

ON THE ROAD TO **CONNECTED MOBILITY:**

An ER&D Perspective



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FOREWORD

Estimates suggest that there are about 1.5 billion vehicles worldwide, or about 1 automobile for every 5 individuals. As the global roadways expand and vehicle count rises, one would often tend to wonder on the validity of what Ivan Illich summed up in his 1974 seminal article, **Energy and Equity**: “Beyond a certain speed, motorized vehicles create [a] remoteness which they alone can shrink. They create distances for all and shrink them for only a few.”

However, the future is not so bleak. Welcome to the world of connected mobility.

Connected mobility is an exciting and rapidly evolving field, spurred on by significant technological advancements. It goes beyond merely transporting individuals from one location to another, encapsulating the convergence of various technologies for enabling vehicles to interact with each other, infrastructure, and even pedestrians. The result is a rich, immersive end-user experience that is reshaping the way we perceive and engage with transportation. Safety is a critical aspect of this transformation. New systems and technologies are being developed to make our roads safer and more efficient. Advanced Driver Assistance Systems

(ADAS), for instance, leverage sensors and software to detect potential hazards and assist drivers in navigating them. These systems can provide warnings for potential collisions, help maintain safe distances from other vehicles, and even automate certain driving functions such as parking.

The growing impact of connected mobility is already apparent across the global automotive landscape – revolutionizing both passenger and commercial vehicles. By 2030, we can expect a very significant number of the new vehicles on the road to be equipped with built-in connectivity from the start. This widespread adoption of connected mobility will be facilitated by the growing prominence of Domain Controllers, serving as the central processing units for vehicle electronics.

L&T Technology Services (LTTS) plays a pivotal role in this transformation, providing customers with next-generation connectivity solutions. We specialize in integrating 4G and 5G enabled telematics systems, driving next-gen real-time communication paradigms between the vehicles and external systems for enabling CV2X. Connectivity is the key to enable the remote enabling, disabling, or upgradation of a vehicle's features through over-the-air (OTA) updates after it

has left the production line, transforming the automobile into a Software Defined Vehicle (SDV). Our solutions and offerings help in enabling feature as a service in addition to relaying crucial information about traffic conditions, route optimization, vehicle diagnostics, and other key variables that deliver a truly unmatched user experience.

Trends indicate that the future is set to evolve beyond ensuring mere connectivity. With this in mind, our global engineering and delivery teams today are helping enable advanced analytics solutions which can analyze the vast amounts of data generated by connected vehicles. This data stream, in turn, holds the key for understanding driver behavior, personalization, vehicle performance, and other major factors – enabling global auto manufacturers to improve their offerings and tailor them to meet specific customer requirements.

As vehicles become increasingly connected, they also become potential targets for cyber-attacks. The LTTS team has undertaken significant steps to ensure comprehensive cyber security in our solutions and offerings, recognizing the importance of protecting sensitive data and systems from external threats. Our robust security measures ensure that the customers' vehicles are well equipped to handle these threats.

Looking at the future, I am confident that the trend toward connected mobility represents a significant shift in the global transportation sector – perhaps among the most important in recent times. Driven by technological advancements, the need for enhanced user experiences and improved safety, and a growing focus on enhanced connectivity across the entire transportation spectrum, the road ahead will be defined by a scenario where connectivity is the norm rather than the exception.

At LTTS, we are committed to help you navigate this new landscape and reap the benefits of the transformation.

Shailendra Shrivastava,
Chief Delivery Officer, L&T Technology Services





A CONSUMER PERSPECTIVE



TOWARD NEW EXPERIENCE AND ENGAGEMENT PARADIGMS

The world is getting incrementally connected, with digital technologies touching and redefining almost every aspect of our lives. The automotive industry is experiencing this digital disruption first-hand.

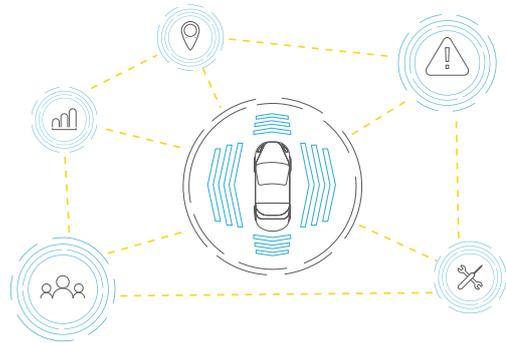
Imagine driving to work on a rainy morning with low visibility, and your car alerts you, "There is a pile-up of vehicles 2 KM ahead; take the next detour to reach your destination on time." Your connected car has not only helped you avoid a delay but also averted a potential accident hazard.

As engineering teams worldwide unlock new value paradigms and use cases, next-gen connected cars may soon have the ability to automatically order and pay for fuel, or recharge their batteries, at a nearby gas station without the driver leaving the car.

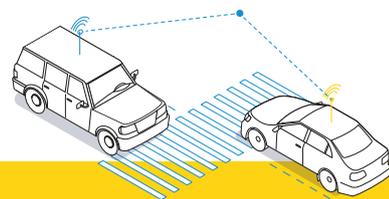
These are just some of the capabilities that connected mobility could unleash in the not-so-distant future.



"37% of consumers would change car brands just to gain more connectivity within their vehicles." – McKinsey



Consumers have evolved from being mere drivers/passengers to subscribers, expecting superior, more personalized user experiences from their vehicles. They expect their vehicles to be an extension of their connected homes and smartphones. Therefore, original equipment manufacturers (OEMs) and manufacturers must find innovative ways to provide consumers the experience they seek. The focus is increasingly on areas like personalized cockpits, improved safety features, vehicle tracking capabilities, greater virtualization, smarter intrusion alerts, effective predictive maintenance, and enhanced driver assistance.



Vehicles have evolved from mere means to go from point A to point B to a connected platform – an ecosystem by itself. Soon, they will become the new smartphones on wheels.

THE CONNECTED HORIZON BEYOND PASSENGER VEHICLES

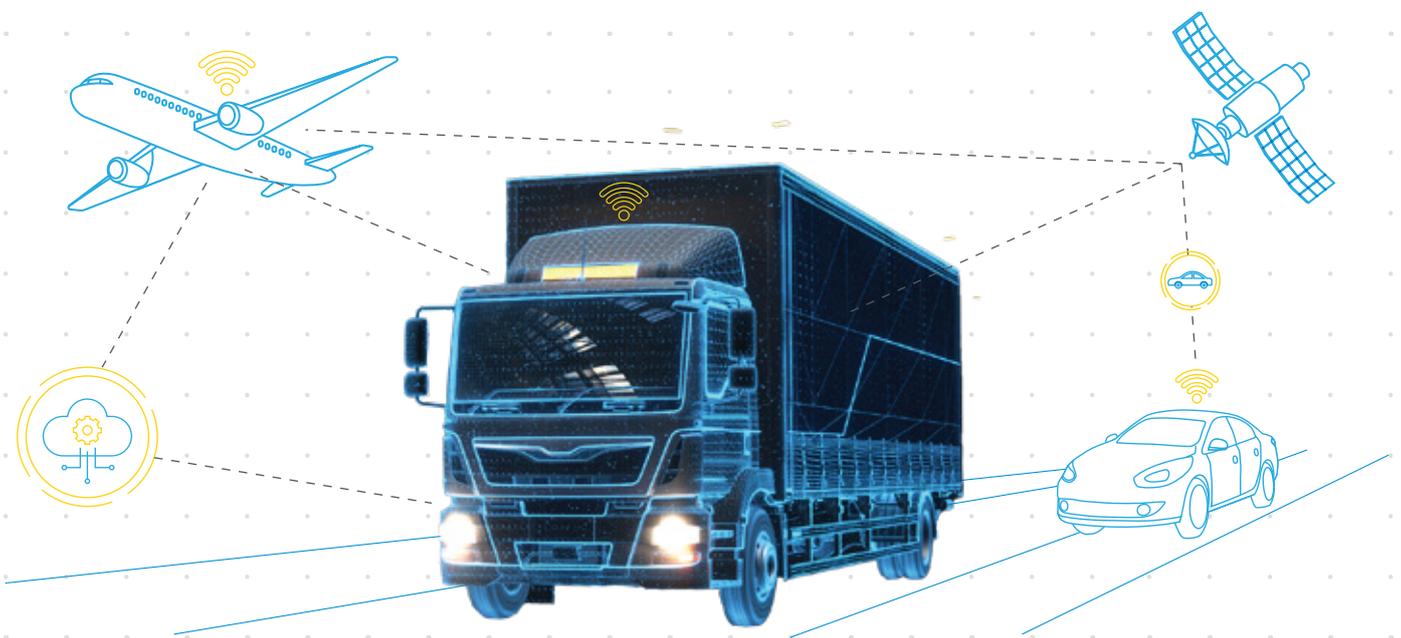
Connected mobility has emerged beyond the passenger vehicle segment for quite some time now, specifically into commercial and off-highway vehicles. The rising adoption of smarter and connected commercial and off-highway vehicles offers competitive advantages through enhanced security, availability, productivity, performance, and operational efficiency.

With the transportation industry serving as the backbone of the just-in-time economy, it is constantly under pressure on various fronts. With connected commercial vehicles, fleet owners today can gain access to valuable fleet health data, manage and secure their fleet, and enable predictive maintenance and productivity tracking. Reinforcing the trend, the next-generation connected off-highway vehicles are being embedded

with sensors. These help measure critical parameters and relay information to telematics devices and the cloud for enabling advanced analytics and optimized performance.

To keep up with the ever-evolving connected world and address today's challenges, the aviation industry, too, has evolved and adopted connectivity to connect the entire aviation ecosystem. The transformation, rapidly gathering momentum, is enabling aircraft operators to predict, analyze, and optimize their entire fleet for radically transforming in-flight experience paradigms.

With the rise of connectivity across the commercial, off-highway, and aviation ecosystems, the proliferation of artificial intelligence (AI), cloud, big data, and shared mobility components has become imminent.



DRIVING SUCCESS: THE GROWING IMPACT OF CONNECTIVITY

The automotive industry has changed drastically over the past few decades. We have seen tremendous advancements in technology, design, and engineering. However, one of the most significant changes we have witnessed is the growing impact of connectivity in the automotive industry. With the advancement of smart technology and the Internet of Things (IoT), the connection between vehicles, drivers, and the world around them has become seamless.

Traditionally, when talking about “connected cars” and “connected vehicles,” we think mainly of the benefits

delivered to consumers, such as personalization, a redefined driving experience, etc. However, connected vehicles and their data deliver various benefits to all business partners in the automotive industry.

The rise of connectivity has had a significant impact on OEMs. It has allowed them to gather real-time data from vehicles, which can be used for predictive maintenance and improving the overall driving experience. Additionally, connectivity has opened up new revenue streams for OEMs through subscription-based services such as in-car entertainment, remote diagnostics, and



vehicle tracking. This not only increases customer loyalty but also generates additional revenue for the manufacturer. Furthermore, connectivity has become a key differentiator for OEMs in a highly competitive market, allowing them to stand out from the crowd and attract tech-savvy customers. In addition, access to better data and intelligent insights can help OEMs select better supply partners. On the other hand, auto suppliers can optimize their lead time and gain value from better-planned supply chains.

Enhanced connectivity can also enable automotive dealerships to automate repair scheduling, accurately predict repair needs before a vehicle comes in for a service, and gain enhanced visibility into parts availability and potential quality issues. Additionally, connectivity also allows for over-the-air software updates, eliminating the need for customers to physically bring their vehicles to the dealership for updates – all of which can lead to enhanced customer satisfaction.



Connectivity technologies are evolving, with growing 5G and edge computing adaptations redefining the global landscape. Automotive industry leaders are increasingly relying on cloud infrastructure and OTA updates along with innovative connectivity paradigms around V2X, CV2X for enhanced customer experiences and better safety. As the transformation journey toward software defined vehicles accelerates, we can expect a redefinition of existing service offerings to drive the expansion of the worldwide connected vehicle ecosystem.

 **Srirama Murthy Kolalapudi**
Practice Head - Transportation, L&T Technology Services



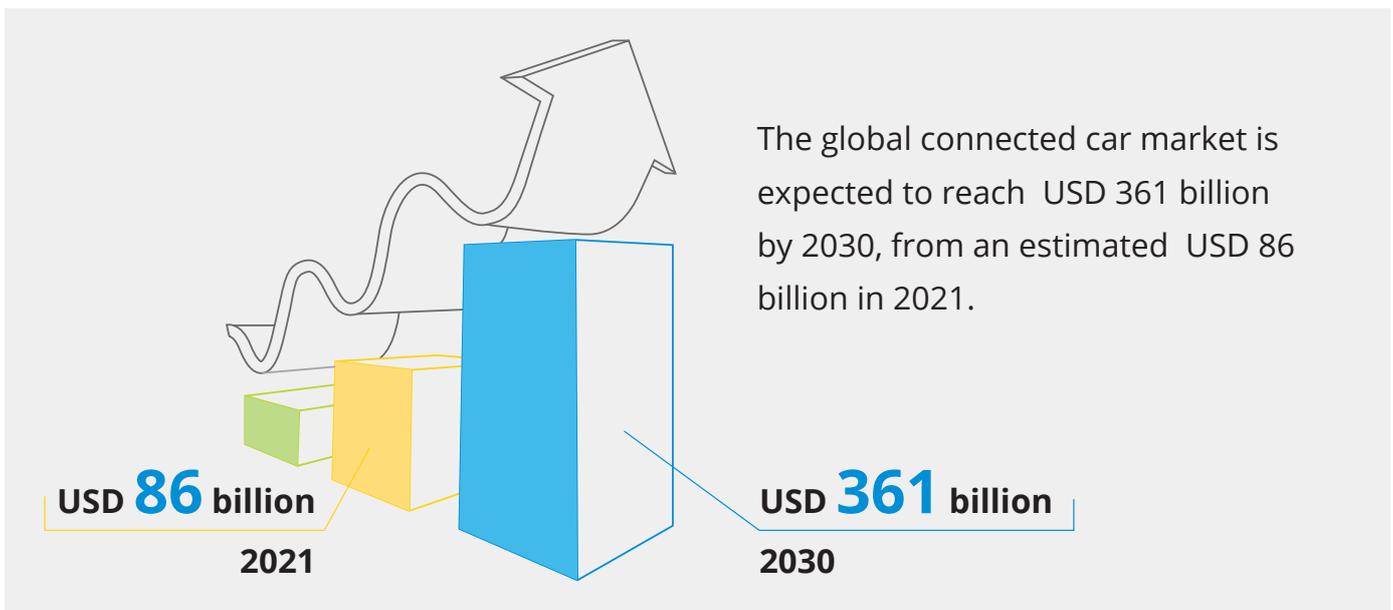
AN INDUSTRY PERSPECTIVE



CURRENT MARKET SIZE AND TRENDS

The adoption of connectivity technologies into vehicles is becoming an industry standard, and the latest advancements are expected to increase vehicle safety, efficiency, and passenger convenience. Currently, manufacturers across all

segments are introducing innovative features that are indicative of a future where in-vehicle technologies and interactions with passengers, the environment, and other vehicles will be seamlessly integrated.



