

Unveiling the Futuristic Trends of 5G Connected Cars in the Automotive Industry

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Abstract: The concept of “vehicle to everything” has completely revolutionized the maker’s and user’s experience. The whirlwind of disruptions is buffeting the automotive world, creating a huge value-chain disconnect. The amalgamation of advanced in-vehicle capabilities and cellular network data services leverages innovations in the automotive sector. The introduction of connected vehicles is expected to change user-vehicle interaction and communication with the world around them. Several countries have initiated the 5G trials, with the results being under evaluation. The rapid increase in enhanced user experience and affordability for various services are increasingly impacting the adoption of various innovative solutions. The advent of this state-of-the-art technology is not only a generational step, but the possibility of opening several opportunities for the industries. The article focuses on the evolution of 5G services and their impact on the global economy. The development of 5G is expected to bolster digitalization trends, significantly impacting the automotive industry, particularly connected cars. The paper discusses the impact of the revolutionary 5G technology on future mobility and reviews the use cases of 5G in the automotive sector. Further, other major areas of study emphasize on the market determinant analysis (trends, drivers, and challenges) of 5G services in the automotive sector.

Keywords: 5G, Automotive, Communication, Connected cars, Networks, Services.

I. INTRODUCTION

With a shift from trial to early commercialization, the 5G technology acts as the game-changer for

life-changing innovations [1]. 5G technology is a myriad of innovations, wherein, the amount of information and number of subscribers they consume, is no longer a restraining factor, however, it enables an infinite number of applications and devices to process, synthesize, and exchange enormous amounts of information for investments to advance the underlying infrastructure [2]. Its network architecture for mobile technology progresses immensely upon the past architectures [3]. Enormous leaps in performances are empowered by large cell-dense networks. The architecture of 5G wireless services provides enhanced security in comparison to the 4G LTE networks. Moreover, 5G wireless technology systems, offer faster speed, in comparison to the earlier generations, such as those delivered through fiber-optic cables. This increased speed is expected to necessitate more spectrally competent technologies with additional spectrums. With telecom companies emphasizing on enhanced infrastructural construction, 5G-enabled applications are expected to have an energizing impact on the economy over the projected period.

Increasing market demand for 5G services is significantly associated with the mobile networks accomplished of provisioning the services comprising of tearing down and launching of networks as per the customer requirements. These requirements can be accomplished by network function softwarization which is independent of hardware and is better to manage the networks [4]. New intermediaries and business models in the value chain processes are also garnering positions nowadays to cater to the rising demand in offering differentiated connectivity services to the end-users in the market. Facts concerning 5G services are

now becoming a reality, piloting in the era of new opportunities in different business verticals [5].

The transition from digital-first to digital throughout unleashes newer revenue streams and applications via innovative business models, impacting diversified industries. 5G, or the fifth generation of cellular technology, leads to reliable and fast connectivity, enabling seamless connectivity for billions. The lightning-fast connection offered by 5G, contributes significantly to the growing advancements in intelligent automation; in terms of blockchain, driverless cars, the Internet of Things (IoT), digital reality, Artificial Intelligence (AI), and breakthroughs untapped yet [6]. Low latency, faster speeds, and the capability to back up a plethora of device termination points make the technology a versatile one.

With the advent of four major trends such as connectivity, diverse mobility, autonomous driving, and electrification, the gap between automotive and high-end industries is narrowing down. As the convenience and comfort quotient among the users witnesses an increase, these trends are expected to revolutionize the integrated automotive value chains [7]. The evolution in wireless technologies bolsters conventional mobility to the current connected car environment with seamless vehicle operations to be driven into an autonomous climate [8].

Purpose of the Article: This article contemplates the current state of the global 5G wireless services market with a major emphasis on different determinants (market trends, drivers, opportunities, and challenges in implementing the technology) impacting the automotive market growth. It emphasizes on the economic contribution of 5G wireless services along with the key focus on future research plans and strategic implications for 5G automotive businesses.

