bosch smart cameras stationed throughout this living laboratory collect video data of their surroundings. This information, supported by Cradlepoint 5G hardware, travels across T-Mobile's Ultra Capacity 5G network for a variety of purposes.

Here's one example. A camera's video combines with data from Beep autonomous shuttles to create a picture of traffic flow and safety hazards. This informs Signal, Phase, and Timing (SPaT) technology by Iteris that adjusts traffic lights accordingly. All of this information also feeds back to Peachtree Corners city planners, guiding decisions about how to design infrastructure and traffic management systems.



Nissan and Verizon:

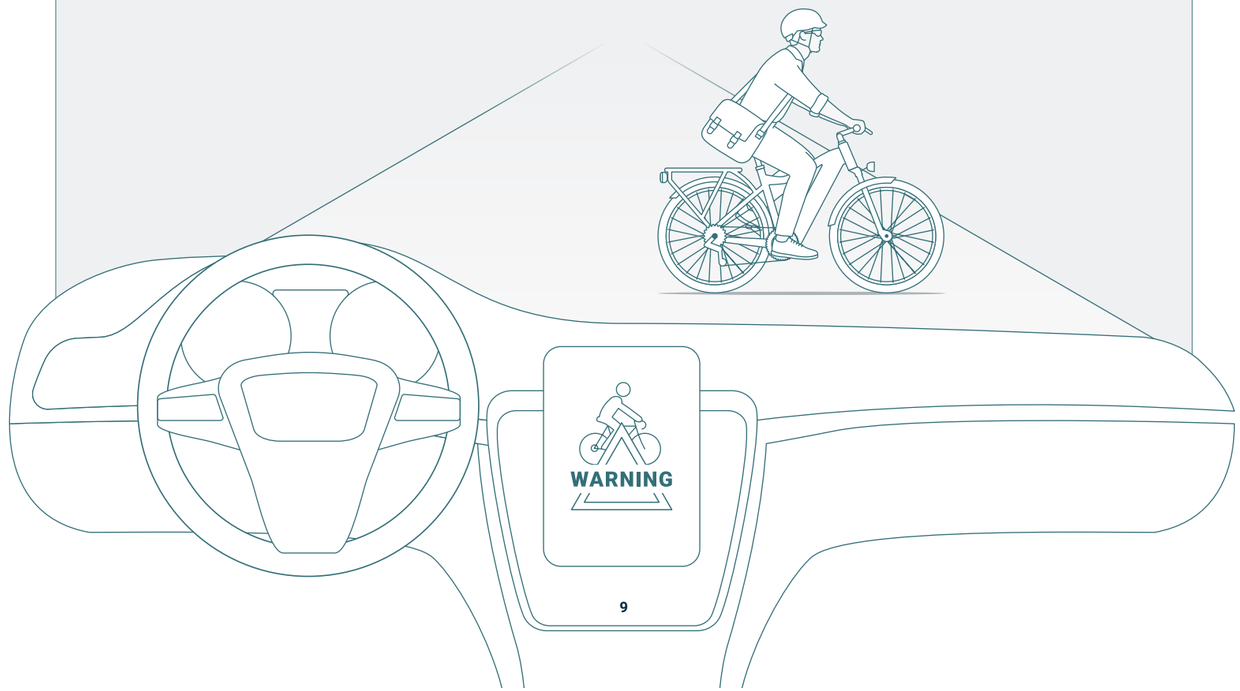
Illuminating Hidden Hazards

During a smooth commute to work, a cyclist suddenly pops out from a hidden alley. It's a nightmare scenario for drivers, and Nissan and Verizon have developed proven technology to prevent it.

Sensor data from vehicles and infrastructure travel to Nissan's proprietary telematics test platform. When the system detects a hazard, it sends the driver an urgent warning via 5G, which the driver then sees as a notification in the vehicle.

The trial, conducted by Nissan's Research and Advanced Engineering team in Silicon Valley, is an important milestone demonstrating the power of C-V2X communication to notify drivers about vehicles or pedestrians entering into traffic. And it's part of an overall initiative in California to explore different vehicle- and infrastructure-based sensor configurations for identifying hazards beyond the line of sight.

Projects like these build upon Nissan's award-winning history of using connectivity to strengthen driver safety. The 2023 Nissan Arriya received IIHS TOP SAFETY PICK+ designation for features like Nissan Safety Shield 360® and driver's assistance technologies like intelligent cruise control and ProPILOT Park—capabilities that 5G connectivity promises to augment even more.