The global connected car market is expected to reach USD 361 billion by 2030, from an estimated USD 86 billion in 2021.

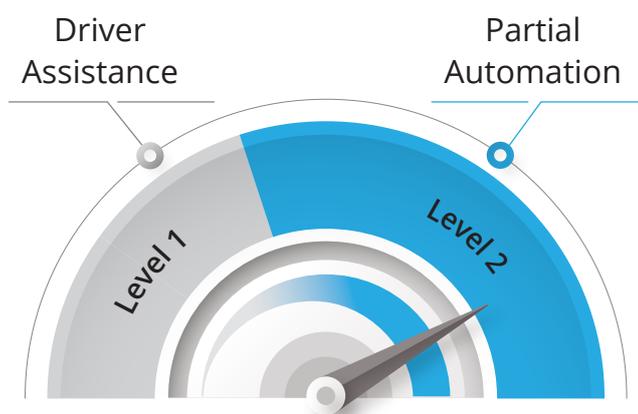
As per McKinsey, by 2030, approximately 95% of all new vehicles sold globally will be connected. Out of these, around 45% of vehicles are expected to have intermediate to advanced connectivity features, such as multisensory interactions for all occupants, access to personal profiles for digital services, connection to other ecosystems and platforms, and intelligent decision-making through seamless environmental linkages.

The rise in consumer demand to stay connected, the increase in the dependency on technology, and the surge in a tech-savvy population are the key factors

driving automotive manufacturers across the globe to add connectivity solutions to their vehicles.

While the industry has made incredible headway in a few short years, but the best is yet to come. Technologies such as artificial intelligence (AI), next-gen advanced autonomous driving, the 5G wave, future-proof telematics, and the increasing vehicle-to-everything (V2X) and cellular vehicle-to-everything (cV2X) infrastructure will redefine the connected mobility industry.

The autonomous driving market is not limited to passenger vehicles; it has a huge potential in commercial vehicles (logistics) and off-highway vehicles (mining, construction, etc.) to address the skill shortage, ease drivers' load, reduce cost, increase safety, and enhance vehicle efficiency and utilization.



In the current market, most vehicles are already equipped with Level 1 (Driver Assistance) and Level 2 (Partial Automation) automation or Advanced Driver Assistance System (ADAS) features that include lane-keeping assistance, emergency braking assistance, proximity warning, adaptive cruise control, and so on. Moreover, in various countries, the installation of the ADAS system has become a regulatory requirement in all upcoming vehicles.

ADAS adoption across global car shipments will reach 78.7% by 2024.

The next significant transformation in the autonomous vehicle segment is from assisted to fully autonomous driving. In fact, the transformation has already started with Level 3 (Conditional Automation) features being introduced in vehicles. At CES 2023, Mercedes-Benz became the first automaker to launch Level 3 Self-Driving in the United States. It is expected that L3 and L4 features will be available in vehicles by 2025 in Europe and North America.

In this journey to fully autonomous driving, OEMs are focusing on co-developing software (neural networks) and hardware (chips) through partnerships, start-up alliances, and building in-house competencies. OEMs are also investing in R&D on more flexible and reusable software and hardware-driven architectures that are easy to upgrade.

Tesla is one of the first companies to use deep neural networks for autonomous driving.

In recent years, Elon Musk's Tesla Motors has become synonymous with cutting edge technology, and the automotive giant continues to roll out new innovations. Its latest advancement is the integration of neural network technology into its vehicle navigation and control systems.



The major technology trends the segment is witnessing include:

-  Sensor fusion
-  Automotive human-machine interface (HMI) design
-  Vehicle AI/ML and neural networks
-  Advanced semiconductors and custom processors designed to handle autonomous driving applications
-  Generative AI
-  5G integration
-  Embedded vision-based systems



Waymo is all set to provide fully driverless rides in San Francisco.

Waymo can now provide driverless rides to passengers in San Francisco. On Friday, the California Public Utilities Commission (CPUC) said it granted the Alphabet-owned Waymo a permit to participate in its driverless pilot program, which lets autonomous vehicle (AV) companies transport passengers in test AVs without anyone at the wheel.

Cruise, Honda are testing autonomous vehicles in Japan.

We recently started testing AVs [autonomous vehicles] in Tochigi, Japan," Vogt said. "Unlike me, our AI systems for prediction and planning quickly re-learned how to drive well on the other side of the road.

With the rise of autonomous driving, another new opportunity and revenue stream emerges to reengineer the vehicle interiors to be more spacious,

passenger-centric, and sustainable designs with haptic and motion controls, projected displays, rearrangeable seating, and so on.

THE 5G WAVE

5G will be one of the key enablers of more reliable vehicle communication, which will play a crucial role in managing the safety challenges of connected mobility. Battling the challenges of existing direct and network-based communications (4G/LTE, satellites, and DSRC), 5G brings the promise of super data transfer speeds, ultra-low latency, and exponentially increased device density that will improve reliability, enabling new use cases such as

real-time local updates, blind spot monitoring, and smart city integrations.

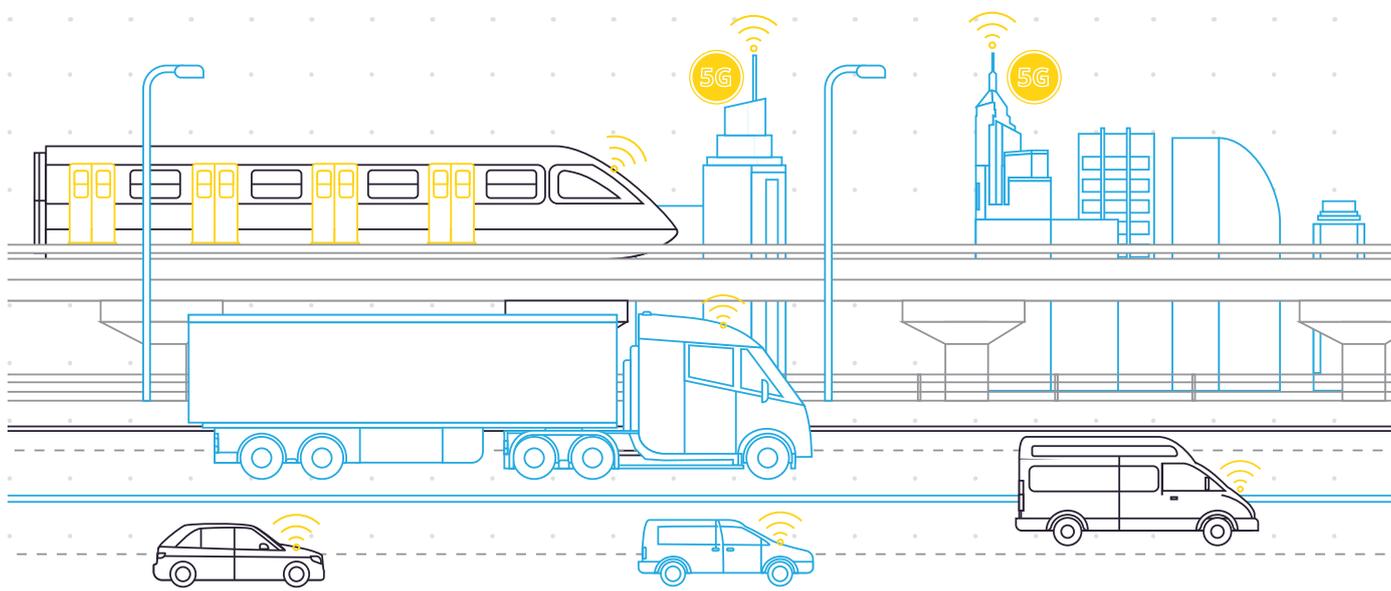
5G-based vehicle-to-everything (V2X) communication or cellular vehicle-to-everything (C-V2X) will drive how vehicles communicate with each other and everything around them. It will provide a 360° non-line-of-sight awareness, adding an increased level of predictability for enhanced road safety.

Porsche Engineering and Vodafone Business have created Europe's first 5G hybrid mobile private network (MPN) at Nardò Technical Center (NTC) to develop intelligent and connected vehicles.

The proving ground in Southern Italy, which is owned by Porsche and operated by Porsche Engineering, now offers its customers a real-time communication network, which promises reduced delays, and faster deployment time.

Autotalks enhances its 5G C-V2X chipsets with proteanTecs deep data analytics.

HAIFA, Israel, Aug. 16, 2022 /PRNewswire/ -- proteanTecs, a global leader of deep data analytics, announced today that Autotalks has selected the company's health and performance monitoring solutions to enhance reliability of the TEKTON3 and SECTON3—the world's first chipsets to support 5G vehicle-to-everything communication.





ADDING THE ARTIFICIAL INTELLIGENCE (AI) FACTOR

AI is already driving the connected mobility sector with refined machine learning (ML) algorithms. OEMs are leveraging AI interfaces to create superior, personalized in-vehicle experiences through:

-  Cutting-edge in-vehicle infotainment systems that serve as virtual personal assistants to drivers coupled with voice commands.
-  Integration of real-time driver, vehicle, and environment data to detect safety risks or quality issues and enable immediate action.
-  Usage of data from vehicle sensors and analytics to understand and predict driver behavior.

In research conducted during the Thanksgiving rush hour in Nashville, Tennessee, US researchers successfully leveraged AI in a group of wirelessly connected cars to help ease rush hour “phantom” traffic on a major road.

Further advancements in AI/ML could also help solve the biggest roadblock in autonomous driving – human behavior prediction.

Qualcomm Innovation Fellowship and Toyota Research Institute supported research at Massachusetts Institute of Technology (MIT), where MIT researchers created a behavior prediction framework that can predict the next moves of nearby drivers, cyclists, and pedestrians more accurately than any framework before it.

The world is witnessing a sudden increase in the number of vehicles on the road, leading to problems like traffic jams, roadblocks, and lack of parking spaces. OEMs can leverage advanced connectivity features like vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I), clubbed with AI and ML, to mitigate these challenges, improving the driving experience and fueling their growth.

SoundHound recently showcased its dynamic interaction with Generative AI serving a variety of products and services in an in-vehicle demo.

SoundHound AI, Inc SOUN +0.90% + Free Alerts launched Dynamic Interaction With Generative AI, further extending the capabilities of its landmark real-time, multimodal interface by granting users hands-free access to a vast wealth of ideas, information, and sophisticated search functionality.

Honda invests in the US-based Helm.ai to strengthen its software technology development.

Honda Motor Co., Ltd. today announced that, in December 2021, the company invested in U.S. (California)-based Helm.ai to strengthen its software technology development in the areas of artificial intelligence (AI) and computer vision technologies.



ADDRESSING SAFETY AND SECURITY CONCERNS

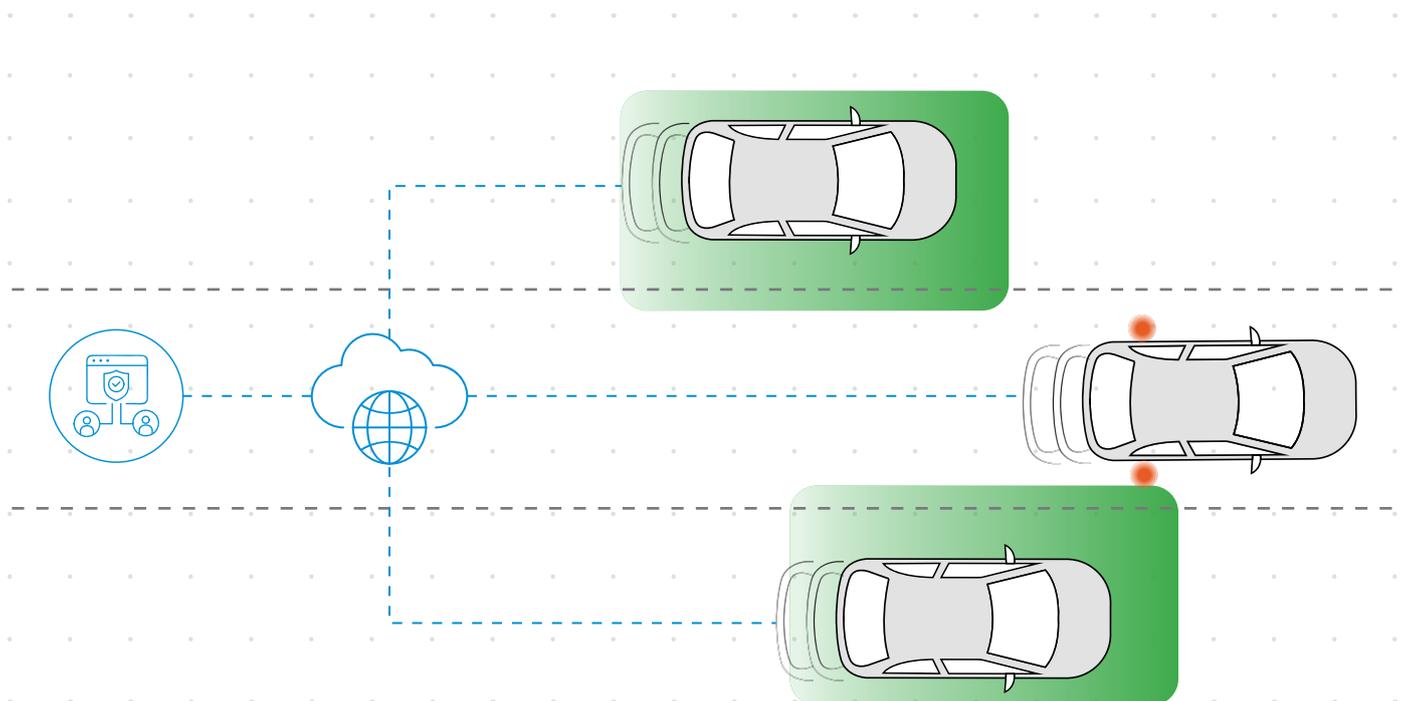
Connected cars leverage wireless and internet technologies to communicate with other vehicles, networks, and infrastructure. With the rise of the smart technologies ecosystem, connected cars have the potential to transform the transportation industry in multiple ways.

A key area where connected cars can make a significant impact is passenger safety and security.