The proposed article further intends to offer an outline for 5G wireless services along with different market-related information that enables the vendors to gain a competitive edge and profitability in the industry. A holistic competitive analysis thereby, helps the businesses deploying these wireless services across, to discover their potential to compete in the market.

Findings in the Article: Adoption of 5G technology in the automotive industry paves the way for

futuristic developments such as vehicle-to-vehicle communication and real-time traffic optimization in connected vehicles and intelligent transportation systems. This article explores how 5G technology is transforming the automotive industry and driving the sector towards a connected and safer future.

II. LITERATURE REVIEW

The introduction of 5G technology enables manufacturing companies to get an alternative for communication processes for several Industry 4.0 applications which includes wireless control such as robots, machines, and mobile tools. 5G aids the implementation of specialized functions and tasks, such as connected cars, and remote precision medicine, along with augmented and virtual reality experiences. Advancements linked with 5G offer seamless coverage, lowered latency, with enhanced ability to back up many devices. With exponentially high download speeds of nearly 20 gigabits per second, users with 5G wireless services are expected to download the contents within seconds. On the basis, of, trials to date, the 5G networks are expected to offer higher performance in various application segments such as indoor hotspots along with dense urban areas as well. A few innovative usages of 5G technology include remote monitoring of patients in hospitals, increased usage of smart ambulances that can communicate with doctors on a real-time basis, digital wallets to connect wearables, phones, and cars, with smart devices to offer unified financial transactions, 5G-aided factories with connections being sustained among sensors and few more.

Rising emphasis on building partnerships by an amalgamation of 5G wireless service providers with different telecom operators is expected to bolster the implementation of these services in different industry verticals. Connection of the cellular antennas to data centers with fibers ensuring real-time speeds are anticipated from 5G. Although the fiber optic infrastructure prevalent in today's scenario is being used by the 4G systems, more infrastructural development will be required to support the widespread usage of 5G. Factors such as fiber-optic infrastructural development are expected to bolster the execution of 5G to certainty.

Analyzing a wide range of micro-market indicators and statistics contributing to the prospects and dynamics of the market strategically plays a vital role. The technological trends and critical domains of 5G wireless services need to be catered upon, to illustrate its evolution and projected quantum leap for profitability to the end-users. The advent of 5G thereby, focuses on advancing societies, enhancing experiences, transforming industries, and opening avenues for businesses. Identifying the research needs and priorities in terms of strategy-making to support the easy and cost-effective deployment of wireless technologies and solutions are gaining significant traction across the world.

III. 5G AND THE AUTOMOTIVE SECTOR

In the automotive sector, 5G is envisioned to augment the aspects of automated cars and in-car entertainment. The evolution of the connected-car ecosystem impacts different value chains, comprising those for semiconductors, automotive, software, and telecommunications. Inclusion of the specifications, on the cellular Vehicle-to-Everything (C-V2X) in Rel-16, helps boost the realization of connecting technology, designed to connect road users, roadside infrastructure, cloud services, and vehicles-to-vehicle services to enhance the overall transportation experience [9].

Embedded connectivity is anticipated to unlock the latest capabilities and features, changing the driving experience holistically, and making it satisfying and safe [10]. To remain relevant and competitive, it is significantly necessary for industry leaders to embrace the digital revolution and be dynamic investors in coordinating, constructing, and cementing the right ecosystem for the successful adoption of 5G service. The paper focuses on the important changes transforming the automotive sector, with the implementation of 5G technology. It also examines the value captured and incorporated by the market players, in their future product segments as well as operational, and organizational capabilities. Evaluating and forecasting future opportunities and trends serve as the first step for all the business activities of any small-sized or large-sized firm.

The influence of 5G on different telecom business shareholders along with its relevance and potentiality across varied application segments is witnessing immense growth. The market players are increasingly, focusing on striving towards implementing different research and development initiatives to deploy and develop efficient technologies and cater to the global product and service demand, revenue strategies, and pricing trends.