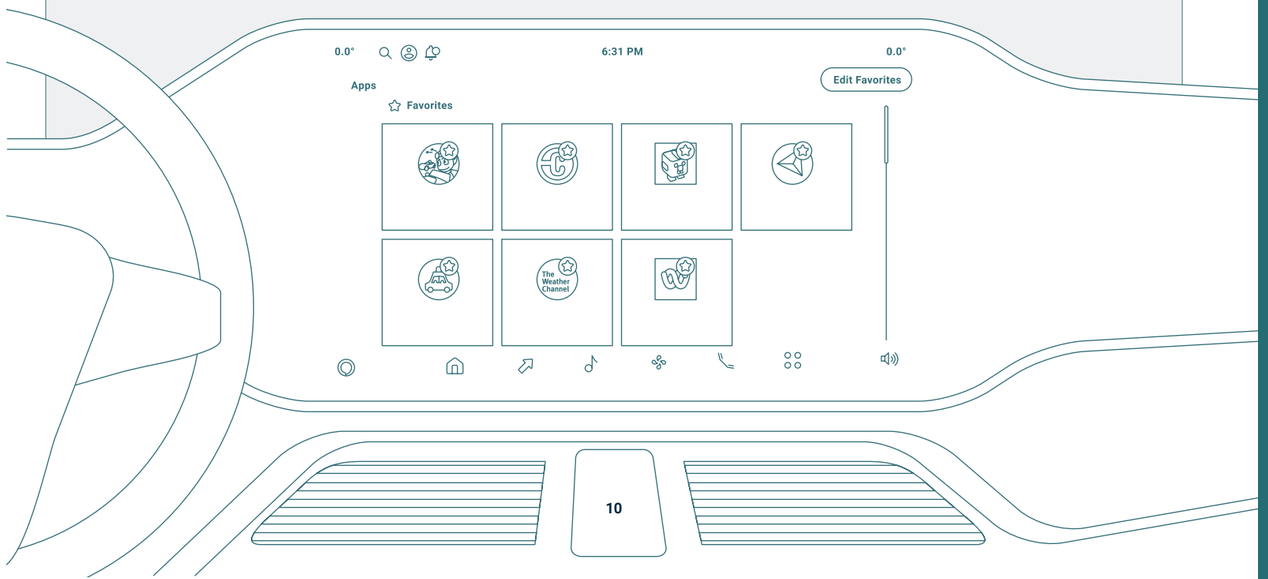
HARMAN:

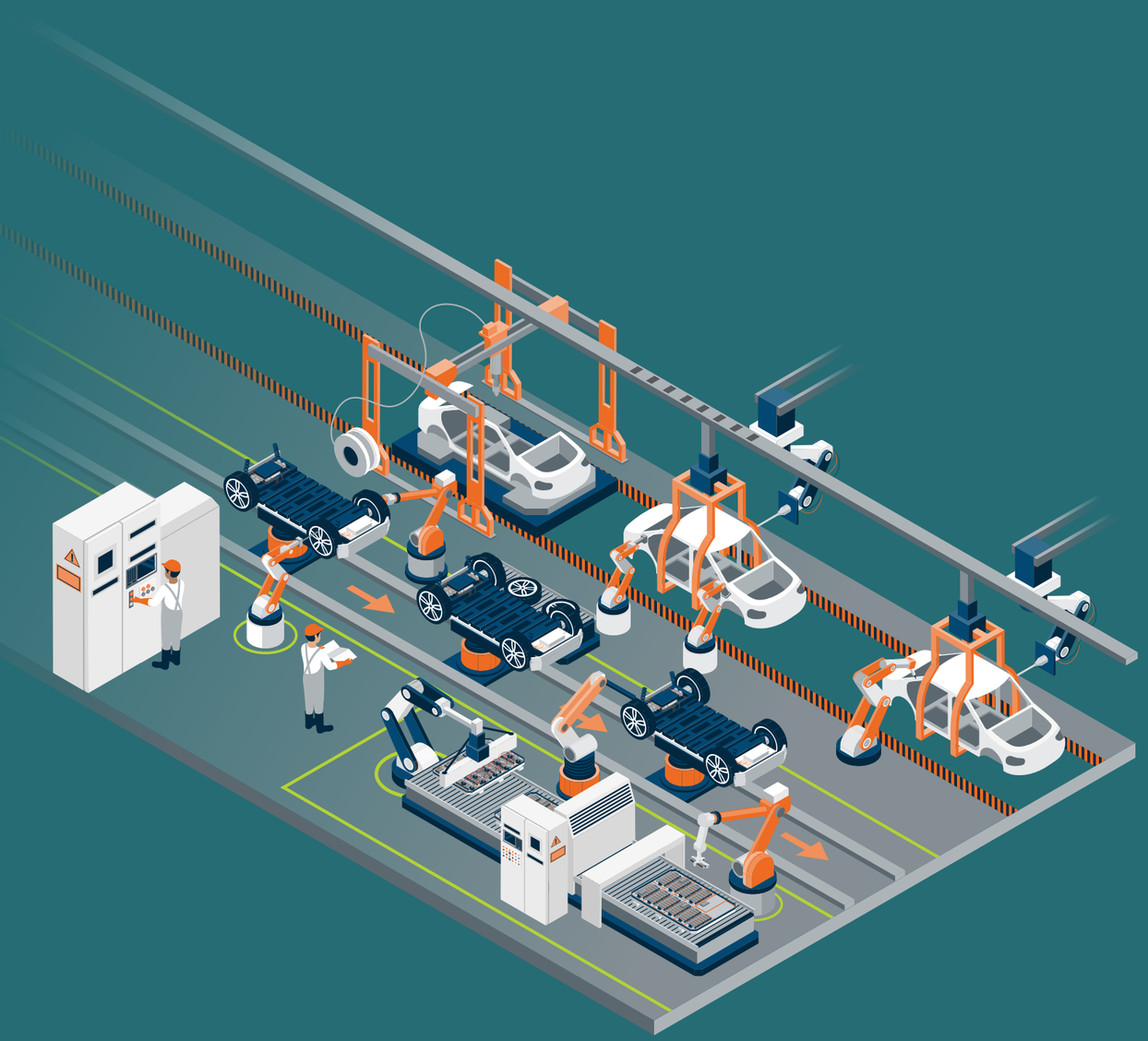
Designing for a Connected Future

The company now known as HARMAN was one of America's first audio electronics companies. Today as a subsidiary of Samsung Electronics, it's hard at work designing products that make vehicles 5G-ready, from antennas optimized for high-speed, low-latency connectivity to a new platform that supports multi-access edge computing (MEC).