Connected cars have the ability to constantly communicate with their surroundings and collect real-time data about weather conditions, traffic patterns, and road construction activities. This information can be used to alert drivers and help them make informed decisions while on the road. In addition, connected cars also play a crucial role in enhancing

passenger security, by enabling features such as automatic emergency calling systems/ emergency calling systems (eCall/SOS Alerts) and remote vehicle tracking to assist in case of emergencies or theft. These features allow passengers to quickly call for help and provide their precise location, making it easier for emergency responders to reach them.

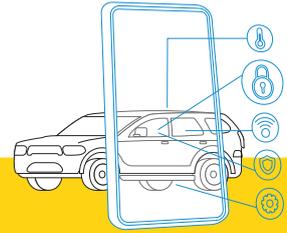
Yet another benefit of connected cars is the ability to monitor driver behavior and identify potential risks. By analyzing data such as speed, braking patterns, and lane changes, connected cars can alert drivers if they are driving recklessly and provide suggestions for safer driving. This not only helps prevent accidents but also promotes responsible driving habits among passengers.



CYBERSECURITY FOR THE VEHICLES OF TOMORROW

Electric Autonomous Connected Vehicles (EACVs) are not just a mode of Point A to B transportation. They are a hub of advanced hardware, sensors, cameras, processors, systems, and apps – forming a complex ecosystem of millions of lines of code.

As the complexity of these EACV ecosystems increases, however, so does the surface of potential cyberattacks, making it a crucial factor in driving market demand for cybersecurity in EACVs. Therefore, while global automotive manufacturers, Tier-1s, and OEMs continue to focus on ways and means to enhance driver and passenger safety, comfort, and experience, there is a growing focus on ensuring data privacy and securing and protecting the EACV infrastructure and network from unwanted intrusions.



The automotive industry is expected to lose a whopping USD 505 billion by 2024 to cyberattacks. - 2022 Global Automotive Cybersecurity Report

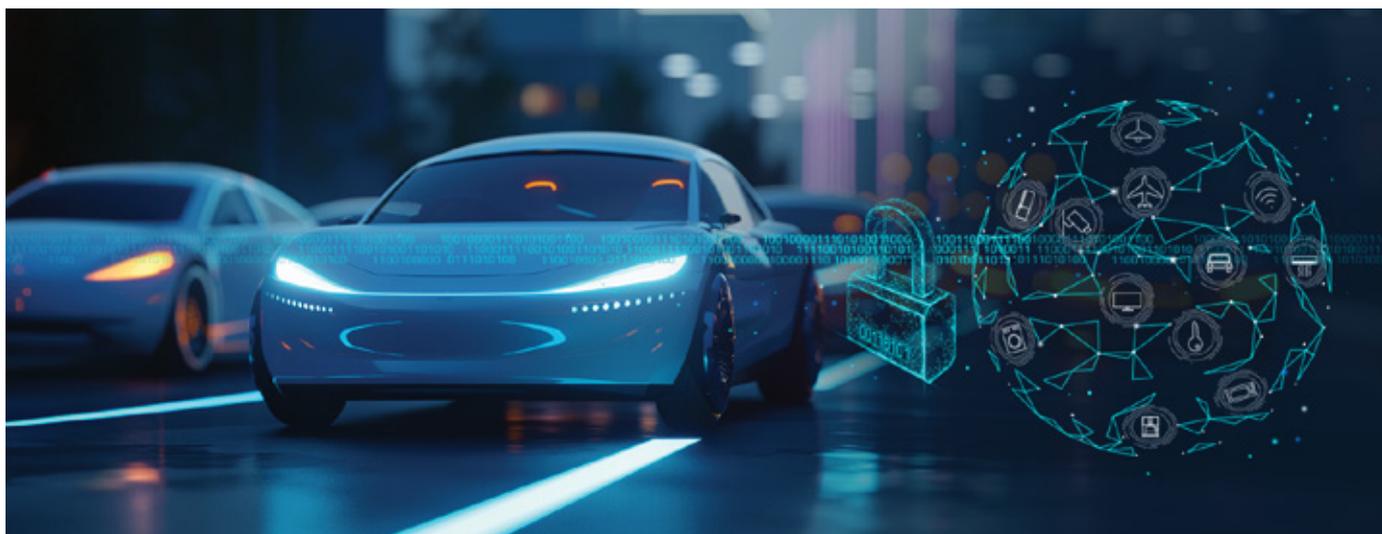
Cyberattacks can have both internal (revenue loss, lawsuits, and reputational damage) and external (personal data theft, vehicle theft, car accidents, and disabled vehicles) impacts on manufacturers and OEMs. Data servers, keyless entry, electronic control units (ECUs), mobile apps, and in-vehicle infotainment (IVI) systems have emerged as some of the top attack vectors for hacking a connected vehicle.

Hacker shows how to unlock, start and drive off with someone else's Tesla.

Tesla Inc. customers might love the carmakers' nifty keyless entry system, but one cybersecurity researcher has demonstrated how the same technology could allow thieves to drive off with certain models of the electric vehicles.

Jailbreaking John Deere: "Doom" on a tractor reveals big edge security implications.

The jailbreak, developed by an independent researcher known only as Sick Codes, allows users to bypass security restrictions on John Deere equipment. At DEF CON earlier this month, he showed off how to break into a vintage Deere monitor and played the classic first-person shooter Doom game on Deere's hardware.



To address the cybersecurity challenges, OEMs and Tiers 1's are adopting "secure by design" principles across the product development lifecycle and implementing data encryption, hardware security modules (HSM), incident response and readiness, and network security and segmentation. Further, they are implementing best practices and creating their own cybersecurity strategies. In 2021, the [International Standardization Organization \(ISO\)](#) and the [Society of Automotive Engineers \(SAE\)](#) published a

[joint automotive cybersecurity standard](#). It outlines a pragmatic approach for cybersecurity professionals and product developers to create a solid foundation to integrate cybersecurity within their product development lifecycle.

Due to its decentralized nature, blockchain can play a significant role in ensuring vehicle cybersecurity. For instance, it can help secure payment transactions on automotive networks.

German automakers targeted in year-long malware campaign.

A years-long phishing campaign has targeted German companies in the automotive industry, attempting to infect their systems with password-stealing malware.

Hitachi Astemo, Ltd. and Trend Micro Inc. and its subsidiary VicOne Inc. expanded their collaboration to provide security solutions for connected cars.

Hitachi Astemo, Ltd., Trend Micro Inc. and its subsidiary VicOne Inc. have expanded their collaboration to provide security solutions for connected cars, aiming for commercialization by 2025.

SpiceJet: Passengers stranded as India airline hit by ransomware attack.

India's SpiceJet airline said its systems faced an "attempted ransomware attack" on Tuesday, delaying flights and leaving many stranded at airports.



REAL-TIME TELEMATICS – CONNECTING THE VEHICLES OF THE FUTURE

Connected vehicles today do not just collect data on the vehicle's health but also interact with their environment (V2X). As more and more fleet owners recognize the benefits of monitoring their fleet activities to reduce costs, boost productivity and efficiency, improve fleet safety and uptime, and ensure compliance with government regulations, telematics continues to witness exponential growth.

To capitalize on these trends, manufacturers and OEMs are equipping their vehicles with advanced connectivity by taking advantage of AI, data insights, modern GPS units, electronic logging devices (ELDs), advanced sensors, cameras, and widespread mobile design usage. Further, technologies, such as software development kits and application programming interfaces,

continue to increase the use of telematics by integrating with other business systems like route planning, maintenance, risk management, and safety compliance.

AI and data insights, paired with the real-time video feed and sensors, unleash the true power of vehicle data to help fleets reduce their environmental footprint. This, combined with real-time digital twins, enables fleet owners to stay competitive by benchmarking their operations with real-world data. Additionally, these data insights provide fleet owners with an unprecedented level of visibility into their fleet operations, allowing them to make data-driven decisions and improve overall efficiency.

Volvo Trucks has introduced route planning and connected technology tools to support customers in scaling electromobility solutions.

Volvo Trucks North America is introducing two new innovative technology tools to support customers in successfully deploying Volvo VNR Electric Class 8 models into their fleet operations.

Jaguar Land Rover, what3words, and HERE deliver OTA navigation solutions.

Jaguar Land Rover is offering customers accurate and precise navigation even in the most remote locations, by becoming the first automotive manufacturer to integrate what3words global location technology into vehicles already on the road through a software-over-the-air (SOTA) update.





WHAT DOES THE FUTURE HOLD?

The demand for connected mobility is growing at a tremendous pace owing to the emergence of on-demand services and heightened experience and ease, and there's no stopping the future of the automotive world from getting connected. The future of connected mobility is expected to be driven by data, vehicle AI, advanced software, vehicle electrical/electronic (E/E) architecture, cybersecurity, and metaverse, among other trends.

DATA: DRIVING THE CONNECTED LANDSCAP

The advent of connected mobility presents a significant opportunity for manufacturers and OEMs to capitalize on the valuable data generated by these systems. As consumers demand increased personalization in their vehicles, this data becomes a crucial tool in delivering a truly personalized experience. A connected vehicle is therefore, in essence, a mobile data center providing unique insights into customer behavior and preferences. To fully leverage this data, companies need to shift their focus from a singular

one-time sale to acquiring and retaining customers for the long term.

Software-driven vehicle architecture, the digitization of customer interactions, and the effective use of data from the connected vehicle ecosystem are essential for realizing the potential of hyper-personalization. By utilizing these strategies, manufacturers and OEMs can create a truly customized experience for their customers throughout their ownership journey.

Automotive manufacturers and OEMs can leverage the data to unearth new opportunities for data monetization, such as:



Generate revenue through functionality and service customization and subscription (add-ons). For instance, a younger driver can opt for a better infotainment system add-on, wherein an elder driver may want a better safety features add-on.



Add value to existing products, such as partnering with insurance companies to provide usage-based insurance.

GM aims to build Netflix-sized subscription business by 2030.

General Motors said it expects its in-car subscription services to generate nearly \$2 billion in revenue this year and will reach as high as \$25 billion by the end of the decade, an amount the company said Wednesday will put it in the same league as Netflix, Peloton and Spotify.



Another interesting revenue opportunity becomes visible when we think about connected cars and autonomous in the context of smart cities. Auto manufacturers and OEMs can partner with smart cities to provide them insights for:

- // Creating systems to estimate and predict traffic movements
- // Enabling parking and signal management systems
- // Allowing authorities and first responders to respond quickly to accidents and collisions
- // Reducing emissions
- // Minimizing commute times
- // Predictive maintenance of public transport

DIMO helps drivers gain and monetize their car data.

One Michigan-based driver sold his car for \$7,000 more than what he would have at his local dealer just by using data gathered by DIMO, an open-source, decentralized project that aims to connect drivers and their data with developers and manufacturers. As DIMO sees it, car data can provide valuable and monetizable insights – but drivers often aren't the ones benefiting. DIMO wants to change this.



Software will Play a Crucial Role

The software has taken center stage as the driving force behind critical advancements in the automotive industry, specifically in the areas of EACV. OEMs must shift towards a software-centric approach, including the development of a new electrical/electronic (E/E) architecture and the adoption of processes and best practices to support efficient software development.

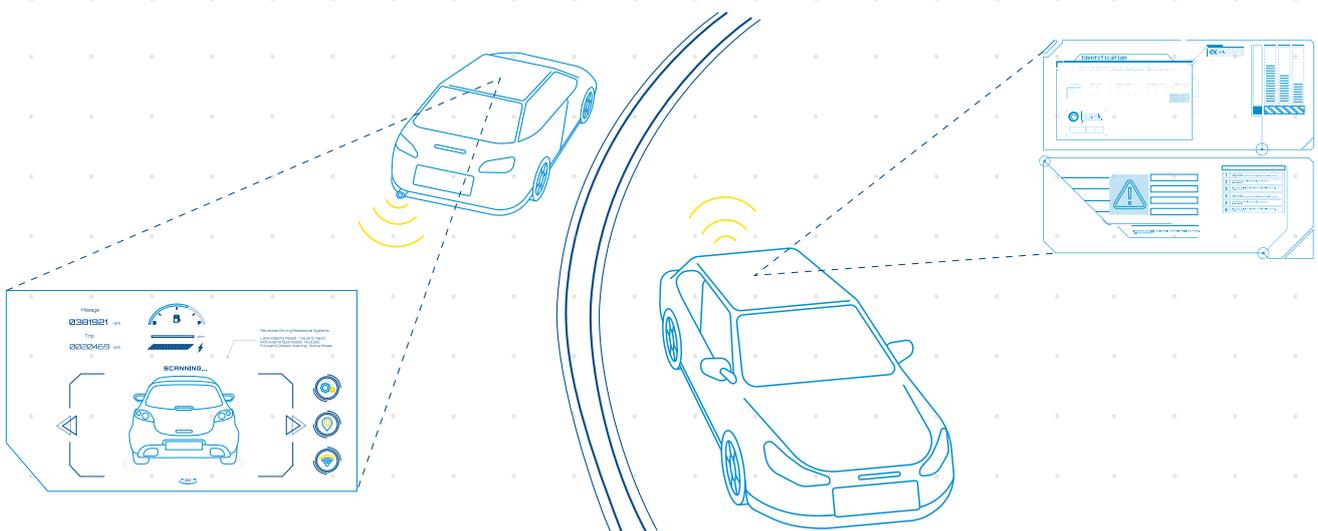
One of the key advantages of a software-driven approach is the ability to offer features on demand, supported by software updates. Tesla has been a pioneer in this space by enabling feature upgrades and fixes remotely via software updates. Many other OEMs are now also looking to offer similar options.

Developing the infrastructure to deliver vehicle features via software updates makes it possible to respond quickly to customer needs and offer capabilities tailored to specific journeys. For instance, a vehicle owner might opt for highway-driving assistance capabilities for a long drive planned over a long weekend.

To stay ahead in this emerging software-centric model, OEMs must develop strategies to decouple hardware from software on technical and operational levels. They must clearly define and uphold their target values, strive for operational excellence, and make strategic organization-wide optimizations.

At CES 2023, Qualcomm unveiled Snapdragon Ride Flex SoC to bring software-defined vehicles to reality.

The annual Consumer Electronics Show (CES), held in Las Vegas from January 5 to 8 this year, focused primarily on the automotive, IoT, smart home, healthcare, metaverse and XR, AI and computing segments.