IV. IMPACT OF 5G TECHNOLOGY ON THE AUTOMOTIVE SECTOR

In today's scenario, 5G is exponentially changing the way businesses are working. The technology opens the door for groundbreaking developments in intelligent transportation systems along with driverless and connected vehicles.

The automotive companies are embracing the advantages of technology and rekindling the industry's creativity. Millions of vehicles are being connected to cellular networks for emergency services, connected infotainment, and real-time navigation services [11]. Leveraging 5G is expected to enable automakers to launch new business models, and augment the overall manufacturing and operational efficiencies.

Improved Infotainment and User Experience: Developers nowadays are continually striving to cater to consumer needs, owing to the increasing number of latest technology adopters and smart device users [12]. The high-speed data transfer by 5G will offer individuals with immersive car infotainment experiences. Integration of 5G with personal devices will enable passengers to use AR/VR, cloud-based gaming, and high-quality streaming services efficaciously.

Smart Roads: 5G technology acts as a major component for the implementation of smart roads. Execution of smarter road infrastructure paves the way for increased profitability with revolutionized transport networks. These smart roads incorporate the usage of sensors, and smart devices, wherein, the data is transmitted both with volume and speed, via various data points to enable real-time

communication between the infrastructure and the vehicles deploying it. The technology also augments the controlling of congestion, traffic flow, and traffic lights through automated artificial intelligence and machine learning programmes. Nearly, twenty-one percent of the crashes occur due to weather conditions [13]. The incorporation of smart road technology paves the way to easily detect nearby weather conditions with sensors and subsequently send updates to the satellite navigation systems of the adjoining vehicles, to let the drivers get an idea about the roads ahead. Further, improvements can also be witnessed in road safety and transit-route planning with the transmission of real-time information.

Universal Connectivity: 5G Connected cars enable the analytics to efficiently understand customer needs and offer subsequent predictive maintenance. The technology enables the car manufacturers to manage the cost and connectivity with the One Standard Level Agreement (SLA) contract. Worldwide connectivity, thereby acting as a solution for the efficacious connectivity and integration of the connected vehicles with the related ecosystems [14].

Optimizing the smart data downloads and uploads at off-peak locations and times enables the cost control of the OEMs. The optimization of the data transfer in terms of cost of the connection, quality, and time, helps to discern the scheduling optimal conditions and the type of traffic, thereby saving the costs for OEMs.

Enhanced Mobile Broadband (EMBB): 5G technology offers more uniform and faster experiences and speed, in comparison to the 4G technology. This is thereby anticipated to augment the higher-bandwidth use cases such as machine and real-time human interface rendering, vehicle teleoperation, and in-car infotainment [15].

Re-Imagining Vehicle Maintenance: With the vehicles becoming more connected and intelligent, the maintenance of such a fleet of vehicles, with real-time initiated repair, problem identification, and performance evaluation becomes an essential factor. The combination of edge computing and cellular connectivity helps the technicians to seamlessly predict and subsequently fix the issues [16].

Enormous Internet of Things (IoT): With a million connections per square kilometer, the 5G networks are anticipated to efficaciously back up several concurrent connections from connected infrastructure, cars on the road, and end-user devices. This is further expected to minimize the probability of cars and other devices getting disconnected from the mobile network accidentally owing to many connections.

V. USE CASES OF 5G TECHNOLOGY IN THE AUTOMOTIVE INDUSTRY

The automotive sector is anticipated to witness profound developments concerning the past differentiators, such as focusing on the layers of hardware and software comprising of vehicle's operating system, and powertrains. Intelligent connections between the internet, and vehicles, poses to be one of the key areas shaping the future of the industry. The industry is emphasizing on shifting to networked ecosystems with the interaction between several players and the end customers from the linear value chains with OEMs at the end of the assembly line.