These products include the new HARMAN Savari MobiWAVE, an onboard wireless unit that brings existing telematic control units and V2X services together to communicate about traffic hazards.

The HARMAN Savari StreetWAVE enables communication between connected infrastructure and the vehicles around it. And the company is also developing the market's first 5G-ready telematics control unit, which gives auto dealers the ability to upgrade vehicles from 4G to 5G for a safer, better driving experience.





5G Innovation for Automotive Manufacturing

The auto industry has been synonymous with American manufacturing for decades. Today, auto manufacturers are taking advantage of state-of-the art technologies and building safer, more sustainable vehicles with major economic benefits. As Auto Innovators reports, for every $1 added to the economy by auto manufacturing, an additional $3.45 in economic value is created, and for every direct auto manufacturing job, another 10.5 American jobs are created.

5G connectivity is starting to play a big role in the future of auto manufacturing, giving the increasingly technical, data-driven process of assembling vehicles a competitive edge.

In a survey by the Manufacturing Institute, 93% of manufacturers said that they anticipate cost savings from 5G-connected floor technology, and 94% indicated that they expect more productive machines.

Workers stand to benefit too. Boston Consulting Group reports that the 5G economy will enable 4.5 million jobs by 2030. On the job, these workers will be trading cumbersome paper safety binders and training manuals for virtual and augmented reality tools that immerse them in the information they need, when they need it.

How does 5G innovation in auto manufacturing work? 5G-connected sensors alert facility managers to inventory supply and demand, power usage, and safety issues in real time as automation keeps processes moving and AI and machine learning tools drive further improvements behind the scenes. Meanwhile, autonomous vehicles shuttle parts where they're needed most and 5G-powered robots, like Roombas with superpowers, keep the factory floor clean and safe, unencumbered by wires or cables.

That's full-powered, licensed 5G spectrum in action—and a vision of connected automotive manufacturing that's taking shape right now.

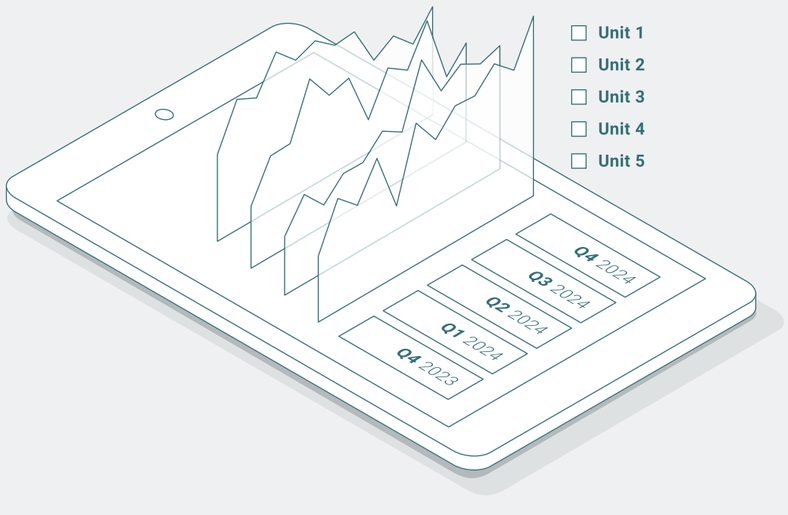
Ford and AT&T:

Lightning-fast Communications on the Factory Floor

Ford's historic Rouge industrial complex in Dearborn, Michigan, is building the vehicles of the future, including the all-electric Ford F-150 Lightning pickup truck. So, it's only natural that the facility uses the latest in advanced manufacturing technologies in the process, powered by AT&T's 5G connectivity.

5G-enabled multi-access edge computing (MEC) helps to move data processing from a centralized cloud to the network's edge—a game-changer on an expansive factory floor. 5G's ultra-fast speeds make MEC possible, enabling scores of production line workers to scan trucks, send information, and check equipment or materials in real time today and implement time-saving automation tools for even greater efficiencies tomorrow.

For a factory doubling its production, this ultra-fast connectivity and ability to support high-volume IoT networks is vital. In the critical area of safety, 5G's ultra-low latency means faster responsiveness to any issues that arise across the plant's hundreds of devices and machines.



Mercedes:

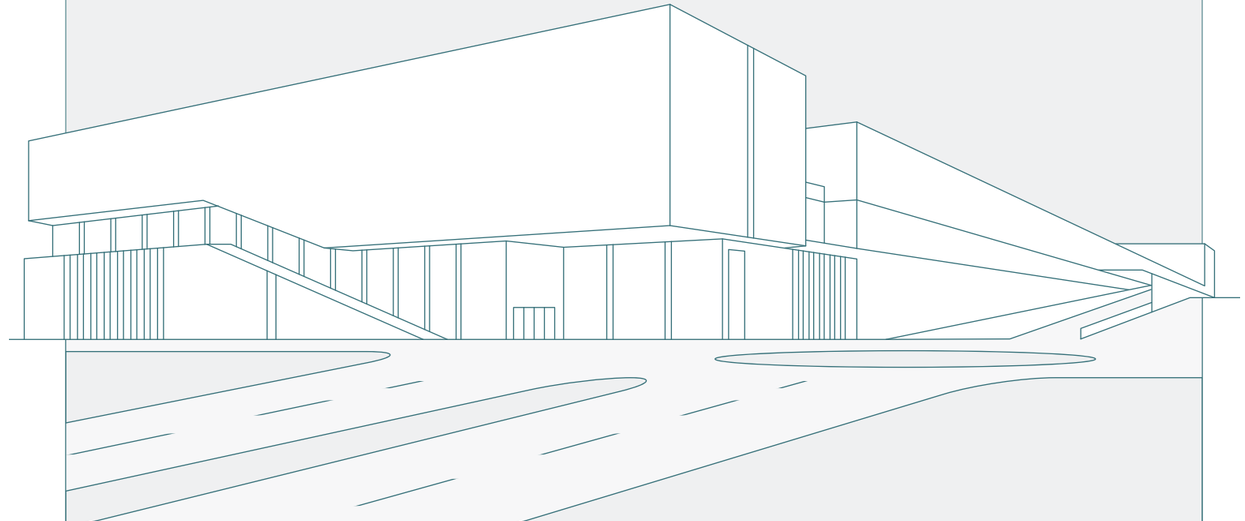
5G Supports the Factory of the Future

Testing is a critical part of the vehicle manufacturing process, ensuring quality and enabling more efficient processes. Across thousands of complex components, it's a massively data-intense undertaking as well, and security concerns add to the challenge.

Mercedes Factory 56, which proudly calls itself "the factory of the future," worked with German wireless provider Telefonica and equipment manufacturer Ericsson to build a private wireless network to support the factory's specific needs. The factory now benefits from the 5G-powered network's faster speeds, greater responsiveness, and ability to support more devices.

Mercedes and their wireless partners were the first to incorporate 5G into running auto production. The luxury automaker has been reaping the benefits ever since. On the assembly line, the private 5G network enables more precise product tracking and more efficient processes.

Throughout the facility, 5G is supporting driverless transport systems, automated picking systems, predictive maintenance, and more. And 5G is the most secure generation of wireless technology to date, with enhanced protections built in, making the Mercedes floor and trade secrets safe and secure.



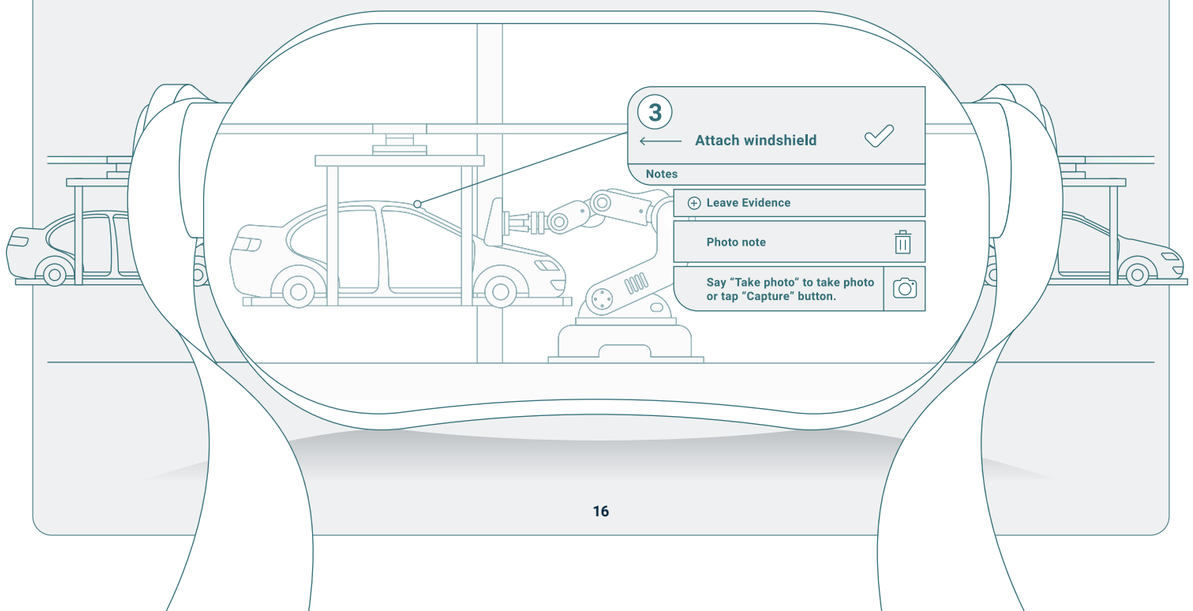
Taqtile:

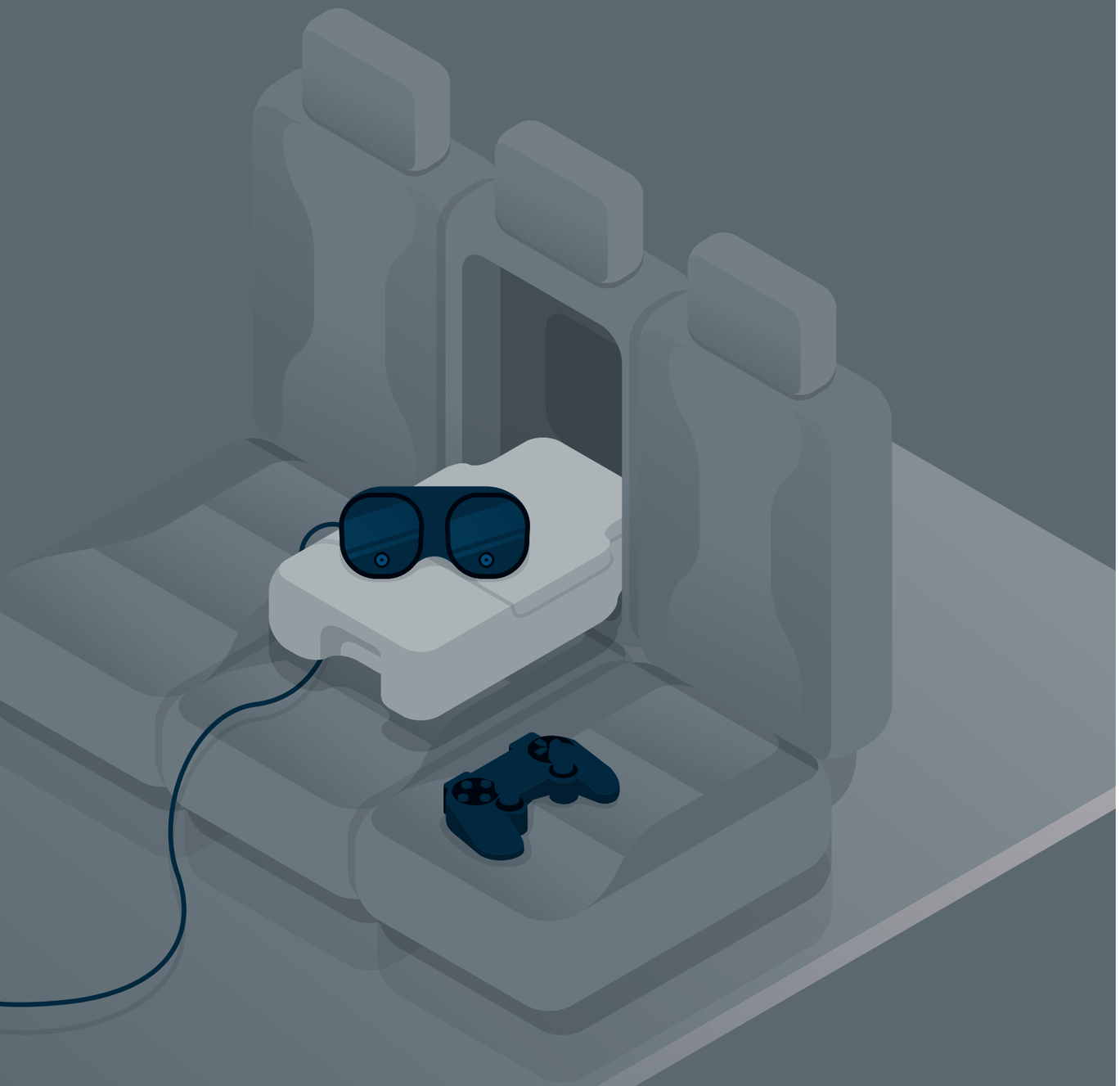
Troubleshooting with a Hands-on Touch

In auto manufacturing, frontline workers are the bridge between ambitious renderings and actual vehicles on the road. They assemble complex parts, inspect them for quality, integrate them into larger systems, and much more.

Seattle-based software company Taqtile is transforming this important work through augmented and mixed reality (AR/MR). Its Manifest work instruction platform brings spatial computing powers to the digital or paper-based materials that frontline workers traditionally use to check next steps, troubleshoot problems, and access training. From a tablet, phone, or AR/MR headset, users simply log in and get the information they need to work quickly, consistently, and safely. The information comes to them via audio, video, spatial indicators, and animated 3D models, overlaid with real-time sensor data, and alerts.

By bringing more speed, responsiveness, and capacity to the platform, 5G takes Manifest's capabilities to the next level. Real-time communication and collaboration are now possible. Now when a frontline worker encounters a particularly thorny problem, they can bring in a colleague or expert to weigh in through their headset or mobile device, from anywhere in the world. It's "in-person support" at their fingertips, saving time, money, and carbon emissions.





5G Innovation for Connectedness and Entertainment

Today, the part of the vehicle that consumers interact with most might just be their dashboard and infotainment system. Automakers are paying attention. They're using data from these digital tools to refine the in-vehicle entertainment experience and incorporating features like voice control capabilities to keep drivers safe.

By 2027, roughly one out of every four new vehicles that drives off the lot will be 5G-enabled. They'll be the envy of the road, given all of the advanced capabilities 5G makes possible, such as sharper-quality calls, more accurate navigation, more applications built into the vehicle itself, and the ability to function as a hotspot for other devices.

Vehicles connected via full-power, licensed 5G spectrum bring transportation and entertainment together and transform the driving experience. Drivers will be able to pay for parking in a connected garage without fumbling through their wallets for a credit card or smartphones for an app. Passengers will be able to catch up with work, TV, or movies or level up their gaming scores as they ride, with the same quality experience they'd have at home.

Throughout, 5G's speed, responsiveness, and capacity will allow for real-time software updates, enhancing vehicle performance and data protection via a network with security already built in.

Holoride and T-Mobile:

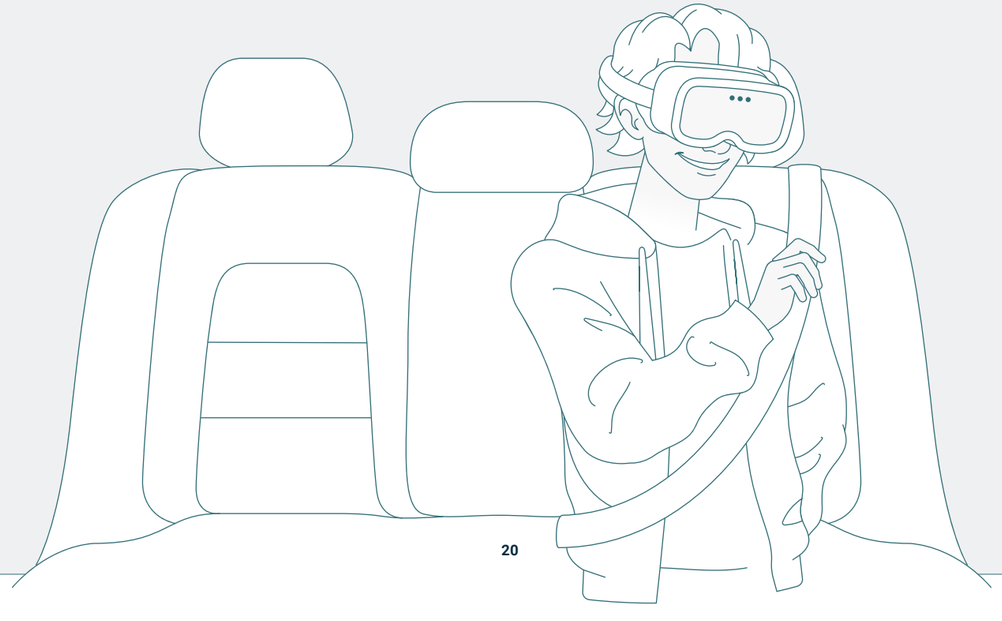
Integrating Your Tide with VR

Passengers of all ages want to be entertained on a long drive. Holoride, with backing from investors like Audi, makes that possible by integrating the motion of a car ride into games and entertainment that can be enjoyed through a VR headset while riding along in a vehicle.

T-Mobile partnered with Holoride to successfully connect the passenger VR system to the T-Mobile 5G network, enabling a low-latency connection that could support edge-computing capabilities.

This kind of connectivity helps provide a VR entertainment experience that is well synced with the motions of the car to enhance how immersed a person can be with the game or show and eliminate any feelings of nausea that come from a lag in the game's responsiveness to its surroundings.

Now passengers can enjoy a VR entertainment experience on the go.

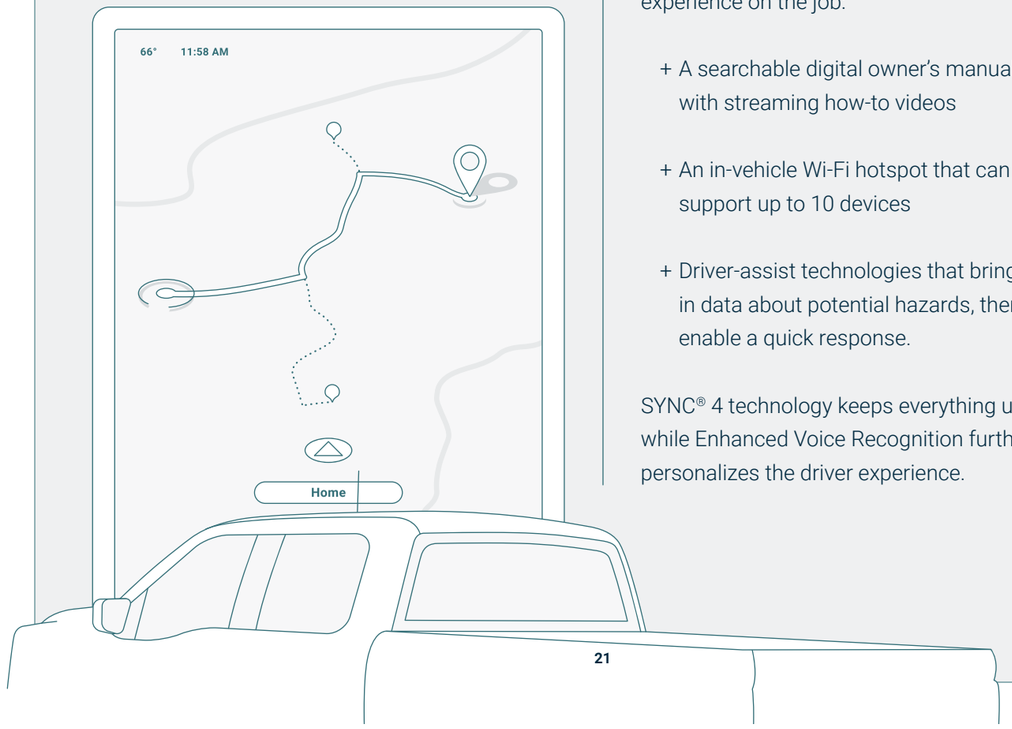


Ford and AT&T:

Bringing Super Connectivity to the Super Duty Truck

IoT networks and data analytics are transforming efficiency and decision making in farming, and augmented/immersive reality are bringing similar possibilities to contracting and construction. But all of these cutting-edge applications are of limited use without sufficient connectivity in the field or on site, where the work is getting done.

To address challenges like these, Ford and AT&T have joined forces to turn the workhorse Super Duty truck into the ultimate mobile device.



The trucks now come with a Qualcomm Snapdragon® 5G Modem-RF System built in. This connects the truck to AT&T's 5G network, enabling a suite of productivity-enhancing software and services, faster navigation for getting where you need to go, and software updates while you're on the move. High-speed, low-latency connectivity also means richer, more immersive music, streaming and gaming when it's break time.

Ford calls its connected vehicle experience "brains to match its brawn," and here are just a few of the 5G-powered benefits a driver might experience on the job:

+ A searchable digital owner's manual with streaming how-to videos
+ An in-vehicle Wi-Fi hotspot that can support up to 10 devices
+ Driver-assist technologies that bring in data about potential hazards, then enable a quick response.