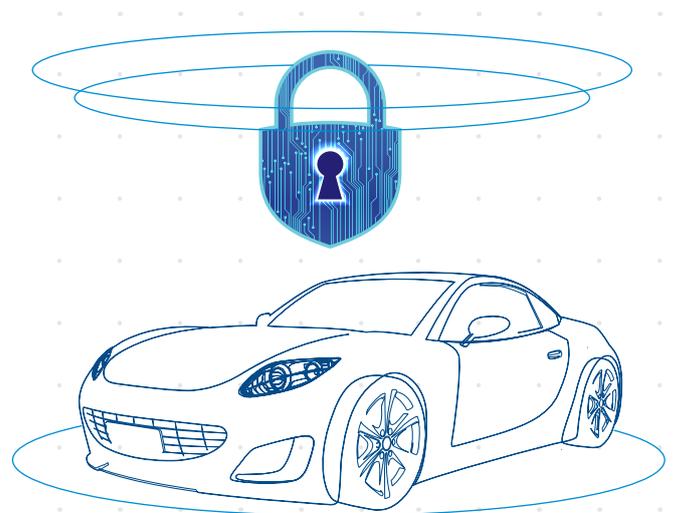
CYBERSECURING THE CORE: ENSURING SEAMLESS MANUFACTURING PARADIGMS FOR CONNECTED MOBILITY

Industry 4.0 adoption exposes manufacturers and OEMs to new cyber threats and vulnerabilities. Any information that travels through the internet is at risk of being targeted by cyber-attacks. For instance, migrating manufacturing data from factory floor Operational Technology (OT) systems to interconnected Information Technology (IT) systems within the corporate network can lead to the emergence of newer risks. During migration, this data may be more vulnerable, and cyber criminals could potentially gain access to sensitive information, disrupt production schedules, and affect product quality.

To mitigate these risks, manufacturers and OEMs must take a holistic approach to cybersecurity in the manufacturing setting, even if some processes are not connected to the internet. Hackers or attackers may use connected devices to

gain access to other parts of the setting or steal sensitive information from non-connected processes.

Additionally, it is essential to be vigilant in vendor management, as third parties with authorized access to a company's network can become unknowing avenues of attack. A bad actor with access to the login credentials of these external partners can potentially get unauthorized access to the company's network and levy a heavy price.



Honda global operations halted by ransomware attack.

Honda has confirmed a cyberattack that brought parts of its global operations to a standstill.

Ferrari falls victim to ransomware attack; 7GB of its internal documents made public.

Italian luxury sports car manufacturer Ferrari might have become the latest victim of a ransomware attack. As per a Reuters report, internal documents belonging to the brand had been posted online.

Toyota halts production after reported cyberattack on supplier.

Japanese automaker Toyota Motors has announced that it stopped car production operations.

THE METAVERSE SHOWROOM

The global automotive industry is undergoing a digital transformation driven by digital-only online sellers, evolving consumer requirements, increased connectivity, and the rise of the sharing economy. Metaverse, the new buzzword in the industry, is emerging as a means to accelerate growth and create immersive customer experiences.

By 2026, an estimated 25% of people are expected to spend at least one hour per day in the metaverse, providing opportunities for improving customer engagement. Primary use cases for automotive companies include virtual dealerships and experience centers, meta factories, live events, workforce training, and in-world advertising.

The global metaverse automotive market is expected to reach \$16.5 billion by 2030.

The rapid growth of the metaverse industry is being driven by the growing interest of automotive manufacturers in developing technologies like digital twin factories and virtual showrooms in the metaverse space. Software companies and start-ups are also developing AR/VR technologies to be used in cars. In addition, metaverse technologies are making it easier to simulate and test vehicles.

Automotive companies are leveraging the metaverse to connect with Gen Z customers and streamline operations with virtual experience centers, virtual factories, and remote workforce training.

MG Motor launches Metaverse platform MGverse with five experience centers.

Automaker MG Motor on Monday said it has launched a Metaverse platform MGverse to provide an immersive experience to its customers and stakeholders through multiple arenas.

Auto manufacturers like Toyota Motor North America and Nissan Motor Corporation are training their employees virtually, without experts and paper manuals present physically. FIAT launched a virtual FIAT 500 showroom hosted in the metaverse, where customers in Italy can discover the vehicle by interacting with product specialists, simulate a test drive, and purchase a new vehicle from the comfort of their couches.

FIAT Metaverse Store, the world's first metaverse-powered showroom, a revolution in customer experience.

FIAT Metaverse Store is the world's first metaverse-powered interactive showroom, which makes the brand a front-runner in offering an immersive and simple brand experience.



THE SHARED MOBILITY POTENTIAL: UNLOCKING NEW VALUE STREAMS

Although private vehicles remain the most preferred mode of transportation, consumer demand is growing for more convenient and cost-effective modes of commuting. Combined with a growing concern about sustainability, this is driving the shift from privately owned vehicles to on-demand shared mobility or Mobility-as-a-Service (MaaS). The availability of flexible and high-quality shared and public transport options could also help minimize emissions and reduce parking issues and traffic congestion.

Evolving connected mobility technologies (cloud, 5G, AI/ML, and real-time telematics) offer exciting new revenue streams for auto manufacturers and OEMs in the MaaS segment, as these technologies and their data are the keys to providing a hyper-personalized experience. Additionally, once fully autonomous vehicles become prevalent

on roads, the future of shared mobility will be driven entirely by platforms and apps, in-vehicle entertainment, comfort, and safety.

To capitalize on this growing shared mobility trend, automotive manufacturers can consider engineering purpose-built vehicles for mobility on demand, including shared mobility shuttles, and offering MaaS through subscription models to consumers and shared mobility providers. Moreover, as shared mobility moves beyond public transport and cars to personal vehicles including bikes, e-bikes, and even electric scooters, automotive manufacturers could also invest in designing autonomous two and three-wheelers for shared micro-mobility. These new concepts may provide OEMs the opportunity to capture newer revenue streams in the market of declining private vehicle ownership and usage.

First robotaxi service launched on Uber Network.

Motional and Uber have launched a public robotaxi service in Las Vegas, USA. Now Uber customers can hail an autonomous ride using Motional's all-electric Hyundai IONIQ 5-based robotaxis.

Prague has launched a Mobility-as-a-Service app.

Motional and Uber have launched a public robotaxi service in Las Vegas, USA. Now Uber customers can hail an autonomous ride using Motional's all-electric Hyundai IONIQ 5-based robotaxis.



R&D AND INVESTMENT TRENDS: AN OVERVIEW OF THE CONNECTED LANDSCAPE

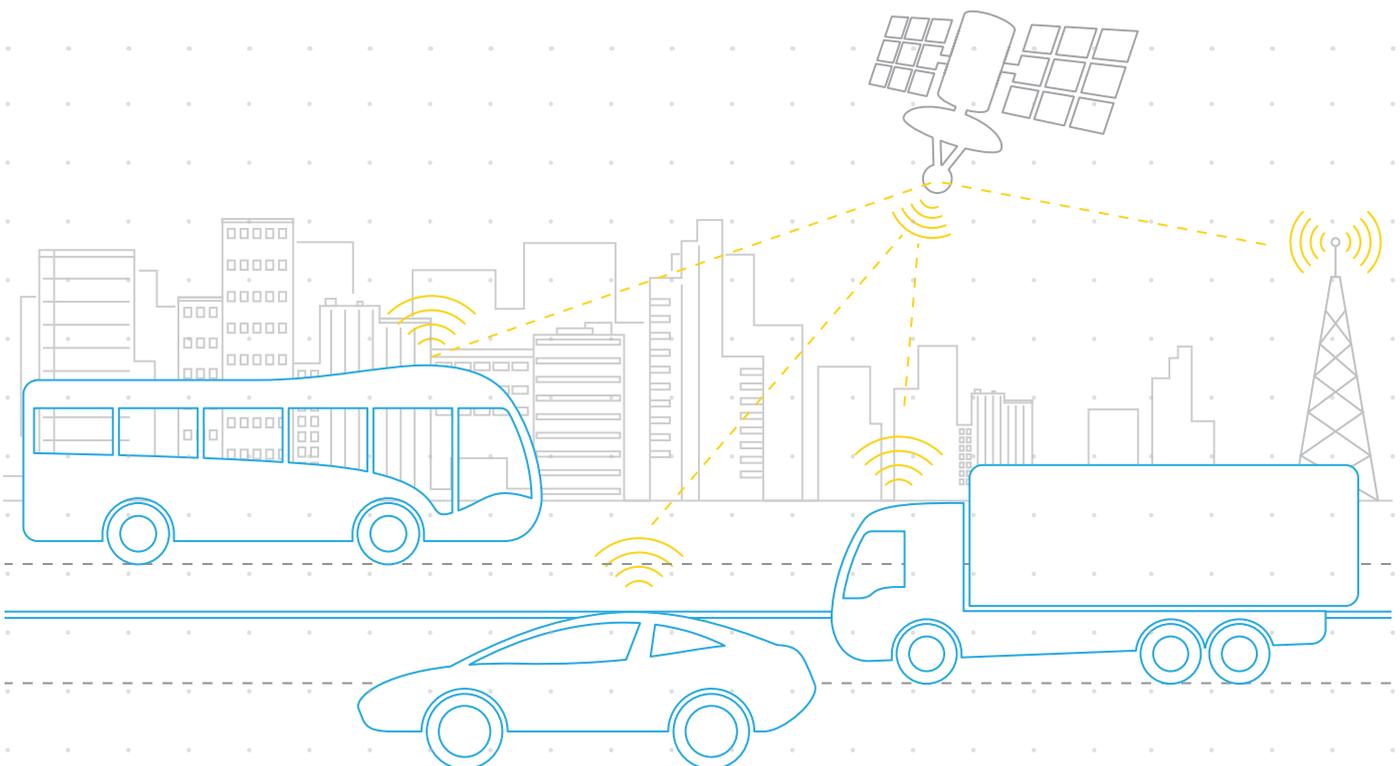
Automotive OEMs are increasingly realizing that although all connected capabilities rely on the technical foundation of connected mobility – the underlying technologies that drive connected mobility also cross paths with vehicle autonomy and electrification. The combined synergies of these trends will power the industry's future transformation.



With the level of connectivity in vehicles growing exponentially, vehicles will soon become the new smartphones on wheels.

As the connected mobility industry evolves, the roles of OEMs and manufacturers expand, and they will need to break the box to stay competitive and seize the connected mobility future. Like other technology industries, the connected mobility industry, too, is moving towards add-ons and subscription-based services, leading to manufacturers actively investing in:

-  **Digital Cockpit**
-  **Telematics**
-  **V2X offerings**





Connected mobility: Investment priorities

Manufacturers are actively investing in...

INFOTAINMENT



Focus on connectivity with the Driver/Passenger

Enhanced animated UI/ UX
Digital cockpits
Testing & validation

KEY FOCUS AREAS

- // HMI software development & integration
- // IVI & Cluster Apps validation
- // Advanced Display Systems - AR/VR
- // Multimedia simulation & testing

TELEMATICS



Focus on connectivity with the Cloud

Software updates
Data Management
Intelligent Transportation

KEY FOCUS AREAS

- // Telematics Control Unit (CU) Development
- // Fleet Management
- // Predictive Maintenance & diagnostics
- // Over-The-Air updates - SOTA/FOTA

V2X (VEHICLE-TO-EVERYTHING)



Focus on connectivity with the Environment

5G Connectivity
Driving Assistance
Crash Avoidance

KEY FOCUS AREAS

- // Remote Monitoring & Control
- // C-V2X systems Integration & Deployment
- // Feature Development & Testing
- // Cybersecurity integration with Functional Safety

DIGITAL COCKPITS

The mass adoption of smart gadgets and smartphones has evolved the vehicle consumer base to a tech-savvy consumer base, making them expect more from their vehicles' digital cockpits to not only connect to their smartphones but also deliver a seamless experience powered with advanced human-machine interfaces (HMIs). Today, the vehicle cockpit is all digital, fully connected, and software-defined in-vehicle dashboard platform. As a result, the digital cockpit plays a crucial role in unlocking the future of the connected vehicle experience.

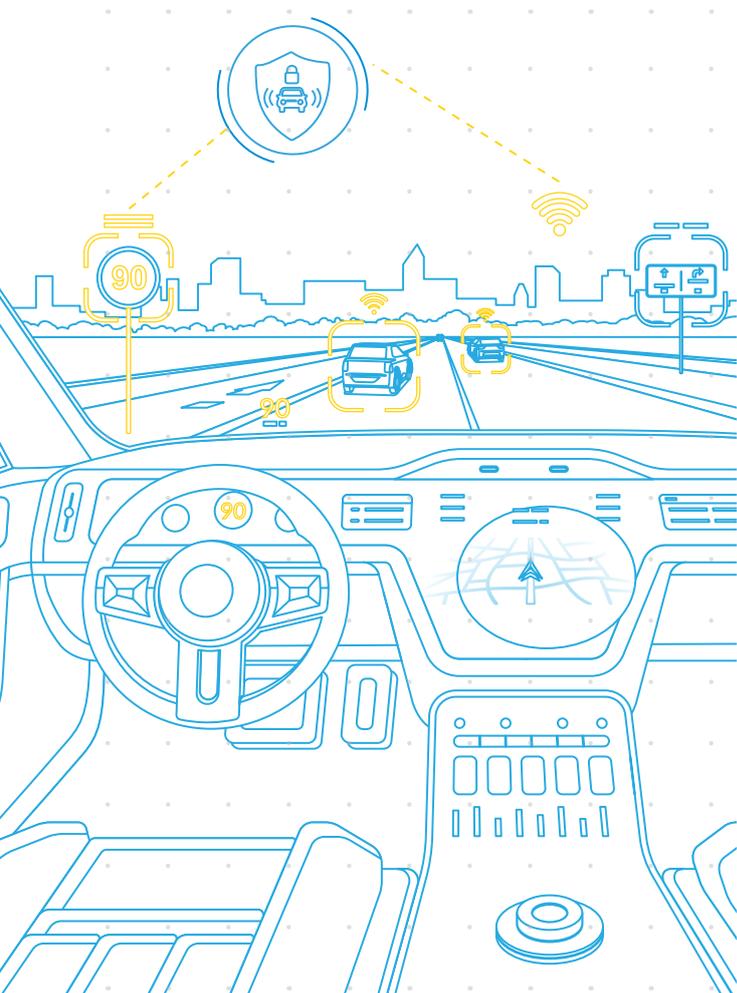
Major technology companies, OEMs, and manufacturers are heavily investing in

creating and innovating the digital cockpit platform and its integration with other connected car features.

Keeping connectivity with the driver and passenger as the focal point, manufacturers realize the criticality of investing in the following:

- // Enhanced user interface and user experience (UI/UX) through next-level HMI software development and integration and advanced display systems equipped with augmented reality and virtual reality (AR/VR).
- // In-vehicle infotainment that transforms itself into an in-vehicle personal assistant, a streaming service, and so on. In this segment, IVI and cluster app development and validation and multi-media simulation and testing are essential.
- // Integration of the digital cockpit with other connected vehicle features like telematics, autonomous driving, etc.
- // Testing and validation of the digital cockpit platform.