Fundamental improvements in environmental impact, convenience, cost-effectiveness, safety, and experience when combined, disintegrate the diversified business models at an unprecedented scale. For instance, in the regions of Germany and the U.S., connected car startups are playing a significant role, with the major expertise sections being on mobility management systems, maintenance and diagnostics solutions, and connectivity. Advances in connectivity and computing are anticipated to augment new use cases in the automotive industry. A few of the use cases can be illustrated as:

A. 5G for Vehicle Production

5G connectivity offers services such as Automated Factory Parking (AFP), wherein, the remotely controlled vehicles are mechanically moving across the logistics hubs and production areas. The private networks offer the prospect of tailoring the correlation capabilities for highly on-premise and personalized demand. For instance:

- *BMW Brilliance Automotive Ltd.*

About the Company: BMW Brilliance Automotive, founded in 2003, is a joint venture company between the Brilliance Group and the BMW Group. The business operation segments offered by the company include procurement, research and development, sales, production, and after-sales of automobiles in China. The company emphasizes on high-quality development and is one of the leading sustainable providers of first-class mobility across the automotive industry in China [17].

Solutions Offered: BMW Brilliance Automotive (BBA), announced the introduction of 5G wireless coverage across all its manufacturing plants, thereby increasing the efficacy of the production processes. The venture enables the transfer of data at a rate of one gigabyte a second, via high-performance and small computer centers directly on-site, thereby helping seamless exchange of data on real-time basis. Incorporating this ground-breaking technology is expected to open avenues including augmented reality and cloud-based control of human-machine interaction and autonomous transport systems with the help of smart devices [18].

B. 5G for Telematics

The automobile industry poses to be a vital technological intersection, wherein, information and communication are becoming a widespread aspect nowadays [19]. Increasing connectivity is expected to bolster the role of telematics with varied valuable insights. The different 5G telematic units offer benefits such as the application software development kit (SDK), enabling the co-development models with OEMs, along the integration of the connectivity hub with the latest wireless technologies [20]. The Obtainability of automobile telematics data from the fleet poses to be one of the significant resources for the automotive OEMs, and enables seamless monitoring of the predictive maintenance and fleet performance, thereby benefitting both the OEMs and the customers. For instance:

- *Harman International*

About the Company: Harman International, a US-based company, is developing solutions

designed around passengers and drivers. The in-depth expertise offered by the company is largely redefining the overall automotive landscape, with the most immersive and intuitive communication with in-vehicle technology. Harman is a subsidiary unit of Samsung Electronics Co. Ltd.

Solutions Offered: Market players such as Harman International, announced the launch of the first-to-market 5G Telematics Control Unit (TCU), to enable users to upgrade to enhanced experiences, thereby laying the groundwork for mechanized driving. The company offers connected and integrated audio car systems and services powering billions of mobile systems and devices, enabling automakers to create an ecosystem with rich in-vehicle experiences.

C. 5G for ADAS

The Advanced Driver-Assistance Systems are the cutting-edge features assisting the drivers and subsequently augmenting road safety. Connectivity plays a pivotal role in ADAS, supplementing onboard sensors with data that comes from sources outside the vehicle, such as ADAS service providers or infrastructure sensors, or is processed in the cloud. The capabilities are extended beyond the limitations of onboard processing and sensors. For example:

- *Valeo*

About the Company: Valeo, is a French company, founded in 1923. Valeo is a motor vehicle part manufacturing company, offering innovative solutions to make mobility smarter, safer, and cleaner. The company is one of the leaders in the reinvention of the interior experience, driving assistance systems, and electrification across. Valeo operates with nearly 183 manufacturing plants, 44 development centers, in 21 research centers in approximately 29 countries across the world.