SYNC® 4 technology keeps everything updated, while Enhanced Voice Recognition further personalizes the driver experience.

General Motors (GM) and AT&T:

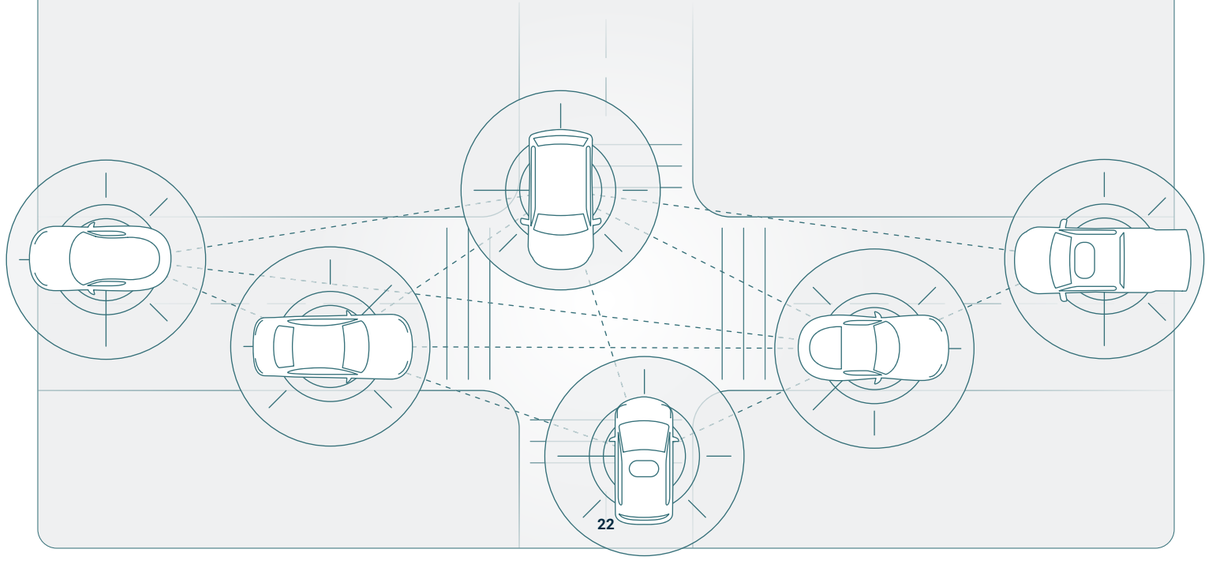
Bringing Drivers Nationwide into the 5G Revolution

If you're buying a 2024 model year Chevrolet, Buick, Cadillac, or GMC vehicle, you'll drive them off the lot with 5G capabilities already built in.

It's all part of a joint effort between GM and AT&T to bring 5G connectivity and its advantages to millions of drivers nationwide.

As the next generation of wireless connectivity, 5G enhances the driving experience in many ways. Faster speeds enhance a vehicle's ability to support the increasing volumes of data used by today's navigation systems and connected services. A low-latency 5G network is able to relay safety information to a connected vehicle before a human driver can even process it. For protecting personal information, strong encryption safeguards the data as it travels over 5G networks built with security in mind.

The GM-AT&T partnership reflects years of strategy, investment, and planning. Starting with the 2019 model year, GM equipped its vehicles with AT&T's 4G LTE connectivity, offering enhanced vehicle performance capabilities and improved navigation, plus streaming video and the delivery of other multimedia. With the rollout of 5G connectivity in their 2024 vehicles, GM is taking these capabilities further, laying the groundwork for autonomous transport and other milestones in connected vehicle innovation that thrive on the increased data sharing 5G supports.



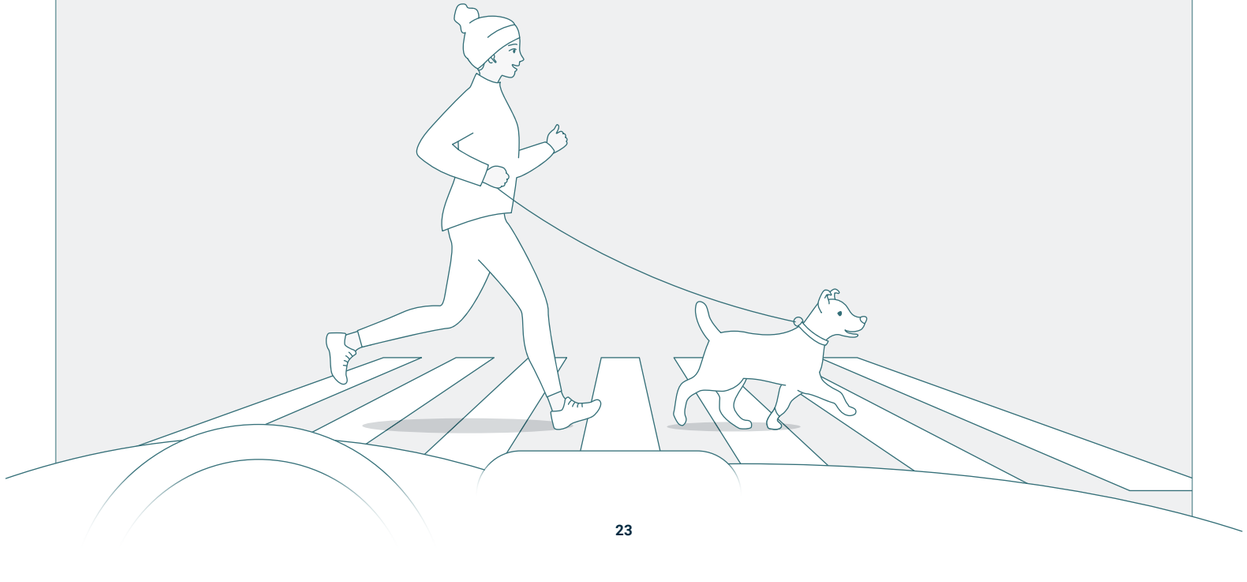
Audi of America and Verizon:

Powering the Journey from Smart Cars to C-V2X

While rolling out its 5G network, Verizon has also been working with Audi of America on ways for drivers nationwide to take advantage of it.