With the digital cockpit's current trajectory, it is not far-fetched to see gaming integration in connected vehicles. In fact, gaming consoles could soon become standard in consumer vehicles, with AR displays helping scale the experience beyond the confines of a digital cockpit and into the outside world.



TELEMATICS

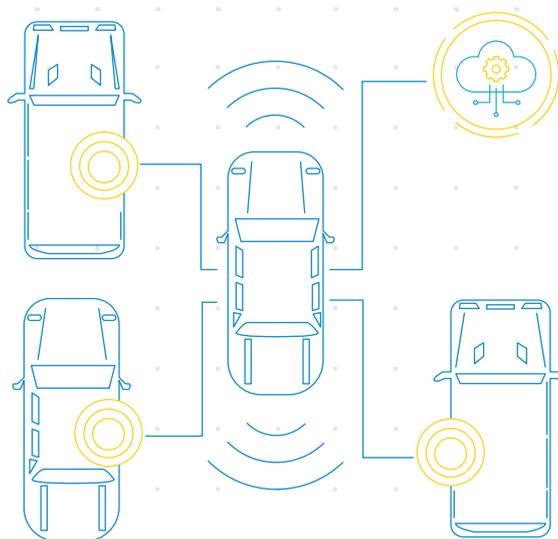
The future of connected car will be driven by next-gen telematics with 5G as a key enabler. Along with 5G, manufacturers, and OEMs will be focusing on edge computing and cloud technology to leverage richer data analytics and insights and enhance fleet efficiency, safety, and productivity.

In this segment, manufacturers and OEMs are actively investing in the following key focus areas in telematics:

5G-ready Telematics Control Unit (TCU) development – With 5G adoption gaining traction, the demand for 5G-ready TCUs is rising and the market is expected to be USD 33 billion by 2033. Next-gen, future-proof TCUs are expected to deliver unmatched performance, enable interoperability, and enhance user experience to unleash truly intelligent transportation. Another crucial investment avenue for OEMs is APIs, as they enable data integration, exchange, and connection between various solutions within and outside of the vehicle (V2X). As telematics customers have become more demanding and familiar with digitalization, APIs provide them with an ecosystem experience where everything is interconnected. They also give customers the ability to expand the ecosystem as per their needs.



Fleet management – As vehicles become more connected and the need for enhanced security and safety grows, it has become extremely critical for fleet management solution providers to deliver seamless software updates, data analysis, and other functionalities. Again, as more electric vehicles (EVs) and autonomous vehicles enter the fleet, access to vehicle data becomes crucial for fleet managers and owners. In fact, managing an automotive fleet has become similar to managing a fleet of devices that involves targeting multiple components and functions on both the vehicle and the cloud sides. Therefore, manufacturers and OEMs must focus on vehicle data collection and analytics using advanced telematics, AI, ML, IoT, and in-vehicle video surveillance.



Predictive maintenance and diagnostics – As EVs, connected mobility, and autonomous vehicles rise, OEMs must rev up the predictive maintenance and diagnostic and vehicle health monitoring engines. With predictive maintenance solutions, issues can be detected early on, enabling OEMs and Tier-1s to conduct software updates remotely (over-the-air), preventing potential crises, and improving the manufacturing process and quality of future vehicles and their components. This results in significant cost savings on maintenance, increased sustainability, and enhanced reliability for fleet owners, Tier 1s, OEMs, and manufacturers. The auto industry today is therefore focusing on creating a holistic, integrated predictive maintenance and vehicle health monitoring system powered

by advanced technologies like IoT, AI/ML, cloud, edge computing, and real-time digital twins.

Over-the-air (OTA) updates – In the era of software-defined vehicles, software updates are more than just bug and security gap fixes. Software updates are about providing additional functionality in existing products and services to address the user's needs. As network connectivity becomes universal, manufacturers are focusing on software over-the-air (SOTA) and firmware over-the-air (FOTA) updates as differentiators in the software-defined vehicles as it saves both effort and time while addressing consumers' ever-evolving demands. Further, manufacturers and OEMs have realized the potential of OTAs in vehicle issue resolution, cybersecurity enhancement, and as a revenue and subscription opportunity.



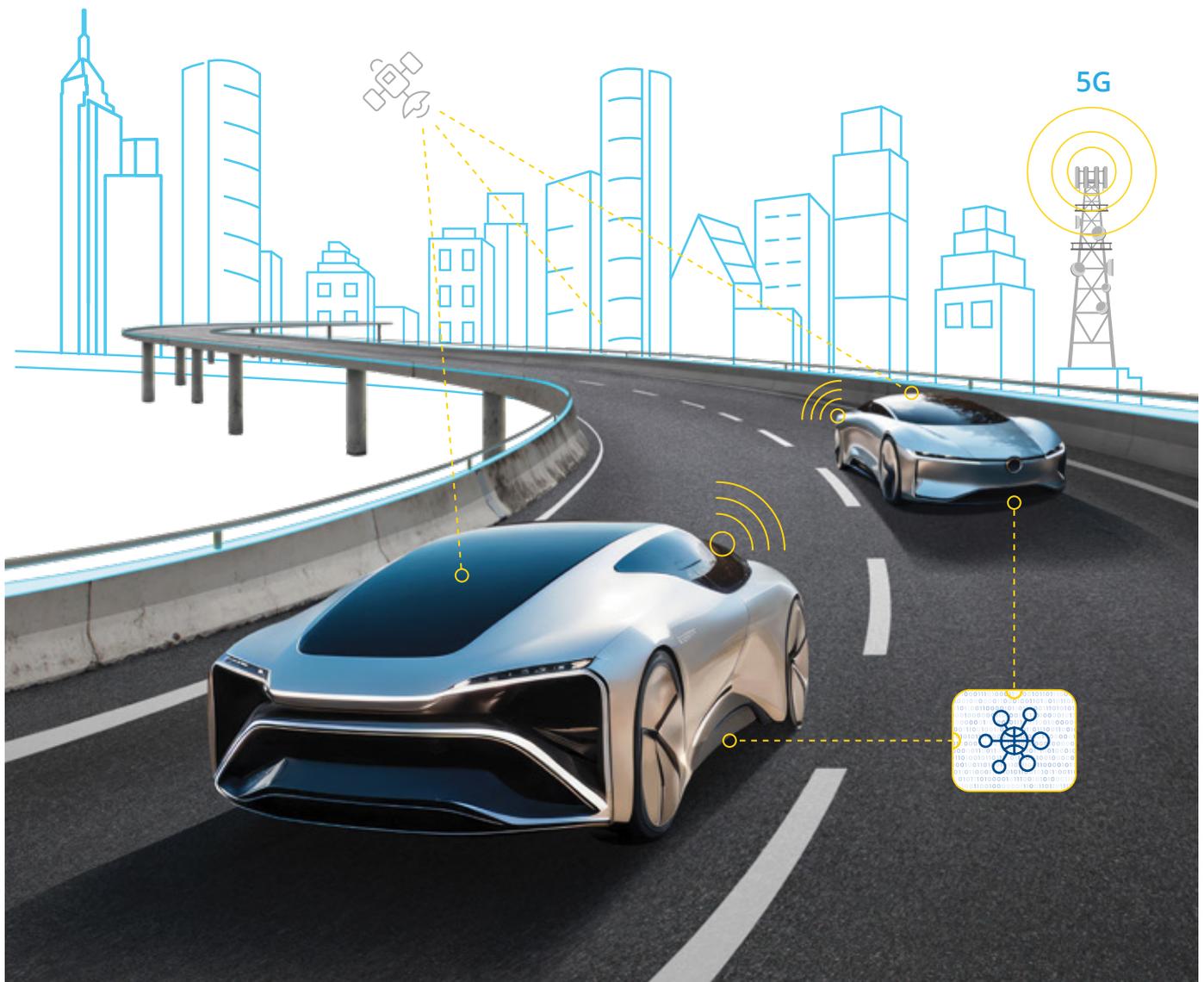
VEHICLE-TO-EVERYTHING (V2X)

The global V2X market is expected to reach USD 19.6 billion by 2028 – Markets and Markets

Increased adoption of vehicle autonomy, the evolution of cellular networks (5G), demand for driver and passenger safety and cybersecurity, growing smart cities, and increasing popularity of telematics are driving the growth of the V2X market. With a range wider than a dedicated short-range communication (DSRC) and

lower latency, 4G LTE and 5G-based C-V2X will boost real-time data communication. And when combined with onboard vehicle intelligence, AI/ML, and predictive maintenance, C-V2X will accelerate intelligent transportation and level 3 and above autonomous driving.

The C-V2X market is expected to exceed the valuation of USD 6 billion by 2030 – Global Market Insights



Keeping driver and passenger safety as key, OEMs and manufacturers are investing in the following key focus areas in V2X:

-  Remote monitoring and control – Autonomous vehicles are becoming more prevalent, making it important to have the ability to remotely monitor them and provide support, such as contacting emergency services, remotely controlling the vehicle to move it to a safe location, and real-time communication with passengers or pedestrians. With safety being the top priority and the biggest barrier for autonomous vehicle manufacturers, V2X-enabled real-time monitoring and control of vehicles have become a top R&D and investment priority for manufacturers and OEMs. Moreover, for the connected and electric vehicle segments, too, remote monitoring and control play a significant role in battery management, safety and smart driving, fault alert and preventive maintenance, real-time communication of the telematics data, and so on.
-  C-V2X systems integration and deployment – Manufacturers and OEMs are actively investing in the transition of V2X applications to C-V2X. This transition is unlocking newer features and functionalities that were not possible with the DSRC, such as platooning, advanced autonomous driving, remote driving, and so on.
-  Feature development and testing – The features that can be unraveled through V2X are limitless. More than ever, manufacturers and OEMs must invest in new feature development and testing.
-  Cybersecurity integration with functional safety – Significant development in V2X and the large amount of data transmitted through V2X are not hidden from hackers and cybercriminals, leading to an increase in cyberattacks (phishing attacks, brute force attacks, ransomware attacks, and VANET attacks such as man-in-the-middle attack, Denial of Service (DoS), malicious code, etc.). Cybersecurity, therefore, has taken center stage with manufacturers and OEMs. They must find ways to minimize the attack surfaces and assure limited and controlled access to security assets. For manufacturers and OEMs, developing and integrating the cyber-defense solution with V2X has become a key R&D area. The evolution of cybersecurity solutions for connected vehicles must go hand in hand with the evolution of connected mobility features.



An acceleration in the pace of vehicle software innovation is driving the rapid adoption to L1-L3 autonomous features among global automakers and shaping the emergence of Software Defined Vehicles. This growing focus on software is enabling OEMs worldwide to increase the value of a vehicle by offering new features and functionalities over-the-air (OTA). Periodic OTA updates help improve safety, comfort, and performance, while leveraging new age AI capabilities opens up untapped areas of collaboration and growth across enabling predictive maintenance, streamlining service monetization, and enhancing overall customer satisfaction in the connected vehicle ecosystem.

 **Madhav Komaragiri**
Vice President – Automotive, L&T Technology Services

LTTS' TECHNOLOGY, R&D, AND INVESTMENT AREAS

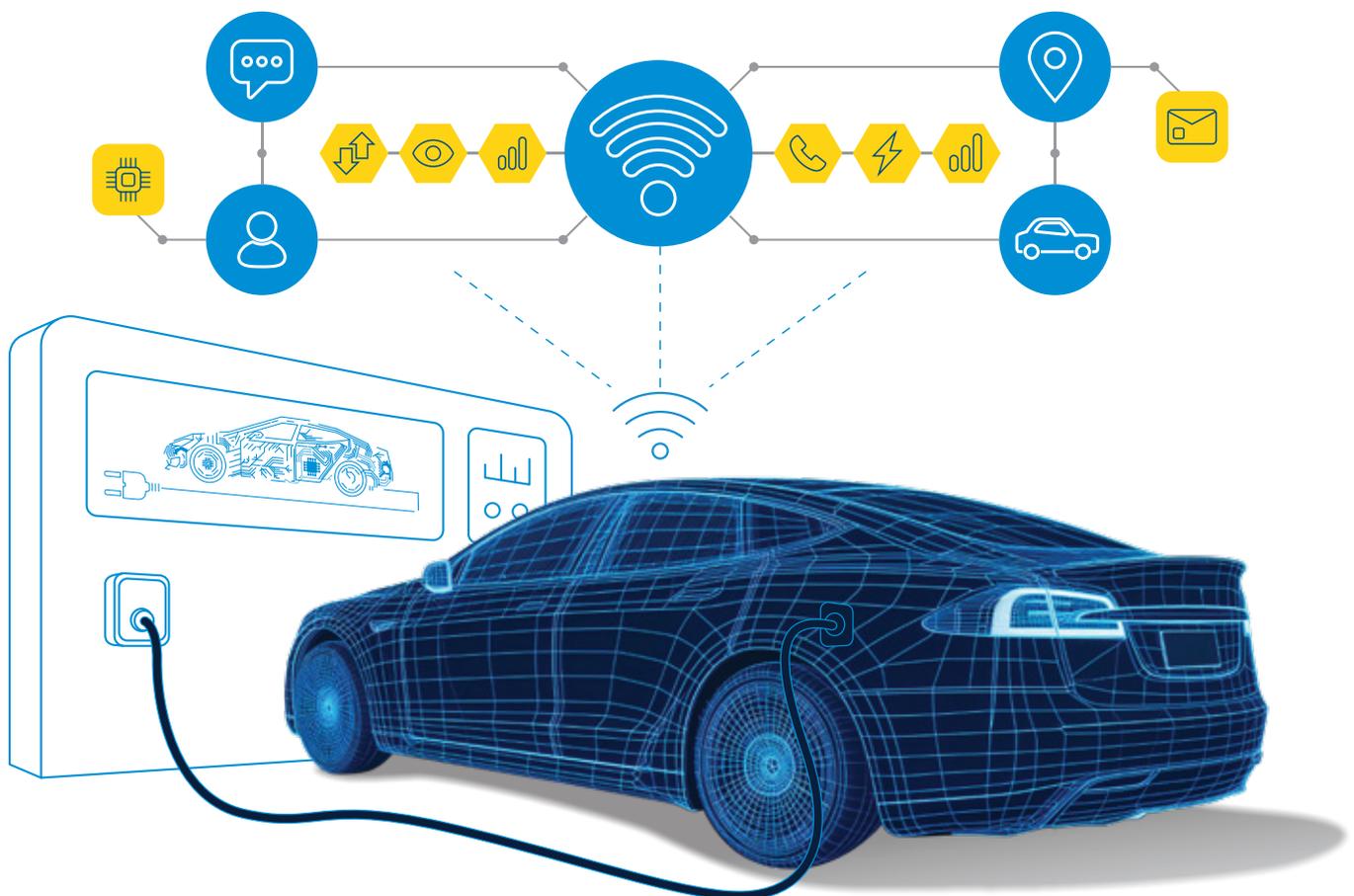


LTTS' TECHNOLOGY AND SOLUTIONS

The automotive industry is amidst a transformation journey toward a hyperconnected, software-driven, and intelligent tomorrow, one that surpasses the legacy “driving experience” mindset. Consumers today no longer see the connected vehicle as just a vehicle, but rather, as a ‘system of systems,’ an intelligent, connected, and personalized ecosystem with the consumer experience, safety, and convenience at the center.