Solutions Offered: Valeo is engaged in offering transformative Advanced Driver Assistance System (ADAS) solutions integrated with state-of-the-art technologies to augment several functionalities. These solutions comprise of a range of real-time data processing, intelligent algorithms, and sensors, to offer inclusive assistance, ensuring convenient and safer rides for the car owner. These solutions include

a wide range of driving features that enhance comfort and safety on the road. With the help of features such as LiDAR sensors, radar, and cameras, enables constant and seamless monitoring of the surrounding environment, thereby assisting the drivers with real-time alerts. Incorporation of concepts such as:

- *Adaptive Cruise Control (ACC)* helps maintain a safe distance from the vehicles by minimizing the risks of rear-end collisions with automatically adjusted speed.
- The *Lane Keeping Assist System (LKAS)* exploits the cameras and lane detection algorithms to detect lane markings and subsequently corrects the deviating trajectory of the vehicles from their intended path.
- *Blind Spot Detection (BSD)* signals the drivers regarding the existence of vehicles in their blind spots, thereby averting probable accidents at the time of lane change.
- *Rear Cross-Traffic Alert (RCTA)* helps in detecting the vehicles coming from the sides when maneuvering out of tight spaces, with enhanced safety [21].

Hence, the solutions represent intelligent and comprehensive systems extending their potential beyond parking, and driving, and subsequently simplifying the daunting tasks if any.

VI. TRENDS OF 5G TECHNOLOGY SHAPING THE AUTOMOTIVE INDUSTRY

The technology-driven ecosystems are gaining significant traction in the automotive industry. The industry is witnessing a continual trend of integrating the electronic control units (ECUs), and car functions into the central domain controllers, thereby pushing the growth towards more connected and integrated infotainment systems.

It is becoming the need of the hour for companies to understand the latest automotive technology stack and the issues grappling within the industry.

The trends revolutionizing the way the automotive industry develops cars can be illustrated as:

A. Autonomous Driving

Autonomous vehicles are anticipated to dramatically enhance security over the forecasted period, wherein, self-driving cars become ubiquitous. Reaching that level, however, requires widespread investments to develop machine learning models for illustrating infrastructure and traffic for low-latency wireless networks [22]. Wireless communication generates a network of advanced technologies such as high-speed information systems, networks, and sensors that enable things such as vehicle-to-network communication or vehicle-to-vehicle communication [23].

The 5G technology acts as a base for autonomous car networks, by seamlessly connecting pedestrians, drivers, infrastructure, and vehicles. With the emergence of 5G networks, autonomous driving is expected to become a reality. The real-time connectivity required for the automated vehicles to engage with the surrounding infrastructure and with one another will be backed by high reliability and low latency of 5G, thereby, increasing the responsiveness and accuracy of these systems. The different ways by which 5G is anticipated to improve autonomous vehicles by making them more safe, reliable, and connected [13].

- *HD Road Mapping*: Enhanced mapping poses to be significant for an autonomous vehicle to drive safely. For instance, the incorporation of HD road mapping is expected to enable the cars to maintain situational awareness and augment the safety of the automated vehicles by giving these, instant 3D access to roads.
- *Vehicle-to-Everything Communication*: The reliable internet connectivity along with the low latency from edge computing, is anticipated to unfold the car door to vehicle-to-everything (V2X) communication, thereby enabling a connected car to seamlessly transmit the data from other road sensors, infrastructure, and nearby vehicles. The forthcoming scenario of road transportation is projected to have cars communicating with other infrastructure, roads, and cars.

- *Edge Computing*: The concept of edge computing brings the data storage and computation nearer to the source, rather than refining the data at a central location. This enables the technology to possess lower latency and subsequently communicate with other devices and sensors on a real-time basis.

B. Shared Mobility

With the shifting customer preferences, the ownership model of the cars is, significantly evolving from renting and sharing. Nearly, one-third of the expected increase in vehicle sales from urbanization and macroeconomic growth likely will not happen because of shared mobility. Different shared mobility solutions include:

- Mobility service offerings.
- Car-sharing profile broker.
- Secondary authentication through mobile phone.
- Seamless mobility application.
- Location data to be sold to the mobility provider.