The result: solutions embedded within the vehicles themselves that connect Audi drivers to a host of cutting-edge capabilities and experiences. Picture navigation systems enhanced with HD/3D mapping and video, mobile retail capabilities enabling passengers to shop on the go, and cloud-based user profiles, delivering streaming video and other infotainment faster and sharper than ever. Behind the scenes, 5G-powered firmware and software upgrades keep everything as up-to-date and secure as the latest smartphone.

These in-car solutions are just the beginning as Verizon continues to enhance its offerings and Audi partners with state departments of transportation, infrastructure providers, and technology companies. In the works are direct C-V2X communication solutions like alerts and other safety advancements, putting 5G's low latency to work to protect pedestrians, children, road maintenance crews, cyclists, and other vulnerable users of the road.



5G Innovation for Reducing Emissions

With the rise of electric vehicles and their ability to continually improve vehicle fuel efficiency, automakers are on the forefront of efforts to reduce carbon emissions in the transportation sector.

5G can help take emission reduction efforts further. Accenture estimates transportation-related 5G-enabled use cases will cut carbon emissions by 86.5 million metric tons—that's equal to the carbon sequestered by 106 million acres of U.S. forests each year.

With its high speeds, low latency, and ability to support growing numbers of IoT devices, 5G delivers information in real time. When this data is put to work in smart transportation solutions, vehicles use less power, reduce time on the road, and release fewer emissions.

Think about connected traffic infrastructure. When drivers know what's ahead of them sooner, there's less need to accelerate or brake quickly. When sensors at intersections respond to real-time traffic flow, vehicles idle for less time at stoplights and traffic signals. And when all of this information is analyzed at lightning speed, traffic management systems are able to anticipate, flag, and resolve the congestion that unnecessarily burns fuel and adds to our carbon footprint.

Smart parking systems are one example of how 5G connectivity will reduce emissions. Sensors on lamp posts and utility cabinets are another. They provide a bird's-eye, real-time view of open spots. Drivers equipped with this information spend less time idling, circling, waiting, and guessing. Their vehicles, in turn, use fuel more efficiently and operate in a more environmentally friendly fashion.

Halo.Car, Beep, and T-Mobile:

Connecting Travelers to Earth-friendly Transport

Millions of people visit Las Vegas and Atlanta each year. If each of them was to rent a car, these cities would experience major gridlock. Gas usage skyrockets along with emissions—which is not the kind of future that any city, or our planet, wants.

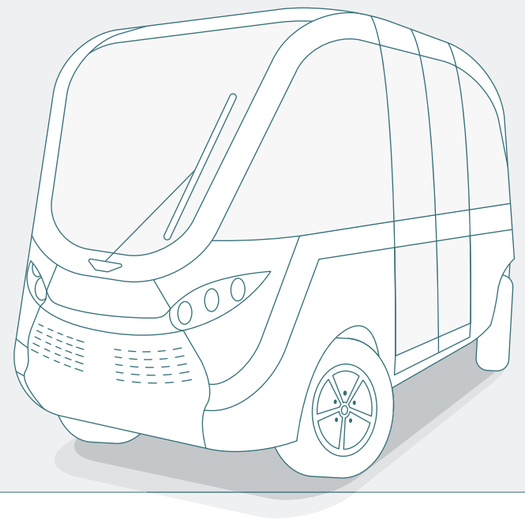
In Las Vegas, Halo.Car is piloting a fleet of autonomous electric vehicles addressing this challenge on multiple levels: connecting travelers to available vehicles on demand, navigating vehicles to the most efficient route, and reducing idling, circling, and congestion by tourists unfamiliar with the city. Partnering with T-Mobile's network means 5G's high speeds, low lag time, and ability to support data collection and processing from multiple sources deliver the real-time information that makes it all possible.

"We want to make it so easy to get a car on-demand that you no longer need to own a car or use a rideshare service—you just call a car to drive when you need to go somewhere," Halo CEO Anand Nandakumar told the Las Vegas Review Journal. "This commercial launch of driverless delivery is a landmark achievement not only for our company, but for the entire transportation industry."

Visitors to CES 2024 got to experience this mix of safety and sustainability for themselves. A fleet of remotely controlled Halo EVs joined traditional taxis and ridesharing options as a way to get around, making travelers in town checking out what's new part of the future themselves.

And in suburban Atlanta, all-electric autonomous public shuttles by Beep transport residents to popular restaurants, retail shops and hotels—moving safely and efficiently around bikes, pedestrians and other vehicles. 5G's low latency, high bandwidth and high-speed connectivity support the "vehicle to everything" technology that makes it possible. Beep's shuttles lower carbon emissions and traffic congestion. In fact, a single shuttle route can eliminate up to eight private car trips.

"Beep is transforming mobility through the use of autonomous, electric, multi-passenger vehicles enabled by 5G," said Beep CEO Joe Moye.

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