There is no doubt that the future of mobility lies in EACV technologies. And traditional car manufacturers and OEMs face the challenge of balancing their

current priorities of improving products, operations, and finances while acquiring the necessary skills and technologies to compete in the emerging EACV market. Again, as non-auto companies and technologies enter the market, traditional OEMs must form partnerships with other engineering players and EACV leaders to reduce the costs and risks of entering this new market. L&T Technology Services (LTTS) believes in building long-term relationships with our partners and customers to engineer the future of connected mobility.





Our Connected Mobility Centre of Excellence (CoE) is focused on the following key areas:



V2X Connectivity and Telematics

- A proprietary end-to-end telematics platform (onboard and offboard)
- Network operator integration and interoperability
- V2X and C-V2X system integration and deployment



Digital Cockpits

- AUTOSAR-based turnkey development for IVI, cluster, and head-up display (HUD) on a single ECU
- Platform software development
- HMI and application software development
- Hardware and mechanical component design and development
- Testing and validation

Testing and Validation

- Testing and validation
 - Systems integration and validation
 - Test bench development and commissioning
 - Connected services testing
- Test automation
- Interoperability testing
- Feature testing



Connected Vehicle Services

- Onboard or crowd data collector development and integration
- Local or regional eGovernance system integration
- Vehicle data management and analytics platform-as-a-service



Safety and Cybersecurity

- Cybersecurity through:
 - Penetrative testing
 - Vulnerability assessment
 - Security component development
- DevSecOps implementation and aftermarket support
- Onboard and offboard security management
- Functional safety



5G Offering

- End to End Product Design
- 5G Modem Customization
- 5G System Integration
- 5G Application Support
- Product Sustainance & Maintenance Support
- Device Management
- Testing and Validation
- Certification Support





CONNECTED VEHICLE R&D AND INVESTMENTS

OEMs and Tier1's today are not just manufacturing vehicles but crafting a more connected, personalized consumer experience. And future vehicle architecture's increased connectivity, software, and electronic capabilities are pushing global automotive manufacturers and OEMs to increase their Engineering Research and Development (ER&D) and cutting-edge infrastructure investments.

As a pure-play ER&D services leader, LTTS' top R&D and investment priority in the automotive sector is to create innovative, customer-centric, and connected products and services while accelerating time-to-market and reducing development costs for our customers. The Company is strategically investing in EACV, 5G, digital manufacturing, and AI and digital products as part of its six big bets.





In our endeavor to disrupt the connected mobility market, we have crafted engineering marvels in the form of our in-house accelerators:

Accelerator	Value Delivered
<p>Turnkey Product Development for infotainment cluster and multi-function display</p>	<p>Up to 50% reduction in development time and non-recurring engineering (NRE) efforts</p>
<p>End-to-end Telematics Platform (Platform-as-a-Service)</p>	<p>Up to 40% reduction in hardware and software development time</p>
<p>Data Management Platform with unified data and drive analytics Platform-as-a-Service</p>	<p>Up to 40% reduction in development time and NRE efforts</p>
<p>Secure Car Platform that enables secure data collection and transfer for ML SOTA or FOTA updates</p>	<p>Up to 30% reduction in development time and efforts</p>
<p>SAFEX™, a CI-BA-driven functional safety framework and test scheduler</p>	<p>Up to 25% reduction in development time</p>
<p>ADROIT Test Automation framework compatible with an existing test setup</p>	<p>Up to 60% reduction in testing cycle time</p>
<p>COGMATION™, a test automation platform for Android-based infotainment</p>	<p>Up to 30% reduction in testing cycle time</p>
<p>NOVIOUS™, a log analysis tool for infotainment validation</p>	<p>Up to 30% reduction in development time and efforts</p>

LTTS' ready-to-use, pre-developed connectivity reference programs provide a competitive edge to our partners and

customers. In addition, these reference programs can be quickly deployed to add future-ready connected features to vehicles.





READY-TO-USE CONNECTIVITY REFERENCE PROGRAMS



In this hyper-evolving connected mobility space, auto manufacturers and OEMs must innovate to stay ahead of the competition. LTTS believes in investing in

innovation through our state-of-the-art ER&D labs that can be effectively utilized to accelerate customers' product and manufacturing requirements.



INVESTING IN INNOVATION: IN-HOUSE STATE OF THE ART LABS

LTTS Bengaluru



5G TESTING & PRE-CERTIFICATION LAB

- Interoperability testing
- Pre-certification testing

LTTS Various Locations



MICRO-HIL SIMULATION LABS

- Closed loop HIL test benches

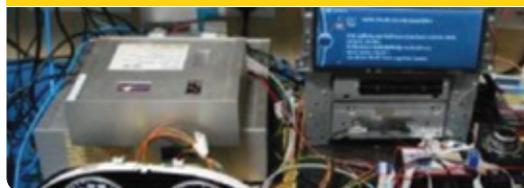
LTTS Bengaluru



IOT LAB

- IoT and Connected ecosystem solution development and testing

LTTS, Munich



AUTOMOTIVE LAB

- System Integration, Validation and Testing for Automotive Sub-Systems

LTTS, Dublin, OH

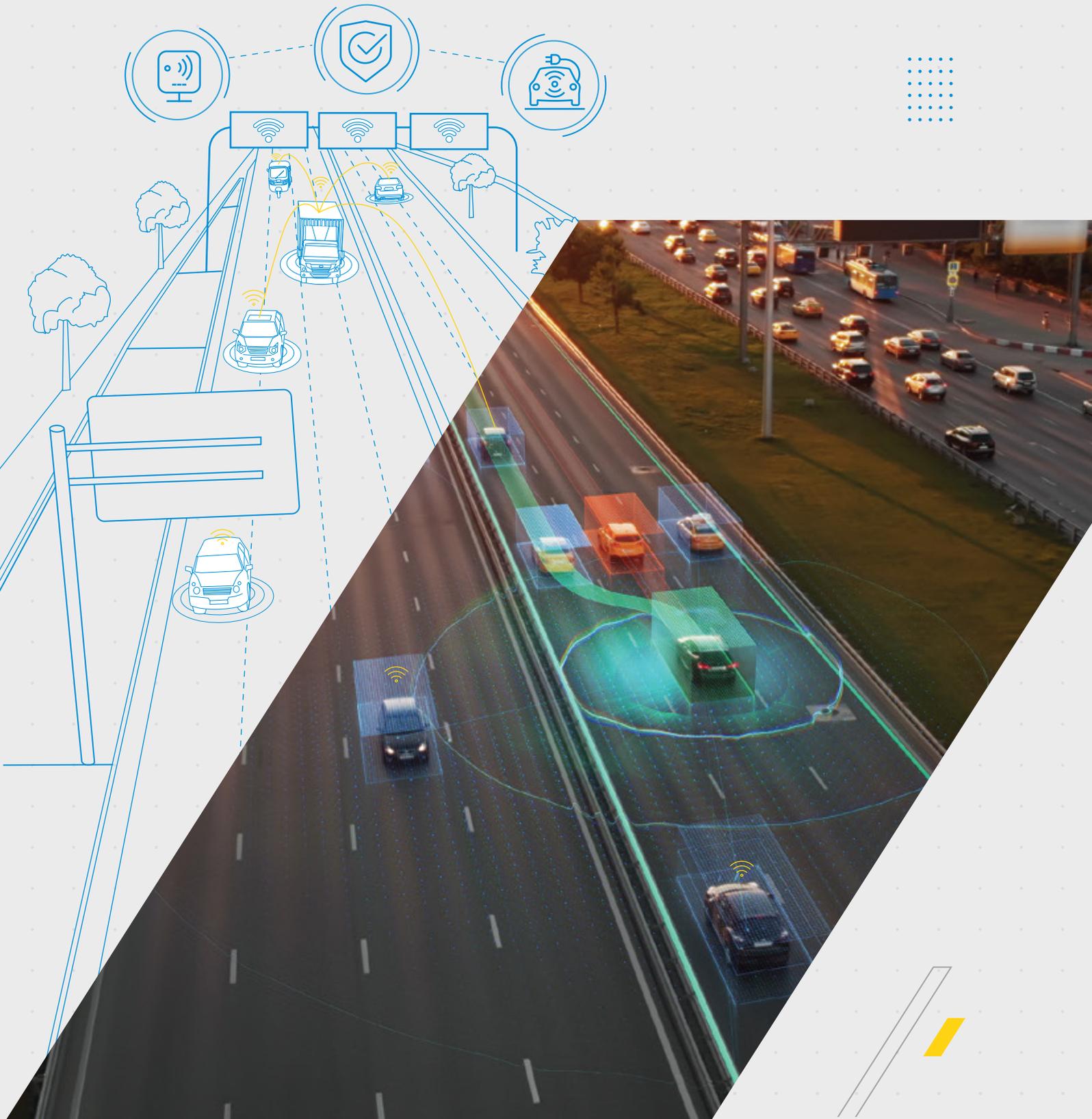


AUTOMOTIVE CENTER

- Vehicle design, validation and testing
- Virtual Simulation for Process Efficiency Improvement



THE CONNECTED MOBILITY LANDSCAPE: A ROUNDUP

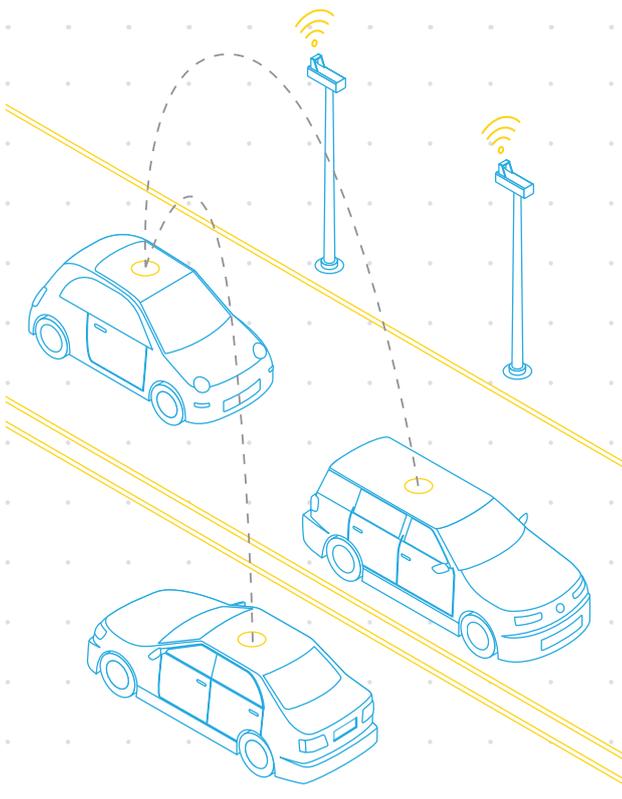


PASSENGER VEHICLES

The automotive landscape is transforming, and evolving consumer behavior, mobility preferences, and technological advances are the driving forces behind this transformation. Consumers expect their vehicles to not just drive them to places but be the extensions of their smart homes and smartphones, delivering a seamless connected experience. So, there is no doubt that enhancing the in-car experience is a major focus area for automotive manufacturers.



Passenger vehicles with in-built connectivity are expected to touch ~400 million globally by 2025.



To enable a hyper-personalized experience for the drivers and passengers of cars, auto manufacturers, OEMs, and Tier 1s must focus on the following three pillars:

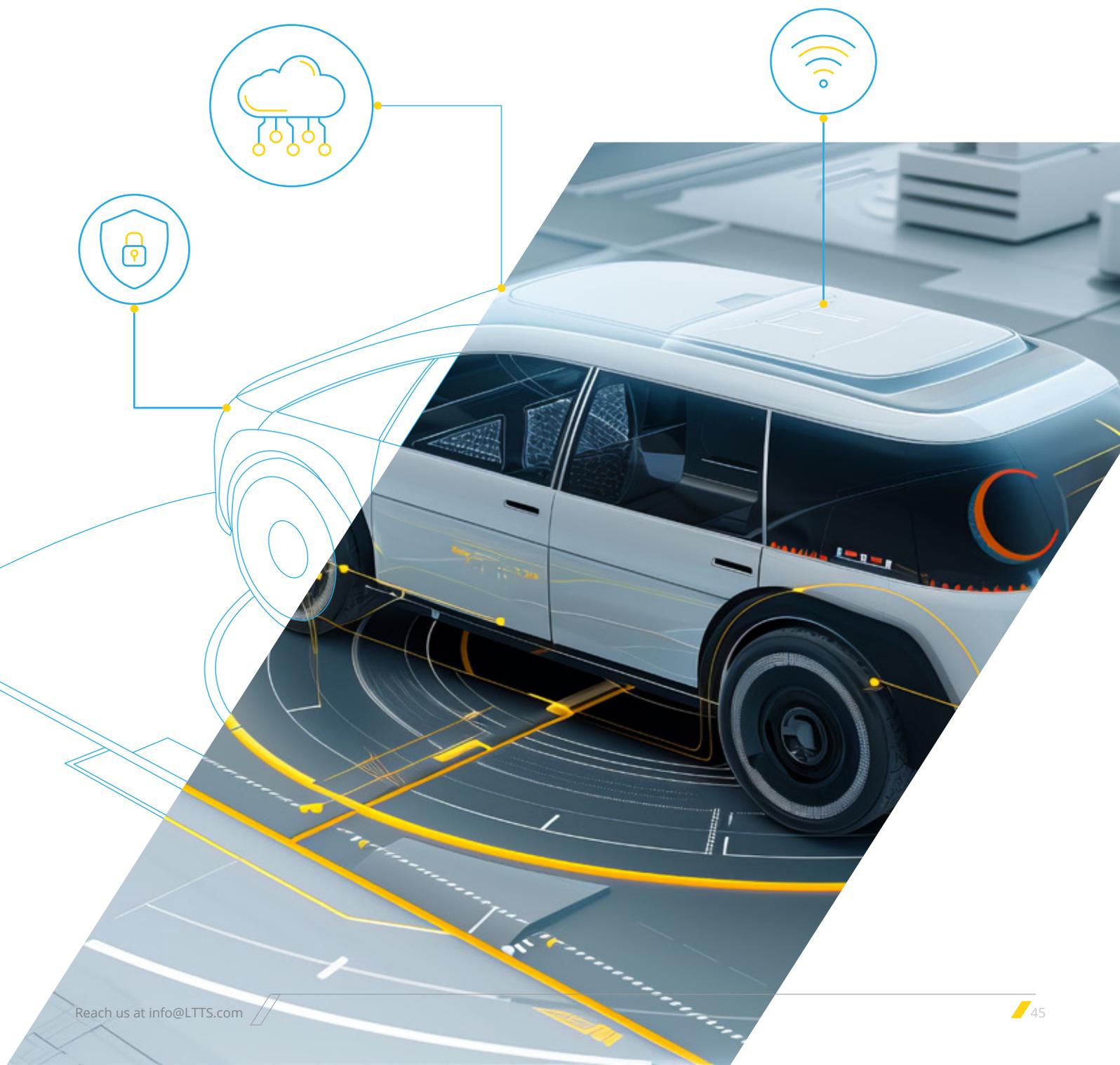
- Connected and enhanced infotainment
- Multi-media streaming
- Voice controls and voice assistants