C. Connectivity

5G networks being deployed are offering low latency, wider coverage, and increased speed, required for the projected advances in the transportation sector. The automotive industry, with the broader mobility ecosystem, is engaged in the transformation, prompted by the shift bolstering in tandem with the build-out of distributed communication infrastructure providing connectivity to the car [24].

Intelligent communication outside and within the car acts as an enabler for autonomous technologies. These include the different connected services and technologies such as data monetization, fleet solutions, smart traffic, dashcam solutions, predictive maintenance and remote diagnostics, payment solutions, intrusion detection, and a few more.

D. Electrification

With the advent of technology, automakers are increasingly mastering the art of designing, building, and validating vehicles with internal combustion

engines (ICEs), and catering to the changing scenario [25]. With the introduction of cutting-edge technologies, connected cars are increasingly featuring electric powertrains, thereby connecting the cars digitally and subsequently performing remote operations.

VII. MARKET DRIVER BOOSTING 5G TECHNOLOGY IN THE AUTOMOTIVE INDUSTRY

A. Growing Connected Car Ecosystem

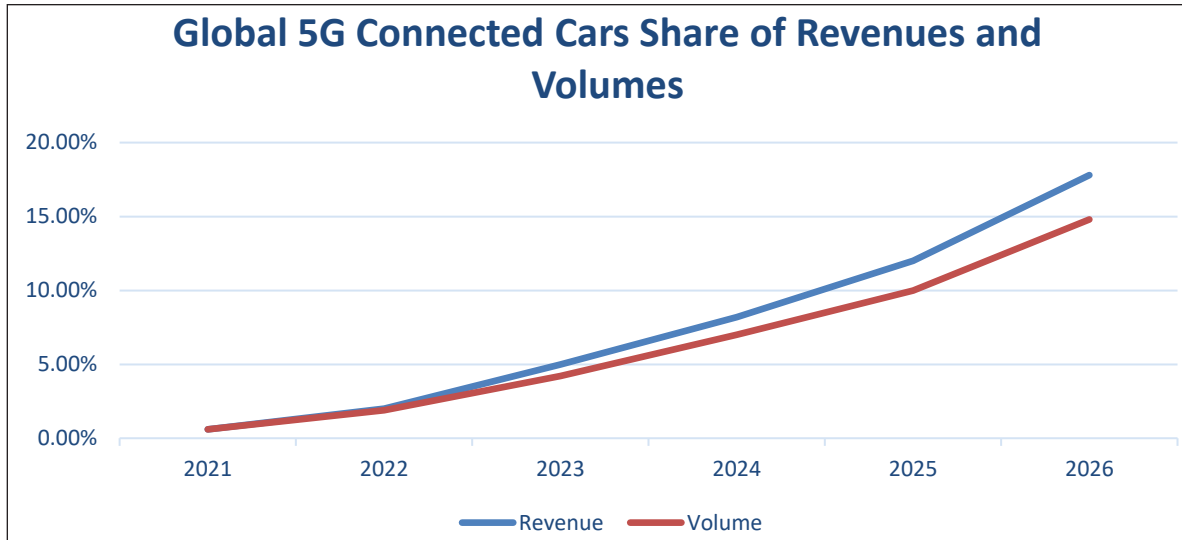
Ensuring connectivity in the ecosystem necessitates the integration of several services across the same. Shifting from a feature-driven to a holistic approach, wherein, functionalities are often upgraded on demand and play a crucial role in the automotive connected key space.

The concept of connected car technology is gaining significant traction, to cater to the increasing and changing needs of the clients, in the ever-expanding horizon. The figure mentioned below illustrates the market share for the connected cars in terms of revenues and volumes from 2021-2026.

This groundbreaking innovativeness has created an ecosystem in the automotive industry, with technological partnerships with the original equipment manufacturers (OEMs), and players, functioning outside the scope of the conventional motoring process [27].