The road to delivering an excellent connected experience, however, has a few speed bumps:

- Consumer-side
 - // Additional cost for connected features
 - // Privacy concerns
 - // Cybersecurity
- Product-side
 - // Shorter innovation cycle
 - // Integration of various devices and chip protocols
 - // Monetization of connected car services
- Infrastructure-side
 - // Inadequate assets to manage vast data streams
 - // High-speed and low-latency network needs
 - // Investment in sophisticated equipment and sensors

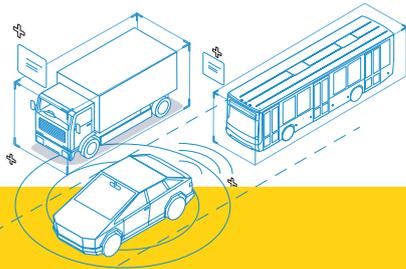
To overcome these bumps, OEMs and Tier 1s must target to achieve:

- // A faster time-to-market
- // Optimized costs through modular and reusable designs
- // Embedded safety and security features; implementing the “secure by design” approach
- // Customization and scalability across platforms
- // Continuous maintenance and upgrades (OTA)
- // Enhanced computing power and interconnectivity
- // Integrated autonomous driving features



COMMERCIAL AND OFF-HIGHWAY VEHICLES

A growing adoption of telematics, ease of vehicle diagnosis, and the need for enhanced safety and security are some of the key trends propelling the growth of the global connected commercial and off-highway vehicle markets.



The number of connected commercial vehicles is expected to be more than 120 million in 2023. On the other hand, the number of off-highway vehicles with connectivity is expected to reach more than 7 million by 2025.

In this segment, trucks lead in connected technology. The commercial and off-highway vehicle connectivity is driven by a single telematics platform, smart fleet management, remote diagnostics, and predictive maintenance. The rise of low latency 5G will fuel the future era of connectivity and ADAS in commercial and off-highway vehicles, across real-time navigation and communication, fuel-tracking, IVI, and enhanced fleet management.

Auto manufacturers and OEMs must revamp their development, support, and

administration processes to use advanced telematics, V2X, AI/ML, cloud, data analytics, and 5G to produce meaningful insights and find innovative ways to monetize connected services and their data.

The following factors are impeding the connectivity adoptions for heavy vehicles:

- 👤 Customer-side
 - Fleet owners need to manage multi-brand fleet
 - Uncertain return on investment (ROI)
 - Cybersecurity
- 📊 Business-side
 - Renewed investment
 - Highly cyclical nature of the business
 - Unclear business case
- 🔧 Legacy infrastructure
 - Lack of backend digitization and automation
 - Retrofitting advanced connected features in the existing fleet
- 🏗️ Infrastructure-side
 - Lack of the ability to extract insights
 - Cost-intensive testing
 - Spectrum availability

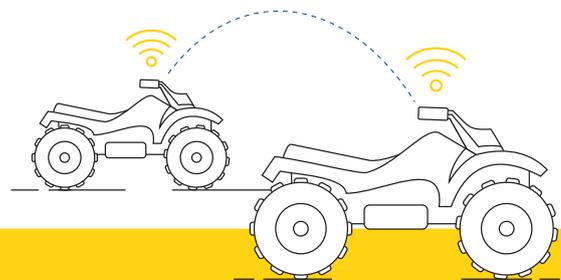
Auto manufacturers, OEMs, and Tier 1s will need to focus on the following objectives to overcome a range of challenges, including:

-  Lowering the total cost of ownership (TCO)
-  Minimizing the need for continuous maintenance and upgrades
-  Enabling access to comprehensive testing
-  Integrating autonomous driving features
-  Embedding safety and security features
-  Reimagining the go-to-market (GTM) model using AI/ML insights
-  Intensifying process digitization and automation



TWO AND THREE-WHEELERS AND POWERSPORT VEHICLES

Connected mobility trends such as V2X, navigation, digital cluster, advanced rider assistance system (ARAS), and so on that are transforming the automotive landscape are also infiltrating the two and three-wheeler and powersport vehicles enhancing connectivity, convenience, and safety. Shared mobility is a significant factor driving the two-wheelers' connected landscape.



The global connected motorcycle market is expected to reach >700 million by 2027.

Road safety, rider comfort, vehicle security, and subscription-based features for both personal and business use are the driving forces for two-wheeler connectivity.

Auto manufacturers, OEMs, and Tier 1s are focusing on the following aspects of connected two and three-wheeler and Powersport mobility:

-  Smartphone integration
-  In-built navigation
-  Rider assistance and safety

Factors impeding the connectivity adoption in this segment include the following:

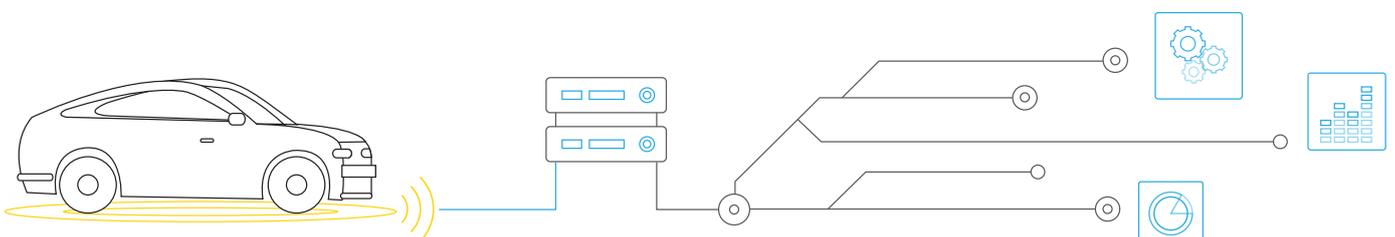
-  Business Factors:
 - // Cost resistance due to this being the ultra-price-conscious consumer
 - // Preference for tethered over embedded to avoid cost and compliance
 - // Lack of integration due to outsourcing to start-ups working in silos
 - // Inherent technology resistance leading to no clear functional ownership

Technical Factors:

- // Design constraints due to limited space and high vibrations
- // Absence of a cabin leading to components being exposed to the harsh environment
- // Peculiar dynamics of the vehicles
- // Exact positioning of components to ensure higher localization accuracy

Auto manufacturers, OEMs, and Tier 1s must focus on the following to transform the two and three-wheeler and powersport vehicle segment into a connected ecosystem:

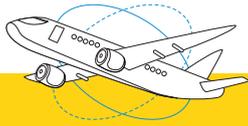
-  Lowering the cost of product development
-  Continuous maintenance and upgrades
-  Compact, rugged designs for the rough environment
-  Reimagining the GTM model to improve affordability
-  Embedded telematics and smart assistance
-  Integrating autonomous riding and driving features
-  Rigorous performance testing



AVIATION

Consumers' demand for staying connected has reached the sky, making this the major factor fueling aviation connectivity. As a result, global aircraft manufacturers are actively exploring ways

to increase in-flight connectivity and systems to connect aircrafts to the broader world beyond the airport environment.



The global connected aircraft market is expected to reach USD 12.3 billion by 2028.



By 2025, 23,000 aircrafts across 115 airlines will have in-flight connectivity terminals.



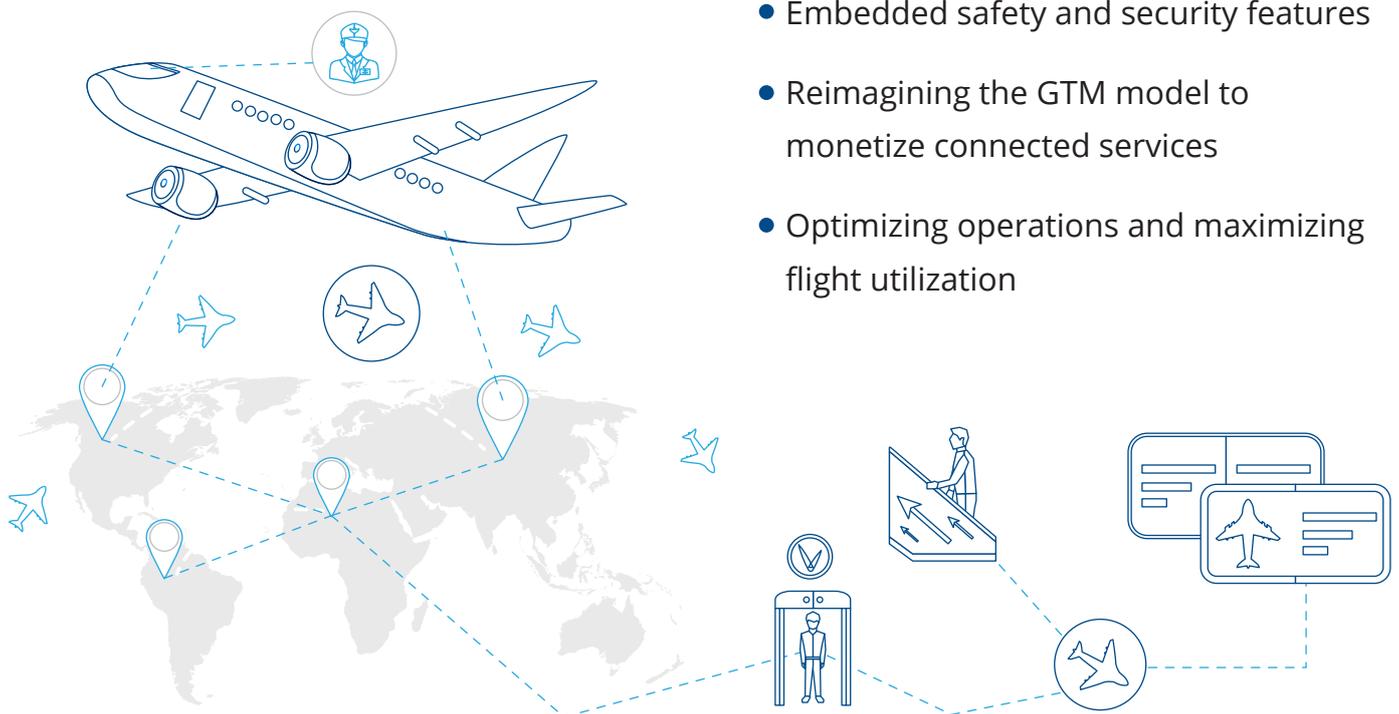
Day by day, aircrafts are getting more and more connected, from in-flight connectivity and digital cockpits to streaming live video of operations. Aviation connectivity can unlock advanced capabilities, making aircrafts safer and more enjoyable for passengers while improving airline operations and profits. However, as with any innovative technology, there are some challenges to overcome, like:

- Economic challenges:
 - /// High upfront cost
 - /// Unclear TCO
 - /// Frequent hardware updates
- Security challenges:
 - /// Increased risk of cyberattacks
 - /// Functional safety
 - /// Data ownership and privacy concerns

- Infrastructure challenges:
 - /// Inadequate assets to manage vast data streams
 - /// Reliability concerns for satellite-based connections
 - /// Network speed and consistency limitations
 - /// Lack of a single platform with unified data across airlines for better data monetization

Aircraft manufacturers are focusing on the following to overcome the connectivity challenges:

- Lowering the TCO
- Hardware configuration that is sustainable for more prolonged use
- Lowering the power consumption and lightweight designs
- Easy system installation and maintenance
- Embedded safety and security features
- Reimagining the GTM model to monetize connected services
- Optimizing operations and maximizing flight utilization



CHALLENGES ON THE ROAD TO CONNECTIVITY

Irrespective of the vehicle category, the future of mobility is EACV. This transformation will unlock the next era of superior experience for consumers, and new revenue and business opportunities for OEMs, and Tier 1s. In each of the vehicle categories that we discussed in the previous section, auto manufacturers, OEMs, and Tier 1s face similar challenges on the road to connectivity, making them the top priorities:

Faster time-to-market

- // Building scalable hardware and software platforms
- // Reference designs for an early head start

Ensure safety and security

- // Adherence to Functional Safety standards
- // Build robust cybersecurity protocols

End-to-end cost optimization

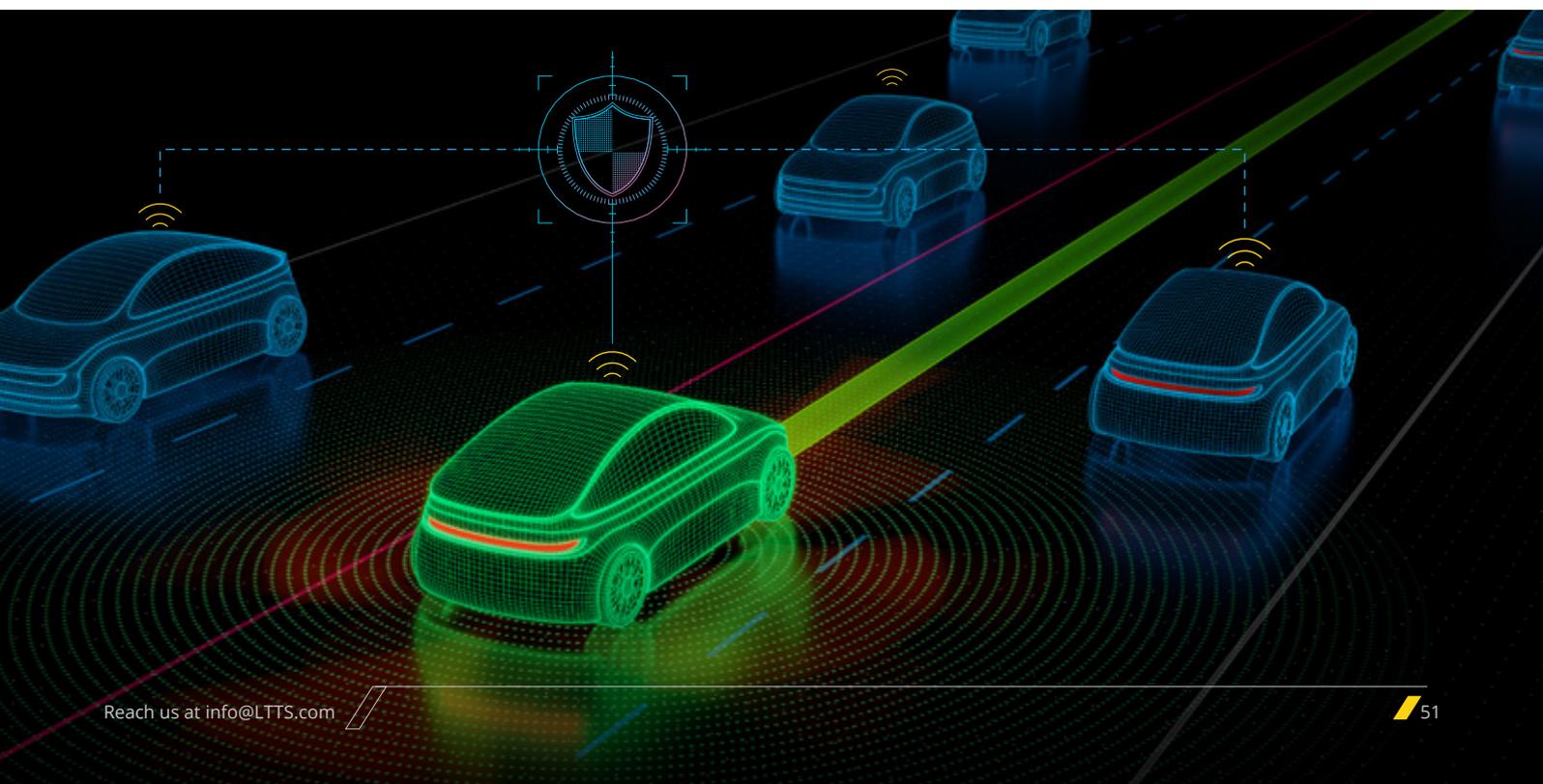
- // Employing reusable frameworks or accelerators
- // Intensifying process digitization and automation

V2X and telematics

- // Integrating various sensors, chipsets, and devices
- // Mobile network operator (MNO) integration and interoperability

Data management

- // Infrastructure for managing vast data streams
- // Real-time AI/ML to extract insights



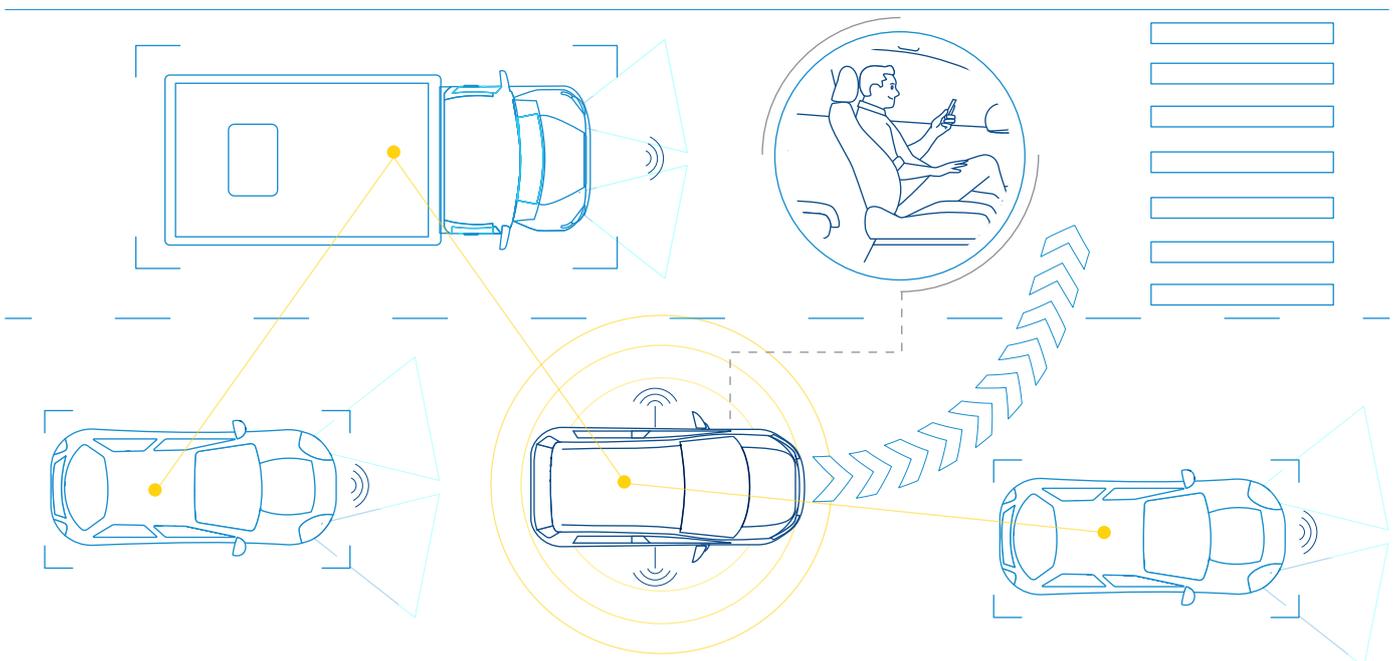
SILICON TO ANALYTICS: ENABLING END-TO-END CONNECTED MOBILITY DEVELOPMENT

With every segment of mobility undergoing transformation, auto manufacturers, OEMs, and Tier 1s must strive to design and build the next-gen vehicle hardware, software, electronics, and computing to revolutionize mobility and craft new use cases that deliver unmatched experiences, enhanced efficiency, and increased safety to stay competitive in this evolving landscape.

Many auto manufacturers, OEMs, and Tier 1s are restructuring their organizations to become more service-oriented, while others are adopting new technologies and tools (developed in-house or through acquisitions) or working with technology vendors to develop, deploy, integrate, and update software-driven features. Further, they must take advantage of the limitless

opportunities unlocked through new technologies, like 5G, C-V2X, real-time telematics, AI/ML, metaverse, and more. Such technologies can lead to innovative business models, new revenue streams, rapid scaling, enhanced customer experience, convenience, and safety, and a sustainable future.

To stay ahead in this competitive connected mobility landscape, auto manufacturers, OEMs, and Tier 1s need to craft strategic partnerships with pure-play ER&D players, like LTTS, to build innovative features indicative of a future where in-vehicle technologies and interactions with passengers, the environment, and other vehicles are seamlessly integrated.



LTTS is enabling end-to-end connected mobility development, from silicon to analytics, via:

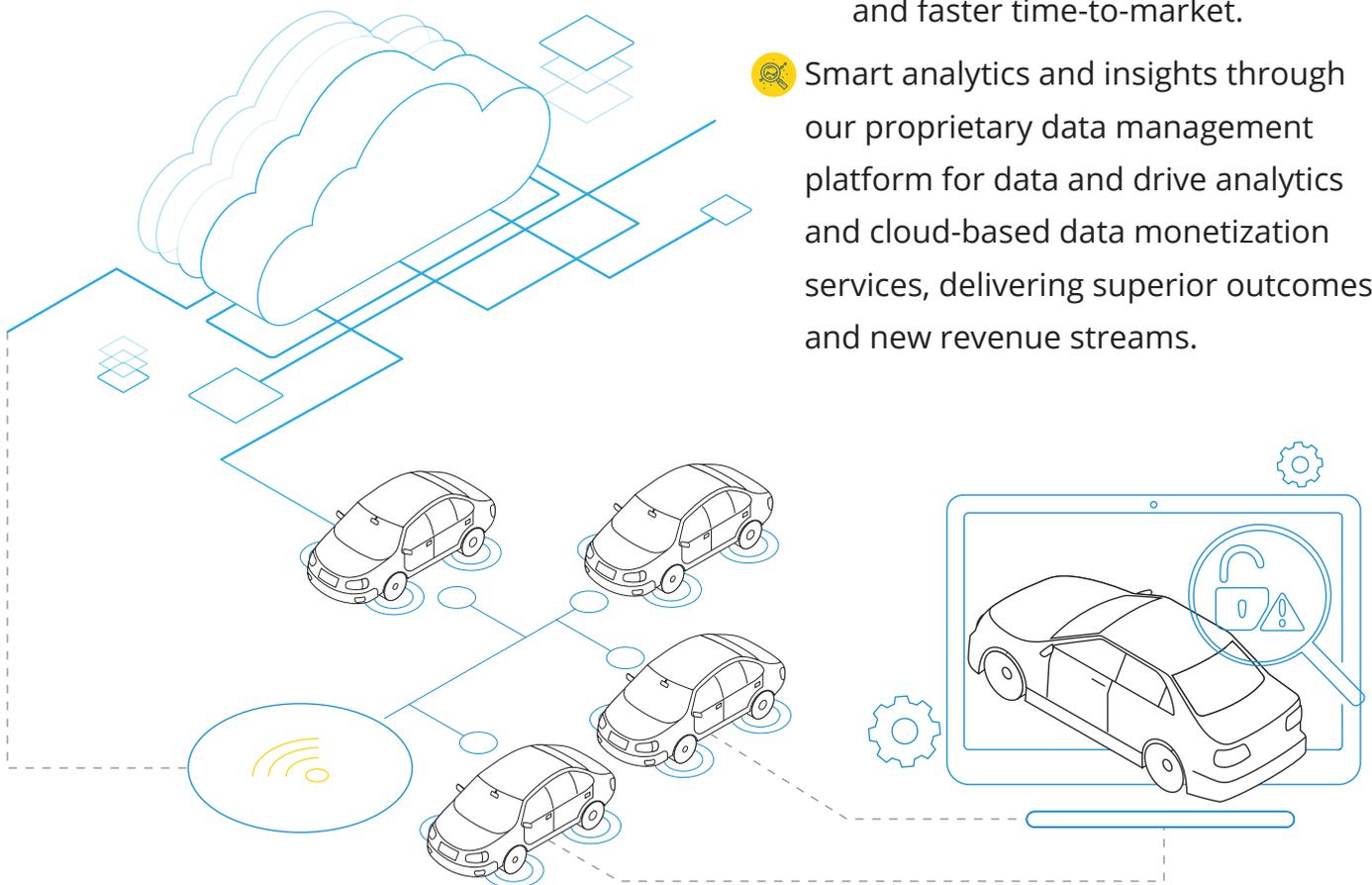
🕒 Accelerated development through the following:

- ✓ Platform expertise demonstrated by our 5G-ready end-to-end telematics platform and own secure car platform with car identity management and OTA capabilities, enabling faster time-to-market and rapid scalability.
- ✓ Rapid development showcased by our AUTOSAR-based turnkey development on a single ECU for IVI, cluster, and HUD and in-vehicle integration of Voice Service, enabling accelerated development and reusable design.

📄 Seamless integration and validation through the following:

- ✓ C-V2X powered by our strong ecosystem alliances with multi-national organizations (MNOs), network equipment vendors (NEPs), chipset vendors, and in-house state-of-the-art 5G lab infrastructure enabling faster integration and reduced upfront cost.
- ✓ Security via our dedicated cybersecurity CoE with reusable frameworks and vulnerability assessment and penetration testing providing built-in security and reusable frameworks.
- ✓ Extensive testing via in-house closed loop micro-HIL simulations labs and proprietary test automation suite (Cogmation™), delivering reduced upfront cost and faster time-to-market.

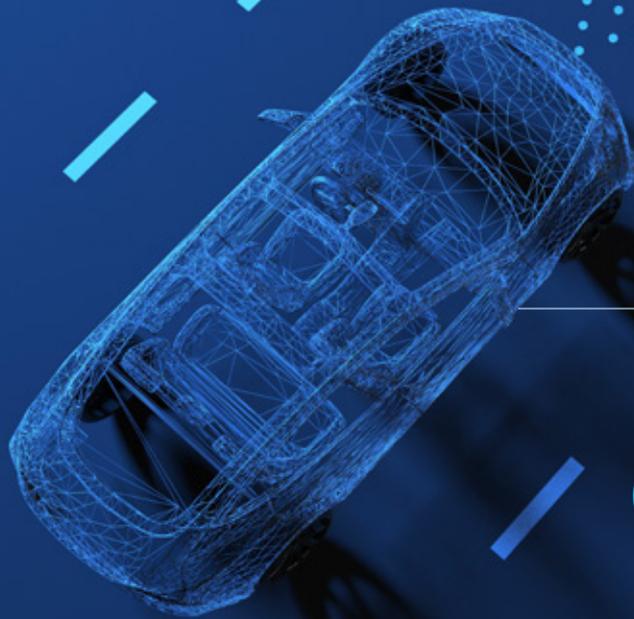
🔍 Smart analytics and insights through our proprietary data management platform for data and drive analytics and cloud-based data monetization services, delivering superior outcomes and new revenue streams.





As a strategic engineering partner, LTTS understands the needs of its customers and delivers solutions to address them.





THE WAY FORWARD

As the automotive industry recovers from the supply chain issues caused during the pandemic and approaches a new era of electrification, connectivity, autonomy, and sustainability, both auto manufacturers and consumers can expect exciting opportunities driven by the next level of autonomous technology, 5G-powered C-V2X, AI/ML, cybersecurity, and real-time telematics.

The consumer will be at the center of the connected mobility's way forward, and the industry will witness trends like data monetization, software-driven features, metaverse, shared mobility, AR/VR, and sustainability. Global auto manufacturers, OEMs, and Tier 1s are focusing more on providing personalized in-vehicle experiences, digital cockpits, voice-enabled features, and transforming

displays from touchscreens to haptic feedback and voice-controlled with AI-based digital assistants.

With the global push for sustainability, the electrification of vehicles has taken center stage, and modern EVs continue their journey to becoming connected mobility marvels driven by cutting-edge technology and smartphone-like connectivity.

To give life to these next-gen EACV features, auto manufacturers, OEMs, and Tier 1s will need to find the right mix of in-house capabilities and strategic partnerships with pure-play ER&D companies, like LTTS, to deliver best-in-class connected mobility experiences to customers.



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