The connected cars ecosystem has revolutionized traditional mobility by hardwiring content platforms, real-time analytics, operating systems, and telecommunications, among other factors in the driving experience. The technology-enabled cars are to be equipped with connectivity, software service, information, and data.

With the advent of pioneering technologies, connected cars are anticipated to become generic commodities over the forecast period, however, also emphasizing on the fact, that the services are largely the evolution of what the market players can offer, by posing as a differentiating criteria for the vehicle manufacturers [28]. The connected ecosystems thereby, pose an essential factor in bolstering the incorporation of 5G technology in the automotive industry.



Source: [26]

Exhibit 1: Global 5G Connected Cars Share of Revenues and Volumes

VIII. CHALLENGES OF IMPLEMENTING 5G IN THE AUTOMOTIVE INDUSTRY

Compatibility and Standardization: Adhering to the standardized requirements and protocols is expected to play a significant role in the seamless integration and communication process. Ensuring compatibility in between the automobile gadgets and 5G technologies poses to be a challenge.

Security Issues: With the increasing connectivity, unauthorized access to vehicles and infrastructures along with the possibility of cyberattacks is witnessing a rise. The inclusion of 5G technology in the automotive industry poses several restraints in establishing strong security measures and thereby protecting sensitive information to prevent privacy violations and hacking attempts [29].

IX. FUTURE OF MOBILITY AND 5G CONNECTED CARS

The emerging innovations and collaborations are enabling the operations to become efficient. The adoption and availability of technological solutions is expected to bolster most of the key trends in the auto industry. The entire industry, from automakers to suppliers, is challenged to keep the prevailing operations beneficial, while concurrently building

out the capacity to cater to these innovations. In today's scenario, the market players are emphasizing on finding the balance between the endurance of a profitable business, and at the same time paving the way to disintegrating the business models.

A few instances of innovativeness in mobility in the future can be illustrated as [30]:

- Vehicles embedded with several sensors, and internet-connected engine control units (ECUs), offering insights and data.
- Cars offering a connected platform for the latest business models.
- The capability to bundle the sales with the latest subscription-based offerings for car share, rideshare, electric vehicle (EV) charging, and parking services.
- Continual rise and expansion of the fleet services to include charge point operations.
- The algorithm-based insurance based on the data collected from the connected cars.

X. CONCLUSION

5G, the future of mobile connectivity, is anticipated to create great value for society as well as industries. Accelerated rollout and adoption of 5G technology, draws insight on quantifying its potential impact in

terms of economic values. As per the International Telecommunication Union (ITU), the number of connected devices on the Internet is expected to be nearly 50 million by 2028 [31]. 5G, the fifth generation or next generation of mobile technologies, is anticipated to connect various applications, people, transport systems, data, and cities in smarter networked communication environments. Implementation of 5G networks focuses on representing higher performance in different facets. With the deployment of these advanced technologies, enormous amounts of data can easily be transported, and various processes and devices with massive volumes of data can be connected, with full reliability.

In the automotive sector, the cutting-edge 5G technology benefits are expected to contribute to a wider range of edge applications. The workloads that are not defense critical, for instance - smart traffic and infotainment management, are expected to move to the edge from in the cloud or onboard. 5G connectivity thereby minimizes the latency to the point that only a few defense-critical functions begin to be amplified by the edge infrastructure, despite relying completely on the onboard systems.

Key market players along the value chain, such as hyperscalers, communication system suppliers, tier 1 suppliers, semiconductor players, and OEMs, are anticipated to increase the value capture in the growing automotive landscape [15].

Hence, the constant relocation of the spectrum towards 5G, along with the integrated features such as edge cloud, dynamic policies, network slicing, and QoS is expected to cater to a wide range of services. The amalgamation of all pioneering features, thereby, enables car manufacturers to evolve and roll out efficacious connected cars in the future [32].

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